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**Editorial Information:**
For details please write to the Executive Editor, International Journal of Engineering, Sciences and Management, Dronacharya Group of Institutions, # 27, Knowledge Park-III, Greater Noida – 201308 (U.P.), India.

**Telephones:**
Landline: +91-120-2323854, 2323855, 2323856, 2323857, 2323858
+91-120-2322022
Mobile: +91-8826006878

**Telefax:**
+91-120-2323853

**E-mail:**
advisor.r&d@gnindia.dronacharya.info
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# FROM THE DESK OF
# EXECUTIVE EDITOR...

Dear Readers,

The qualitative and timely publication of Vol. VI / Issue-I (Jan–Jun 2016) of our esteemed International Journal of Engineering, Sciences and Management (ISSN: 2231-3273) has brought great joy and happiness to the entire fraternity of the journal and honorable members of the Editorial and Advisory Board. The board members rich experience and varied expertize is providing immense succour in propelling the journal to attain an envious position in areas of research and development and accentuate its visibility. The distinctive feature is indexing of the journal by Jour Informatics, Index Copernicus, Google Scholar and DOAJ. It is a matter of great pride and honor that the journal has been viewed by researchers from one hundred and twenty seven countries across the globe. The aim of journal is to percolate knowledge in various research fields and elevate high end research. The objective is being pursued vigorously by providing the necessary eco-system for research and development.

Large number of research papers were received from all over the globe for publication and we thank each one of the authors personally for soliciting the journal. We also extend our heartfelt thanks to the reviewers and members of the editorial board who so carefully perused the papers and carried out justified evaluation. Based on their evaluation, we could accept eleven research papers for this issue across the disciplines. We are certain that these papers will provide qualitative information and thoughtful ideas to our accomplished readers. We thank all the readers profusely who conveyed their appreciation on the quality and content of the journal and expressed their best wishes for future issues. We convey our deep gratitude to the Editorial Board, Advisory Board and all office bearers who have made possible the publication of this journal in the planned time frame.

We invite all the authors and their professional colleagues to submit their research papers for consideration for publication in our forthcoming issue i.e. Vol.VI | Issue II | Jul–Dec 2016 as per the "Scope and Guidelines to Authors" given at the end of this issue. Any comments and observations for the improvement of the journal are most welcome.

We wish all readers meaningful and quality time while going through the journal.

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**Jan 2016**

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# SILENT MUSIC: THE EXPRESSION OF MUSIC THROUGH TOUCH

Kenneth J. Faller II*
Computer Engineering Program
California State University, Fullerton
E-mail: jfaller@fullerton.edu
*Corresponding Author

Richard Jung
Computer Engineering Program
California State University, Fullerton
E-mail: richard.y.jung@gmail.com

Olivia Meza
Computer Engineering Program
California State University, Fullerton
E-mail: oliviameza44@gmail.com

## ABSTRACT

The educational purpose of this work was to create a platform to easily incorporate seemingly disparate computer engineering concepts, such as real-time Digital Signal Processing (DSP), embedded design and interfacing, and haptics, into a single easy to implement project. The goals for this paper are: 1) to provide materials for educators for incorporation into their courses, and 2) provide a platform that allows for the integration of several computer engineering concepts into a single project. This particular project focuses on the development of an assistive device that allows people with hearing loss to experience music through touch. This was achieved using a real-time embedded system that converts the beats of a song into vibrations on a haptic motor. This project was used to introduce community college students, during a summer research experience, to the engineering concepts listed above. With only introductory programing experience, the students were able to implement the project and gained an introductory level of understanding of the material and how the concepts were connected to create a fully functioning system.

***Keywords –*** *Assistive technology, Computer Engineering education, Digital Signal Processing (DSP), embedded systems, haptics, real-time audio effects.*

## 1. INTRODUCTION

The importance of connecting disparate concepts in the engineering curriculum was best expressed by Dr. Joseph Bordogna, former National Science Foundation (NSF) deputy director, during his keynote address at the NSF's 1997 Engineering Education Innovator's Conference:

Most curricula require students to learn in unconnected pieces - separate courses whose relationship to each other and to the engineering process are not explained until late in a baccalaureate education, if ever. Further, an engineering education is usually described in terms of a curriculum designed to present to students the set of topics engineers need to know, leading to the conclusion that an engineering education is a collection of courses. The content of the courses may be valuable, but this view of engineering education appears to ignore the need for connections and for integration - which should be at the core of an engineering education [1].

The purpose of this paper are to provide materials for educators for incorporation into their courses, and to provide a platform that allows for the integration of several seemingly disparate computer engineering concepts (i.e., real-time Digital Signal Processing (DSP), embedded design and interfacing, and haptics) into a single project. The project described in this paper uses a haptic motor that is controlled, in real-time, by a digital signal processor. The processor is used to apply

DSP techniques to detect the beats of a song in real-time which is subsequently used to vibrate a haptic motor accordingly. The purpose of this is to create an assistive device to allow hearing impaired individuals to experience music through touch.

Potentially, devices such as this could be used in immersive environments such as virtual reality and computer gaming. Considering the growth in these technical areas [2] and the impact of DSP, embedded design and interfacing, and haptics on them, it is important to provide students in relevant technical fields (i.e., computer engineering, computer science, electrical engineering etc.) with a basic understanding of the techniques and concepts of these areas.

The materials from this paper are freely available to interested educators and the pre-packaged embedded programs and Matlab software can be used in their lectures. The paper is organized to first provide the reader with a basic understanding of the DSP and haptic techniques used for the project. Then the Matlab and embedded programs are described. Finally, an example Matlab project that can be incorporated into existing courses (i.e., DSP related courses) is described.

## 2. SILENT MUSIC PROJECT

Music is an integral part of the human experience. Unfortunately, people with disabling hearing loss, which is approximately about 13% of the U.S. population (about 38 million people) [3], are incapable of experiencing music. The idea behind this project is to create a simple assistive device using a digital signal processor and a haptic motor to help the hearing impaired experience music through touch. The following subsections describe how this can be achieved.

**2.1 DSP Starter Kit (DSK)** The development kit used was the Texas Instruments (TI) C6713 DSP Starter Kit (DSK) (Fig. 1) [4]. This kit contains a TI C6713 floating-point digital signal processor that operates at 225 MHz with 1800 MIPS and 1350 MFLOPS performance, dual fixed/floating point multipliers capable of up to 450 multiply-accumulate operations per second, 2MB x 32 on-board SDRAM, 512 kB of on-board flash ROM, and a TI AIC3204 32-bit programmable low-power stereo audio COder-DECoder (CODEC). A digital signal processor, often referred to as a DSP, is a specialized microprocessor with its architecture optimized for the operational needs of DSP applications [5]. The kit also has several external peripherals (see Fig. 1) including four programmatically controlled LEDs (arrow), four DIP switches (dashed box), and four 1/8" audio jacks (solid box). Going from left to right, the audio jacks are microphone, line-in, line-out, and headphone, respectively. Other more inexpensive kits, such as the TI C5515 eZdsp USB stick development tool [6], could be used in lieu of this DSK. The user can feed a stereo signal into the line-in 1/8" audio connector. However, considering only a monaural input is required, only the left channel was used during the beat detection process.

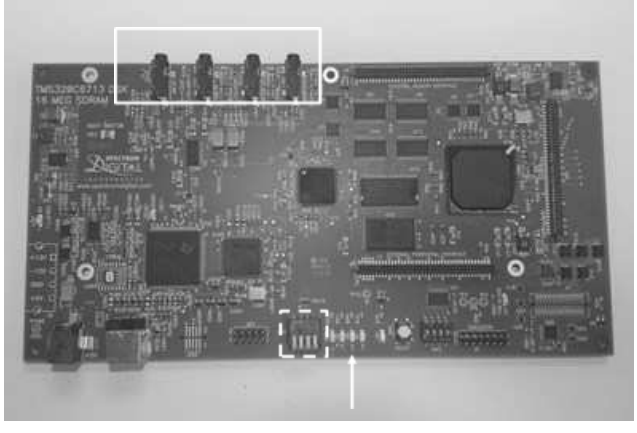

Fig. 1: The Texas Instruments (TI) C6713 DSP Starter Kit (DSK).

**2.2 BEAT DETECTION** The beat detection scheme used on the TI C6713 DSK is a real-time adaptation of the algorithm described in [7]. The incoming signal was sampled at 8 kHz ( $f_s = 8kHz$ ) and stored in a buffer that could hold 4000 samples. The CODEC contains a 4 kHz anti-aliasing filter to eliminate frequencies about the Nyquist frequency. The buffer was then separated into 20 smaller buffers of 200 points each (which will be referred to as "chunks"). The signal energy of a chunk, which contains the most recently collected samples, is compared to the signal energy of the entire buffer. This is used to determine the average energy. The average algorithm is described by equations 1 to 3. $\langle E \rangle$ and $\langle e \rangle$ represent the average energy of the entire buffer and of the chunk, respectively. C is the comparison factor, B is the buffer, and $i_0$ is the start position in the chunk. N and n represent the number of points in the buffer and in the chunk, respectively. Equations 1 and 2 represent the average for the entire buffer and for a chunk, respectively, and equation 3 describes the actual beat detection logic. A spike in the average energy is considered to be a beat (see Fig. 2). A buffer stored in internal memory with a length of half a second (4000 points) decomposed into 20 chunks seems to work best. The General-Purpose Input/ Output (GPIO) pin 0 on the DSK is used to send a signal to the Arduino. The Arduino is used in conjunction with a DRV2605L haptic motor controller to vibrate the haptic motor. The LEDs on-board the DSK are flashed and a logic 1 (5V) is sent out of GPIO pin 0 whenever a beat is detected. The code for the beat detection used is shown in Fig. 3.

$$\langle E \rangle = \frac{1}{N}\sum_{k=0}^{N} B[k]^2 \qquad (1)$$

$$\langle e \rangle = \frac{1}{n} \sum_{k=i_0}^{i_0+n} B[k]^2 \quad (2)$$

$$beat = \begin{cases} true & \langle e \rangle > \langle E \rangle \cdot C \\ false & otherwise \end{cases} \quad (3)$$

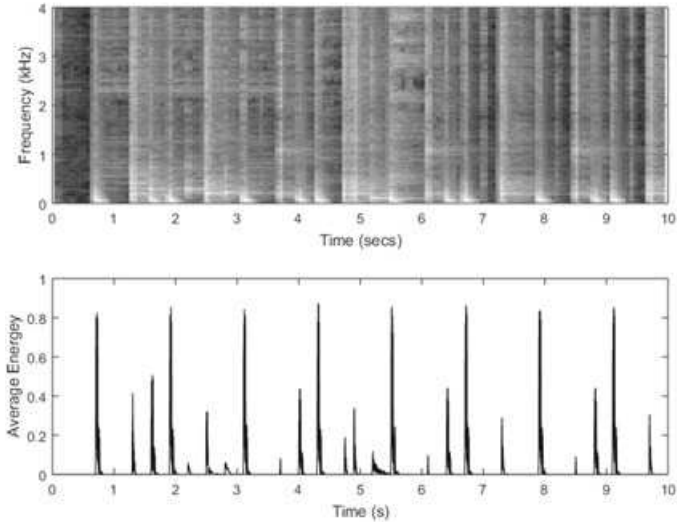


Fig. 2: Spectrogram plot of a music sample for a beat detector project.

```
#include <stdio.h>
#include "C6713dskinit.h"
#include "dsk6713_dip.h"              // Support file for DSK DIP Switches
#include "dsk6713_led.h"              // Support file for DSK LEDs
#include <csl_gpio.h>
#include <csl_gpiohal.h>
#include <csl_irq.h>

Uint32 fs = DSK6713_AIC23_FREQ_8KHZ;    // Set sampling rate
const int chunks = 20;                  // Number of frames in buffer
const int instant_length = 200;         // Length of 1 buffer
#define average_length 4000             // Length of buffer
const float c = 2;                    // Confidence multiplier
double ae = 0, ie = 0;
short buffer[average_length];           // Buffer

// Set SW3 to 0001
GPIO_Handle gpio_handle;                // GPIO Handle

GPIO_Config gpio_config = {
   0x00000000,        // gpgc = Passthrough mode interrupts and direct control over GP0
   0x0000FFFF,        // gpen = All GPIO pins from 0 to 15 enabled
   0x0000FFFF,        // gdir = All GPIO pins as outputs
   0x00000000,        // gpval = save the logic level of the pin
   0x00000000,        // gphm all interrupts disabled for IO pins
   0x00000000,        // gplm all interrupts to CPU or EDMA disabled
   0x00000000         // gppol -- default state */
};

void main() {
   short average_counter = 0;
   short instant_counter = 0;
   short chunk_counter = 0;

   comm_poll();               // Init DSK, codec, McBSP
   DSK6713_LED_init();        // Init LED from BSL
   DSK6713_DIP_init();        // Init DIP from BSL
```

```
// GIPO Config
   gpio_handle = GPIO_open(GPIO_DEV0,GPIO_OPEN_RESET);
   GPIO_config(gpio_handle,&gpio_config);
   GPIO_pinDirection(gpio_handle,GPIO_PIN0,GPIO_OUTPUT);

   // Sample entire buffer
   while(average_counter < average_length){
      buffer[average_counter] = input_sample();
      average_counter++;
   }
   average_counter = 0;

   // Main loop
   while(1) {
      instant_counter = 0;

      // Sample one frame and Move it to circular buffer
      while(instant_counter<instant_length){
         buffer[chunk_counter*instant_length+instant_counter]=input_sample();
         instant_counter++;
      }
      instant_counter = 0;

      // Av energy in entire buffer
      for (average_counter=0;average_counter<average_length;average_counter++) {
         ae=ae+buffer[average_counter]*buffer[average_counter];
      }
      ae = ae / average_length;

      // Average energy in last few msec
      for (instant_counter=0;instant_counter<instant_length;instant_counter++) {
         ie=ie+buffer[chunk_counter*instant_length+instant_counter]
         *buffer[chunk_counter*instant_length+instant_counter];
      }
      ie = ie / instant_length;

      // If energy in short buffer>whole buffer,turn on LEDs and output 1 on GPIO0
      // If not, turn off LEDs and output 0 on GPIO0
      if (ie > ae*c) {
         DSK6713_LED_on(0);
         GPIO_pinWrite(gpio_handle,GPIO_PIN0,1);
      } else {
         DSK6713_LED_off(0);
         GPIO_pinWrite(gpio_handle,GPIO_PIN0,0);
      }

      // Incr position in chunk counter
      // Right point in buffer
      chunk_counter++;
      if(chunk_counter>=chunks) chunk_counter=0;
   }
      }
```

Fig. 3: Code for the beat detection algorithm and GPIO on the TI C6713 DSK.

**2.3 HAPTIC INTERFACE** Haptics is about conveying information to the user/operator through their sense of touch. As mentioned, the beat detection algorithm above is used in the TI C6713 DSK to detect the beats of a song and then a signal is sent from the DSK to the Arduino. The Arduino serves as the interface between the TI C6713 DSK and the DRV2605L haptic motor controller [8] (see Fig. 4). When a beat is detected, the DSK sends a logic 1 (5V) to the digital I/O pin 2 on the Arduino. When this is detected by the Arduino, a signal is then sent to the DRV2605L haptic motor controller to vibrate the haptic motor. The code for the Arduino is shown in Fig. 6 below.

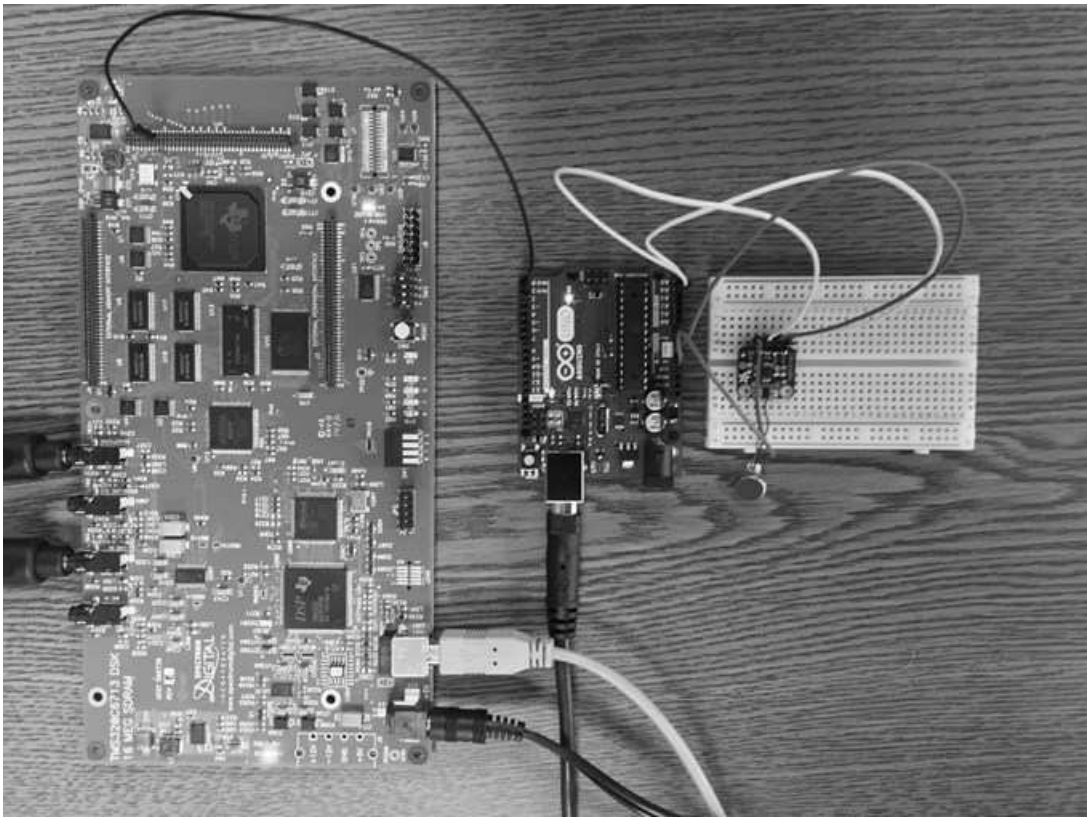

Fig. 4: Complete silent music project.

Instead of controlling the motor directly, the DRV2605L haptic motor controller is used which is designed specifically for controlling haptic, buzzers, and vibration motors (e.g., see Fig. 5). Normally, a motor is toggled between an on and off state, but this driver has the ability to do various effects. For example, ramping the vibration level up and down, click effects, different buzzer levels, etc. For this project a simple buzz effect is used. The DRV2605L is controlled over an $I^2C$ interface. After initialization, a "string" of multiple effects can be concatenated together in the chips memory and then triggered to actuate in a row. The built in effects are superior to toggling between "on" and "off" states and achieve a more natural feel.

Fig. 5: Vibrating mini motor disk.

```
#include <Wire.h>
#include "Adafruit_DRV2605.h"

Adafruit_DRV2605 drv;
int inPin = 2;
int in = 0;
uint8_t effect = 50;

void setup() {
  Serial.begin(9600);
  pinMode(inPin, INPUT);    // Sets the digital pin as input

  Serial.println("Init DRV");
  drv.begin();

  drv.selectLibrary(1);

  // I2C trigger by sending 'go' command
  // default, internal trigger when sending GO command
  drv.setMode(DRV2605_MODE_INTTRIG);
}

void loop() {
  in = digitalRead(inPin);
  Serial.println(in);

  if(in == 1) {
    // Set the effect to play
    drv.setWaveform(0, effect);  // play effect
    drv.setWaveform(1, 0);       // end waveform

    // Play the effect!
    drv.go();

    // wait a bit
    delay(100);
  }
}
```

Fig. 6: Arduino code used to communicate with the controller.DRV2605L haptic motor

# 3. SUPPLEMENTAL MATERIALS

The following subsections describe the supplemental materials that accompany this paper which include the Matlab based teaching software and a real-time embedded program. Also included are brief explanations of how to setup and use the supplemental materials. All of these materials are included in a single ZIP file at: http://ecs.fullerton.edu/~jfaller/IJIER_2015_Supp_Mats.zip.

**3.1 EMBEDDED SYSTEM** All of the embedded software was written in C programming language using the Code Composer Studio (CCS) version 6.0.1 IDE. The embedded software was based on a digital filter example from [9] which contains code for initializing and configuring several of the peripherals on the kit such as the serial port interface (i.e., MsBSP), the audio CODEC, etc. The user can feed a stereo signal into the input 1/8" audio connector. However, considering only a monaural input is required, only the left channel is used during the beat detection process (see 2.2 above).

**3.2 MATLAB TEACHING SOFTWARE** Shown in Fig. 7 below is the Matlab implementation of the beat detection algorithm described in Section 2.2 above. This can be used by educators to explain the beat detection algorithm offline to their students before moving to the embedded system. Included in the supplementary materials is a sample drum sequence that can be used. The educator may wish to use another song. However, music which is energy-rich in the lower frequencies should be used. This is because any higher-frequency portions of the music are filtered out by the beat-detection algorithm which is done to not "confuse" the algorithm or cause erroneous output.

```
clear all;
close all;
clc;

load example_drum_beat.mat;

N = 1024;

subplot(2,1,1);
spectrogram(x,N,N/2,N,fs,'yaxis');
legend off;
box on;
colorbar off;
colormap bone;

hold on;

chunks = 20;
buff_len = 4000;
instant_length = 200;
average_length = 4000;
c = 1.3;
ae = zeros(size(x));
ie = zeros(size(x));
chunk_counter = 0;
buffer = zeros(average_length,1);

for ind=1:length(x)
   for instant_counter=1:instant_length
      buffer(chunk_counter*instant_length+instant_counter) = x(ind);
   end

   for average_counter=1:average_length
      ae(ind) = ae(ind) + buffer(average_counter)^2;
   end

   ae(ind) = ae(ind) / average_length;

   for instant_counter=1:instant_length
      ie(ind) = ie(ind) + buffer(chunk_counter*instant_length+instant_counter) * ...
         buffer(chunk_counter*instant_length+instant_counter);
   end

   ie(ind) = ie(ind) / instant_length;

   % if (ie(ind) > ae(ind)*c)
   %   disp('ON');
   % else
   %   disp('OFF');
   % end

   chunk_counter = chunk_counter + 1;
   if(chunk_counter>=chunks)
      chunk_counter=0;
   end
end

subplot(2,1,2);
t = linspace(0,length(ae)/fs,length(ae));
plot(t,ae);
xlabel('Time (s)');
ylabel('Average Energey');
```

Fig. 7: Matlab code.

## 4. RESULTS AND DISCUSSION

The use of the Matlab teaching software and the embedded program on the TI C6713 DSK were utilized during a summer undergraduate research experience at California State University, Fullerton (CSUF). Despite only having introductory computer programming, math, and physics experience, the project is organized in such a way that the undergraduate students involved were capable of understanding the material. Overall, students reported that they gained an introductory understanding of the concepts. Additionally, a small sample experiment was conducted using some of the students in the lab. The students that participated in the experiment reported that they could generally "feel" the beat of the music. However, some students did report that some songs, particularly those with more high-frequency content, did not translate well. As discussed, the beat detection algorithm is only capable of detecting low-frequency content whereas the high-frequency content is filtered out. The first author is in the process of proposing a graduate/senior undergraduate level course on real-time audio processing and plans to incorporate the discussed project into the course.

## 5. CONCLUSION

Education on real-time Digital Signal Processing (DSP), embedded design and interfacing, and haptics are often taught as separate, disparate concepts. Additionally, DSP textbooks and education literature do not generally connect these concepts in a concrete manner. This paper demonstrates how these concepts can be connected to create an assistive device to allow a hearing impaired individual to feel music. Through a Matlab based teaching tool and an embedded system that runs on a TI C6713 DSK and an Arduino microcontroller, students gain an understanding of how these topics are related. Interested educators and students can obtain all the supplementary materials at the web site given in the paper. The materials are provided to facilitate the incorporation of the topics into existing DSP courses and they can be used to teach more fundamental DSP concepts such as: transfer functions, impulse response, convolution, frequency response, etc.

## 6. ACKNOWLEDGEMENTS

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# DESIGN, SIMULATION AND PARAMETRIC STUDY OF 10:1 BANDWIDTH COMPACT BICONICAL ANTENNA

Dr. Sanjay Kumar*
Former Principal Advisor
Defence Avionics Research Establishment (DARE)
Kaggadasapura Main Road,
C V Raman Nagar, Bangalore-560093
080-25047522
E-mail: tnksk@yahoo.co.in
*Corresponding author

Saurabh Shukla
Defence Avionics Research Establishment (DARE)
Kaggadasapura Main Road,
C V Raman Nagar, Bangalore-560093
080-25047699
E-mail: saurabh.dare@gmail.com

## ABSTRACT

A compact Biconical antenna operating over 2-20 GHz has been presented in this paper. The designed biconical antenna is fed by a simple coaxial line to achieve $360^0$ azimuth coverage with moderate gain. The designed antenna provides omnidirectional pattern with maximum VSWR of 2.2:1 over the entire band and therefore it can be used for biomedical, communication and defence applications.

***Keywords -*** *Biconical antenna, bandwidth, coaxial line, azimuth coverage and VSWR.*

## 1. INTRODUCTION

Biconical antenna is a broadband antenna which was first proposed by Schelkunoff [1]. Biconical antenna is derived from dipole antenna which consists of two conical conductors, which are driven by alternating EM field. The two conical conductors are basically two thick arms of a dipole antenna and this configuration results in increased bandwidth because the current distribution in conical conductors remains no longer sinusoidal and therefore influences the input impedance of the antenna.

In a typical Biconical configuration, both the conical conductors have common axis and the feed is provided along this axis. The impedance of the feeding point of Biconical antenna is generally chosen to be 50Ω because most of the coaxial connectors have 50Ω impedance. The impedance of a Biconical antenna depends upon its conical geometry and impedance decreases with increase in conical geometry. In most of the Biconical antennas, the impedance varies between 50-75Ω based on the cone angle.

The input impedance of a Biconical antenna with conical length (l) and cone angle (α) is given by Papas and King [2] as:

$$Z_{in} = Z_0 (1-\beta/\delta)/ (1+\beta/\delta) \quad (1)$$

Where,
$Z_o$ = characteristic impedance= 60 ln cot (α/4)
β/δ = ratio of reflected and outwards propagating TEM wave in antenna region.

The equation (1) suggests a relationship between the cone angle/flare angle and the characteristic impedance of a Biconical antenna.

## 2. DESIGN PARAMETERS

The compact Biconical antenna has been designed and simulated to operate in 2-20 GHz frequency range with maximum VSWR 2.2:1 and omnidirectional pattern in Azimuth plane. As shown in Fig-1, the important parameters of a Biconical antenna are cone angle (α), radius of the cone (r), gap between the cones (g) and the conical length (l).

The relationship between cone height (h), cone angle (α) and cone radius (r) is given as:

$$\tan(\alpha/2) = r/h \quad \ldots (2)$$

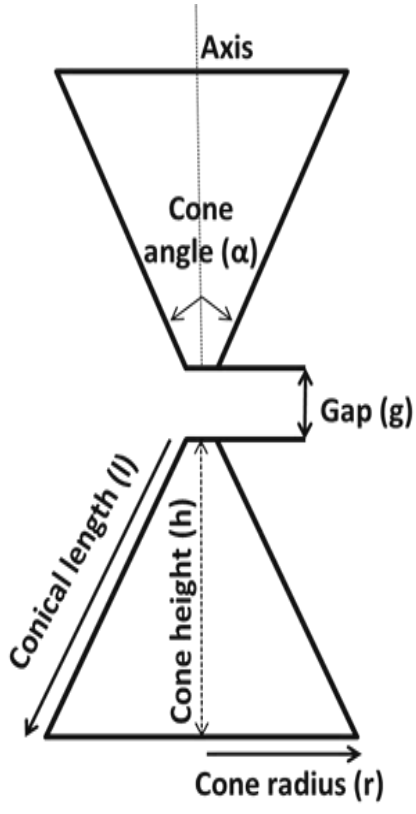


Fig. 1 Conical Antenna Geometry

Based on the design parameters, the compact Biconical antenna has been modeled in CST Microwave Studio [6] as shown in Fig-2. The modeled Biconical antenna is excited by a 50Ω coaxial connector. The two conic sections of compact biconical antenna are solid cones. These conic sections are separated from each other with the help of connector dielectric which maintains the gap [3] [4].

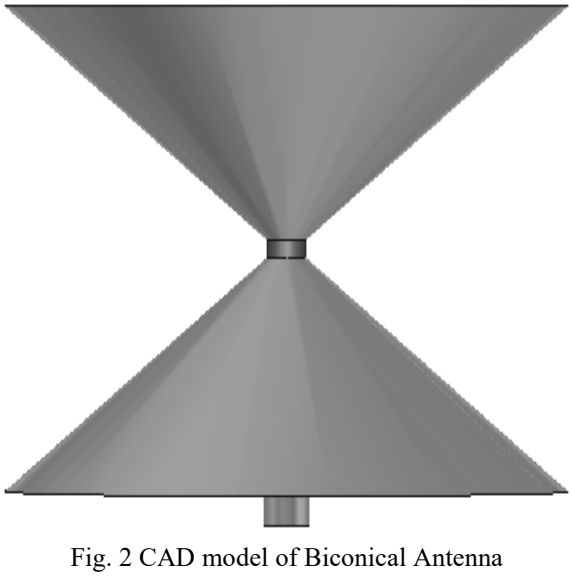

Fig. 2 CAD model of Biconical Antenna

## 3. PARAMETRIC STUDY

The effect of the parameters on the reflection coefficient of the antenna has been studied in two steps. In the first step, the gap (g) between the cones has been varied from 1mm to 3mm and the variation in the refection coefficient has been presented in Fig. 3. From the figure, it is clear that the best matching is achieved for 1 mm gap for a given cone angle.

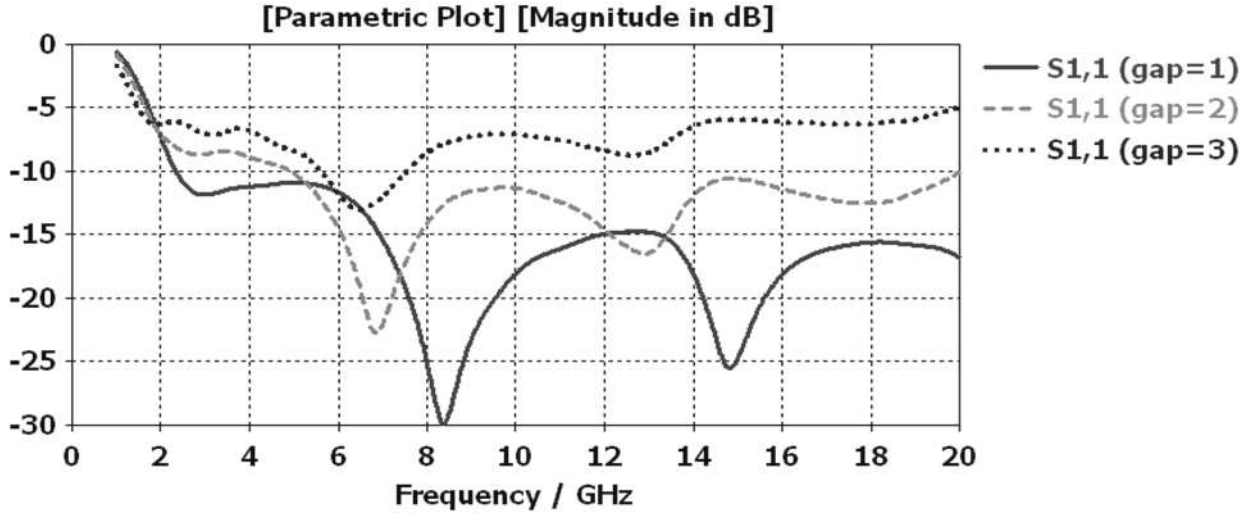


Fig. 3 Gap between the cones vs. $S_{11}$ dB

In the second step, the cone angle (α) is varied by varying the cone height (h) and keeping the cone radius (r) and gap (g) between the cones as constants. The cones height (h) has been varied from 13mm to 15mm and the variation in the refection coefficient has been presented in Fig. 4. From the figure, it is clear that the best matching is achieved for 15 mm cone height (h) which corresponds to $111^0$ cone angle.

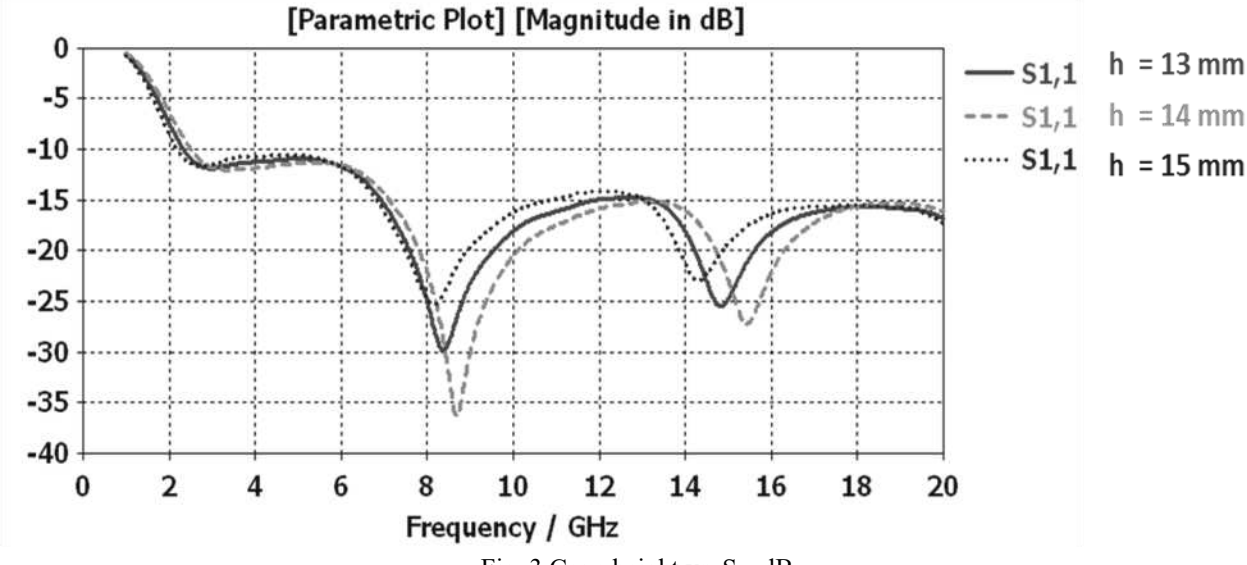


Fig. 3 Cone height vs. $S_{11}$ dB

The important design parameters have been optimized and their final values are given in Table1 for reference.

**Table -1:** Design Parameters

| Parameter Name | Optimized value |
|---|---|
| Gap (g) | 1 mm |
| Cone Radius (r) | 22 mm |
| Cone Angle (α) | $111^0$ |
| Cone Height (h) | 15 mm |
| Conical Length (l) | 26.6 mm |

By using the optimized value of antenna parameters, it is found that the VSWR of the designed antenna is well within the desired range i.e. 2.2:1 for the 10:1 bandwidth. VSWR plot for the Biconical antenna has been presented in Fig 5.

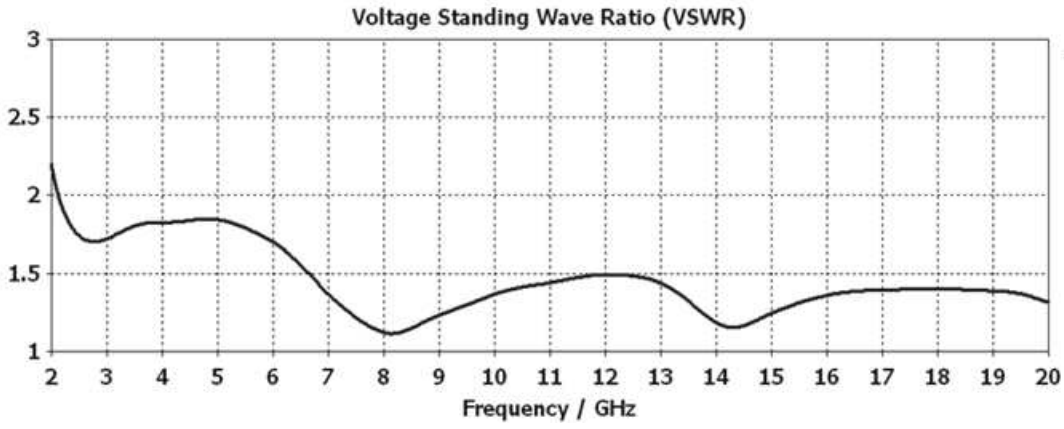


**Fig. 4** VSWR of optimized Biconical Antenna

The radiation pattern of the antenna at 12 GHz is presented in Fig 6 which shows that if the antenna is kept in vertical polarization, it provides $360^0$ azimuth coverage. This property is extremely useful because EM wave coming from any direction in azimuth plane is very well intercepted by this antenna due to its omnidirectional pattern [5].

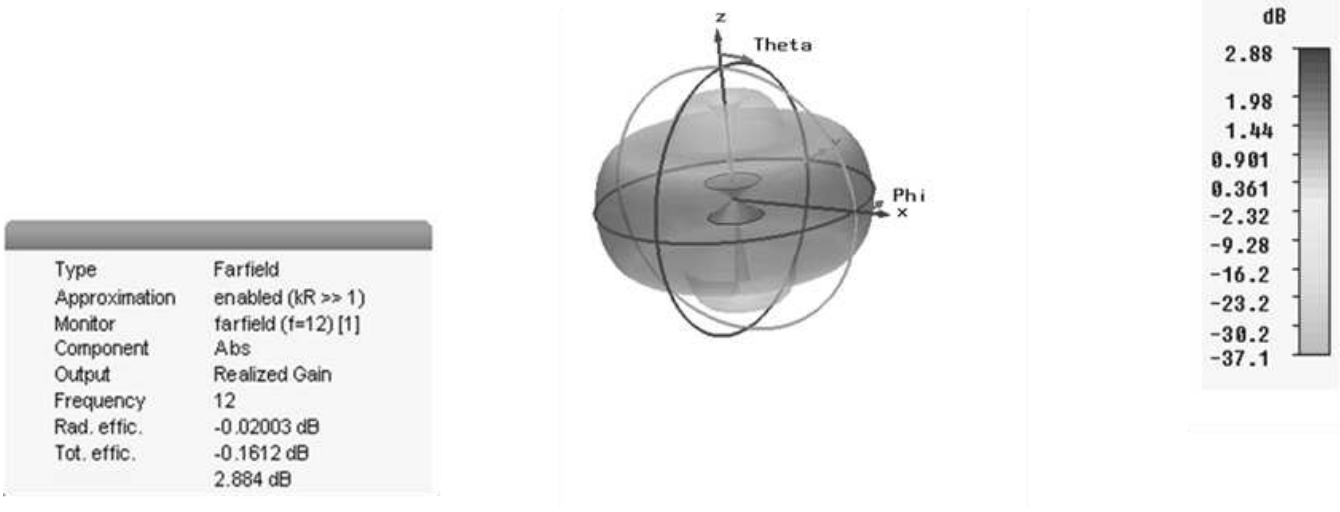


Fig. 5 Radiation Pattern of optimized Biconical Antenna

## 4. CONCLUSION

A compact 10:1 bandwidth Biconical antenna has been reported in this paper. The simulated results suggest that the antenna performs well within the frequency range of 2-20 GHz. The antenna also exhibits moderate gain ranging between 2-4 dB which helps in improving the received signal strength. The mechanical dimensions of the antenna are kept as small as possible to make it compact and light weight. Therefore, the proposed Biconical antenna is extremely useful for those platforms where volume is a constraint. The proposed design can be further optimized to achieve larger bandwidth i.e. 1-20 GHz with omnidirectional radiation pattern. The proposed antenna can intercept EM signals in $360^0$ azimuth plane along with limited coverage in elevation plane. Such type of antennas is very useful for low powered ultra-wideband (UWB) wireless communication for civil as well as military applications. Because of its low power the interferences caused with other wireless spectra are minimal. Such antennas are sometimes referred as "Bi-con". Very interesting applications for Bi-con antenna are in Electromagnetic Interference (EMI) Testing. It could be for immunity testing or emission testing. This type of antenna, although broadband, exhibits poor efficiency at lower frequency which can be treated as one of the drawbacks.

## 5. ACKNOWLEDGEMENTS

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# ARTIFICIAL COOPERATIVE SEARCH ALGORITHM FOR SOLVING REACTIVE POWER PROBLEM

Mr.K.Lenin*
Research Scholar, JNTU, Hyderabad 500 085 India
Affiliation to University/College.
E-mail: gklenin@gmail.com
*Corresponding Author

Dr.B.Ravindhranath Reddy
Deputy executive engineer,
JNTU, Hyderabad 500 085 India

Dr.M.Surya Kalavathi
Professor of Electrical and Electronics Engineering
JNTU, Hyderabad 500 085, India

## ABSTRACT

In this paper an Artificial Cooperative Search Algorithm (ACSA) is utilized to solve the Reactive power problem. ACSA algorithm is based on interaction between two artificial super organisms as they interact and migrate to different zones to find global minimum of a problem. To improve the ACSA algorithm performance, randomized algorithm parameters are utilized instead of static parameters. Proposed ACSA algorithm has been tested in standard IEEE 30 Bus test system and simulations results reveal about the better performance of the proposed algorithm in reducing the real power loss and voltage profiles are within the limits.

***Keywords—*** *Artificial cooperative search, Chaotic systems, Metaheuristic algorithms, Parameter identification.*

## 1. INTRODUCTION

Optimal reactive power problem plays most important role in the stability of power system operation and control. In this paper the main aspect is to diminish the real power loss and to keep the voltage variables within the limits. Previously many mathematical techniques like gradient method, Newton method, linear programming [4-7] has been utilized to solve the optimal reactive power dispatch problem and those methods have many difficulties in handling inequality constraints. Voltage stability and voltage collapse play an imperative role in power system planning and operation [8]. Recently Evolutionary algorithms like genetic algorithm have been already utilized to solve the reactive power flow problem [9,10].In [11-20] Genetic algorithm, Hybrid differential evolution algorithm, Biogeography Based algorithm, fuzzy based methodology, improved evolutionary programming has been used to solve optimal reactive power flow problem and all the algorithm successfully handled the reactive power problem. In this paper Artificial Cooperative Search Algorithm (ACSA) [21-26] is proposed to solve the optimal reactive power problem. To upgrade the search mechanism of the ACSA algorithm, randomized algorithm parameters are used which are bounded between real valued numbers instead of static parameters. The proposed ACSA has been evaluated in standard IEEE 30 bus test system. The simulation results show that our proposed approach outperforms all the entitled reported algorithms in minimization of real power loss and also voltage profiles are within the limits.

## 2. OBJECTIVE FUNCTION

**2.1 ACTIVE POWER LOSS** The objective of the reactive power dispatch problem is to minimize the active power loss and can be defined in equations as follows:

$$F = PL = \sum_{k \in Nbr} g_k \left( V_i^2 + V_j^2 - 2V_i V_j \cos\theta_{ij} \right) \quad (1)$$

Where $g_k$ : is the conductance of branch between nodes i and j, Nbr: is the total number of transmission lines in power systems.

**2.2 VOLTAGE PROFILE IMPROVEMENT** To minimize the voltage deviation in PQ buses, the objective function can be written as:

$$F = PL + \omega_v \times VD \quad (2)$$

Where $\omega_v$: is a weighting factor of voltage deviation.
VD is the voltage deviation given by:

$$VD = \sum_{i=1}^{Npq} |V_i - 1| \quad (3)$$

**2.3 EQUALITY CONSTRAINT** The equality constraint of the problem is indicated by the power balance equation as follows:

$$P_G = P_D + P_L \quad (4)$$

Where the total power generation PG has to cover the total power demand PD and the power losses PL.

**2.4 INEQUALITY CONSTRAINTS** The inequality constraint implies the limits on components in the power system in addition to the limits created to make sure system security. Upper and lower bounds on the active power of slack bus, and reactive power of generators are written as follows:

$$P_{gslack}^{min} \leq P_{gslack} \leq P_{gslack}^{max} \quad (5)$$

$$Q_{gi}^{min} \leq Q_{gi} \leq Q_{gi}^{max}, i \in N_g \quad (6)$$

Upper and lower bounds on the bus voltage magnitudes:

$$V_i^{min} \leq V_i \leq V_i^{max}, i \in N \quad (7)$$

Upper and lower bounds on the transformers tap ratios:

$$T_i^{min} \leq T_i \leq T_i^{max}, i \in N_T \quad (8)$$

Upper and lower bounds on the compensators

$$Q_c^{min} \leq Q_c \leq Q_C^{max}, i \in N_C \quad (9)$$

Where N is the total number of buses, NT is the total number of Transformers; Nc is the total number of shunt reactive compensators.

## 3. ARTIFICIAL COOPERATIVE SEARCH ALGORITHM (ACSA)

Artificial Cooperative Search algorithm **(**ACSA) is swarm intelligence based metaheuristic algorithm used for solving numerical optimization problems. The algorithm is based on interaction between two artificial super organisms as they interact and migrate to different zones to find global minimum of a problem. Amount of food that can be found in a specific zone is tied to yearly climate a change. For this reason, super organisms develop some kind of seasonal migration behaviour to discover better food sources. It is known that, in nature, most species form super organisms and divide into sub -groups (sub-super organisms) prior to migration in order to find a better food source. This super organism behaviour is determined by the coordination of sub-groups. Interaction and explorer usage are two main behaviours of the super organisms. Before migrating to a new zone, first, super organism sends an explorer to collect information about the possible migration zones. Then, explorer shares the information with the super organism individuals and these individuals give their opinion for the possibility of migration to the new discovered areas. During the migration process, exploration behaviour is sustained to find better zones. Interaction behaviour is another important behaviour among the living species. All super organisms living in the same habitat, naturally interacts with each other. Parasite/host or predator/prey relationships may

emerge in alturation, coextinction, coevolution or cooperation interactions between super organisms. In ACSA algorithm, two super organisms named a and b consist of random solutions of the problem move to more fruitful nesting or feeding areas. Each super organism consists of N members and each sub super organism consists of D members, which corresponds to dimension of the problem. Also, the two superorganisms decide the predator and prey sub super organisms. Predator sub-super organism tracks the prey sub-super organism while they move towards global minimum of the problem.

The initial values of the individuals of the two superorganisms are calculated by using following equations

$$\alpha_{i,j,r} = rnd \times (up_j - low_j) + low_j \quad (10)$$

$$\beta_{i,j,r} = rnd \times (up_j - low_j) + low_j \quad (11)$$

Where $i$=1,2,3..,$N$ , $j$=,2,3,..,$D$ & $r$=1,2,3,..,*maxiter*
*rnd* represents a random number chosen from a uniform distribution between [0, 1]. $up_j$ and $low_j$ represents the upper and lower bounds of the search space for $j^{th}$ dimension of the problem.

Fitness values of the associated sub-superorganisms are determined by using following Equation

$$y_{r,\alpha} = f(\alpha_i) \, , y_{r,\beta} = f(\beta_i) \quad (12)$$

Predator individuals are determined by the following rule.

***Rule a. Calculation of Predator individuals***

**If** $rnd < rnd$
$predator = \alpha \, , y_{predator} = y_{\alpha} \, , key = 1$
**Else**
$predator = \beta \, , y_{predator} = y_{\beta} \, , key = 1$
**End**

***Rule b. Calculation of Prey individuals***
$if \; rnd \; < rnd \; prey = \alpha \; else \; prey = \beta \; end$
**Prey = premature (prey)**

In above calculation permute ( ) function randomly changes the places of all row elements of prey individuals. Since only active individuals are permitted to migrate, passive individuals are determined by calculation of passive individuals as following .

***Rule c. Calculation of passive individual***
$M_{N \times D} = 1$
**For all elements in M**
**If** $if \; rnd < (p \times rnd) \; then \; M_{randit(N),randit(D)} = 0 \; end$
**End**
**If** $rnd < (p \times rnd)$ **then**
**For i=1 to N**
**For j=1 to D**
**If** $if \; rnd < (p \times rnd)$ **then** $M_{i,j} = 1 \; else \; M_{i,j} = 0$ **end**
**End**
**End**
**For i=1 to N**
$if \; \sum_{j=1}^{D} M_i = D \; then \; M_{i,randint(D)} = 0 \; end$
**end**

*rndint* ( ) function generates random integers between a chosen interval by employing gauss distribution and p represents the probability of biological interaction. Biological interaction location between prey and predator individuals is calculated by using the following equation:

$$x = predator \; + R \times (prey - predator) \quad (13)$$

R is a variable that controls the speed of biological interaction. R is generated by using the Decision Rule procedure.

***Rule d.Decision rule to obtain scale factor (R)***

**If** $rnd < (p \times rnd)$ **then**
$R = 4 \times rnd \times (rnd - rnd)$
**Else**
$R = \Gamma(4 \times rand, l)$

Where *rnd* is a random number between 0.0 and 1.0; Γ ( ) represents the gamma distribution with a shape parameter of *rnd'*4 and scale parameter of 1.0.

***Rule e.Position update procedure used by active individuals is shown below***

**For i=1 to N**
**For j=1 to D**
$if\ M_{i,j} > 0\ then\ x_{i,j} = predator_{i,j}\ end$
**End**
End

If biological interaction locations exceed boundaries, new locations are generated according to the following rule

***Rule f.Application of boundary control mechanism***

**For i=1 to N**
**For j=1 to D**
$if\ (x_{i,j} < low_j) \vee (x_{i,j} < up_j)\ then$
$x_{i,j} = low_j + rand \times (up_j - low_j)$
**End**
**End**
End

Predator sub-superorganisms are compared with biological interaction locations concerning their fitness values. If the fitness values of biological locations are better than objective function values of Predator individuals, Predator individuals are updated by implementing the methodology given below

***Rule g. Predator sub-super organism update***

**For i=1 to N**
$if\ f(x_i) < y_{ipredator}, then$
$predator_i = x_i$
$y_{ipredator} = f(x_i)$
**End**
**End**

New α and β superorganisms and their fitness values for next generations are determined by the strategy presented in following rule

***Rule h.Determination of new sub superorganisms for next generations***

**If key = 1 then**
$\alpha = predator, y_\alpha = y_{predator}$
**Else**
$\beta = predator, y_\beta = y_{predator}$
**End**

***ACSA algorithm for solving reactive power problem***

- *Initialize population size, problem dimension, maximum number of iteration, lower and upper bounds,*
- *initialize Super organisms (a, b ) and determine their corresponding fitness values with Equation (10) and (11)*
- *for iter = 1 to maxiter*
- *Calculate Predator individuals by applying Rule a*
- *Determine Prey individuals with Rule b*
- *Calculate the scale factor (R) with Rule d*
- *Calculate passive individuals by binary valued integer map as explained in Rule c*
- *Decide biological interaction locations with Rule c*

- *Update biological interaction locations by active individuals with the rules of Rule e*
- *Apply boundary control with Rule f*
- *Update Predator super organisms by Rule g*
- *Determine new superorganisms for next generations by Rule h*
- *Store the best solution and its corresponding fitness value end Output best results*

## 4. SIMULATION RESULTS

Validity of the Artificial Cooperative Search Algorithm (ACSA) has been verified by applying in IEEE 30-bus, 41 branch system. And the system has 6 generator-bus voltage magnitudes, 4 transformer-tap settings, and 2 bus shunt reactive compensators. Bus 1 is taken as slack bus and 2, 5, 8, 11 and 13 are taken as PV generator buses and the rest are taken as PQ load buses. Control variables limits are given in Table 1.

Table 1.Variable Limits (Pu)

| List of Variables | Min. | Max. | Type |
|---|---|---|---|
| Generator Bus | 0.91 | 1.11 | Continuous |
| Load Bus | 0.94 | 1.03 | Continuous |
| Transformer-Tap | 0.94 | 1.03 | Discrete |
| Shunt Reactive Compensator | -0.10 | 0.30 | Discrete |

In Table 2 the limits of generators has been given as follows:

Table 2.Generators Power Limits

| Bus | Pg | Pgmin | Pgmax | Qgmin |
|---|---|---|---|---|
| 1 | 98.00 | 50 | 201 | -20 |
| 2 | 81.00 | 21 | 80 | -20 |
| 5 | 53.00 | 15 | 52 | -15 |
| 8 | 21.00 | 10 | 33 | -15 |
| 11 | 21.00 | 10 | 28 | -10 |
| 13 | 21.00 | 12 | 40 | -15 |

Table 3.Values of Control Variables after Optimization

| List of Control Variables | ACSA |
|---|---|
| V1 | 1.0604 |
| V2 | 1.0508 |
| V5 | 1.0305 |
| V8 | 1.0406 |
| V11 | 1.0801 |
| V13 | 1.0602 |
| T4,12 | 0.00 |
| T6,9 | 0.01 |
| T6,10 | 0.90 |
| T28,27 | 0.90 |
| Q10 | 0.12 |
| Q24 | 0.12 |
| Real power loss | 4.2798 |
| Voltage deviation | 0.9090 |

Table 3 shows the control variables are within limits.

And Table 4 summarizes the comparison results of the optimal solution obtained by various methods.

Table 4.Comparison Results

| Techniques | Real power loss (MW) |
|---|---|
| SGA (27) | 4.98 |
| PSO (28) | 4.9262 |
| LP (29) | 5.988 |
| EP (29) | 4.963 |
| CGA (29) | 4.980 |
| AGA (29) | 4.926 |
| CLPSO (29) | 4.7208 |
| HSA (30) | 4.7624 |
| BB-BC (31) | 4.690 |
| ACSA | 4.2798 |

## 5. CONCLUSION

In this paper, Artificial Cooperative Search Algorithm (ACSA) has been productively implemented to solve reactive power problem. Proposed Artificial Cooperative Search Algorithm (ACSA) successfully handles the equality and inequality constraints. The validity of the Artificial Cooperative Search Algorithm (ACSA) has been proved by testing it in standard IEEE30bus system. The results are compared with the other heuristic methods and the Artificial Cooperative Search Algorithm (ACSA) established its efficiency and strength in minimization of real power loss. And control variables are well within specified limits.

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# MODERNIZATION OF IRRIGATION SYSTEM FOR THE IMPROVEMENT OF CROP PRODUCTIVITY, LIVELIHOOD AND LIVING STANDARD OF FARMERS: A CASE STUDY OF SUNSARI MORANG IRRIGATION SYSTEM IN NEPAL

Khet Raj Dahal*
Visiting Professor
Centre for Post Graduate Studies
Nepal Engineering College, Kathmandu
E-mail: dahal.khetraj@gmail.com
*Corresponding Author

Baidehi Sharan Dutta
Senior Divisional Engineer, Department of Irrigation
Bagmati Irrigation Project, Nepal
E-mail: duttabaidehi@yahoo.com

Januka Gyawali
Civil Engineer, Nepal Electricity Authority
Kathmandu, Nepal
E-mail: janukagyawali123@gmail.com

## ABSTRACT

This study, "Modernization of Irrigation System for the Improvement of Crop Productivity, Livelihood, and Living Standard of Farmers: A Case Study of Sunsari Morang Irrigation Project in Nepal was conducted in 2014. During the study, semi-structured questionnaire was prepared to collect the field data. Moreover, interaction with people and focus group discussion was also organized during the field work. Such study has found the positive impact of modernization in irrigation system. Therefore, the overall findings comprise the change in cropping intensity, productivity and livelihood of the people in the study area. Due to modernization of irrigation system, cropping intensity has increased from 184% to 216% and, furthermore, paddy productivity has also increased from 2.2ton/ha to 4.2 ton/ha. Increment in productivity of other crops like wheat, potato, pulse, oilseed and jute can also be witnessed after the modernization of the irrigation system. Similarly, cropping intensity, crop productivity and livelihood of farmers has improved in modernized area in comparison with the non -modernized one. Thus, this research concludes that living standard of the farmers in the study area has increased significantly due to the positive impact of modernized irrigation system.

***Key words:*** *modernization, irrigation system, cropping intensity, livelihood, and productivity*

## 1. INTRODUCTION

Modernization of irrigation system is defined as a process of technical and managerial upgrading of irrigation systems along with institutional reforms. It also includes the aim to improve resource utilization, such as, labor, water, economic resources, environmental resources, and water delivery to the farms of the existing system **[1, 2, 3]. Therefore, i**rrigation plays a significant role in the improvement of rural livelihood and living standard of the farmers **[4].**

Modernization of irrigation system is different from rehabilitation of the canal. As the word 'rehabilitation' only covers the works, which are carried out to meet the original objectives of the scheme for which it was built whereas 'modernization' refers to the improvements in the system to meet a new goal and new type of services in it **[5].** Thus, modernization includes redesign and automation of irrigation system, improvement of water use efficiency (i.e. reducing losses), increase in water availability, and operational efficiency of existing irrigation system. Furthermore, it focuses on

proper water distribution, drainage works, and required infrastructures for water storage along with promotion of high value crop farming among irrigators' communities **[6].**

Modernization in irrigation system has not been successful especially in under-developed and developing countries because irrigation managers are facing various types of problems. In those countries, the major problem is scarcity of modern technology. Thus, irrigation managers need to apply the available local technology and resources as much as possible **[6].** At this background, the construction of modern irrigation system in Nepal was started in 1922 **[7].** The first modern irrigation channel in Nepal is Chandra Nahar which is located in Sunsari Morang district. Prior to 1922, irrigation systems were Farmers Managed Irrigation System (FMIS) i.e. developed, operated and maintained by farmers themselves. Later, from 1922 to 1957, Government of Nepal put substantial effort to develop the irrigation infrastructures in the entire country.

FMIS of Nepal were mostly built from the locally available materials such as mud, stone, bamboo, and grass woods. Later, the Nepal Irrigation Sector Project (NISP) supported FMIS but the contribution of the irrigators' communities in the civil works was compulsory which ranged from 7 to15 % of the total cost **[7].** During the survey, design, and implementation phase the beneficiaries were involved. This model of the government project had a positive impact on system improvement as well as in agricultural production **[8].**

Nowadays, Nepal has many modern irrigation projects. Among them, Sunsari-Morang Irrigation Project (SMIP) is one of them. This project was designed for protective purposes. As the project was run by the government, the canal was operated and maintained by the Department of Irrigation (DOI). The water was supplied and distributed to the area as much as possible. The irrigation canal of this project carried almost a constant discharge and it had no significant adjustment in the controlled mechanism **[7].** As a result, performance of system operation decreased along with the decrease in irrigable command area. And this resulted decrease in crop production. Because of this fact, Sunsari-Morang Irrigation Project started to modernize the system with a purpose of increasing production and productivity **[9].** Slowly, as the system became modern. It did not only improve the production and productivity of crops, but also improved livelihood and living standard of the farmers. But there has not been yet a study which could quantify the change in life style of the people in that area. Thus, the objective of this study was to find out the positive impacts of modernization, particularly livelihood and living standard of the people due to the result of Sunsari-Morang Irrigation Project.

## 2. MATERIALS AND METHODS

**STUDY AREA** Sunsari-Morang Irrigation Project (SMIP) was started in 1975, with a command area of 68,000 ha. **[7, 10].** It covers both Sunsari and Morang districts of eastern Terai of Nepal. Initially, the canal was known as Chatara Nahar and was assisted by the government of India. The water is diverted into the canal from the left bank of the Koshi River (Fig.1). The intake structure of this canal is located in Chatara village of Sunsari district, which is in the downstream of the gorge section of the Koshi River. The length of Chatara Main Canal is about 53 km **[10].** The headwork of Chatara canal consists of a side intake, three-barrel Reinforced Cement Concrete (RCC) culvert of about 1000 m length and a pre-settling basin of 300 m length. The canal has a primary settling basin of 950 m length along with two dredging machines and a small hydro-power plant in the system **[10]** (Fig. 1). The command area is divided into many service areas like S1, S2, S3…… up to S19. The study was conducted in S14 area (as a developed one or modernized one) and S15 area (as an undeveloped or non-modernized one). It was then compared between two systems. The productivity, crop intensity, livelihood and living standards of farmer's were compared between those systems (i.e. S14 and S15).

Water users associations WUA) has been formed to suit the requirements of joint management as per irrigation policy. There are two organizations with responsibilities for management. These are: below the structured level - the water users committee (WUC) for the sub-secondary canal (typically 200-700 ha), and the water user groups (WUG) for watercourses (30 ha) in the whole Sunsari-Morang Irrigation System [**10**]. There is a provision of water users' association in each branch of canal. Each and every layer is formed of representatives of the irrigators' communities, which has been registered as a legal entity of the government of Nepal (GON).

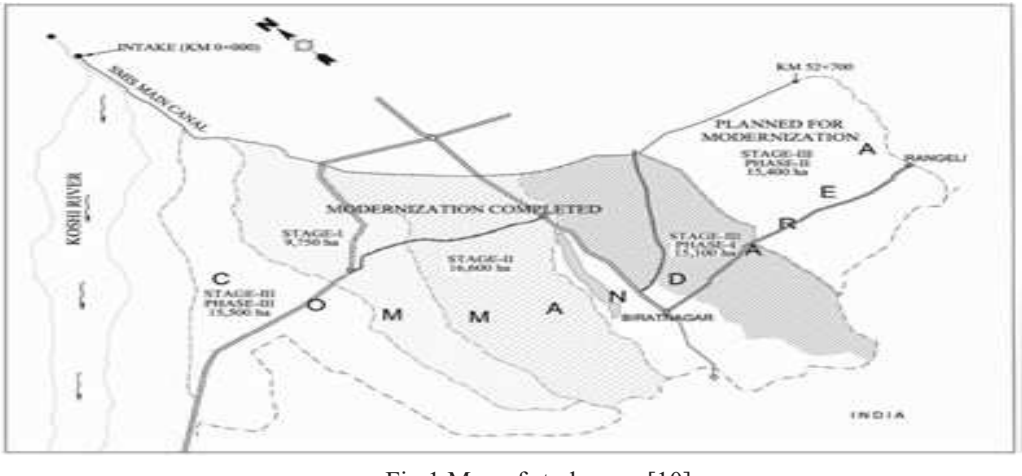


Fig.1 Map of study area [10]

Flow into main canal is variable though the intake is on a very large perennial river due to absence of weir in intake. The water level fluctuates both seasonally and diurnally due to rainfall and snow melt. The upper part of the irrigation system is fully controlled. So the supply to each secondary and sub-secondary canal can be controlled by SMIP **[7, 10].** There is usually too little water for continuous supply to each sub-secondary canal, so there is a system of rotations to ensure that each gets a supply corresponding to its irrigated area. Thus the main system above the head of the sub-secondary canal (which is the formal interface between SMIP and the WUA) needs to be fully regulated and actively managed. To cope with this situation, each sub-secondary canal receives water for alternate four-day periods (although this may be varied in practice). Informally, the interface for managing water distribution is at the head of the secondary canal since the WUCC makes the key decisions regarding water-sharing between sub-secondary canals. Field observation, survey with semi-structured questionnaire, interaction with irrigator's community, and focused group discussion (FGD) was conducted during study. The comparison was made before and after modernization of the Sunsari-Morang irrigation project.

Household survey was carried out for the beneficiary households who have irrigated land in command area (developed area and undeveloped area). Focus Group Discussion (FGD) was carried out to the specific groups, related beneficiaries (WUA) presidents, 2 representatives and related project engineers, 3 representatives in the project study area comprising with the discussion to find out the qualitative information. The FGD was conducted with the help of checklists. Key Informants Interview was carried out with the concerned stakeholders and project related people in order to collect the relevant information and triangulation of respondent's information as well. The checklist was used for the key informant's interview.

The ever-increasing demand for research has created a need for an efficient method of determining the sample size needed to be representative of a given population. In the article "Small Sample Techniques," the research division of the National Education Association has published a formula for determining sample size **[11].** The following formula was used for the determination of sample size.

$$s = (X^2 NP(1-P)) \div (d^2(N-1) + X^2 P(1-P)) \qquad \textbf{(I)}$$

Where,

$s$ = required sample size, $X^2$= the table value of chi-square for 1 degree of freedom at the desired confidence level,

$P$ = the population proportion (assumed to be .50 since this would provide the maximum sample size), and d = the degree of accuracy expressed as a proportion.

**HOUSEHOLD AND POPULATION** Harinagara secondary canal (S14) area has 18 VDC with household 22597 and population 108497 **[12].** Similarly, S15 canal area has 2684 households and 11478 populations in 3 VDCs **[12].** The sample size was calculated from the formula (as mentioned above in **(I)**).

**SAMPLE SIZE** No. of sample size in S14 canal area were 77, and in S15 canal area were 74. Thus, total sample size was of 151.

## 3. RESULTS AND DISCUSSION

**3.1 CROPPING INTENSITY** Cropping intensity is a measure of agricultural performance because it represents utilization of land and water resources. In general, higher the cropping intensity, more efficient is the utilization of these resources. Mathematically, cropping intensity is the ratio of gross cropped area (sum of area under all crops in a given agricultural season/year) to net operated area. The impact of modernization on the cropping intensity was carried out in study area. The cropping intensity of S14 area was increased after the modernization which is presented in the table below (Table 1).

**Table 1:** Cropping intensity before and after Modernization in S14 area (%)

| Particular | Before | After | Difference (mean) |
|---|---|---|---|
| S14 Area | 184% | 216% | 32% |

**Source: [10, 13]**

The cropping intensity was found high in developed (S14) area against undeveloped (S15) area. It is presented in the table (Table 2).

**Table 2:** Cropping intensity in developed S14 area and undeveloped S15 area (%)

| **Particular** | **S15 area** | **S14 area** | **Difference (mean)** |
|---|---|---|---|
| Crop | 208% | 216% | 8% |

**Source: [10, 13]**

The cropping intensity observed in the area both before and after modernization is quite high. In general, cropping intensity is much lower in systems in South Asia than in systems in Southeast Asia (IWMI, 2004). If compared with Pehur High Level Canal, Pakistan, the cropping intensity of this project is satisfactory. As reported by **Habib (2002)** the cropping intensity of Pehur High Level Canal, Pakistan before modernization was 130% while after modernization it increased up to 170% **[14]**.

Thus, the cropping intensity of 184% before modernization should have been considered satisfactory. The cropping intensity of 216% is envisioned in irrigation policy and irrigation master plan, as climatologically only three crops are possible in the Terai of Nepal **[7].** This is clear that the impact of modernization and this should have positive impact in the overall crop production, reduction in poverty level and in the livelihood. Financial constraints resulting from the gap between the cost of equipment for the improved method and the gain in water savings and improved services, as water is generally not priced or charges are low. Social constraints, human resources are relatively less expensive in developing economies than alternative technological solutions **[15].**

**3.2 PRODUCTIVITY** As mentioned in methodology, the impact of modernization on the productivity of major crops was worked out in study area. The productivity was calculated on average annual production in the study area of major crops. The mean yield of paddy of S14 area was found to be increased significantly after modernization (Fig. 2).

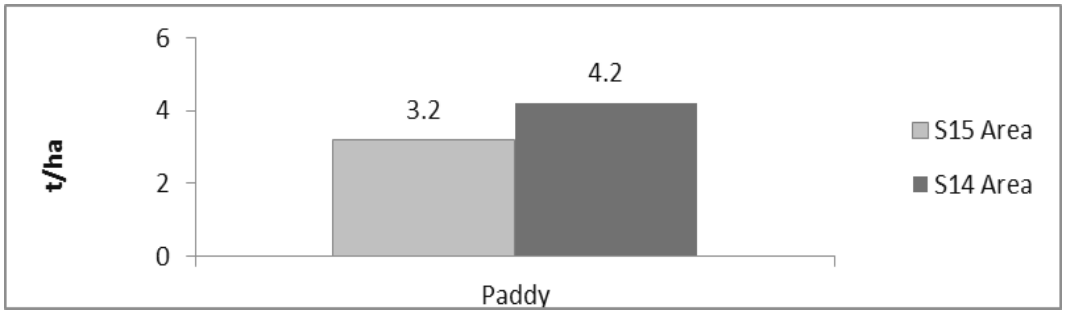


**Fig. 2:** Mean productivity of paddy before and after Modernization in S14 Area
**Source of previous data: [7, 10, 13]**

The mean yield of paddy was found to be high in developed area against undeveloped area (Fig. 3). It has shown that the yield of paddy is significantly higher in S14 area than in S15.

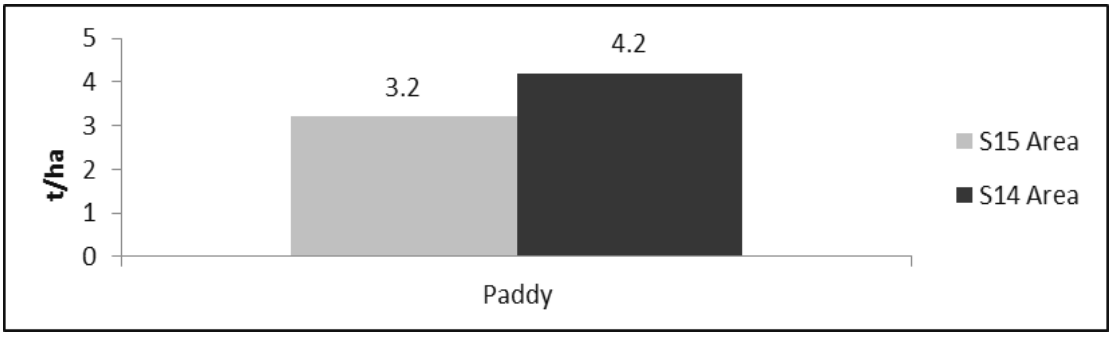


**Fig. 3:** Mean productivity of paddy in S14 and S15 area
**Source of previous data: [7, 10, 13]**

Similarly, productivity of wheat (mean) at before and after Modernization of S14 area as well as undeveloped S15 area and developed S14 area was also compared. The mean yield of wheat was found to be increased significantly after modernization in S14 area (Fig.4).

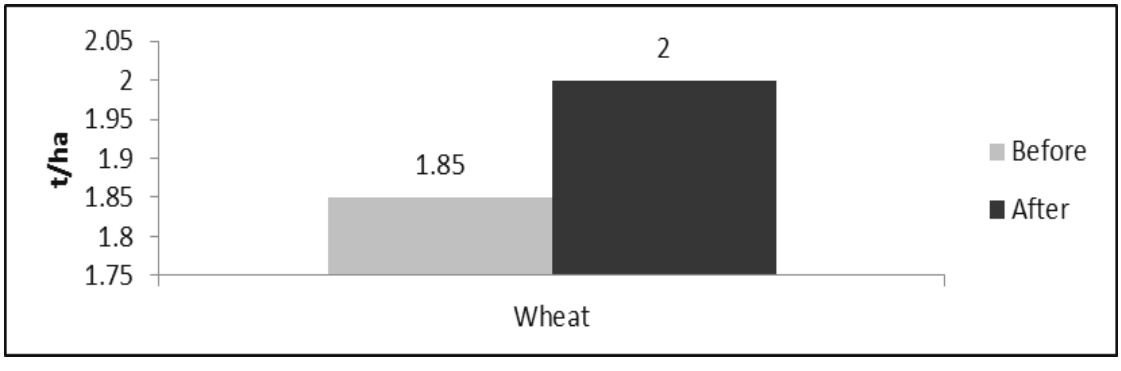


**Fig. 4:** Mean productivity of wheat before and after modernization in S14 area
**Source of previous data: [7, 10, 13]**

The mean yield of wheat was found higher in developed area in comparison with undeveloped).


**Fig.5:** Mean productivity of wheat in S14 and S15 area
**Source of previous data: [7, 10, 13]**

The mean yields of spring paddy, potato, pulse, oilseeds and jute were found to be increased significantly after Modernization (Fig. 6).

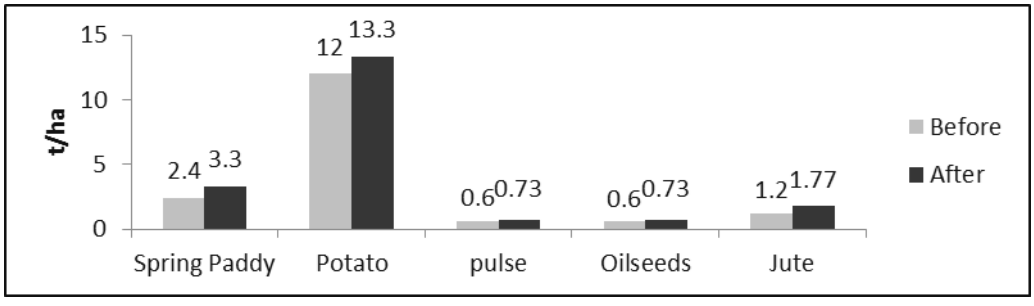


**Fig. 6:**Mean productivity of crops before and after modernization in S14 area
**Source of previous data: [7, 10, 13]**

The mean yields of spring paddy, potato, oilseed and jute were found higher in developed area rather than undeveloped area (Fig. 7).

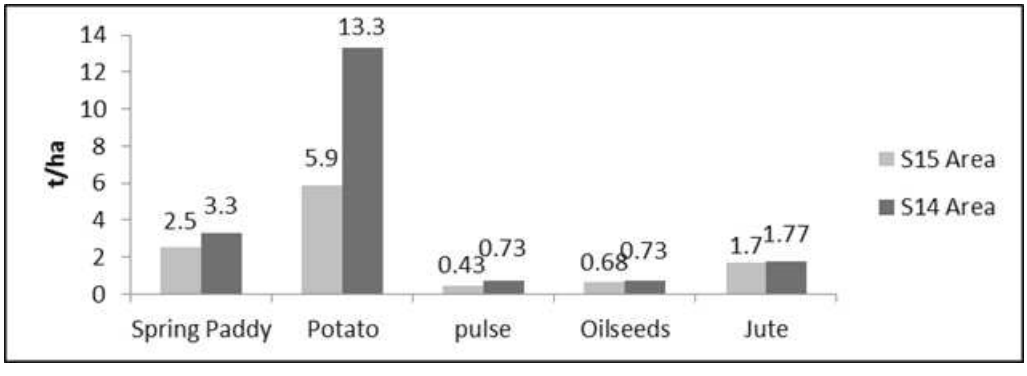


**Fig.7:** Mean productivity of different crops in S14 S15 area

**Source of previous data: [7, 10, 13]**

According to Ministry of Agriculture Development (MOA), national average productivity of paddy is 3.72 t/ha and that of wheat is 2.83 t/ha **[16].** The productivity of paddy in the study area was found to be 4.2 t/ha, which is high in comparison to the national average but productivity of wheat in the study area was 2 t/ha which is low in comparison to the national average **[16]**. This shows the general trend of rice dominant cropping culture. With reliable irrigation, good Terai soil for rice, relatively easy access to agri-inputs and favorable climatic conditions, rice production should have been more than national average and the observation also supports this. Study conducted by **IWMI (2004)** shows that rice productivity varies from as low as 1.348 ton/ha up to 5.416 ton/ha in South Asia. In Southeast Asia, rice productivity varies from 3.36 ton/ha to as high as 7.39 ton/ha **[17].** Similarly, wheat productivity in selected Chinese systems (4.52 ton/ha to 5.29 ton/ha) is almost double that in most systems in Pakistan (1.82 ton/ha to 3.47 ton/ha) **[17, 18].**

**3.3 LIVELIHOOD AND LIVING STANDARD** It is figured out how the modern irrigation canal changed the agricultural production, income sources and expenditures, educational situation, lifestyle of the households and the infrastructure of the study site.

**3.3.1 LEVEL OF EDUCATION** Level of education of S14 area was improved by the introduction of the modernization (Table 3)

Table 3: Level of education before and after modernization in S14 area

| Items | Before | | After | | Likert Scale | | |
|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | Scale Scale | Before | After |
| Bachelor | 2 | 1% | 3 | 4% | 5 | 0.05 | 0.20 |
| Intermediate | 24 | 14% | 13 | 17% | 4 | 0.56 | 0.68 |
| Secondary | 39 | 23% | 21 | 27% | 3 | 0.69 | 0.81 |
| Primary | 43 | 25% | 22 | 28% | 2 | 0.50 | 0.56 |
| Literate | 26 | 15% | 11 | 14% | 1 | 0.15 | 0.14 |

**Source of previous data: [7, 10, 13]**

Paired t-test revealed that the value of 'p' is less than 0.05 (Pearson Correlation=0.98, p (one tail=0.018, p (two tail) =0.036, and df = 4). The difference between the 'before' data and the 'after' data is statistically significant (p< 5%). Thus, it is clear that the level of education has been improved by the introduction of the modernization in irrigation system.

The level of education has improved in S14 area in comparison with S15 area by the introduction of the modernization in irrigation system (Table 4).

Table 4: Comparison of education level between **S14** and **S15** Area

| **Particulars** | **S14 Area** | | **S15 Area** | | | **S14 Area** | **S15Area** |
|---|---|---|---|---|---|---|---|
| | **No.** | **%** | No. | % | Likert Scale | | |
| Bachelor | 1 | 2 | 3 | 4 | 5 | 0.10 | 0.20 |
| Intermediate | 10 | 13 | 13 | 17 | 4 | 0.52 | 0.68 |
| Secondary | 18 | 24 | 21 | 27 | 3 | 0.72 | 0.81 |
| Primary | 19 | 26 | 22 | 28 | 2 | 0.52 | 0.56 |
| Literate | 10 | 14 | 11 | 14 | 1 | 0.14 | 0.14 |

**Source of previous data: [7, 10, 13]**

Statistical analysis (Paired t-test) showed (p=0.04, Paired t-test revealed that the value of 'p' is less than 0.05 (Pearson Correlation=0.98, p (one tail=0.012, p (two tail) =0.04, and df = 4)). This means that the difference between the "S15 Area" and the 'S14 Area' is statistically significant (p< 5%).It concluded that the level of education has been improved in S14 area against S15 area by the introduction of the irrigation system modernization.

The increment in educational activities is certainly assisted by the level of income due to better crop coverage and productivity**. John (2013)** studied the impact of irrigation scheme on food security in Wei-Wei irrigation scheme in Central Pokot District, West Pokot County, Kenya **[19].**

**3.3.2 HOUSE HOLDING ASSET** Capacity of bearing house holding asset of S14 area has improved by the introduction of the modernization (Table 5).

**Table 5: House holding asset before and after in S14 area**

| **SN** | **Asset** | | **Before** | | **After** |
|---|---|---|---|---|---|
| | | **No.** | **%** | **No.** | **%** |
| 1 | Tractor | 3 | 2% | 3 | 4% |
| 2 | Thresher | 12 | 7% | 8 | 10% |
| 3 | Computer | 0 | 0% | 2 | 3% |
| 4 | Television | 70 | 41% | 58 | 75% |
| 5 | Bullock cart | 72 | 42% | 46 | 60% |
| 6 | Motorcycle | 0 | 0% | 9 | 12% |
| 7 | Pump set | 22 | 13% | 12 | 15% |
| 8 | Cycle | 144 | 84% | 69 | 90% |
| 9 | Pressure cooker | 68 | 40% | 62 | 80% |
| 10 | Mobile | 0 | 0% | 65 | 85% |

Thus, we can say the capacity of bearing House Holding Asset has been improved by the introduction of the modernization. Capacity of bearing House Holding Asset of '**S14** area' has improved against '**S15** area' by the introduction of the modernization (Table 6).

**Table 6:** Comparison of house holding asset between S14 and S15 Area

| SN | Asset | S15 Area | | S14 Area | |
|---|---|---|---|---|---|
| | | **No.** | **%** | **No.** | **%** |
| 1 | Tractor | 1 | 1 | 3 | 4 |
| 2 | Thresher | 2 | 2 | 8 | 10 |
| 3 | Computer | 1 | 1 | 2 | 3 |
| 4 | Television | 48 | 65 | 58 | 75 |
| 5 | Bullock cart | 37 | 50 | 46 | 60 |
| 6 | Motorcycle | 4 | 5 | 9 | 12 |
| 7 | Pump set | 15 | 20 | 12 | 15 |
| 8 | Cycle | 67 | 90 | 69 | 90 |
| 9 | Pressure cooker | 56 | 75 | 62 | 80 |
| 10 | Mobile | 59 | 80 | 65 | 85 |

**Source of previous data: [7, 10, 13]**

Paired t-test revealed that the p (one tail) =0.018 (DF=9, p (two tail) = 0.03, Pearson correlation=0.71). Statistical analysis showed that the difference between the **"S15"** and the **"S14"** is significant (p< 5%).Thus, it is clear that the capacity of bearing house holding asset has been improved in '**S14** area' than in '**S15** area' by the introduction of the modernization.

**3.3.3 INCOME** Income of house hold before and after modernization was calculated out in S14 area. Income of house hold by agriculture in 'S14 area' has found to exceed after modernization (Table 7).

Table 7: Income of house hold before and after modernization in S14 area

| Particulars | Before | | After | |
|---|---|---|---|---|
| | NRs. | % | NRs. | % |
| Agriculture | 40906 | 57 | 110295 | 65 |
| Business | 9329 | 13 | 16969 | 10 |
| Service | 11482 | 16 | 30543 | 18 |
| Wage | 5024 | 7 | 8484 | 5 |
| Others | 5024 | 7 | 3394 | 2 |

**Source of previous data: [7, 10, 13]**

Similarly, Income of house hold in developed 'S14 area' and undeveloped 'S15 area' was calculated. Income of house hold by agriculture was found to be high in S14 area against S15 area due to modernization (Table 8).

Table 8: Comparison of income between S14 and S15 area

| Particulars | S15 Area | | S14 Area | |
|---|---|---|---|---|
| | NRs. | % | NRs. | % |
| Agriculture | 92000 | 58 | 110295 | 65 |
| Business | 15862 | 10 | 16969 | 10 |
| Service | 23793 | 15 | 30543 | 18 |
| Wage | 22206 | 14 | 8484 | 5 |
| Others | 4759 | 3 | 3394 | 2 |
| Total | 158620 | 100 | 169685 | 100 |

**Source of previous data: [7, 10, 13]**

On an average after modernization of '**S14** area', house hold income was increased to 84% of national average house hold income (i.e. Rs.202, 374.00). There are a number of studies in different countries, which show that irrigation has served as the key driver behind growth in agricultural productivity and in increasing household income and alleviating rural poverty. Irrigation can reduce poverty through increasing production and income. This helps very poor households because it maintains the basic needs associated with improvements in overall economic welfare, protection against risks of crop loss due to erratic, unreliable or insufficient rainwater supplies. The positive impact of modernization obviously promotes the additional employments of common people, which cuts off the poverty cycle **[19].**

**3.3.4 EXPENDITURE** The expenditure pattern of household before and after modernization was estimated in S14 area. Expenditure of household was found to exceed in food, cloth and education due to result of modernization in S14 area (Table 9).

Table 9: Expenditure pattern of household before and after modernization in 'S14 area'

| **Particulars** | **Before** | | **After** | |
|---|---|---|---|---|
| | **NRs.** | **%** | **NRs.** | **%** |
| Food | 9083 | 22 | 44686 | 31 |
| Cloth | 7018 | 17 | 28830 | 20 |
| Social Activities | 2064 | 5 | 7207 | 5 |
| Festival | 4128 | 10 | 11532 | 8 |
| House maintenance | 2890 | 7 | 10091 | 7 |
| Education | 6193 | 15 | 30272 | 21 |
| Medicine | 2890 | 7 | 8649 | 6 |
| Others | 7018 | 17 | 2883 | 2 |
| Total | 41284 | 100 | 144150 | 100 |

**Source of previous data: [7, 10, 13]**

Similarly, the expenditure pattern of household in developed S14 area and undeveloped 'S15 area' was worked out. Percentage of expenditure of household in food was found higher in '**S15 a**rea' due to low productivity. At the same time, expenditure of household in education was found to be high in '**S14** area' due to high income by the result of modernization (Table 10).

Table 10: Comparison of expenditure between S14 and S15 area

| **Particulars** | **S15 Area** | | **S14 Area** | |
|---|---|---|---|---|
| | **NRs.** | **%** | **NRs.** | **%** |
| Food | 45689 | 35 | 44686 | 31 |
| Cloth | 26108 | 20 | 28830 | 20 |
| Social Activities | 3916 | 3 | 7207 | 5 |
| Festival | 13054 | 10 | 11532 | 8 |
| House maintenance | 6527 | 5 | 10091 | 7 |
| Education | 19581 | 15 | 30272 | 21 |
| Medicine | 9138 | 7 | 8649 | 6 |
| Others | 6527 | 5 | 2883 | 2 |
| Total | 130540 | 100 | 144150 | 100 |

**Source of previous data: [7, 10, 13]**

In the average level after the modernization of 'S14 area', house hold expenditure was increased up to 83%, which was more than national average house hold expenditure (i.e. Rs.173, 215.00). Rehabilitation and modernization of the existing water resource projects can be carried out fewer than three main headings: engineering, agronomy and administration **[20].** The engineering side includes modernization and rehabilitation of all headwork and their replacement, where they have outlived their usefulness, and modernization of canals, canal structures, in particular the regulating devices, provision of additional cross regulators, permanent outlets and on-farm development works such as field channels, field drainage and land leveling **[21].** The agronomic side includes the review of current cropping patterns, scientific assessment

of crop water requirements to upgrade the system to meet the new demand, adoption of high-yielding varieties, and propagation of proper cultural practices and so on. The administrative side includes the consolidation of land, volumetric supply of irrigation water, changes in water rate policy and the rest of the things. Such conditions can be achieved by improved water management at farm level by keeping in mind of the existing constraints of the physical system and its operational constraints **[22].**

Modernization requires both 'hardware' and 'software' investments. Hardware investments go beyond the simple rehabilitation of existing systems to include physical improvements to the system, such as the correct selection of gates and control structures, lining of canals with geo-synthetics, construction of interceptor canals and reservoirs, and installation of modern information systems as well as on-farm irrigation improvement technologies such as drip irrigation, and a drainage network that allows a non-polluting management of the salt balance. Modernization investments also include a range of 'software' improvements such as scheme management and institutional structures, on-farm water management practices, combined water and soil fertility management, drainage water management, and integrated approaches to combating drought, salinity and floods.

Investment in irrigation modernization for sustainable and high-productivity agriculture requires an economic environment that provides undistorted incentives, manageable risk and market access **[3].** Modernization contributes efficient irrigation facilities. Besides it improves variety of seeds, fertilizers, and mechanisms, which is the main input for increasing productivity by increasing the cropping intensity for agriculture production.
The new water management strategies in the SMIS involve paying more attention to the technical/engineering details of water control, primarily in the Chatara Main Canal (CMC) and secondary canals. The recommendations include the adoption of new operating rules for maintaining constant water levels in the main canal and improving control of the flows into the secondary canals. Other priority actions deal with the need for better communications and an integrated decision-making process **[23, 24].** In Nepal, future sustainable advancements in agricultural productivity, including increased rice yields and crop diversification, are only achievable with modernization of poor-performing irrigation projects, along with the support of national-level water resources policies that promote modernization **[2, 25].**

In principle, all users are entitled to receive the demanded water. Comparatively, the situation is worst in SMIP. Although, at country level in Nepal the Irrigation Regulation 2000 has defined water use right, at scheme level there exist no specific rules and regulation for supplying water in an equitable manner. Tail end farmers were always raising the voice of dissatisfaction **[26];** Ghazalli **(1998)** stated in his article that a program for modernization of irrigation system has been initiated in Malaysia with a view to improve irrigation performance on the farm productivity **[27].** Thailand invested large amounts of capitals for the development of new water resources in the past. There is now, however, very little scope for further expansion of water supplies. Increased competition from industrial and urban consumption and explosive growth of rice cultivation during the dry season over the last three decades raise a new challenge for the government of that country **[5, 28].**

There are hundreds of technologies and practices for improving water productivity, but in the case of modernization in irrigation system have following three solutions: using the same volume of water more efficiently to produce more food (e.g., stop leaking canals; timely irrigation and inputs and using new crop varieties); increase supplementary irrigation in rainfed areas (e.g., rainwater harvesting and groundwater); and practice deficit not only consumptive water use but also to reduce water and maintain yields leaving excess water for downstream users to increase their yields. None of these solutions can be truly effective without the right policy interventions **[18, 29].** Currently, the Department of Irrigation, which is known as a sole authority responsible for irrigation development in the country, is implementing Community Managed Irrigated Agriculture Sector Project (CMIASP). CMIASP aims to enhance the productivity and sustainability of existing FMIS in 35 districts in the central and eastern regions through participatory planning. Furthermore, Water Users Association (WUA) is strengthening the improved irrigation facility and Operation and Maintenance (O&M), and, therefore, it supports for agricultural development and livelihood enhancement **[30, 31].**

Likewise, since 2008, the Irrigation and Water Resources Management Project (IWRMP) is being implemented. IWRMP has been working towards improving agriculture productivity and the management of selected irrigation schemes in Nepal as well as enhancing institutional capacity for integrated water resources management. The project is showing good results at the field level in terms of meeting the project objective of increasing agricultural productivity as well as it is improving water use efficiency and enabling water users to manage irrigation systems **[32].**

## 4. CONCLUSION

The overall impact of modernized irrigation system's evaluation findings comprise with the change in cropping intensity, productivity and livelihood of the study area. The cropping intensity was increased from 184% to 216% due to the positive aspect of modernization. During the study, the productivity of paddy was increased from 2.2 ton/ha to 4.2 ton/ha. Similarly, productivity of other crops like wheat, potato, pulse, oilseed and jute were also increased. There are various positive results in the life style of common people, particularly in education level, capacity of bearing house holding assets, income of household, expenditure of household, and so on . Similarly, cropping intensity, crop productivity and livelihood of farmers was more improved in modernized area rather than non-modernized area. Thus, the modernization of Sunsari-Morang irrigation system has improved the agricultural production and productivity along with livelihood of the farmers.

# 5. ACKNOWLEDGEMENTS

We would like to acknowledge Dr. Krishna Prasad Paudel, Dr. Khem Raj Sharma, Mr. Robert Dangol, Mr. Megh Prasad Kharel and Mr. Anjay Mishra for their immense help and encouragement during this study, which resulted to improve the quality of the work

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# OPTIMIZED PID CONTROLLER CONTROL FOR pH NEUTRALISATION PROCESS

R.Satheesh*
Assistant Professor
Department of Electronics and Electronics Engineering
SVS College of Engineering, Coimbatore-642 109
*Corresponding author

M. Karthick
Assistant Professor
Department of Electronics and Electronics Engineering
SVS College of Engineering, Coimbatore-642 109

## ABSTRACT

The common problem in pH reactors to determination and control and concerning chemical-based industrial processes by virtue of the non-linearity observed in the titration curve. The pH control had always drawn attention of chemical engineers because of its connotation in various fields as medicine, where the effect of pH on the enzymes and blood is acutely investigated, and the industry which is perturbed with manufacturing of textile dyes, and bleach products. The high non-linearity in pH is an immeasurable challenge in process control and it cannot be effective controlled by the linear PID controller. Hence advanced tuned PID controllers are best suited which are designed and developed for a pH control process in order to control the plant to the desired set point with high quality performance over the entire operating range. The mathematical model of pH process is obtained to ensure the dynamic modifications and stability enhancement. The ZN tuned PID, automatic tuned PID and PSO PID controller is implemented in simulation. The simulation is done using MATLAB software and the results are compared.

***Keywords:*** pH control, Proportional Integral Derivative, Zeigler Nichols, Particle Swarm Optimization, Auto tuning.

## 1. INTRODUCTION

In recent years the industrial application of advanced control techniques for the process industries has become more demanding, mainly due to increasing complexity of the process themselves as well as to enhanced requirements in terms of product quality and environmental factors. Therefore the process industries require more reliable, accurate, robust, efficient and flexible control systems for the operation of process plant. In order to fulfill the above requirements, there is a continuing need for research on improved forms of control. Control of industrial process is a challenging task for several reasons due to their non-linear dynamic behavior, uncertain and time-varying parameters, constraints on manipulated variable, interaction between manipulated and controlled variables, unmeasured and frequent disturbance, dead time on input and measurements.

Control of the pH neutralization process plays an important role in different chemical plants, such as chemical and biological reaction, waste water treatment, electrochemistry and precipitation plants, production of pharmaceuticals, fermentation, and food production [16]. However, it is difficult to control a pH process with adequate performance point due to its nonlinearities, time-varying properties and sensitivity to small disturbances when working near the equivalence point.

## 2. pH PROCESS

The pH process consist of various tanks, controller and sensor parts as shown in fig.1 . The pH value of the process tank is sensed by using pH transmitter. The pH that is sensed by the pH sensor is converted into corresponding current in the range of (4-20) mA by pH transmitter. This sensor measures the current pH value of the solution in which it is partially dipped.

The sensed pH value is converted to (4-20) mA current. The sensed pH value will be given to the PID controller. Depending upon the pH value, controller takes the corrective action through control valve by opening or closing the control valves. Control valve directly controls the amount of acid and base solution added in the process tank. So, pH value will be maintained in the process tank. The desired pH value can be precisely adjusted by the addition of acid or alkali[12]. An absolute must, particularly in neutralization processes with stringent requirements for reliability and accuracy. ProMinent

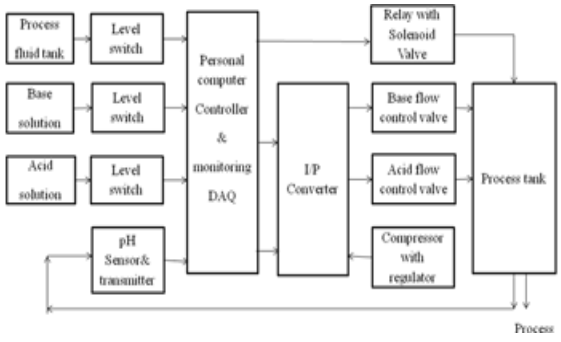


Fig.1. Control and monitoring of pH process

**EXPERIMENTAL SET UP** The pH process station is shown in fig.3.The controlling variable is the inflow rate of the process tank. The outflow rate of the process tank is kept constant. The inflow rate of the process tank comprises of outflow rate from acid and base tank. The inflow rate can be controlled either manually using hand valves or automatically using controller. The controlled variable is the pH of the process fluid and is measured with the help of pH electrode. The pH value is converted into an current signal and transmitted to the controller. Based on the pH value, controller takes an action either on acid flow or base flow to maintain the pH value.

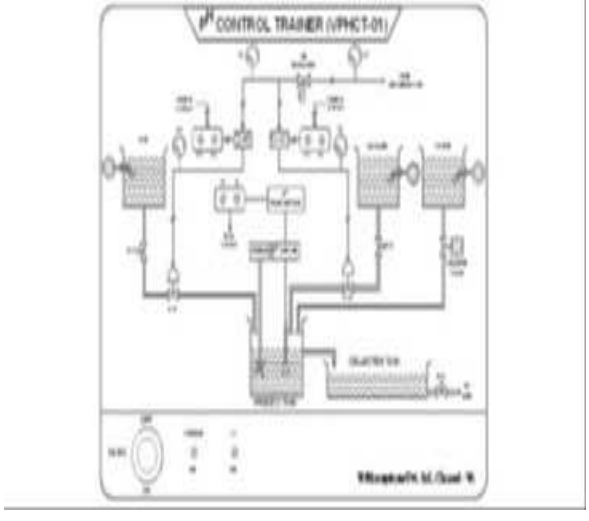

Fig.2.Experimental set up of pH process

## 3. MATHEMATICAL MODEL

In science, computing, and engineering, a black box is a device, system or object which can be viewed in terms of its input, output and transfer characteristics without any knowledge of its internal workings. Its implementation is "opaque" (black). Almost anything might be referred to as a black box: a transistor, an algorithm, or the human brain.

The "black box" portion of the system contains formulas and calculations that the user does not see any need to know to use the system. Black box systems are often used to determine optimal trading practices. These systems generate many different types of data including buy and sell signals.

It does not use any particular prior knowledge of the character or physics of the relationships involved. It is therefore more a question of “curve-fitting” than “modeling”. In this presentation several examples of such black-box model structures will be given. Both linear and non-linear structures are treated. Relationships between linear models, fuzzy models, neural networks and classical non-parametric models are discussed. Some reasons for the usefulness of these model types are also given. Ways to fit black box structures to measured input-output data are described, as well as the more fundamental (statistical) properties of the resulting models.

## MODELING OF pH PROCESS

The requirements are

Acid solution - HCL (1 pH) (0.1N)

Base solution - NaOH (13 pH) (0.1M)

Process solution - Distilled water (7 pH)

**Table 1. Time Vs. pH for acid solution**

| Time (sec) | pH |
|---|---|
| 0.00 | 7.00 |
| 5.57 | 5.65 |
| 6.00 | 5.71 |
| 7.00 | 5.64 |
| 10.00 | 5.54 |
| 20.00 | 5.56 |
| 30.00 | 5.10 |
| 40.00 | 2.83 |
| 50.00 | 2.00 |
| 60.00 | 2.54 |

Table 1 denotes the variation of pH with respect to time by the addition of acid solution.

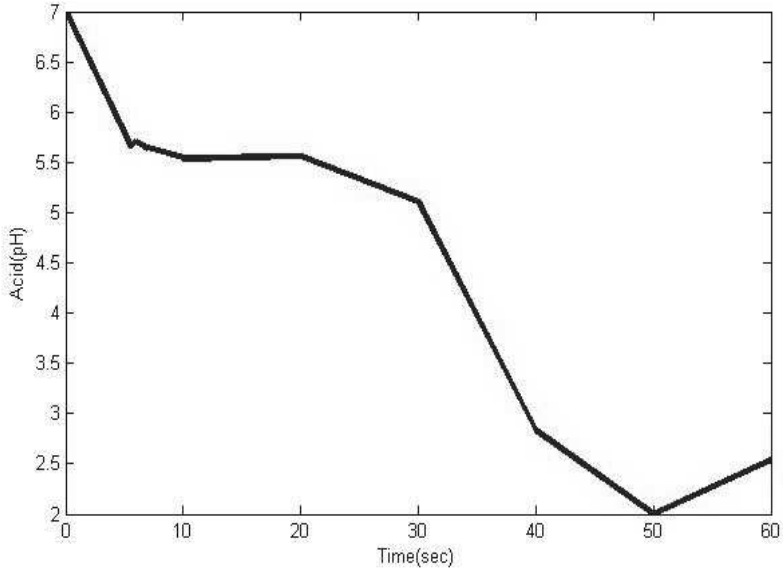


Fig. 3. Open loop response of acid added in process fluid

The Open loop response of pH process by the addition of acid in process tank is shown in Fig. 3.Here the acid is added to process fluid say distilled water, as the acid is mixed the pH value of process fluid is adjusted between the range of 3 to 7.Hence the acidic nature of the process fluid increases.

Table 2. Time Vs. pH for alkaline solution

| Time(sec) | pH |
|---|---|
| 0 | 7 |
| 10 | 8.4 |
| 40 | 10.14 |
| 80 | 10.63 |
| 100 | 10.76 |
| 320 | 10.88 |
| 440 | 11.059 |
| 560 | 10.97 |
| 630 | 11.14 |

The variation of pH with respect to time by the addition of alkaline solution shown in Table2.From the tabulation of pH values for alkaline solution the titration curve is drawn for the open loop response of base added in the process fluid, where it becomes alkaline in nature.

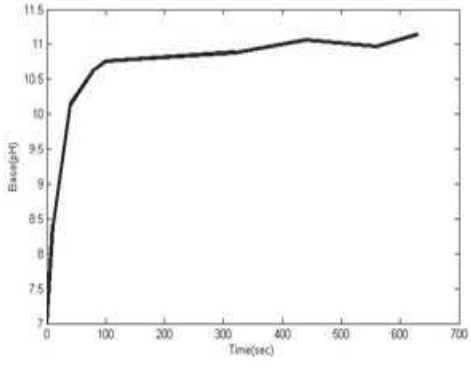


Fig. 4.Open loop response of base added in process fluid

The Open loop response of pH process by the addition of alkaline in process tank is shown in Fig.4.Here the base is added to process fluid say distilled water, as the base is mixed the pH value of process fluid is adjusted between the range of 7 to 14.

The alkaline nature of the process fluid increases. The Fig.4 explains the open loop response of base added in the process tank, where the titration curve is drawn by plotting the graph between Times Vs. pH value of acid.
The procedures followed to obtain the transfer function for both acid and base are as follows. The open loop response is also called as manual mode in which manually stem position of 40% opening is made to reach the steady state value. Empirical modeling or black box modeling was performed. Keeping stem position at a constant 40% opening, the characteristics of pH versus time was studied. The readings are noted till the system attains its steady state value. The values shown in Table 1 and Table 2 were loaded in system identification toolbox and the transfer functions were obtained.The transfer functions obtained are:

$$\text{For acid : } Gp(s) = \frac{0.0714}{(100s+1)} \quad (1)$$

$$\text{For base : } Gp(s) = \frac{0.04912}{(320s+1)} \quad (2)$$

The transfer function is obtained from the parameters identified by system identification tool box. Here we get input and output parameters. The transfer function is obtained which is the Laplace transform of output to the Laplace transform of input under zero initial conditions.

# 4. CONTROLLER DESIGN

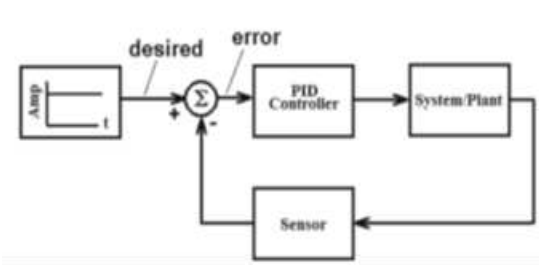


Fig.5 Block Diagram of Closed loop PID controller

Proportional-Integral-Derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. A general PID controller shown in Fig.5 calculates an error value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process through use of a manipulated variable.

The PID controller algorithm involves three separate constant parameters, and is accordingly sometimes called three-term control: the proportional,the integral and derivative values, denoted P, I, and D[4].

Simply put, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process.

By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point. Some applications may require using only one or two actions to provide the appropriate system control. This is achieved by setting the other parameters to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are fairly common, since derivative action is sensitive to measurement noise, whereas the absence of an integral term may prevent the system from reaching its target value due to the control action.

**TUNING OF CONTROLLER** There are several methods for tuning a PID loop. The most effective methods generally involve the development of process model, by choosing P, I, and D based on the dynamic model parameters. Manual tuning methods can be relatively inefficient, particularly if the loops have response times on the order of minutes or longer.

The Ziegler Nichols tuning method is a heuristic method of tuning a PID controller. The "P" (proportional) gain, $K_P$ is then increased (from zero) until it reaches the ultimate gain, $K_U$ at which the output of the control loop oscillates with a constant amplitude. $K_U$ and the oscillation period $T_U$ are used to set the P, I, and D gains depending on the type of controller used.

To determine PID controller parameters, reduce the integrator and derivative gains to 0. Increase Kp from 0 to some critical value Kp=Kc at

which sustained oscillations occur. Note the value Kc and the corresponding period of sustained oscillation Tc .The formulae for Zeigler Nichols is given in Table 3 .

Table 3. ZN Formulae

| Control Type | $K_p$ | $K_i$ | $K_d$ |
|---|---|---|---|
| **P** | $0.50K_u$ | - | - |
| **PI** | $0.45K_u$ | $1.2K_p/P_u$ | - |
| **PID** | $0.60K_u$ | $2K_p/P_u$ | $K_pP_u/8$ |

**PARTICLE SWARM OPTIMIZATION** Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. Compared to GA, the advantages of PSO are that PSO is easy to implement and there are few parameters to adjust. PSO has been successfully applied in many areas: function optimization, artificial neural network training, fuzzy system control.

**Tuned Parameters for PID Controllers**

**Table 4. Tuned value for PID controller**

| Controller | Kp | Ki | Kd |
|---|---|---|---|
| ZN tu<br>ned PID | 0.63 | 0.05 | 1.96 |
| Auto tuned PID | 23.922 | 0.296 | -177.31 |
| Optimized PID | 72.56 | 0.721 | 23.25 |

Various controllers like ZN tuned PID, Auto tuned PID, Optimized PID controllers are employed to find their respective values of Kp, Ki, Kd as shown in Table 4.

Table 5. Parameters of PSO algorithm

| | |
|---|---|
| Population Size | 10 |
| Number of Iterations | 50 |
| Variables/Dimension of the problem | 03 |
| W | 0.7 |
| $c_1$ | 1.5 |
| $c_2$ | 1.5 |

The various parameters of PSO algorithm is shown in Table 5 where, W denotes the best particle, $c_1$ and $c_2$ indicates the learning parameters of PSO algorithm.

## 5. SIMULATION RESULTS

**PID controller using ZN tuning method**

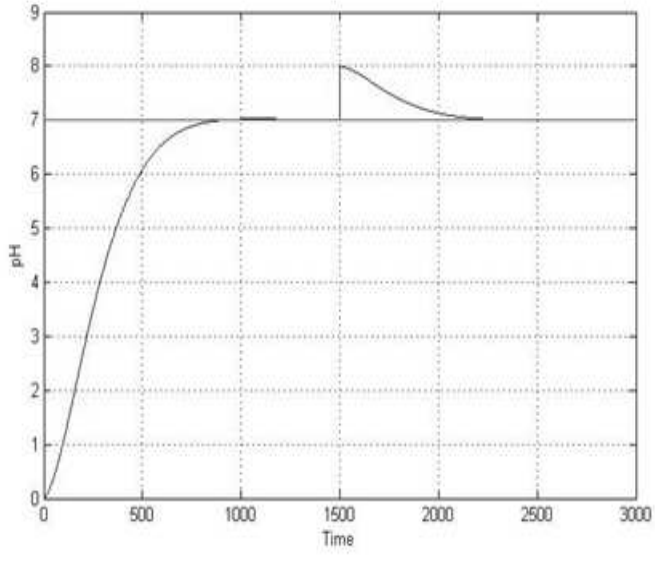


Fig.6. Closed loop response of ZN tuned PID controller

The closed loop response of ZN tuned PID controller as shown in Fig.6 shows that the rise time and settling time is maximum. The non-linear pH process settles at 1280 seconds with an absolute error of 8940.

**PID controller using automatic tuning method**

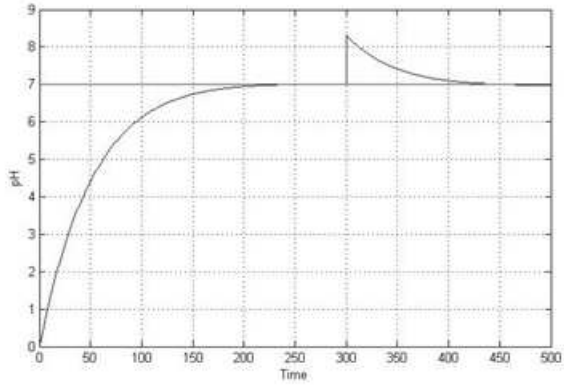


Fig.7. Closed loop response of Auto-tuned PID Controller

The closed loop response of Auto-tuned PID controller as shown in Fig.7. shows that the rise time and settling time value is minimum compared to ZN tuning. The non-linear pH process settles at 250 seconds with an absolute error of 1222.

**PID controller with PSO**

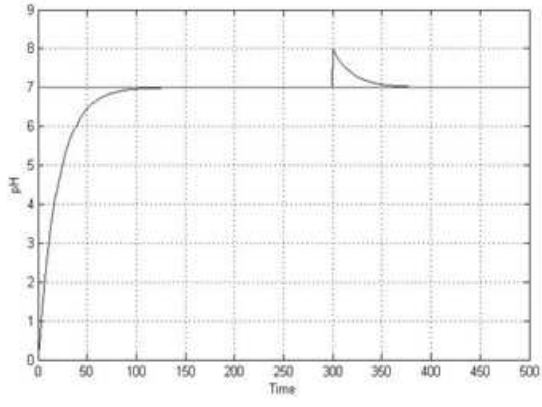


Fig. 8. Closed loop Response of Optimized PID Controller

The closed loop response PSO as shown in Fig.8 shows that rise time and settling time value is very less compared to auto-tuning and ZN tuning. The non-linear pH process settles at 140 seconds with an absolute error of 481.

## 6. CONCLUSION

The simulation results for PID controller using ZN tuning, automatic method and PSO method are compared to find the better performance of controller. The rise time and settling time value is maximum for ZN tuned PID, reduced in Auto tuned PID and minimum in Optimized PID as shown in Table 6. The value of ISE is also very high for ZN tuned PID and Auto tuned PID compared to Optimized PID controller. From the above results, the PSO tuned PID controller seems to provide optimum control over ZN an automatic tuned PID controller.

**Table 6.Comparison Table**

| Control | Rise time (sec) | Settling Time (sec) | ISE |
|---|---|---|---|
| ZN tuned PID | 465 | 1280 | 8940 |
| Auto tuned PID | 105 | 250 | 1222 |
| Optimized PID | 43 | 140 | 481 |

The split range controller can be implemented to obtain the optimum control of pH value

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# ENHANCING THE QUALITY CHARACTERISTICS OF GREENS AND CASTING BY OPTIMIZING PROCESS PARAMETERS USING TAGUCHI METHOD

S.S.Jamkar*
Department of Mechanical Engineering,
Govt. College of Engineering, Amravati, India .
E-mail:jamkarsumit@gmail.com
*Corresponding Author

M.J.Deshmukh
Department of Mechanical Engineering, Govt.
College of Engineering, Amravati, India

N.R. Vidhate
Jadhao Steel & alloys Amravati, India

## ABSTRACT

This paper analyses various significant process parameters of the green sand casting process. An attempt has been made to obtain optimal settings of the green sand casting process in order to yield the optimum quality characteristics of the grey cast iron ginning component machine components casting. The process parameters considered are moisture content, green compression strength and permeability. An orthogonal array, the signal-to-noise (S/N) ratio, and analysis of variance are used to analyze the effect of selected process parameters and their levels on the casting defects. The results indicate that the selected process parameters significantly affect the casting defects of grey cast iron ginning machine castings. A confirmation run is used to verify the results, which indicated that this method is more efficient in determining the best casting parameters for cotton ginning component.

***Keywords:*** *Green sand casting, Casting Defect, Optimization, Taguchi Method, ANOVA.*

## 1. INTRODUCTION

In Green sand casting process, there are various process parameters with different adjustment levels, which may influence the final characteristics of the product. To optimize a green sand casting process, the trial and error method is used to identify the best parameters to manufacture a quality product.However, this method demands extensive experimental work and results in a great waste of time and money. Thus, design of experiments appears to be an important tool for continuous and rapid improvements in quality.

These experimental methods may be employed to solve problems related to a green sand casting process, to substitute a process for another one, to develop different products and to understand the influence of various factors on the final quality of a given product. The Taguchi Method is an experimental technique that helps to investigate the best combinations of process parameters, changing quantities, levels and combinations in order to obtain results statically reliable. It is a systematic route that may be followed so as to find solutions to industrial process problems with greater objectivity by means of experimental and statistical techniques. The green sand casting process is controlled by several parameters. When properly determined and adjusted, they result in an improvement in quality of the green sand casting parts. Usually, the main controlled variables are moisture content, green compression strength (GCS) and Permeability. According to Taguchi, the parameters which exert a great deal of influence on the green sand casting process can be adjusted to varying levels of intensity so that some settings can result in robustness of the casting process.

## 2. METHODOLOGY

The literature review indicates that the Taguchi method is the best option for design of experiments when number of process parameter are involved in the process. Taguchi approach is suitable in experimental design for designing and developing robust products or processes irrespective of variation in process parameter (within set limits) and or variation in environmental conditions. The present research as associated with green sand casting process which involves various parameters at different levels and affects the casting quality. Considering these features of Taguchi method, it is used to reduce the % of rejection due to sand and moulding related defects by setting the optimum values of the process parameters of the green sand casting. The methodology used to achieve optimized process parameters using DoE is as given below:

- Select any defect observed due to sand and mould. Set the target to achieve "lower casting defects" by adjusting the process parameters.
- Select the most significant parameters influencing defects in casting by cause effect diagram.
- Select the parameters and their levels. Perform the experiments (trial castings) as per DoE (Taguchi method) and collect the data.
- Analyze the data using statistical tools. An analysis of variance (ANOVA) can be obtained to determine the statistical significance of the parameters. Means plots can be plotted to determine the preferred levels of parameters considered for experimentation.
- Select optimum levels of control parameters, perform confirmation experiments and implement the process

## 3. EXPERIMENTATION

Experiments were performed in a medium scale ferrous foundry producing grey cast iron ginning machine components. For each process parameter two/three levels are selected which define the experimental region. The levels selected are based on the standards acceptable and foundry men experience in this organization for ginning machine components castings. Three interactions within control parameters are also considered. The parameters, along with their ranges are given in Table 1.

**Table1. Process parameters and their levels**

| Process Parameters | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| A: Moisture (%) | 4.5-4.9 | 5.0-5.4 | -------- |
| B : Green Compression strength (kg/cm2) | 1000-1100 | 1101-1200 | 1201-1300 |
| C : Permeability (number) | 115-125 | 126-135 | 136-145 |

**3.1 QUALITY CHARACTERISTICS** Casting defects was selected as a quality characteristic to be measured. The smaller the better number of casting defect implies better process performance. Here the objective function to be maximized is:

$SNratio\ \eta' = -10\log\ mean\ square\ surface\ defects$

$S/N\ ratio\ (\eta') = -10\log\ (\Sigma yi\text{^}2)/n$

Maximizing η' leads to minimization of quality loss due to defects. Where *S/N* ratio is used for measuring sensitivity to noise factors, *n* is the number of experiments orthogonal array, and *yi* the *ith* value measured.

**3.2. SELECTION OF ORTHOGONAL ARRAY** Selection of an orthogonal array depends upon the number of control factors and interaction of interest. It also depends upon number of levels for the control factors of interest. Therefore with one control factor moisture percentage of two levels and other control factors green compression strength (GCS), permeability number with three levels are considered, L18 orthogonal array is selected with 18 experimental runs and eight columns. Taguchi has provided in the assignment of factors and interaction to arrays. The assigned L18 orthogonal array is shown in Table 2 and the experimental orthogonal array having their levels are assigned to columns are shown in Table 3.

**Table2. Orthogonal array L18**

| Trial No. | A | B | C |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 2 |
| 3 | 1 | 1 | 3 |
| 4 | 1 | 2 | 1 |
| 5 | 1 | 2 | 2 |
| 6 | 1 | 2 | 3 |
| 7 | 1 | 3 | 1 |
| 8 | 1 | 3 | 2 |
| 9 | 1 | 3 | 3 |
| 10 | 2 | 1 | 1 |
| 11 | 2 | 1 | 2 |
| 12 | 2 | 1 | 3 |
| 13 | 2 | 2 | 1 |
| 14 | 2 | 2 | 2 |
| 15 | 2 | 2 | 3 |
| 16 | 2 | 3 | 1 |
| 17 | 2 | 3 | 2 |
| 18 | 2 | 3 | 3 |

**Table3. Experimental Orthogonal Array**

| Trial No. | A | B | C |
|---|---|---|---|
| 1 | 4.8 | 1050 | 120 |
| 2 | 4.8 | 1050 | 130 |
| 3 | 4.8 | 1050 | 140 |
| 4 | 4.8 | 1150 | 120 |
| 5 | 4.8 | 1150 | 130 |
| 6 | 4.8 | 1150 | 140 |
| 7 | 4.8 | 1250 | 120 |
| 8 | 4.8 | 1250 | 130 |
| 9 | 4.8 | 1250 | 140 |
| 10 | 5.3 | 1050 | 120 |
| 11 | 5.3 | 1050 | 130 |
| 12 | 5.3 | 1050 | 140 |
| 13 | 5.3 | 1150 | 120 |
| 14 | 5.3 | 1150 | 130 |
| 15 | 5.3 | 1150 | 140 |
| 16 | 5.3 | 1250 | 120 |
| 17 | 5.3 | 1250 | 130 |
| 18 | 5.3 | 1250 | 140 |

**3.3. EXPERIMENT RESULTS AND S/N RATIOS** The experiments were conducted thrice for the same set of parameters using a single-repetition randomization technique. The casting defects that occur in each trial conditions were found and recorded. The average of the casting defects was determined for each trial condition as shown in Table 4. The casting defects are the "lower the better" type of quality characteristics. Lower the better S/N ratios were computed for each of the 18 trials and the values are given in Table 4:
Lower is better: S/N = -10 log [(Σy^2i) / n]

**3.4. ANALYSIS OF VARIANCE** After the experiments are conducted, the ANOVA is used to analyze the results of the experiments. The significant factors and/or their interactions are identified, for various trial conditions and the parameters which significantly influence the casting defects. However, some more information is required to conclude with an optimum setting of parameters. In applying ANOVA technique, certain assumptions must be checked through analysis of residuals before interpreting and concluding the results. It is highly recommended to examine these residuals for normality, independence, and constant variance, when using ANOVA. In this paper, F ratio test is employed to check constancy of residual variance. If the F ratio test statistic is equal to or less than its corresponding critical value, the residuals have constant variance. The *F*-ratio value can be found using the ratio of mean square of a factor to variance of error. It can seen from the *F*-ratio value result that the significant factors are the control factors in the order of, A (moisture), B (green compression strength) and C (permeability). The expected amount of sum of squares (SS) for each factor is computed by using variance. The percent contribution (P) for each factor is calculated by using expected amount of sum of squares (SS) in Table 5.

**Table4. Casting defects values and signal-to-noise ratio against experimental trial numbers**

| Trial No. | Percentage defects in experiment | | | Total | Average | S/N ratio |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | | |
| 1 | 3.52 | 3.71 | 2.28 | 9.51 | 3.17 | -10.1916 |
| 2 | 4.25 | 3.14 | 2.28 | 9.66 | 3.22 | -10.4298 |
| 3 | 4.14 | 5.42 | 2.38 | 11.94 | 3.98 | -12.4039 |
| 4 | 3.30 | 5.35 | 5.01 | 13.65 | 4.55 | -13.3320 |
| 5 | 1.57 | 3.31 | 3.45 | 8.31 | 2.77 | -9.2640 |
| 6 | 4.23 | 2.86 | 4.86 | 11.94 | 3.98 | -12.1917 |
| 7 | 5.28 | 4.79 | 5.17 | 15.24 | 5.08 | -14.1247 |
| 8 | 2.84 | 3.64 | 3.44 | 9.90 | 3.30 | -10.4335 |
| 9 | 5.05 | 4.43 | 6.51 | 15.99 | 5.33 | -14.1247 |
| 10 | 1.59 | 3.45 | 3.98 | 9.00 | 3.00 | -10.0391 |
| 11 | 5.22 | 4.57 | 5.67 | 15.45 | 5.15 | -14.2750 |
| 12 | 4.38 | 5.10 | 3.10 | 12.57 | 4.19 | -12.6169 |
| 13 | 3.30 | 5.35 | 5.01 | 13.65 | 4.55 | -13.3320 |
| 14 | 4.23 | 7.15 | 3.20 | 14.58 | 4.86 | -14.2191 |
| 15 | 5.61 | 4.71 | 4.47 | 14.79 | 4.93 | -13.8998 |
| 16 | 5.90 | 5.46 | 5.64 | 16.98 | 5.66 | -15.0710 |
| 17 | 5.17 | 4.57 | 4.71 | 14.43 | 4.81 | -13.6672 |
| 18 | 6.17 | 6.18 | 6.35 | 18.69 | 6.23 | -15.8952 |

Avg.Casting defects= 4.38 Standard deviation= 0.86 Avg S/N ratio=-12.78

**Table5.ANOVA result for Casting Defects**

| Parameter | DoF | seqSS | AdjSS | AdjMS | F | P | Percentage (%) |
|---|---|---|---|---|---|---|---|
| A | 1 | 14.2131 | 14.2131 | 14.2131 | 53.34 | 0.002 | 21.78 |
| B | 2 | 16.1135 | 16.1135 | 8.0568 | 30.24 | 0.004 | 24.65 |
| C | 2 | 7.4000 | 7.4000 | 3.7000 | 13.89 | 0.016 | 11.32 |
| A*B | 2 | 0.6385 | 0.6385 | 0.3179 | 1.19 | 0.392 | 0.9 |
| A*C | 2 | 11.6999 | 11.6999 | 5.8499 | 21.95 | 0.007 | 17.90 |
| B*C | 4 | 14.2020 | 14.2020 | 3.5505 | 13.32 | 0.014 | 21.73 |
| Error | 4 | 1.0659 | 1.0659 | 0.2665 | | | 1.63 |
| Total | 17 | 65.3302 | | | | | 100 |

AOM plot in Figure 1 indicates that % rejection is minimum at the first level of moisture content (A1), the first level of green compression strength (B1), and the second level of permeability (C2).

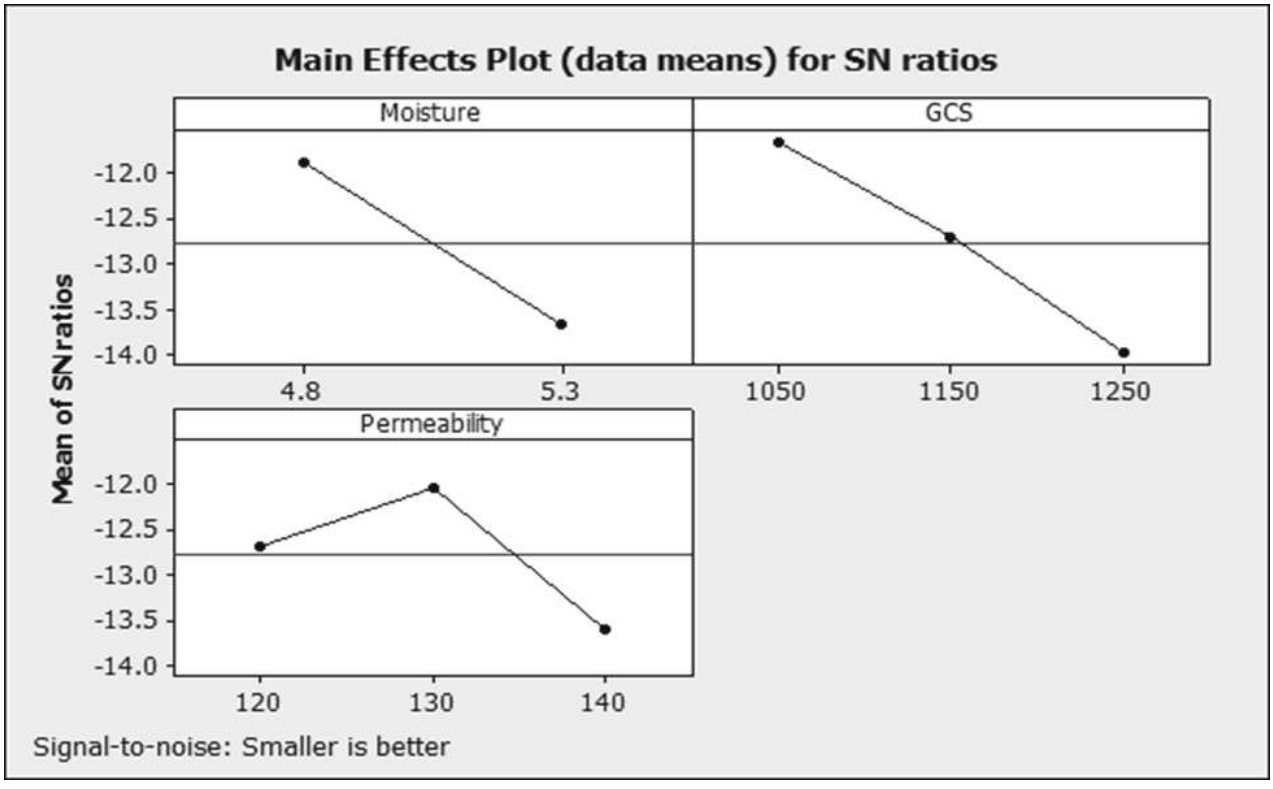


Fig.1 Main effects for S/N ratio

**3.5 CONFIRMATION EXPERIMENTS** Three confirmation experiments were performed at the optimized settings of the process parameters, results of which are shown in Table 5. Prior to the application of Taguchi method rejection due to sand related defects was 4.38% which is reduced to maximum up to 3.37 %.

Table6. Results of confirmation Experiment

| Experiment No. | Rejection | | | Average % of Rejection |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| 1 | 3.10 | 3.30 | 3.40 | 3.27 |
| 2 | 2.88 | 4.10 | 3.18 | 3.39 |
| 3 | 3.28 | 2.50 | 4.10 | 3.29 |
| Total average of % rejection | | | | 3.32 |

# 4. CONCLUSION

- The optimized levels of selected process parameters obtained by Taguchi methods are: moisture content (A): 4.8 %, green compression strength (B): 1050 gm/cm2, and permeability number (C): 130.
- With Taguchi optimization method the % rejection of castings due to sand related defects is reduced from 4.38 % to a maximum up to 3.32%.
- Taguchi method has proved its success in prediction the optimum casting parameters to reach the best properties.

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# INVESTIGATION OF CRACK WIDTH DEVELOPMENT IN REINFORCED CONCRETE BEAMS USING FLY ASH WITH DIFFERENT COVER DEPTHS

U. Venkat Tilak*
Associate Professor, Department of Civil Engineering
Kallam Haranath Reddy, Chowdavaram
Guntur, Andhra Pradesh, India.
Tel.No.9160929919
E-mail: Venkattilak@gmail.com.
*Corresponding Author

A. Narender Reddy
M.Tech Student, Department of Civil Engineering
Newton's Institute of Science & Technology, Macherla
Guntur, Andhra Pradesh, India.
Tel.No.7382940536
Email: 2narender05@gmail.com

## ABSTRACT

Due to increase in thermal power plants in India lot of fly ash is produced. The disposal of fly ash causes negative impact on the environment in the way of water pollution, air pollution and finally effect on the eco system. Hence disposal of fly ash is challenging task for engineers. Lot of earlier investigations reported that fly ash has some cementing properties it can be replaced as cement upto some percentage. Hence in this investigation an attempt has been made to replace the cement by fly ash and investigated the resulting properties. In this project work presented Cubes and Reinforced concrete beams are tested for Compression and Flexural Strength of Design Mix M30 (1:1.34:2.88) by varying the cement content with certain proportions are a normal OPC mix, Cement replace by 20% fly ash mix, Cement replace by 30% fly ash mix and Cement replace by 40% fly ash mixes of the same water cement ratio (0.43). The tests conducted for above mixes are the fresh concrete properties are workability in terms of slump cone test and compaction factor test, 8mm and 10mm diameter bars are used as tension and compression reinforcement and 6mm diameter bars are used as vertical stirrups. The engineering properties such as compressive strength and flexural strength of reinforced concrete were measured in 14 days and determining the crack width development of reinforced concrete beams with different percentage of fly ash with different cover depths. After the investigation it is observed that fly ash can be effectively used to replace the cement upto 40 percentage. The use of fly ash in concrete serves the triple benefits they are Safe disposal of fly ash, Conservation of natural material (cement) and Return of income.

***Keywords:*** *Fly ash, Compression test, Flexural Strength test, crack width, different cover depths, reinforced concrete beams.*

## 1. INTRODUCTION

Concrete is a composite construction material, composed of cement (commonly Portland cement) and other cementitious material like fly ash and aggregate (generally a coarse aggregate made of gravel or crushed rocks such as granite, plus a fine aggregate such as sand), water. Concrete has been most extensively used in buildings ever since Joseph invented and patented Portland cement, about one hundred sixty years ago. At its face value, concrete is a simple material close to the natural one. It is a robust and reasonably durable one, with compressive strength going up to 150Mpa under controlled conditions in suitable combination of the components. The cement industry is one of two primary producers of carbon dioxide ($CO_2$), creating up to 5% of worldwide man-made emissions of this gas, of which 50% is from the chemical process and 40% from burning fuel. The $CO_2$ emission from the concrete production is directly proportional to the cement content used in the concrete mix; 900 kg of $CO_2$ are emitted for the production of every ton of cement. It is widely known

that water/cement ratio primarily governs the strength of concrete and lower water/cement ratio gives higher strength. Another important requirement is that the concrete should have adequate workability at the time of casting so that it can be properly compacted with minimum air voids. The inclusion of Fly ash affects all aspects of concrete. As a part of the composite concrete mass, it can be used both as a fine aggregate as well as a cementitious component. It influences the rheological properties of fresh concrete as well as the finished product. It improves the strength and durability of the hardened mass. It reduces segregation, bleeding and lowers the heat of hydration apart from the energy and cost saving aspects. There are other important points one must pay attention to, regarding reinforcement besides its strength and bond. The durability of a structure depends on the quality of the materials and construction, the design specification and detailing, the time and environmental factors. Concrete structures are subjected to dynamic loads such as guest wind; cyclonic weather and earthquake undergo repeated reversal of stress. Such loads cause micro cracking and increasing brittleness of the concrete. Reinforcement is required for protection against cracking of concrete and also to provide ductility to the structure. Industrial by products, such as fly ash, silica fume and blast furnace slag are increasingly used worldwide to produce dense and impermeable concrete. In countries where these materials are available as waste products, their use in concrete not only enhances its durability but also decreases its lost. It is found that high strength and high performance concrete can be produced using such materials. Fly ash is the material used in the production of high strength concrete. fly ash is used as early as in 1935 for cement replacement. In India about 115 million tones of fly ash have been produced by 82 major thermal power stations. It has been a published fact from research that waste material like fly ash through their use as construction materials can be converted into meaningful wealth. In generally the cracking of concrete will occur whenever the tensile strength of concrete is exceeded or ($F_{cr}$ = 0.57*sqrt ($f_{ck}$)). Cracks are likely to form on the surface in the tensile zone, midway between two adjacent bars. There is a similarity between the development of flexural micro cracking in reinforced and plain concrete beams when the load deflection curve deviates from that of a straight line. There are limits on cracking, those are Cracking is varying with the type of structure and its environment. The limit of crack according to code is 0.3mm and If the cracking is in the tensile zone then the width according to code is 0.2mm (cracking in tensile zone is harmful). The factors affecting the crack width are tensile stress in steel bars, Thickness of concrete cover, Diameter and spacing of bars and Bond and tensile strength.

## 2. LITERATURE REVIEW

According to the American Concrete Institute (ACI) Committee 116R, fly ash is defined as '*the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gasses from the combustion zone to the particle removal system'* (ACI Committee 232 2004). Fly ash is removed from the combustion gases by the dust collection system, either mechanically or by using electrostatic precipitators, before they are discharged to the atmosphere. Fly ash particles are typically spherical, finer than Portland cement and lime, ranging india meter from less than 1μ to no more than 150 μm. The types and relative amounts of incombustible matter in the coal determine the chemical composition of fly ash. The chemical composition is mainly composed of the oxides of silicon ($SiO_2$), aluminum ($Al_2O_3$), iron ($Fe_2O_3$), and calcium (CaO), whereas magnesium, potassium, sodium, titanium, and sulphur are also present in a lesser amount. The major influence on the fly ash chemical composition comes from the type of coal. The combustion of sub-bituminous coal contains more calcium and less iron than fly ash from bituminous coal. The physical and chemical characteristics depend on the combustion methods, coal source and particle shape. The chemical compositions of various fly ashes show a wide range, indicating that there is a wide variations in the coal used in power plants all over the world (Malhotra and Ramezanianpour 1994). Fly ash that results from burning sub-bituminous coals is referred as ASTM Class C fly ash or high-calcium fly ash, as it typically contains more than 20 percent of CaO. On the other hand, fly ash from the bituminous and anthracite coals is referred as ASTM Class F fly ash or low-calcium fly ash. It consists of mainly an alumino silicate glass, and has less than 10 percent of CaO. The color of fly ash can be tan to dark grey, depending upon the chemical and mineral constituents (Malhotra and Ramezanianpour 1994; ACAA 2003). The typical fly ash produced from Australian power stations is light to mid-grey in color, similar to the color of cement powder. The majority of Australian fly ash falls in the category of ASTM Class F low calcium fly ash, and contains 80 to 85% of silica and alumina (Heidrich 2002). A side from the chemical composition, the other characteristics of fly ash that generally considered is loss on ignition (LOI), fineness and uniformity. LOI is a measurement of unburnt carbon remaining in the ash. Fineness of fly ash mostly depends on the operating conditions of coal crushers and the grinding process of the coal itself. Finer gradation generally results in a more reactive ash and contains less carbon. In 2001, the annual production of fly ash in the USA was about 68 million tons. Only 32 percent of this was used in various applications, such as in concrete, structural fills, waste stabilization/solidification etc. (ACAA 2003). Ash production in Australia in 2000 was approximated 12 million tons, with some 5.5 million tons have been utilized (Heidrich 2002). Worldwide, the estimated annual production of coal ash in 1998 was more than 390 million tons. The main contributors for this amount were China and India. Only about 14 percent of this fly ash was utilized, while the rest was disposed in landfills (Malhotra 1999). By the year 2010, the amount of fly ash produced worldwide is estimated to be about 780 million tons annually (Malhotra 2002). The utilization of fly ash, especially in concrete production, has significant environmental benefits, viz, improved concrete durability, reduced use of energy, diminished greenhouse gas production, reduced amount of fly ash that must be disposed in landfills, and saving of the other natural resources and materials (ACAA 2003). **M. M. Prasad** investigated the effect of 17%, 22%, 27% and 32% cement replacement by fly ash and silica fume on conventional M20 grade of concrete. M20 grade of concrete has been considered as reference mix. Specimens are cast and cured normally for 28 days and then tested for flexural strength and split tensile strength to failure as per IS specifications and the results have been compared. The test results shows that the flexural and split tensile strength of fly ash- silica fume concrete containing up to 27% fly ash plus silica fume are comparable to that of conventional concrete. **Canon** has stated that by adding fly ash to the extent of 15% by weight of cement in lean concrete (W/C=0.8) strength equal to the corresponding plane concrete within 90 days was achieved. **Deepa**

**A. Sinha and Elizabeth George** has designed M25 and M30 concrete mixtures with different percentages of fly ash substitution without any addition of chemical admixtures. It was found that not only the 28 and 90 days compressive strength but also the flexural strength and durability of fly ash concrete was satisfactory up to 50% fly ash substitution for cement. **Osman Ahmad** had done extensive work on the utilization of fly ash in concrete with 15 cm max size of coarse aggregate. According to him, large doses of fly ash in lean and rich concrete could result in a saving to about 40% and 30% respectively in cement content over the current practices of substitution of fly ash to the extent of 20% by weight. In all the fly ash mixes studied, the sand content was reduced by amount equivalent to the absolute amount of fly ash added. **Dhuraria** has recorded that earlier strengths could be achieved in fly ash concrete by adjusting the various ingredients in such a way that the quantity of cement and fly ash in the final mix is more than the quantity of cement replaced. Fly ash concrete mix appeared drier than normal concrete mix but gets satisfactorily compacted with adequate vibration. **D.Heinz, K. Miskiewicz and L. Urbonas**has stated that, for ecological and economical reasons the substitution of natural raw materials by industrial by-products is of great importance. The use of fly ash from coal-fired power plants as an active addition in the production of cement can improve special cement properties and lower the $CO_2$ –emissions associated with the cement production.

## 3. MATERIALS

- Cement: The most common cement used in construction is ordinary Portland cement confirming to IS-8112_1989. This type of cement is typically used in construction and is readily available from a variety of sources. The cement is fresh and uniform colour. The cement is free from lumps and foreign matter. The Blains fineness is used to quantity the surface area of cement. The surface area provides a direct indication of the cement fineness. The typical fineness of cement ranges from 350 to 500sq.m/Kg. The type of cement used all throughout the experiment was Ordinary Portland Cement of grade 53 (OPC-53). This is the most common type of cement used in general concrete construction where there is no exposure to sulphates in the soil or in the ground water.

- Water: Potable water available in strength of materials laboratory was used throughout the investigation.

- Fine aggregate: Fine aggregates can be natural or manufactured. The grading must be uniform throughout the work. The moisture content or absorption characteristics must be closely monitored. The fine aggregate used is natural sand obtained from the river Godavari.

- Coarse aggregate: Coarse aggregate is the strongest and least porous component of concrete. It is also a chemically stable material. Presence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring on account of moisture. In the present study locally available blue granite crushed stone aggregates of maximum size 20mm was used and tests were carried out as per IS 2386:1986(111), its specific gravity is 2.78.

- Fly ash: Fly ash is a by-product of the combustion of pulverized coal in thermal power plants. The dust-collection system removes the fly ash, as a fine particulate residue, from the combustion gases before they are discharged into the atmosphere. Fly ash belonging to class-F obtained from Vijayawada thermal Power Station in Andhra Pradesh was used in the present investigation.

- Steel: Steel used is high yield strength deformed (HYSD) bars yields strength of 415 N/mm$^2$. For each beam 8 mm and 10mm ϕ longitudinal reinforcement is adopted and 6mm diameter M.S bars are used as vertical stirrups. The steel bars used are free from dust, rust or any organic matter. Oil etc at the time of use.

## 4. MIX PROPORTIONS

The proportioning of a concrete mixture is based on determining the quantities of the ingredients which, when mixed together and cured properly will produce reasonably workable concrete that has a good finish and achieves the desired strength when hardened. This involves different variables in terms of water to cement ratio, the desired workability measured by slump and cement content and aggregate proportions. The mix is designed to target strength of 36.6 mpa, of M30 Grade. Mix design is done according to Indian standard recommended method of concrete mix design IS 10262-1982.

- Mix proportions: The nominal grade of concrete used in this investigation is M30. The mix design is based on strength criteria and durability criteria suitable for mild environment. The ratios by weight of cement, fine aggregate and coarse aggregate are obtained using the equations given in IS 10262-1982. These proportions are maintained strictly same throughout the casting process to obtain a uniform standard and workable concrete mix. Six cubes are cast for mixing process and jested for compressive strength 14 days curing. The mix design proportions are 1:1.34:2.88 and W/C ratio is 0.43.

- Casting and Curing: After mixing, the concrete was placed in pre-oiled moulds. Curing is done by ordinary water curing for 14 days respectively.

Table 1. Fly ash replacement proportions

| Mix id | Cement | | Fly ash | | Total powder Kg/m$^3$ |
|---|---|---|---|---|---|
| | % | Kg/m$^3$ | % | Kg/m$^3$ | |
| Mix 1 | 100 | 420 | 0 | ------ | 420 |
| Mix 2 | 80 | 336 | 20 | 84 | 420 |
| Mix 3 | 70 | 294 | 30 | 126 | 420 |
| Mix 4 | 60 | 252 | 40 | 168 | 420 |

## 5. PROPERTIES OF FRESH CONCRETE

Fresh concrete or plastic concrete is a freshly mixed material which can be moulded into any shape. The relative quantities of cement, fly ash, aggregates and water mixed together, control the properties of concrete in the wet state as well as in hardened state.

- Slump Cone Test: Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work

Table 2: Slump cone results for different percentages of fly ash

| Mix id | Percentage of fly ash | Slump cone value in mm |
|---|---|---|
| Mix 1 | 0 | 55 |
| Mix 2 | 20 | 60 |
| Mix 3 | 30 | 70 |
| Mix 4 | 40 | 75 |

- Compaction Factor Test: Compaction factor measures the workability in an indirect manner by determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.

Table 3: Compaction Factor Results for Different Percentages of Fly Ash

| Mix id | Percentage of fly ash | Compaction factor value |
|---|---|---|
| Mix 1 | 0 | 0.83 |
| Mix 2 | 20 | 0.856 |
| Mix 3 | 30 | 0.92 |
| Mix 4 | 40 | 0.955 |

# 6. ENGINEERING PROPERTIES OF CONCRETE

- Compressive Strength: Compressive strength is an important criterion used to evaluate the quality of concrete. It is usually the value that the structural design of concrete is based on. This section gives details of the investigation carried out to evaluate the compressive strength of OPC, OPC with different percentages of fly ashes.

Table 4 Cube compressive strength results for 14 days of curing

| Mix id | Percentage of fly ash | Compressive Strength in N/mm$^2$ |
|---|---|---|
| Mix 1 | 0 | 22.3 |
| Mix 2 | 20 | 23.86 |
| Mix 3 | 30 | 26.27 |
| Mix4 | 40 | 28.53 |

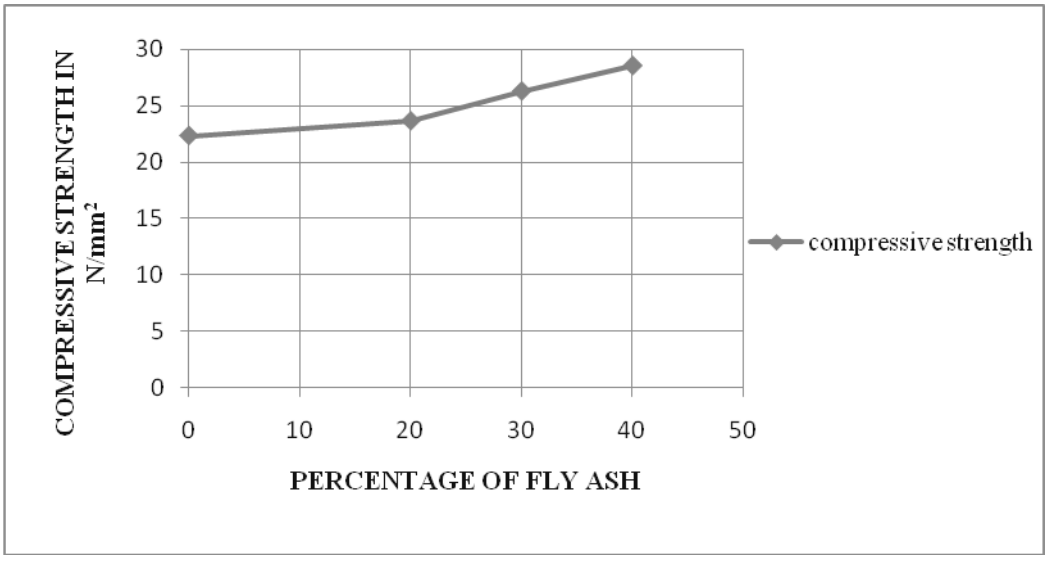


Fig.1. Compressive Strength of Cubes with Different % of Fly Ash

- Flexural Strength: The flexural strength (Modulus of Rupture/ MOR) of Reinforced concrete beams with different percentage of fly ashes and different clear covers at the age of 14 days. Different percentage of fly ashes are 0, 20, 30 and 40 with clear covers of 5 mm,10 mm and 15 mm. Details of the test and the results are presented and discussed in this section.

Flexural Strength Values of Reinforced Concrete Beams With Same Reinforcement Provided (Without Design):

Table 5: Flexural Strength Values of 5 mm Clear Cover without Design Reinforced Beams

| Mix id | Percentage of fly ash | Clear cover in mm | Flexural strength N/ mm$^2$ |
|---|---|---|---|
| Mix 1 | 0 | 5 | 28.92 |
| Mix 2 | 20 | 5 | 29.71 |
| Mix 3 | 30 | 5 | 31.95 |
| Mix 4 | 40 | 5 | 33.3 |

Table 6: Flexural Strength Values of 10 mm Clear Cover without Design Reinforced Beams

| Mix id | Percentage of fly ash | Clear cover in mm | Flexural strength N/ mm$^2$ |
|---|---|---|---|
| Mix 1 | 0 | 10 | 24.65 |
| Mix 2 | 20 | 10 | 29.52 |
| Mix 3 | 30 | 10 | 31.27 |
| Mix 4 | 40 | 10 | 32.37 |

Table 7: Flexural Strength Values of 15 mm Clear Cover without Design Reinforced Beams

| Mix id | Percentage of fly ash | Clear cover in mm | Flexural strength N/ $mm^2$ |
|---|---|---|---|
| Mix 1 | 0 | 15 | 19.78 |
| Mix 2 | 20 | 15 | 25.7 |
| Mix 3 | 30 | 15 | 30.7 |
| Mix 4 | 40 | 15 | 32.22 |

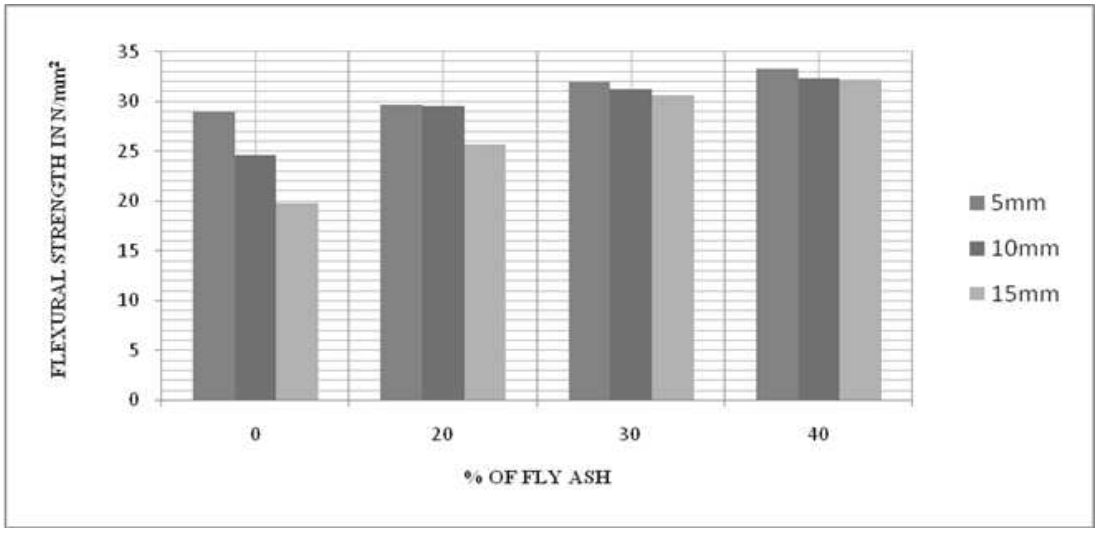


Fig 2. Flexural Strength of Beams without Design Reinforcement Provided with Different % of Fly Ash

Flexural Strength Values of Reinforced Concrete Beams With Same Reinforcement Provided (With Design):

Table 8: Flexural Strength Values of 5 mm Clear Cover with Design Reinforced Beams

| Mix id | Percentage of fly ash | Clear cover in mm | Flexural strength N/ $mm^2$ |
|---|---|---|---|
| Mix 1 | 0 | 5 | 9.725 |
| Mix 2 | 20 | 5 | 11.4 |
| Mix 3 | 30 | 5 | 12.93 |
| Mix 4 | 40 | 5 | 25.35 |

Table 9: Flexural Strength Values of 10 mm Clear Cover with Design Reinforced Beams

| Mix id | Percentage of fly ash | Clear cover in mm | Flexural strength N/ $mm^2$ |
|---|---|---|---|
| Mix 1 | 0 | 10 | 8.23 |
| Mix 2 | 20 | 10 | 9.12 |
| Mix 3 | 30 | 10 | 10.95 |
| Mix 4 | 40 | 10 | 18.56 |

Table 10: Flexural Strength Values of 15 mm Clear Cover with Design Reinforced Beams

| Mix id | Percentage of fly ash | Clear cover in mm | Flexural strength N/ $mm^2$ |
|---|---|---|---|
| Mix 1 | 0 | 15 | 6.57 |
| Mix 2 | 20 | 15 | 7.65 |
| Mix 3 | 30 | 15 | 9.22 |
| Mix 4 | 40 | 15 | 10.37 |

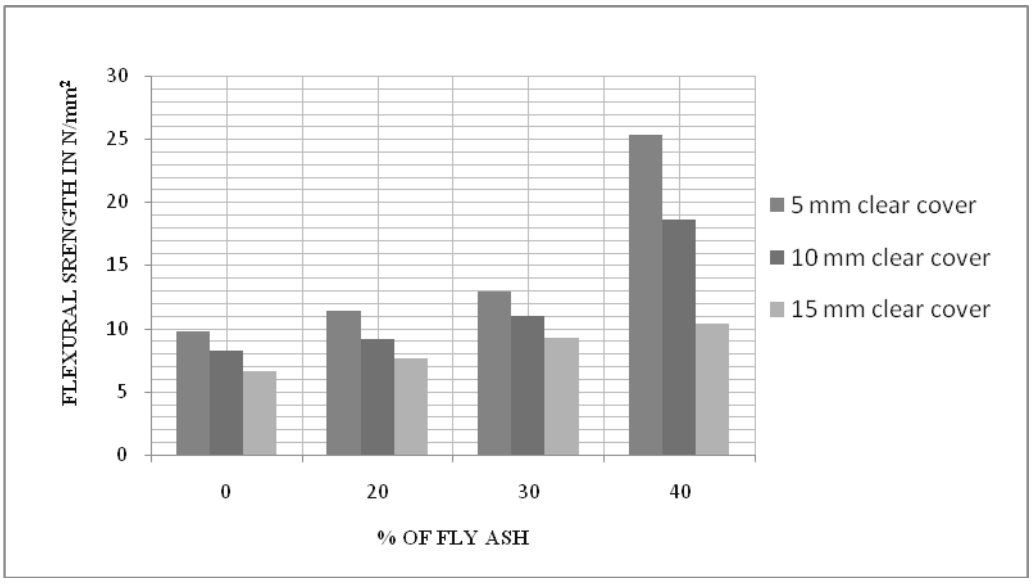


Fig 3. Flexural Strength of Beams with Design Reinforcement Provided with Different % of Fly Ash

- Bending Stress and Crack Width

Table 11: Crack width Development of 5 mm Clear Cover with Same Reinforcement and Different Percentages of Fly Ash

| CRACK WIDTH IN MM | BENDING STRESS IN N/mm$^2$ | | | |
|---|---|---|---|---|
| | 0% F.A | 20% F.A | 30% F.A | 40% F.A |
| 0.5 | 0.01567 | 0.0189 | 0.02865 | 0.0315 |
| 1 | 0.01853 | 0.02175 | 0.03216 | 0.03825 |
| 1.5 | 0.02152 | 0.02977 | 0.0357 | 0.0435 |
| 2 | 0.02595 | 0.0312 | 0.03712 | 0.0465 |
| 2.3 | 0.02853 | 0.0329 | 0.03828 | 0.0497 |
| 2.42 | | 0.0341 | 0.03912 | 0.0512 |
| 2.5 | | | 0.03978 | 0.05775 |
| 2.82 | | | 0.04125 | 0.05831 |
| 3 | | | | 0.05925 |
| 3.12 | | | | 0.06525 |

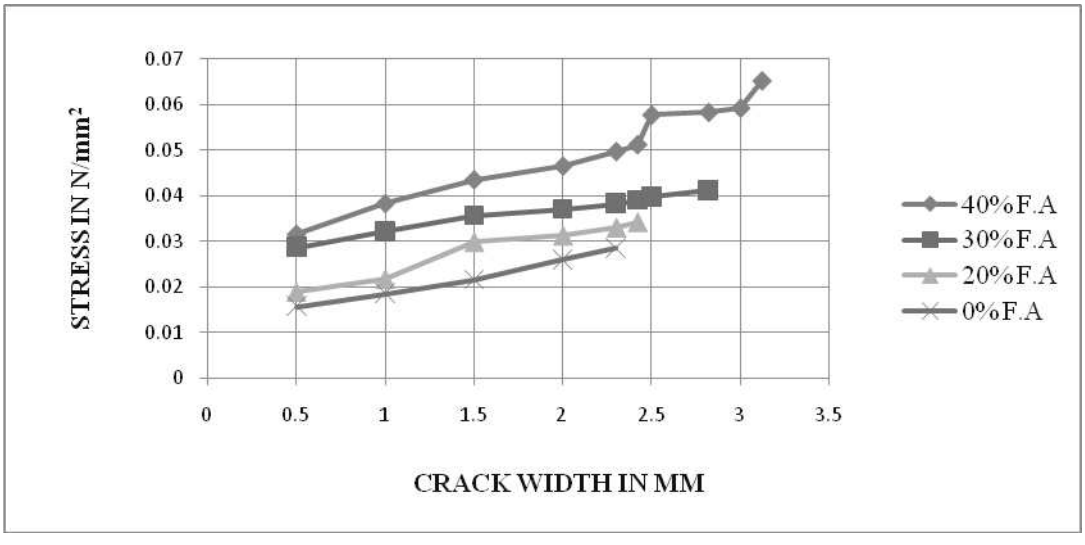


Fig 4. Crack width Development of 5 mm Clear Cover for without Design Reinforcement Provided

Table 12: Crack width Development of 10 mm Clear Cover with Same Reinforcement and Different Percentages of Fly Ash

| CRACK WIDTH IN MM | BENDING STRESS IN N/mm$^2$ | | | |
|---|---|---|---|---|
| | 0% F.A | 20% F.A | 30% F.A | 40% F.A |
| 0.5 | 0.0186 | 0.0187 | 0.0188 | 0.03 |
| 1 | 0.0262 | 0.0282 | 0.029 | 0.0416 |
| 1.5 | 0.0328 | 0.0328 | 0.0341 | 0.0465 |
| 1.97 | 0.034 | 0.0341 | 0.0365 | 0.0472 |
| 2 | | 0.0356 | 0.0385 | 0.0485 |
| 2.3 | | 0.03716 | 0.0381 | 0.0491 |
| 2.5 | | | 0.0429 | 0.0497 |
| 2.6 | | | 0.0443 | 0.051 |
| 2.9 | | | | 0.055 |

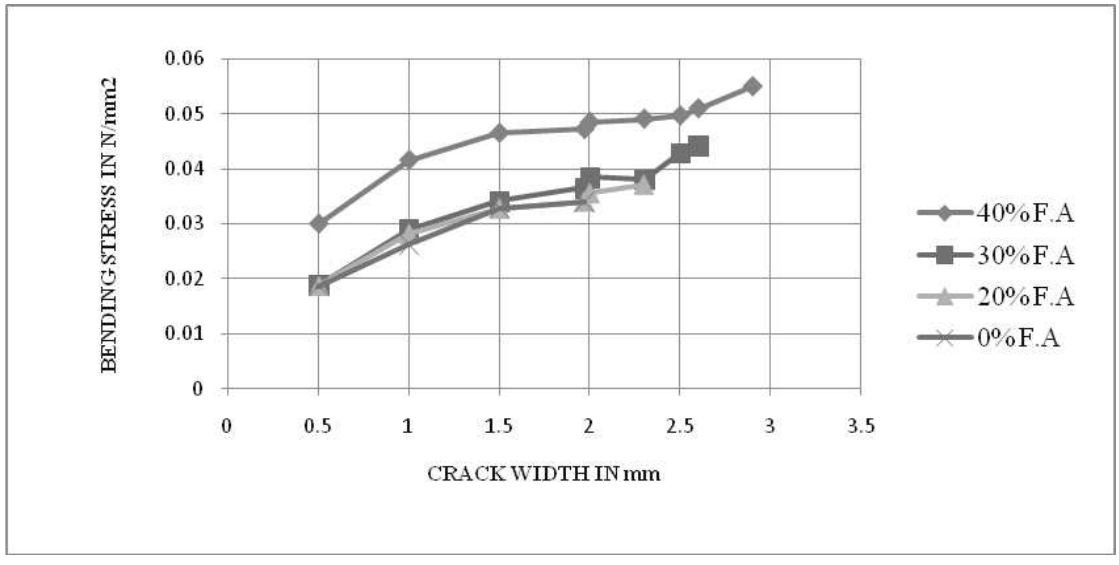


Fig 5. Crack width Development of 10mm Clear Cover for without Design Reinforcement Provided

Table 13: Crack width Development of 15 mm Clear Cover with Same Reinforcement and Different Percentages of Fly Ash

| CRACK WIDTH IN MM | BENDING STRESS IN N/mm$^2$ | | | |
|---|---|---|---|---|
| | 0% F.A | 20% F.A | 30% F.A | 40% F.A |
| 0.5 | 0.0247 | 0.0287 | 0.024 | 0.032 |
| 1 | 0.0262 | 0.0324 | 0.0326 | 0.0341 |
| 1.5 | 0.0283 | 0.0372 | 0.033 | 0.0372 |
| 1.8 | 0.0294 | 0.0374 | 0.0349 | 0.0384 |
| 2 | | 0.0384 | 0.0387 | 0.0413 |
| 2.26 | | 0.0399 | 0.0399 | 0.0416 |
| 2.5 | | | 0.04 | 0.042 |
| 2.78 | | | 0.042 | 0.0451 |
| 3 | | | | 0.046 |

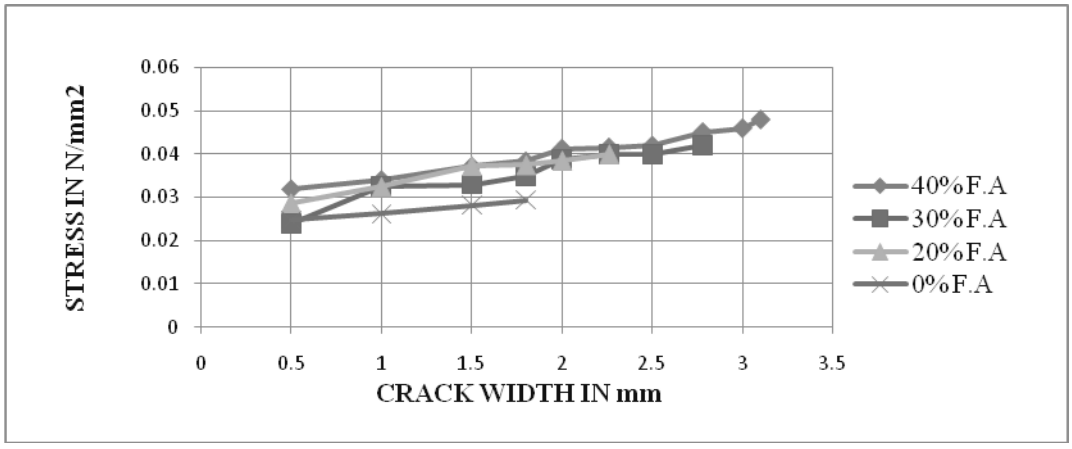


Fig 6. Crack width Development of 15 mm Clear Cover for without Design Reinforcement Provided

Table 14: Crack width development of 5 mm clear cover with Designed Reinforcement and different percentages of fly ash

| CRACK WIDTH IN MM | BENDING STRESS IN N/mm$^2$ | | | |
|---|---|---|---|---|
| | 0% F.A | 20% F.A | 30% F.A | 40% F.A |
| 0.5 | 0.008 | 0.0109 | 0.0124 | 0.0126 |
| 1 | 0.01 | 0.0121 | 0.0129 | 0.0241 |
| 1.5 | 0.0109 | 0.0135 | 0.0137 | 0.0293 |
| 1.93 | 0.0114 | 0.0139 | 0.0142 | 0.0316 |
| 2 | | 0.0147 | 0.0152 | 0.0354 |
| 2.05 | | 0.0152 | 0.0154 | 0.0358 |
| 2.15 | | | 0.0158 | 0.0362 |
| 2.35 | | | | 0.0369 |

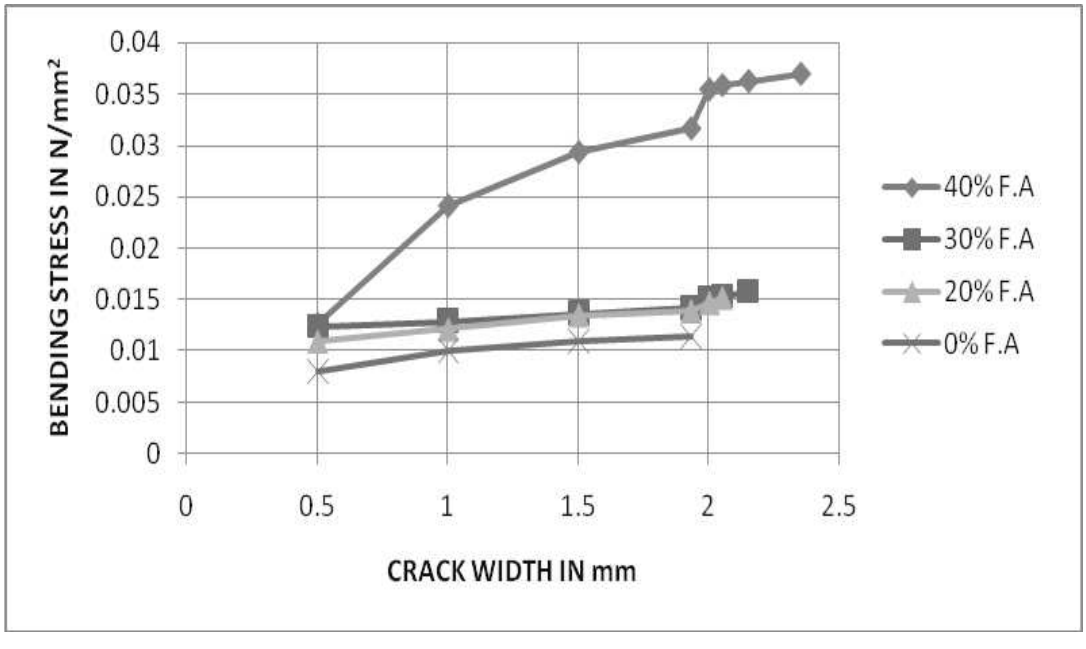


Fig 7. Crack width Development of 5 mm Clear Cover for Design Reinforcement Provided

Table 15: Crack width Development of 10mm Clear Cover with Designed Reinforcement and Different Percentages of Fly Ash

| CRACK WIDTH IN MM | BENDING STRESS IN N/mm$^2$ | | | |
|---|---|---|---|---|
| | 0% F.A | 20% F.A | 30% F.A | 40% F.A |
| 0.5 | 0.0186 | 0.0187 | 0.0188 | 0.03 |
| 1 | 0.0262 | 0.0282 | 0.029 | 0.0416 |
| 1.5 | 0.0328 | 0.0328 | 0.0341 | 0.0465 |
| 1.97 | 0.034 | 0.0341 | 0.0365 | 0.0472 |
| 2 | | 0.0356 | 0.0385 | 0.0485 |
| 2.3 | | 0.03716 | 0.0381 | 0.0491 |
| 2.5 | | | 0.0429 | 0.0497 |
| 2.6 | | | 0.0443 | 0.051 |
| 2.9 | | | | 0.055 |

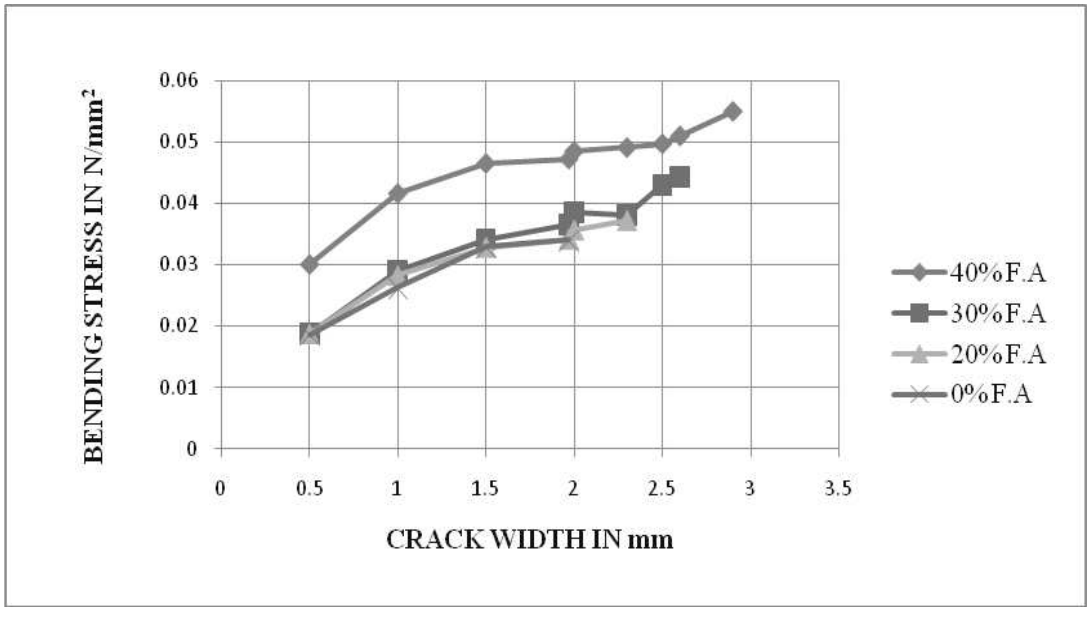


Fig 8. Crack width Development of 10mm Clear Cover for Design Reinforcement Provided

Table 16: Crack width Development of 15 mm Clear Cover with Designed Reinforcement and Different Percentages of Fly Ash

| CRACK WIDTH IN MM | BENDING STRESS IN N/mm$^2$ | | | |
|---|---|---|---|---|
| | 0% F.A | 20% F.A | 30% F.A | 40% F.A |
| 0.5 | 0.0007 | 0.008 | 0.009 | 0.0126 |
| 1 | 0.00195 | 0.01 | 0.01 | 0.0131 |
| 1.5 | 0.0039 | 0.0104 | 0.01 | 0.0137 |
| 1.73 | | 0.011 | 0.0102 | 0.0142 |
| 2 | | | 0.0106 | 0.0147 |
| 2.15 | | | 0.0121 | 0.0149 |
| 2.4 | | | | 0.0152 |

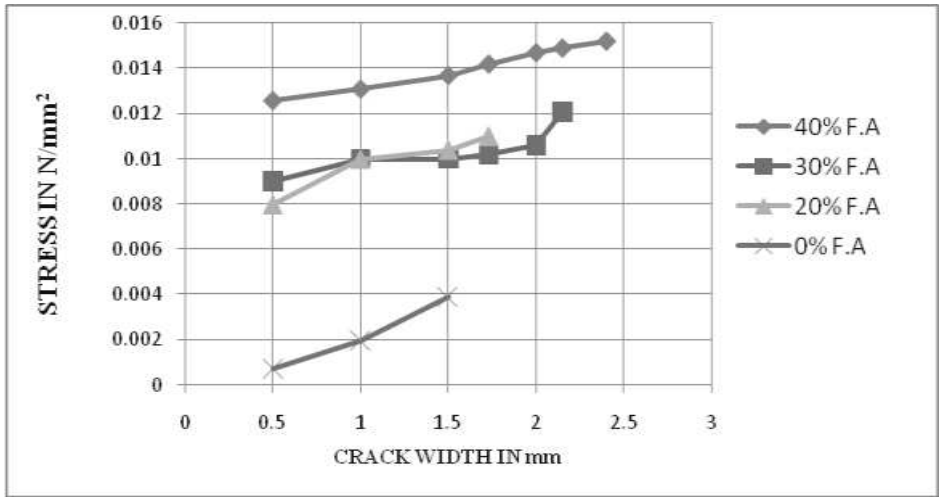


Fig 9. Crack width Development of 10mm Clear Cover for Design Reinforcement Provided

## 7. CONCLUSION

- Workability: The workability of concrete increased with increase in addition of mineral admixtures (Fly ash) up to 40 percentages.
- Compressive strength: The Compressive strength is maximum for 40 percent cement replaced by fly ash concrete mix.
- Flexural strength: With The increase in percentage of fly ash flexural strength in reinforced concrete beams also increases. But if we increase depth of clear cover the flexural strength value decreases.
- Bending stress Vs crack width of beams with same reinforcement (without design): 40 % fly ash replaced concrete is far better to control crack width when compared to traditional concrete in case of 10mm, 15mm and 20 mm clear covers. In case of 20 mm clear cover crack width is less as compared to 10mm and 15mm clear covers.
- Bending stress Vs crack width of beams with different reinforcement (with design): 40 % fly ash replaced concrete is far better to control crack width when compared to traditional concrete.

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# IMPLEMENTATION OF PASSIVE FILTERS FOR HARMONICS REDUCTION USING MIPOWER SOFTWARE

Rachana J. Patel*
Department of Electrical Engineering
Gujarat Power Engineering & Research Institute
Mevad, Mehsana, Gujarat – 382710
Gujarat Technological University
E-mail: rjpatel.ee@gmail.com
*Correspondance Author

Jayendra C. Patel
Department of Electrical Engineering
Gujarat Power Engineering & Research Institute
Mevad, Mehsana, Gujarat – 382710
Gujarat Technological University
E-mail: jayendra.patel@gperi.ac.in

Sweety Patel
Student Electrical Engineering
Gujarat Power Engineering & Research Institute
Mevad, Mehsana, Gujarat – 382710
Gujarat Technological University
E-mail: sweety0109007@gperi.ac.in

## ABSTRACT

In recent years there has been widespread use of power electronics devices and nonlinear elements in rectification and switchgear applied to various areas of power system. At the same time the power quality and safe operation becomes inferior. Therefore mitigation of harmonics is very necessary under the situation. Due to non linear loads in Power systems generate different levels of harmonics which can no longer be ignored by engineers. For harmonic analysis, the network was investigated using MiPower software package. it was found that MiPower software is the preferred package for power system harmonic analysis. As harmonic reduction solution, passive filter is used to decrease the distortion. This paper includes the method to design the passive filter and its impact on Power quality.

***Keywords:*** *Harmonic analysis, Mi Power software, Total harmonic Distortion (THD), passive filters, Current distortion limits.*

## 1. INTRODUCTION

Nowadays industries prefer to use power electronics based devices due to their effectiveness. Though these power electronics based devices are advantageous to the electronics and electrical industry, these devices generate and inject the harmonics in the power industry. These harmonics are known as electrical disturbances which are the main cause of the power quality associated harms. The main problems due to the harmonics are additional power losses in the electrical equipment, irregular function of protective devices, errors in measurement of metering devices and interference with the telecommunication lines. Therefore mitigation of harmonics and improvement of the power quality is essential under the situation. Fortunately, the available software for harmonic analysis has also grown. Also guidelines for the acceptance of harmonic distortion are well-defined in IEEE Standard 519-1992,
It defines the current distortion limits and Voltage distortion limits for the system design which should be met at the point of common coupling (PCC) with the utility.

## 2. POWER QUALITY MEANING AND IMPROVEMENT

Power Quality definition may vary person to person, Perhaps the best definition of power quality [5] is, "the provision of voltages and system design so that the user of electric power can utilize electric energy from the distribution system successfully, without interference or interruption", so basically it involves quality of waveforms of current and voltage in an ac system, Below fig shows the harmonic distortion of the electrical voltage waveform due to non linear load.

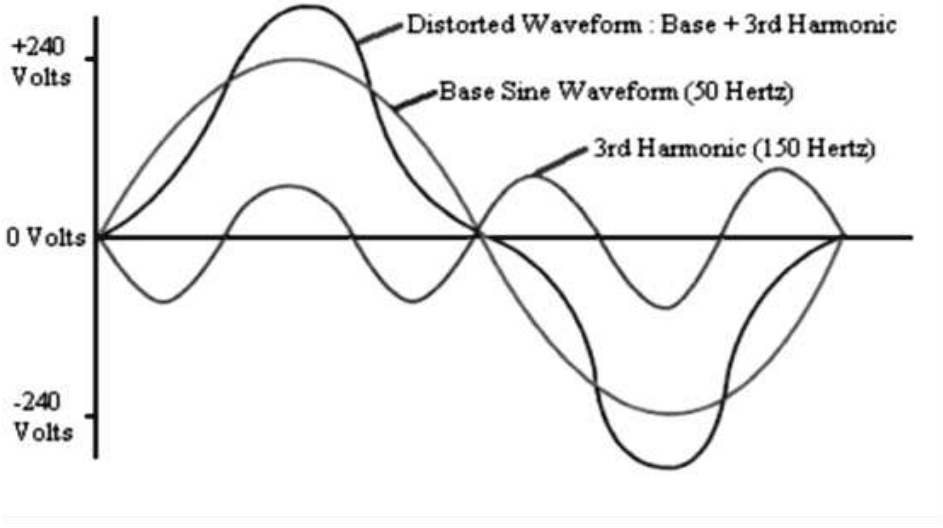


Fig. 1. Distorted voltage waveform

Some examples of nonlinear loads are:

- Adjustable drive systems
- Cycloconverters
- Arc furnaces
- Switching mode power supplies
- Computers, copy machines, and television sets
- Static var compensators (SVCs)
- HVDC transmission
- Electric traction
- Wind and solar power generation
- Battery charging and fuel cells
- Slip recovery schemes of induction motors
- Fluorescent lighting and electronic ballasts

Harmonic can lead to power system inefficiency. Some of the negative ways that harmonics may affect plant equipment are increasing "skin effect" in conductor or cables, dielectric failure or rupture the capacitor, false or spurious operations and trips, damaging or blowing components for no apparent reason, Transformers have increased iron and copper losses etc, in short it change in characteristics of the electric loads, and causing equipment to fail prematurely, so this is the reasons behind the growing concern about power quality.

Power quality improvement [6-8] has become being obligatory to solve the problem of the harmonics. Several different solutions are proposed for harmonic mitigation. The right choice is always dependent on a variety of factors; Passive filter is one of them and has been investigated for the harmonic mitigation. Low cost, simple design and high reliability are main advantages of passive filters, it can be also provide benefits power factor improvement but they present some disadvantages [10]: they only filter the frequencies they were previously tuned for; its operation cannot be limited to a certain load or group of loads; resonance can occur due to the interaction between the passive filters and others loads, with unexpected results.

## 3. ROLE OF PASSIVE FILTERS

Passive filters can be used in the power systems to reduce harmonic voltages and notch effects at particular points. It consists of reactors and capacitors set up in a resonant circuit configuration which is tuned to the frequency of the harmonic order to be mitigated.

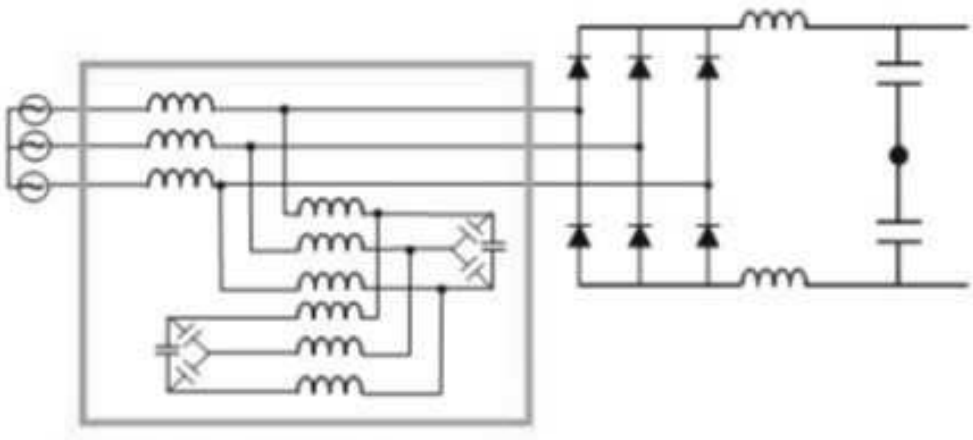

Fig. 2. Passive filter

Usually, the passive filters include different types of parallel paths that present relatively low impedance to the various harmonics. There exists a flow of harmonic currents into this reduced impedance such that the harmonic voltage at that point is reduced. Passive filters are widely used in conjunction with utility-type static VAR compensators and ac electric arc furnaces with megawatt ratings. This research paper makes use of a passive filter while computing THD for a nonlinear load. In this paper power quality improvement with passive filter has been verified by the simulation results with MIPOWER software.

For designing the single tuned filter it is essential to select the appropriate capacitor value that enables good power factor at system frequency.

## 4. ABOUT MIPOWER SOFTWARE

The manual calculation for a sample power system with a non linear load can be rather repetitive and tiresome and there is also a significant chance of human error being introduced. So it is better to use software packages such as 'MiPower' software.

MiPower is the state-of-the-art windows based power systems software. It is highly interactive and user friendly software for all analysis, planning, design and simulation of any given power system irrespective of the geographical and environmental constraints. With the use of this software, power system engineers can become productive with minimum effort and time and results are emphatically visible.

## 5. SIMULATION CIRCUIT AND RESULT

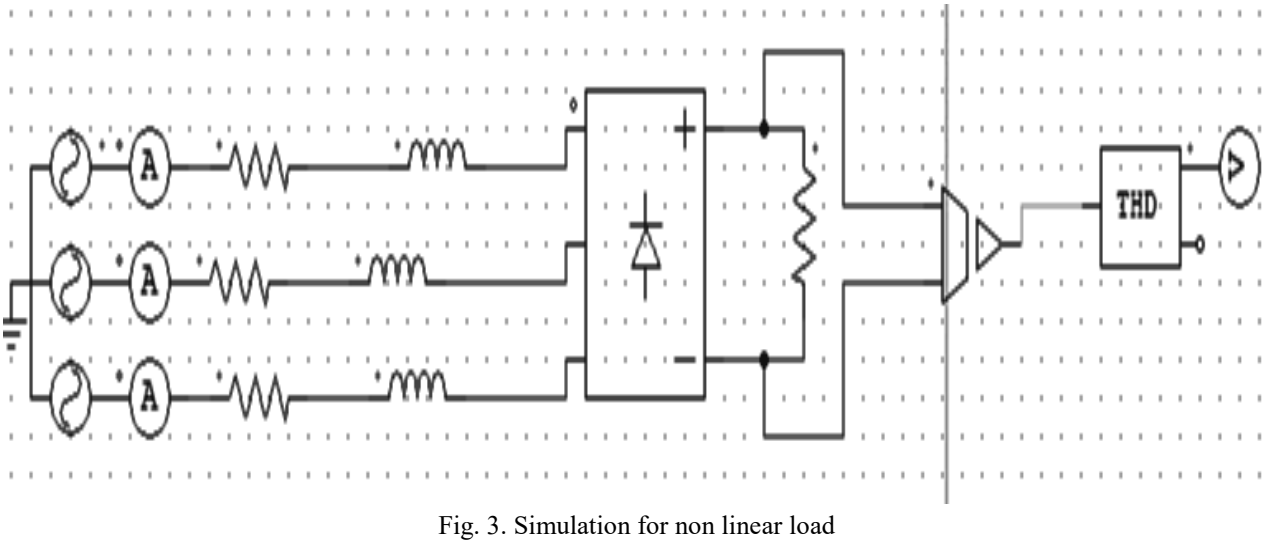


Fig. 3. Simulation for non linear load

To understand effect of non linear load on power system here simple simulation is done in PSIM software without any filtration. Waveform of load current is given here:

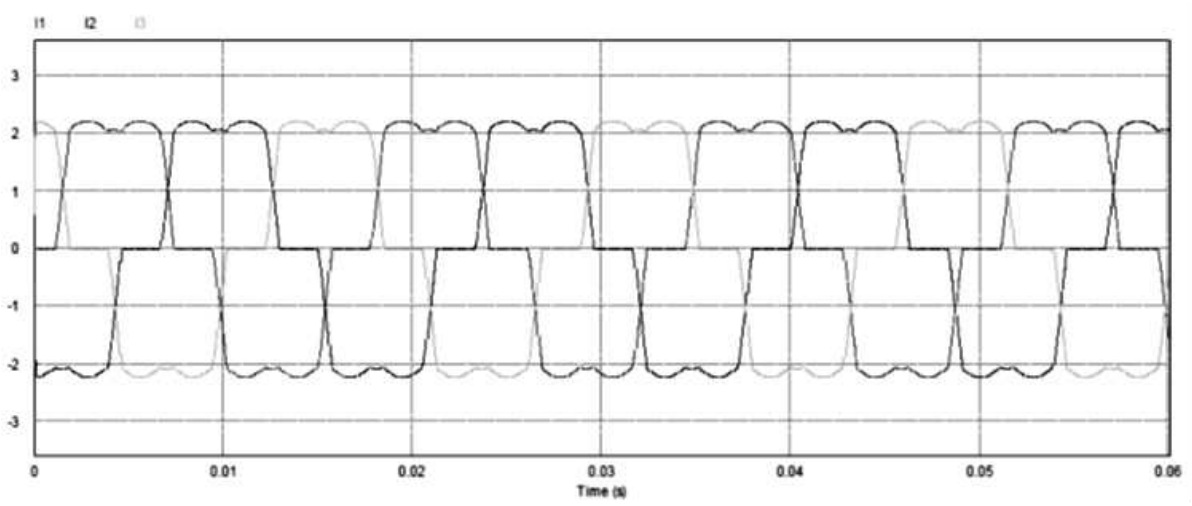


Fig. 4. Current waveform with non linear load

From above waveform one can see that non linear load is responsible for waveform distortion of current. Now in MIPOWER simulation analysis for 8 bus power system is done for two different case,

(i) With harmonic injection

(ii) With passive filter

### 5.1 CASE 1:WITH HARMONIC INJECTION

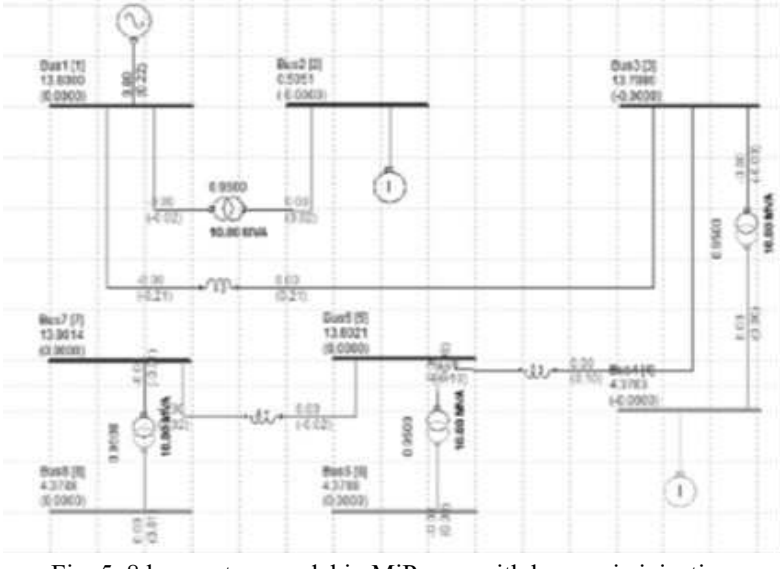

Fig. 5. 8 bus system model in MiPower with harmonic injection

**Table 1. Generator Data**

| | |
|---|---|
| MVA Rating | 10 |
| kV Rating | 13.8 |
| $X_d = X_q$ | 0.1 |
| $X_n = X_d = X_q$ | 0.02857 |
| $X_0 = X_d = X_q$ | 0.02857 |

**Table 2. Series Reactor Data**

| Bus code From-To | MVA Rating | kV Rating | Reactance in P.U |
|---|---|---|---|
| 1-3 | 10 | 13.8 | 0.00476 |
| 3-5 | 10 | 13.8 | 0.0238 |
| 5-7 | 10 | 13.8 | 0.02286 |

**Table 3. Two Winding Transformer**

| Bus code From-To | MVA Rating | Primary Rating in kV | Secondary Rating in kV | Impendence in P.U | X/R Ratio in P.U | Winding Configuration Primary & secondary |
|---|---|---|---|---|---|---|
| 1-2 | 10 | 13.8 | 0.48 | 0.22 | 9999 | Star Ground & Star Ground |
| 3-4 | 10 | 13.8 | 4.16 | 0.11 | 9999 | Star Ground & Star Ground |
| 5-6 | 10 | 13.8 | 4.16 | 0.055 | 9999 | Star Ground & Star Ground |
| 7-8 | 10 | 13.8 | 4.16 | 0.11 | 9999 | Star Ground & Star Ground |

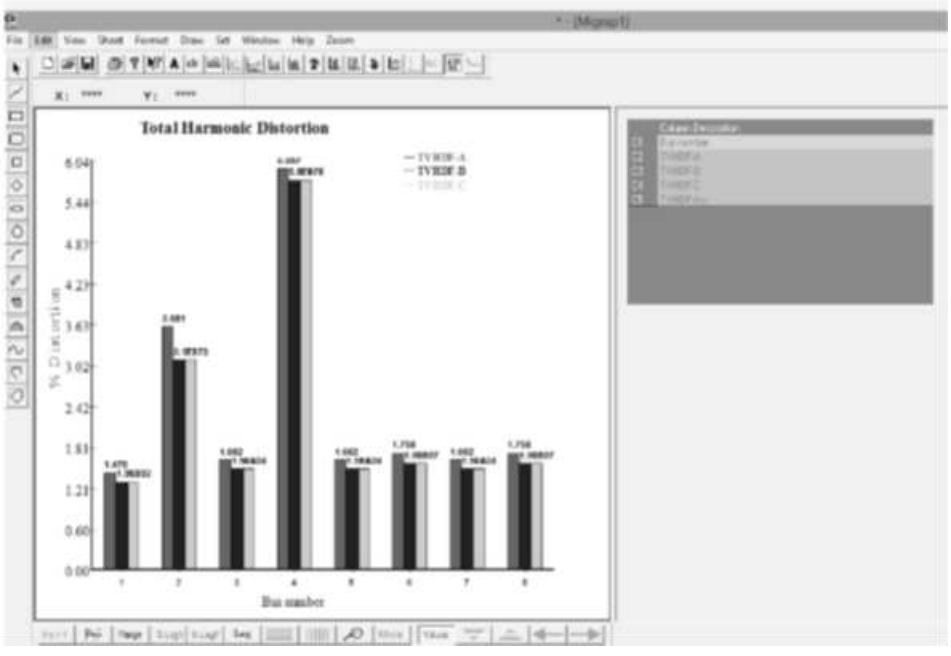


Fig. 6. THD Result: (With harmonic injection) (Case-I)

**Table 4. Individual Voltage Harmonic Distortion on all bus (Phase A) (Case-I)**

| NAME | %HDF-1 | %HDF-5 | %HDF-7 | %HDF-11 |
|---|---|---|---|---|
| BUS-1 | 0.2908 | 0.1794 | 0.1728 | 0.1501 |
| BUS-2 | 2.4336 | 1.5014 | 1.446 | 1.2559 |
| BUS-3 | 0.2908 | 0.1794 | 0.1728 | 0.1501 |
| BUS-4 | 0.6401 | 0.3949 | 0.3803 | 0.3304 |
| BUS-5 | 0.2908 | 0.1794 | 0.1728 | 0.1501 |
| BUS-6 | 0.6401 | 0.3949 | 0.3803 | 0.3304 |
| BUS-7 | 0.2908 | 0.1794 | 0.1728 | 0.1501 |
| BUS-8 | 0.6401 | 0.3949 | 0.3803 | 0.3304 |

**Table 5. Total Voltage Harmonic Distortion on all bus: (Case-I)**

| NAME | %HDF-A | %HDF-B | %HDF-C | %HDF-Avg. |
|---|---|---|---|---|
| BUS-1 | 0.2908 | 0.2908 | 0.2908 | 0.2908 |
| BUS-2 | 2.4336 | 2.4336 | 2.4336 | 2.4336 |
| BUS-3 | 0.2908 | 0.2908 | 0.2908 | 0.2908 |
| BUS-4 | 0.6401 | 0.6401 | 0.6401 | 0.6401 |
| BUS-5 | 0.2908 | 0.2908 | 0.2908 | 0.2908 |
| BUS-6 | 0.6401 | 0.6401 | 0.6401 | 0.6401 |
| BUS-7 | 0.2908 | 0.2908 | 0.2908 | 0.2908 |
| BUS-8 | 0.6401 | 0.6401 | 0.6401 | 0.6401 |

## 5.2. CASE II: WITH PASSIVE FILTER

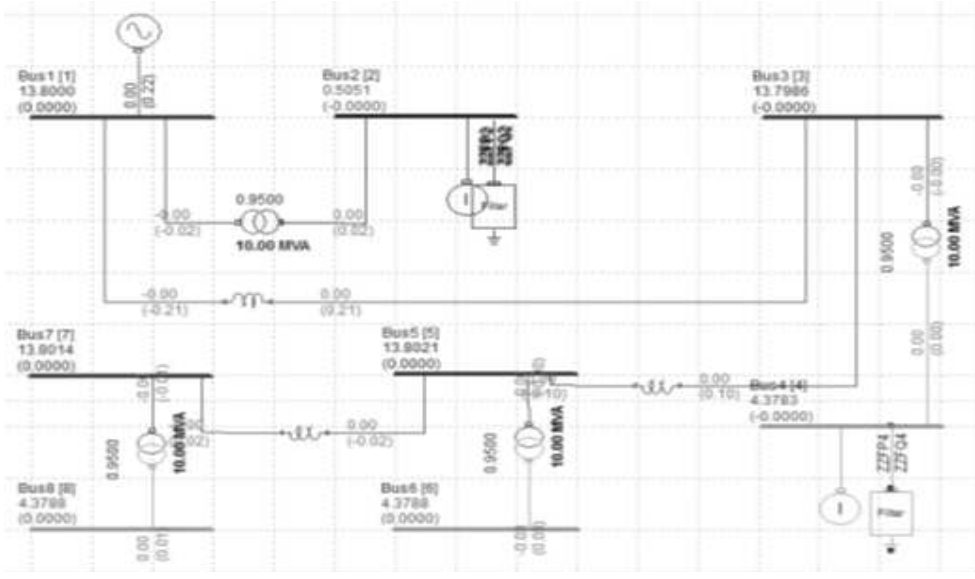


Fig. 7. 8 bus system model in MiPower with Passive filter

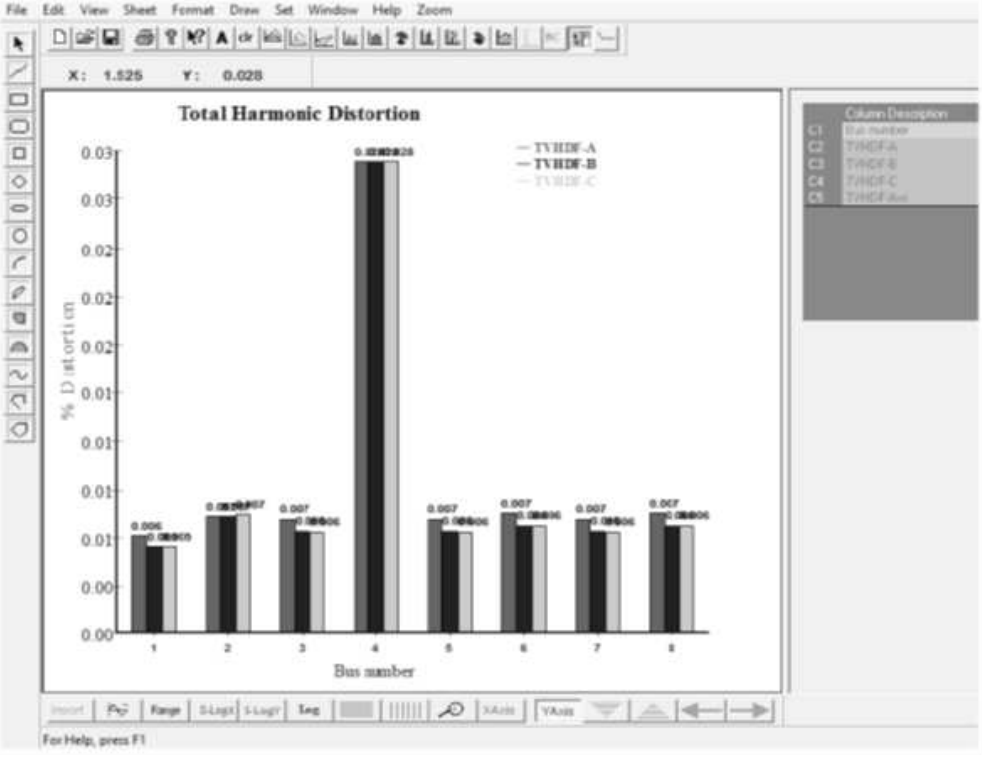


Fig. 8. THD Result: (With Passive Filter) (Case-II)

**Table 6. Individual Voltage Harmonic Distortion on all bus (Phase A): (Case-II)**

| NAME | %HDF-T | %HDF-5 | %HDF-7 | %HDF-11 |
|---|---|---|---|---|
| BUS-1 | 0.0053 | 0.0046 | 0.0025 | 0.0009 |
| BUS-2 | 0.0069 | 0.0062 | 0.003 | 0.001 |
| BUS-3 | 0.0063 | 0.0055 | 0.0029 | 0.001 |
| BUS-4 | 0.028 | 0.025 | 0.0121 | 0.0042 |
| BUS-5 | 0.0063 | 0.0055 | 0.0029 | 0.001 |
| BUS-6 | 0.0066 | 0.0058 | 0.0031 | 0.0011 |
| BUS-7 | 0.0063 | 0.0055 | 0.0029 | 0.001 |
| BUS-8 | 0.0066 | 0.0058 | 0.0031 | 0.0011 |

**Table 7. Total Voltage Harmonic Distortion on all bus : (Table-6) (Case-II)**

| NAME | %HDF-A | %HDF-B | %HDF-C | %HDF-Avg. |
|---|---|---|---|---|
| BUS-1 | 0.0058 | 0.0051 | 0.0051 | 0.0053 |
| BUS-2 | 0.0069 | 0.0069 | 0.007 | 0.0069 |
| BUS-3 | 0.0068 | 0.0061 | 0.006 | 0.0063 |
| BUS-4 | 0.028 | 0.028 | 0.028 | 0.028 |
| BUS-5 | 0.0068 | 0.0061 | 0.006 | 0.0063 |
| BUS-6 | 0.0071 | 0.0064 | 0.0064 | 0.0066 |
| BUS-7 | 0.0068 | 0.0061 | 0.006 | 0.0063 |
| BUS-8 | 0.0071 | 0.0064 | 0.0064 | 0.0066 |

## 6. CONCLUSION

This paper has dealt with the sample 8-Bus power system, for which the considered harmonic analysis program has been found to be extremely fast. The effective use of the software has drawn several conclusions related to the harmonic distortions for the power system to operate under two following different cases:

The first case, where the system has not considered any filter, has described the THD for the voltages at all the buses. The distortion has been observed as maximum at bus 2 as the nonlinear load has been simulated at that bus. The maximum value of the distortion has come as 2.43(%).

The second case, where the system has been considered with a single passive filter at bus 2, has described the THD for the voltages at all the buses considering the simulation of the nonlinear load. The specific conclusion that has been drawn is that the distortions get reduced to a reasonable extent comparatively to the system considered without any filter. The distortion has been observed as maximum at bus 2 as the nonlinear load has been simulated at that bus. The maximum value of the distortion has come as 0.0069(%).

## 7. ACKNOWLEDGEMENTS

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# IDENTIFICATION AND EVALUATION OF CRITICAL FACTORS FOR SERVICE VENDOR SELECTION USING AHP APPROACH

Surajit Bag*
Procurement Head
Tega Industries South Africa Pty Ltd
2 Uranium Road, Vulcania Ext 2, Brakpan,
1541, South Africa
E-mail: surajit.bag@gmail.com
*Corresponding Author

Neeraj Anand
Sr. Associate Professor
University of Petroleum and Energy Studies
P.O. Bidholi Via-Prem Nagar,
Dehradun, Uttarakhand 248007
E-mail: nanand@ddn.upes.ac.in

## ABSTRACT

Performance measurement of service vendors in western countries has been one of the most important activities for management of risks. Unfortunately less focus has been given towards this activity by most firms located in India. It has been realized that critical factors related to service vendor selection need to be identified and evaluated. In the current study researchers made an attempt to analyze ranking of critical factors to service vendor selection. Twenty critical factors have been identified through systematic literature review and refined to thirteen factors using procurement experts' opinion. Finally a conceptual model of interrelationships among these critical factors has been presented for managing service vendor performance. This study will assist procurement managers in cost savings and enhancing firm's profitability.

***Keywords:*** *Service vendor selection, Critical factors, Multi Criteria Decision Making, Analytical Hierarchy Process (AHP)*

## 1. INTRODUCTION

Key outsourced service vendors of high risk services require careful selection, close performance and relationship management. This is where most of the organizational resources should be employed (CIPS 2013). Key service vendor failure can bring significant losses and therefore it is essential to identify the critical factors that drive performance and take necessary proactive action. However existing literature has not been able to focus much in this sub discipline of supply chain management. This has motivated researchers to identify critical success factors for performance measurement of service vendors.

The main objectives of this paper are:

I. To conduct an systematic literature review and identify critical factors for service vendor selection;

II. To analyze and rank final critical factors using AHP technique;

This paper is structured into eight additional sections. The next section presents the systematic literature review which helps to understand the progress in vendor selection process.

The third section presents the critical factors. Fourth section presents the research framework and methodology. Fifth section presents the data analysis and results. Sixth section presents the discussion of findings. Seventh section presents the managerial implications. Finally the conclusions, limitations and future research directions are presented.

## 2. LITERATURE REVIEW

There are several studies on vendor selection using both qualitative and quantitative research methods (eg., Ho et al., 2010; De Boer et al.,2001; Ghodsypour & O'Brien,1998; Choi & Hartley, 1996; Barbarosoglu & Yazgac,1997; Ellram,1990; Spekman, 1988). But these studies have been centered mainly on supply vendors. In this dynamic business scenario it is imperative that most of the noncore jobs are outsourced to bring down costs and meet the sales order delivery schedule. Procurement managers envisage significant savings in outsourcing these jobs. Service vendor selection is a multi criteria decision making problem which includes both qualitative and quantitative factors. Hence it is essential that procurement managers understand the tradeoffs between these tangible and intangible factors. They must also decide which service vendors are the best and how much service should be procured from each vendor.

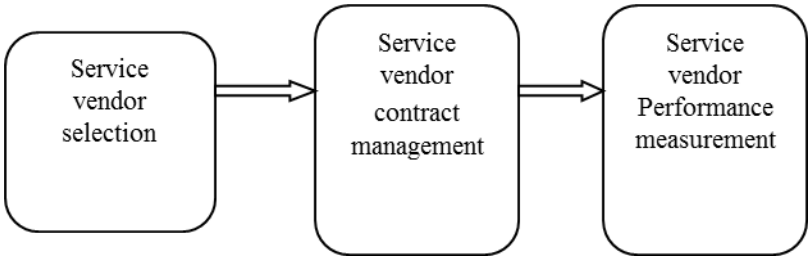


Fig. 1- Service vendor management

The below table 1 presents the selected studies on service vendor management

Table I- Some of the selected studies on service vendor management

| **Author(s), year** | **Theme of Study** |
|---|---|
| Masrom et al., 2013 | Identified determinants of contractor satisfaction |
| Amirkhanyan et al., 2013 | Performance assessment of services |
| Aydin and Kahraman, 2011 | Fuzzy AHP application to vendor selection |
| Straub, 2010 | Competencies required of contractors offering performance based maintenance services to end customers |
| Brochner, 2010 | Innovation technologies in construction |
| Lai and Pang, 2010 | Measuring performance for building maintenance providers |
| Palvia, 2010 | Analyze performance of offshore IS vendors |
| Robinson and Scott, 2009 | Service delivery and performance management |
| Matsumura et al., 2008 | Analyze factors of defect correction |
| Aryichandra and Frolick, 2008 | Critical success factors in business performance management |
| Arditi and Lee, 2004 | Service quality performance of design/build contractors |
| Kim and Chung, 2003 | Critical success factors for IS outsourcing |
| Yasamis et al., 2002 | Assessing Contractor quality performance |
| Weber, 2000 | Vendor selection and negotiation |
| Baker and Faulkner, 1991 | Strategies for managing service suppliers |

# 3. IDENTIFICATION OF CRITICAL FACTORS FOR SEVICE VENDOR SELECTION

Service jobs can be divided in the following categories depending upon the nature of services. Engineering firms generally outsource these jobs to save costs and time.

I. Annual Maintenance: These include annual maintenance of boiler, press, EOT crane, air conditioner and other machinery and equipments.

II. Repairing: Repairing services generally involve giving calls to service engineers for identifying the problem. Either the spare parts are provided by service provider or may only replace of faulty parts subject to purchase of the parts by firm directly from market.

III. Transportation: Transportation services are provided by logistics companies and are generally used for employee transportation, inbound and outbound material movement.

IV. Design: These services are outsourced when organization do not have competent draughtsman. Contract is generally done based on per hour/ per set basis.

V. Testing/Calibration: These include testing of raw material, finished goods from outside testing agencies. Secondly calibration of equipments is also outsourced from agencies.

VI. Labor contract: This is a very important service and generally includes several types of labor services such as rolling, bending, fabrication, machining, blasting, painting, hand lining, molding, material handling, construction, Information technology support etc. Firms generally frame a SLA for any type of labor services to be outsourced with complete technical and commercial terms and conditions.

After conducting review of existing literature researchers identified 20 critical factors which has been refined using five procurement experts' opinion and narrowed down to 13 factors which are relevant to the Indian context. The 13 factors are presented under sub criteria column in Table 2.

Table II- Criteria for service vendor selection

| Criteria | Sub Criteria | Sub sub- criteria |
|---|---|---|
| Cost (CO) | Direct Cost (DC) | Net Price |
| | | Delivery cost |
| | Indirect cost (IC) | Ordering cost |
| | | Inspection cost |
| | | Handling cost |
| | | Capital investment |
| Quality (QL) | Rejects (RJ) | Percentage of incoming rejects |
| | | Warranty |
| | Service Quality (SQ) | No of calls per month/quarterly/ annually |
| | | Customer Focus |
| | Regulatory concerns (RC) | ISO 9000 |
| | | ISO 14000 |
| | | Compliance with industrial norms |
| Delivery (DL) | Compliance with schedule (CS) | Delivery variability |
| | | Mean time to repair |
| | | On time arrival |
| | Compliance with quantity (CQ) | Proper counting and measurement |
| | | Parts availability |

| Criteria | Sub Criteria | Sub sub- criteria |
|---|---|---|
| Management and Organization (MO) | Responsiveness (RE) | Average time to respond |
| | | Average ring time |
| | | Average time to answer |
| | | Average wait time |
| | Behavior (BE) | Honesty |
| | | Friendly Attitude |
| | | Flexibility |
| | | Reliability |
| | Performance (PM) | Frequency of checks |
| | | No of rework |
| | | Continuity |
| | | Past performance record |
| | Risk Management (RM) | Understand urgency |
| | | Delay and consequential losses |
| | | Spare parts in stock |
| | | Priority of jobs |
| | | IT infrastructure |
| | | Managing volume and variety |
| | | Compliance with SLA terms and conditions |
| | | Free trial, training and development support |
| Financial Health (FL) | Financial measures of financial health (FM) | Working capital management |
| | | Total Assets |
| | | Total Liabilities |
| | | Total Equities |
| | Non financial measures of financial health (NF) | Important Accounts |
| | | Turnover among long term employees |
| | | Workforce reductions |
| | | Frequent changes in supplier's source |

# 4. RESEARCH FRAMEWORK AND METHODOLOY

Research methodology is the most critical step in any research study. The research design is different for both qualitative and quantitative methods. Here multi criteria decision making based Analytical hierarchy process has been used to analyze and rank the critical factors under evaluation. Figure 3 presents the framework for the present study.

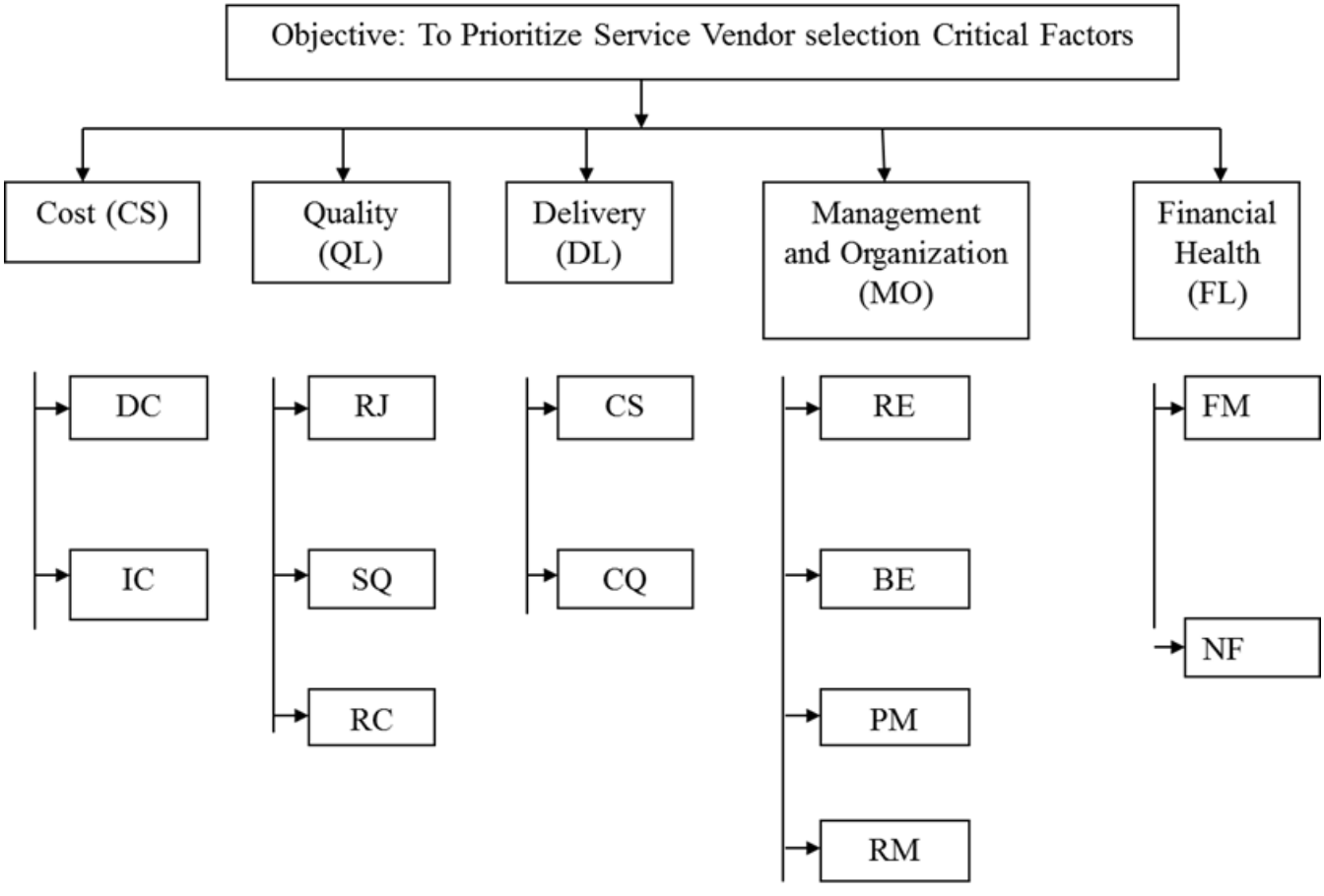


Fig. I- AHP based hierarchical model to evaluate critical factors of service vendor selection

**4.1 AHP TECHNIQUE** The AHP is based on the experience gained by its developer, T.L. Saaty, while directing research projects in the US Arms Control and Disarmament Agency. The AHP has found use in business, government, social studies, R&D, defense and other domains involving decisions in which choice, prioritization or forecasting is needed. Owing to its simplicity and ease of use, the AHP has found ready acceptance by busy managers and decision-makers. It helps structure the decision-makers thoughts and can help in organizing the problem in a manner that is simple to follow and analyze.

Broad areas in which the AHP has been applied include alternative selection, resource allocation, forecasting, business process re-engineering, quality function deployment, balanced scorecard, benchmarking, public policy decisions, healthcare, and many more. Basically the AHP helps in structuring the complexity, measurement and synthesis of rankings. These features make it suitable for a wide variety of applications. The AHP has proved a theoretically sound and market tested and accepted methodology.

# 5. DATA ANALYSIS AND RESULTS

Based on the ratings obtained through five procurement expert's inputs, AHP matrices are developed and subsequent steps are followed as per Satty (1988); Satty (1990); Saaty (1994); Saaty (2008). The framework of AHP is presented where the critical factors are structured hierarchically that includes three levels: objective- To prioritize service vendor selection critical factors; in second level the five key dimensions are presented: Cost, Quality, Delivery, Management and organization and Financial health which have been analyzed. Table 3 shows the pair wise comparison matrix indicating weights provided by procurement experts' to individual dimensions.

Table III –PWCM of criteria

| Criteria | CS | QL | DL | MO | FL | Priority Matrix | Rank |
|---|---|---|---|---|---|---|---|
| CS | 1 | 1/9 | 1/7 | 1/5 | 1/7 | 0.02610 | 5th |
| QL | | 1 | 5 | 7 | 2 | 0.47328 | 1st |
| DL | | | 1 | 5 | 4 | 0.26315 | 2nd |
| MO | | | | 1 | 1/7 | 0.05668 | 4th |
| FL | | | | | 1 | 0.18077 | 3rd |
| Maximum Eigen Value= 5.87883 | | | | | | | |
| CI= 0.219707 | | | | | | | |

From the analysis shown in Table 3- "Quality (0.47328)" was the most important dimension of service vendor selection, followed by "Delivery (0.26315)", "Financial health (0.18077)", "Management and Organization (0.05668)" and "Cost (0.02610)".

In the next step, other constructs in each dimension of service vendor selection have been ranked. Table 4 evaluates the constructs under dimension "Cost" had been checked for hierarchy.

Table IV- PWCA of cost dimension

| Constructs under Cost | DC | IC | Priority Matrix | Rank |
|---|---|---|---|---|
| DC | 1 | 1/3 | 0.25 | 2nd |
| IC | | 1 | 0.75 | 1st |
| Maximum Eigen Value= 2 | | | | |
| CI= 0 | | | | |

'Indirect costs (0.75)' had been observed most important construct in "Cost" followed by 'Direct costs (0.25)'.

Table 5 evaluates the constructs under dimension "Quality" had been checked for hierarchy.

Table V- PWCA of quality dimension

| Constructs under Quality | RJ | SQ | RC | Priority Matrix | Rank |
|---|---|---|---|---|---|
| RJ | 1 | 1/2 | 1/2 | 0.1958 | 3rd |
| SQ | | 1 | 2 | 0.4933 | 1st |
| RC | | | 1 | 0.3108 | 2nd |
| Maximum Eigen Value= 3.05362 | | | | | |
| CI= 0.0268108 | | | | | |

'Service quality (0.4933)' had been observed most important construct in "Quality" followed by 'Regulatory concern (0.3108)' and 'Rejections (0.1958)'.

Table 6 evaluates the constructs under dimension “Delivery” had been checked for hierarchy.

Table VI- PWCA of delivery dimension

| Constructs under Delivery | CS | CQ | Priority Matrix | Rank |
|---|---|---|---|---|
| CS | 1 | 2 | 0.6666 | 1st |
| CQ | | 1 | 0.3333 | 2nd |
| Maximum Eigen Value= 2 | | | | |
| CI= 0 | | | | |

‘Compliance to schedule (0.6666)’ had been observed most important construct in “Delivery” followed by ‘Compliance to quantity (0.3333)’.

Table 7 evaluates the constructs under dimension “Management and Organization” had been checked for hierarchy.

Table VII- PWCA of management and organization dimension

| Constructs under Management and Organization | RE | BE | PM | RM | Priority Matrix | Rank |
|---|---|---|---|---|---|---|
| RE | 1 | 1/3 | 1/5 | 1/7 | 0.0559 | 4th |
| BE | | 1 | 1/7 | 1/5 | 0.0951 | 3rd |
| PM | | | 1 | 2 | 0.5039 | 1st |
| RM | | | | 1 | 0.3449 | 2nd |
| Maximum Eigen Value= 4.24645 | | | | | | |
| CI= 0.0821499 | | | | | | |

‘Performance (0.5039)’ had been observed most important construct in “Management and Organization” followed by ‘Risk management (0.3449)’, ‘Behavior (0.0951)’ and ‘Responsiveness (0.0559)’.

Table 8 evaluates the constructs under dimension “Financial Health” had been checked for hierarchy.

Table VIII- PWCA of financial dimension

| Constructs under Financial | FM | NF | Priority Matrix | Rank |
|---|---|---|---|---|
| FM | 1 | 4 | 0.80 | 1st |
| NF | | 1 | 0.20 | 2nd |
| Maximum Eigen Value= 2 | | | | |
| CI= 0 | | | | |

‘Financial measures (0.80)’ had been observed most important construct in “Financial Health” followed by ‘Non financial measure (0.20)’.

**DISCUSSION OF FINDINGS:**

Table 9 has been prepared by evaluating overall weight of each critical factor by considering local weight of critical factors and multiplying it by respective global dimension's weight and presented in Table 9.

Table IX- Calculation and ranking of CFs of service vendor selection

| Dimension S.N | Dimension of CFs of Service vendor selection | Final weight of dimensions | Rank | CFs S.N. | Identified CFs of Service vendor selection | Local weight of CFs | Overall weight of CFs | Overall ranking of CFs |
|---|---|---|---|---|---|---|---|---|
| 1 | Cost | 0.0261 | 5th | 1.1 | DC | 0.25 | 0.00653 | 11th |
| | | | | 1.2 | IC | 0.75 | 0.01958 | 9th |
| 2 | Quality | 0.47328 | 1st | 2.1 | RJ | 0.1958 | 0.09267 | 5th |
| | | | | 2.2 | SQ | 0.4933 | 0.23347 | 1st |
| | | | | 2.3 | RC | 0.3108 | 0.14710 | 3rd |
| 3 | Delivery | 0.26315 | 2nd | 3.1 | CS | 0.6666 | 0.17542 | 2nd |
| | | | | 3.2 | CQ | 0.3333 | 0.08771 | 6th |
| 4 | Management and Organiza-tion | 0.05668 | 4th | 4.1 | RE | 0.0559 | 0.00317 | 13th |
| | | | | 4.2 | BE | 0.0951 | 0.00539 | 12th |
| | | | | 4.3 | PM | 0.5039 | 0.02856 | 8th |
| | | | | 4.4 | RM | 0.3449 | 0.01955 | 10th |
| 5 | Financial | 0.18077 | 3rd | 5.1 | FM | 0.80 | 0.14462 | 4th |
| | | | | 5.2 | NF | 0.20 | 0.03615 | 7th |

## 6. CONCLUSION

It becomes difficult for procurement managers to deal with multiple factors and selecting the right vendor for service job. This study will assist procurement managers in understanding the interrelationships between critical factors of service vendor selection. It will be easier to understand what each critical success factor will help to achieve and also prepare the action plan. The purpose of the study is to identify the critical factors for selection of key service vendors. Here systematic literature review has been done to identify the critical factors which have been refined using five experts' opinion. These experts are senior procurement managers working in firms located in West Bengal, Delhi and Bangalore having more than fifteen years of experience and professional members of CII, ORSI and IRI. Finally the thirteen critical factors have been used to develop the AHP matrix and ranking. Important observation from the current study is that quality of service is the most important criteria in selection of service vendors. Service quality of vendors must be evaluated, followed by regulatory concerns criteria and rejections criteria.

Managerial implications have been provided. This research study can provide food for procurement managers involved in buying services.

Every research study has certain limitations and present study also suffers from certain limitations. The study is based on AHP method where experts' opinion has been used to refine the critical factors. Also experts' opinion has been used to develop the AHP matrices. It may happen that the experts' opinion is biased. Therefore author propose some of the research directions to extend/validate the present study. Firstly Fuzzy AHP may be used to remove the vagueness and uncertainties associated with AHP. Secondly Structural equation modeling technique may be used to statistically validate the AHP model. Thirdly other MCDM technique such as ANP, ISM/TISM may be used to compare the present AHP model.

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# ASSET LIABILITY MANAGEMENT OF SCHEDULED COMMERCIAL BANKS IN INDIA – AN INDEPTH STUDY

S. K. Baral
Kushagra Institute of Information & Management Science
Cuttack, Odisha, India.
Tel. No. 9437163942
E-mail: drskbaral@yahoo.in,

## ABSTRACT

The banking scenario in India in the 1980s and now, presents a perfect study of contrast. Due to several reforms, banks are now moving away from the traditional lines of service and in the process, are exposed to more risks. One of the ways for managing the risks is Asset Liability Management. Asset liability management is a significant task for banks and financial institutions because of volatile global financial markets, propagation of new financial products and changing regulatory environments. Asset-liability management of commercial banks may be defined as the concurrent development of all asset and liability position on the bank's balance sheet under deliberation of the different bank management objectives and lawful, managerial and market constraints, for the purpose of the enhancing the value of the bank, providing liquidity, and extenuating interest rate risk. Scheduled commercial bank in India plays a significant role in the distribution of credit and mobilization of deposits. This study has been carried to test the logic behind in the management of assets and liabilities of Indian scheduled commercial banks. Public sector banks, private sector banks, foreign banks are considered for the study. Three financial years starting from 2009 to 2011 have been selected and all banks balance sheet are analyzed for the sample period. In order to know the quantum of asset liability management canonical correlation analysis has been performed, redundancy factors show the effective management of assets or liabilities. This study concluded that all scheduled banks are effectively manages its assets and liability management is dependent to the asset management.

***Keywords:*** *Asset Liability Management, Scheduled Commercial Banks, Risk Management, Public Sector Banks, Private Sector Banks, Foreign Banks.*

## 1. INTRODUCTION

Commercial banks play an important role in the development of a country. A sound, progressive and dynamic banking system is a fundamental requirement for economic development. As an important segment of the tertiary sector of an economy, commercial banks act as the backbone of economic growth and prosperity by acting as a catalyst in the process of development. They inculcate the habit of saving and mobilize funds from numerous small households and business firms spread over a wide geographical area. Banking sector in India plays pivotal role in mobilization of deposits and disbursement of loans to the different sectors of the economy. Commercial banks are important ingredients in the economic system to administer overall development of the nation. It is the prime duty of banker to maintain sound and efficient banking system to ensure financial stability. Financial stability can be manageable through proper designing of asset and liability in the company. Asset-liability management essentially refers to the practice by which a bank manages its balance sheet in order to set aside for alternative interest rate and liquidity scenarios. Banking business is related with accepting deposits and lending loans. Bankers are primarily deals with the money related products to satisfy the various needs of its customers. Bankers are always aiming to maximize profitability and trying to ensure sufficient liquidity to repose assurance in the minds of its depositors on their ability in serving the deposits by making timely payment of interest and repayment of their deposits. Timely meeting of all other liability commitment are important to them. To honor depositors and loan seekers demands, it is indispensable that banks have to monitor, maintain and manage their assets and liabilities assortment in a

systematic manner taking into account the diverse risk involved in that arena.

Generally, banking business is exposed to credit, market, operational and reputational risks in view of the asset-liability renovation. In the midst of liberalization in the Indian financial markets over the last few years and increasing assimilation of domestic markets with external markets, the risks associated with banks' operations have become multifarious and huge, requiring strategic management. Indian financial markets have witnessed plethora of changes at fast pace over the last two decades. Concentrated competition for business concerning both the assets and liabilities, in concert with increasing precariousness in the domestic interest rates as well as foreign exchange rates, has brought pressure on the management of banks to preserve a good balance among spreads, profitability and long-term viability. With the view to study the asset liability management in Indian scheduled commercial banks, this study has been carried out.

## 2. STATEMENT OF THE PROBLEM

Banking business is now operating with the practice of accepting deposits or raising borrowings from the cheapest possible route. The deposits are accepted through fixed deposits, recurring deposits, savings bank account and current account. Numerous deposit schemes are coming with as many as possible features on the four types of deposit account. Mobilizing deposit or raising money is largely involves liquidity element and interest rate sensitivity. The banker is a privileged debtor than the creditor i.e. depositor of money. But the banker has to remit interest or principal amount as per the requests of depositor. The huge revenue generating assets are loans & advances and investments; revenue is received in the form of interest for loans and advances and interest or dividend from investments. The interest for the deposit is compensated from the interest income of loans & advances and investments. Deposits are short-term liabilities to the banks, which varies from one month to five years. Loans and advances are long-term assets to the banks, which varies from one year to several years. There is a chance for mismatch between liquidity of deposits and loans & advances. It is imperative to balance the liquidity elements associated with the management assets and liabilities. At the same time, the banker has to face interest rate obligations, interest charged to loans and advances should be more than the interest given for the depositors. Interest rate subject to the economic pressure and performance, having well developed plan should be required for asset and liability management to ensure proper liquidity and interest rate management. As per the norms of RBI, bank has to kept cash and balances with RBI and other banks, investments in the form of fixed assets should be required to discharge its banking business. This strongly impairs pressure on the management of liquidity and interest rate issues with the asset-liability management. Effective use of income generating assets and liabilities will pave the way for the proper asset and liability management. Liquidity Risk is defined as the risk of not meeting the expected and unexpected current and future cash flows and collateral needs efficiently. This can be done without distressing the financial condition or daily operations of the bank. Asset liability management basically consists of managing liquidity and interest rate risks in an effective and efficient way. It has become the prime focal point in the banking industry, with every bank trying to maximize yield and reduce their risk exposure.

## 3. REVIEW OF LITERATURE

There has been good number of studies and plenty of literature relating to asset-liability management in banks is available.

The Basel committee on banking supervision (2001) proposed and formulated the broad supervisory framework and suggested required standards for bringing best practices in the supervision mechanism of banking system. The motto behind this was to encourage global convergence towards common approaches and standards for banking system per-se. This body also suggested setting up of rigorous risk and capital management requirements to ensure adequate capital reserve for various risks exposure in the process of lending and borrowing operations. It infers banks need to hold larger capital amount for greater exposure of risks. This will ensure solvency and stability.

The Basel II norms (2004) focused on international standard for the amount of capital to be maintained by banks as a safeguard against various risks they come across in the banking business. Basel II proposed setting up rigorous risk and capital management requirements designed to ensure that a bank holds capital reserves appropriate to the risk the bank exposes itself to through its leading and investment practices. It infers that the greater risk to which the bank is exposed, the greater the amount of capital the bank needs to hold to ensure solvency and stability.

Gardner and Mills (1991) talked about the philosophy of asset-liability management as a part of banks strategic planning and as a reaction to the varying environment in prudential supervision, e-commerce and new taxation treaties. Their text provided the groundwork of subsequent discussion on asset-liability management. Haslem et al (1999) used

canonical analysis and the interpretive outline of asset-liability management in order to recognize and interpret the foreign and domestic balance sheet strategies of large U.S. banks in the context of the crisis in lending to LDCs. The study found that the least beneficial very large banks have the largest proportions of foreign loans, yet they emphasize domestic balance sheet matching strategies. On the other hand, the most profitable very large banks have the smallest proportions of foreign loans, but, nonetheless, they emphasize foreign balance sheet matching strategies.

Vaidyanathan (1999) conferred issues in asset-liability management and intricate on various categories of risk that necessitate to be managed in the Indian context. In the past Indian banks were primarily apprehensive about adhering to statutory liquidity ratio norms; but in the changed situation, namely moving away from administered interest rate structure to market determined rates, it became important for banks to equip themselves with some of these techniques, in order to immunize them against interest rate risk. Vaidya and Shahi (2001) studied asset-liability management in Indian commercial banks. They suggested in particular that interest rate risk and liquidity risk are two key inputs in business planning process of banks.

Ranjan and Nallari (2004) used canonical analysis to examine asset-liability management in Indian banks. They found that state bank of India and associates had the best asset-liability management in that sample period. They also found that, other than foreign banks, all other banks could be said to be liability-managed; that is, they all borrowed from the money market to meet their maturing obligations. Private bank were found to be aggressive in profit generation, while nationalized banks were found to be excessively concerned about liquidity.

Financial sector reforms during the study period have also an impact on banks assets and liability decomposition. Debasis Bagchi (2003) in his paper "assets and liability information analysis of the Indian public sector banks" studies the behavior of the banks with respect to their capital adequacy ratio dynamics, by decomposing the financial statements. This study shows the evidences that banks re-organized their assets and liabilities to achieve higher capital adequacy ratios, and also that the assets re-organization was more pronounced than the re-organization of the liabilities. ALM is considered a strategic discipline as opposed to a tactical one (Choudhry, 2007).

## 4. OBJECTIVES OF THE STUDY

Banking sector plays most significant role in the economic life and development of the nation. The strength of the financial system is strongly related to the soundness of its banking system. Banking activities creates money circulation for the process of production, distribution, exchange and usage of economic resources of a nation. For effective and smooth administration of money circulation requires sound asset and liability management in banks. Hence this present research work is carried out with the following objectives. These are:

- To analyze classification of different scheduled banks and its composition in the sample.
- To examine the asset-liability position and growth rate of assets and liabilities of scheduled commercial banks in India.
- To analyze the pattern of assets and liabilities movement of scheduled commercial banks.
- To investigate the asset and liability management to ensure liquidity and interest rate sensitivity.
- To examine the dependability of assets or liabilities on the asset liability management of scheduled commercial banks.

## 5. RESEARCH METHODOLOGY

The present research work attempts to analyze asset-liability management in scheduled commercial banks in India to determine its liquidity position, profitability and interest rate movements. This study consists of all scheduled commercial banks excluding regional rural banks. The banks are grouped as per its ownership pattern, that is, public sector banks, private sector banks and foreign banks. This study contains a sample of 27 public sector banks, 22 private sector banks and 34 foreign banks. The public sector banks consist of State Bank of India and its associate banks and all other nationalized banks. The data for the present study consist of the assets and liabilities of a sample of fifty-six banks with nation-wide operations in the study period 2008-09 – 2010-11. The data used for the study included the financial data of banks included in the sample. The required financial data is obtained from the Reserve Bank of India's website. This study is carried out as per the guidelines of asset-liability management issued by Reserve Bank of India on scheduled commercial banks.

This present study focuses canonical correlation analysis to evaluate the nature of asset-liability management of different scheduled commercial banks. For analysis purpose, the assets and liabilities of the banks are classified according to its types and quantum. The outcomes of the canonical correlation analysis are then construed in terms of connotation on profitability, liquidity and interest rate fluctuations. Canonical correlation is a multivariate technique and has been used to review the nature and strength of association between the assets and liabilities of scheduled commercial banks. The correlation between each set of assets and liabilities indicates relationship between assets and liabilities, but all of these correlations assess the assets influence on liabilities. Canonical correlation analysis attempts to measure the linear relationship between two multidimensional variables. It finds two bases, one for each variable, that are most advantageous with respect to correlations and, simultaneously, it finds the consequent correlations. In other words, it finds the two bases in which the correlation matrix between the variables is diagonal and the correlations on the diagonal are maximized.

## 6. RESULTS AND DISCUSSIONS

**6.1. ANALYSIS OF SAMPLE BANKS** The following figure narrates the selection and composition of banks in the sample period.

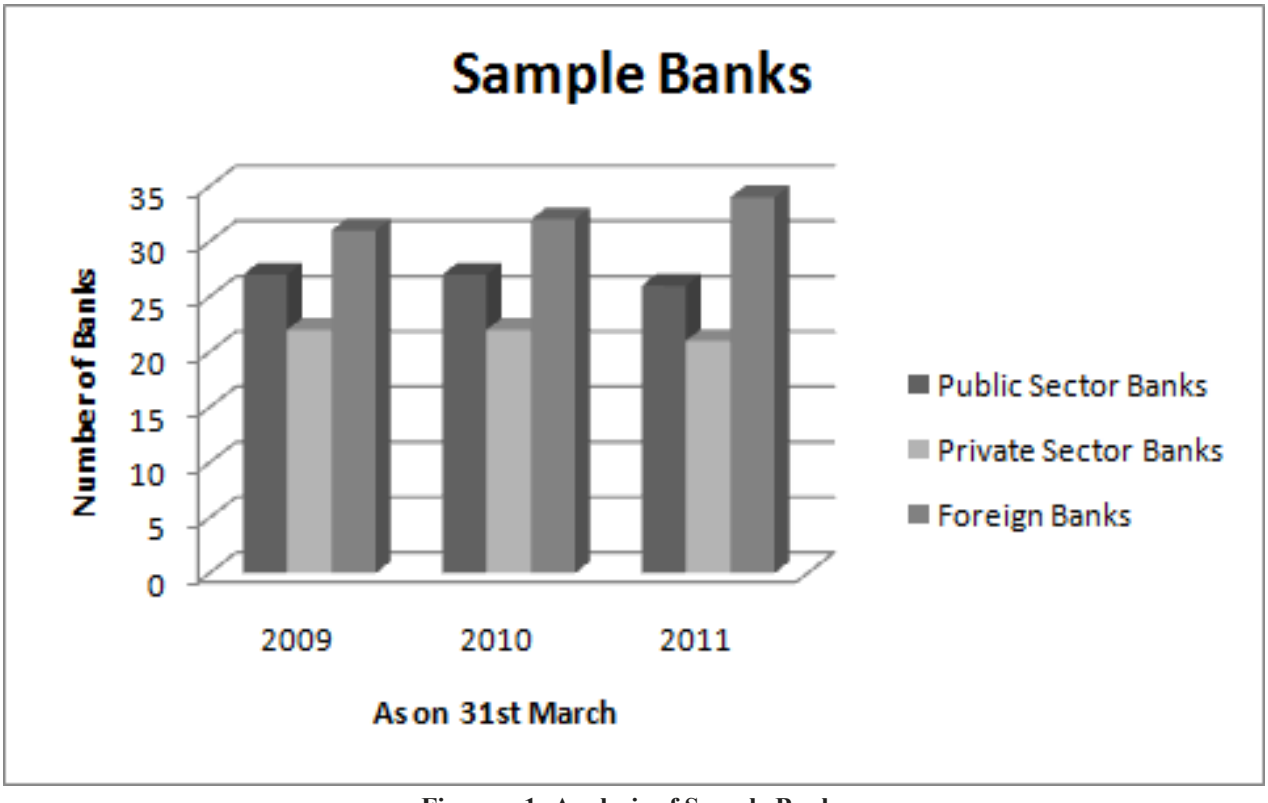


**Figure – 1: Analysis of Sample Banks**

It is clear from the above figure, the sample banks are belonging to three different classifications on the basis of ownership structure. In 2009, 27 public sector banks, 22 private sector banks and 31 foreign banks are included and total sample banks comes to 80. No change has been revealed as to public sector and private sector banks in 2010 and at the same time there is an inclusion of an additional bank in foreign bank category. The total banks considered for the study in 2010 is 81 banks. During the year 2011, there is an exclusion of one bank each in public sector and private sector and addition of two banks in foreign banks retains sample size to 81 banks. There is no partiality has been shown as to public sector, private sector or foreign banks. All the banks have to abide by the rules of and report to the Reserve Bank of India. Hence equality has been applied to all the classification of banks.

**6.2. ASSET-LIABILITY POSITION OF SCHEDULED COMMERCIAL BANKS** The following balance sheet shows the asset-liability position for the years starting from 2009 to 2011. It helps to understand how financial resources obtained from various sources are transformed to investments, that is, various forms of assets during the sample period. The consolidated balance sheet of scheduled commercial banks gives full information about asset and liability position for the three years from 2009.

**Table – 1: Consolidated Balance Sheet of SCBs in 2009 (Rs. in Crores)**

| Items | As on 31st March 2009 | | | |
|---|---|---|---|---|
| | Public Sector Banks | Private Sector Banks | Foreign Banks | All Scheduled Commercial Banks |
| 1. Capital | 13536 | 4241 | 25513 | 43289 |
| 2. Reserves and Surplus | 194806 | 95428 | 34424 | 324658 |
| 3. Deposits | 3112747 | 736378 | 214076 | 4063201 |
| 4. Borrowings | 258406 | 137705 | 77486 | 473597 |
| 5.Other liabilities & provisions | 186262 | 54005 | 93630 | 333897 |
| **Total Liabilities** | **3765757** | **1027756** | **445129** | **5238642** |
| 1.Cash & balances with RBI | 224141 | 57484 | 15642 | 297267 |
| 2.Balances with Banks and Money at call & Short Notice | 131303 | 33947 | 31266 | 196516 |
| 3.Investments | 1012666 | 306531 | 130354 | 1449551 |
| 4. Loans and Advances | 2259212 | 575328 | 165385 | 2999924 |
| 5. Fixed assets | 33743 | 9880 | 4738 | 48361 |
| 6. Other Assets | 104692 | 28523 | 93556 | 174605 |
| **Total Assets** | **3765757** | **1027756** | **445129** | **5238642** |

**Source: www.rbi.org.in**

It is evident from the table 1, the capital position of foreign banks shows that three-fifth on the total capital of all scheduled commercial banks. It is ascertained from the above table that major funds are raised in the form of deposits from the general public for all three types of public sector banks, private sector banks and foreign banks. Borrowings from Reserve Bank of India and other banks are second largest source to the scheduled commercial banks. Other liabilities and provisions stand third largest source to the public and private sectors banks and this will be second largest source to foreign banks. Private sectors banks have enormous wealth through the plough back of profit and kept as reserves and surplus. It shows 22 times larger than its capital. Similarly public sector banks possess 15 times than their capital base. Foreign banks possess small history in the banking business in India and its reserve position is just 1.5 times than its capital position. The assets position shows the clear information about their investment pattern of its liabilities. It is mandatory to maintain 5-6% of total assets as cash reserve with RBI, this can be revised from time to time. It is strictly observed during the sample period, similarly, cash balances with banks and money at call & short notice also relies between 2 to 5% on the total assets. Loans and advances are the prime distribution method to the commercial banks and followed by investments. Investments in fixed assets and other assets may or may not yield direct return, but it is necessary to run the banking business. A little portion of amount is invested in the form of fixed and other assets.

**Table – 2: Consolidated Balance Sheet of SCBs in 2010 (Rs. in Crores)**

| Items | As on 31st March 2010 | | | |
|---|---|---|---|---|
| | Public Sector Banks | Private Sector Banks | Foreign Banks | All Scheduled Commercial Banks |
| 1. Capital | 13544 | 4549 | 30527 | 48619 |
| 2. Reserves and Surplus | 227458 | 115435 | 38649 | 381542 |
| 3. Deposits | 3692019 | 822801 | 232099 | 4746920 |
| 4. Borrowings | 313814 | 149350 | 68247 | 531412 |
| 5.Other liabilities & provisions | 193992 | 58601 | 65839 | 318433 |
| **Total Liabilities** | **4440827** | **1150736** | **435362** | **6026925** |
| 1.Cash & balances with RBI | 270858 | 75866 | 19097 | 365821 |
| 2.Balances with Banks and Money at call & Short Notice | 114400 | 38670 | 20559 | 173629 |
| 3.Investments | 1215598 | 354117 | 159291 | 1729006 |
| 4. Loans and Advances | 2701019 | 632441 | 163260 | 3496720 |
| 5. Fixed assets | 34469 | 10239 | 4860 | 49568 |
| 6. Other Assets | 104482 | 39404 | 68295 | 212181 |
| **Total Assets** | **4440827** | **1150736** | **435362** | **6026925** |

**Source: www.rbi.org.in**

The table 2 shows that similar kind of assets and liability position like its previous year. Maximum revenues are generated in the form of accepting deposits from the common public. Likewise, borrowings, reserves & surplus places second and third to the deposit mobilization. There is a little growth is happened in the capital of all banks. Other liabilities and provisions are increased than previous year to public and private sector banks. There is a slight deep resulted in the foreign banks. Assets side of balance sheet shows the use of financial resources of the bank, loans and advances are the biggest disbursement tool to the banker for the deployment of its funds. Balances with RBI and banks occupy almost 10% of total assets of the all scheduled commercial banks. The remaining resources are invested in the form of fixed assets and other forms of assets. This table insists that a slight growth in the assets and liabilities of all banks.

**Table – 3: Consolidated Balance Sheet of SCBs in 2011 (Rs. in Crores)**

| Items | As on 31st March 2011 | | | |
|---|---|---|---|---|
| | **Public Sector Banks** | **Private Sector Banks** | **Foreign Banks** | **All Scheduled Commercial Banks** |
| 1. Capital | 19055 | 4805 | 35383 | 59243 |
| 2. Reserves and Surplus | 271196 | 133784 | 45668 | 450648 |
| 3. Deposits | 4372985 | 1002759 | 240689 | 5616432 |
| 4. Borrowings | 395144 | 185984 | 92797 | 673925 |
| 5.Other liabilities & provisions | 235438 | 70844 | 76992 | 383273 |
| **Total Liabilities** | **5293817** | **1398176** | **491528** | **7183522** |
| 1.Cash & balances with RBI | 352379 | 86111 | 20293 | 458783 |
| 2.Balances with Banks and Money at call & Short Notice | 132225 | 31616 | 27365 | 191206 |
| 3.Investments | 1328534 | 422020 | 165499 | 1916053 |
| 4. Loans and Advances | 3305632 | 797534 | 195539 | 4298704 |
| 5. Fixed assets | 36156 | 12980 | 4958 | 54093 |
| 6. Other Assets | 138892 | 47915 | 77874 | 264681 |
| **Total Assets** | **5293817** | **1398176** | **491528** | **7183522** |

**Source: www.rbi.org.in**

The above table 3 furnishes information about the asset and liability position. The combined balance sheet of scheduled commercial banks witnessed higher growth in 2010-11 as compared with the previous year. This is in contrast to the trend observed during the last two years and signals a recovery from the divergent effects of global financial commotion. The higher growth in the combined balance sheet of scheduled commercial banks was contributed by all the bank groups except old private sector banks, which recorded marginal deceleration in growth. The highest growth was recorded by new private sector banks followed by public sector banks. Yet, as at end-March 2011, almost three fourths of the total assets of the banking sector belonged to public sector banks followed by private sector banks and its share comes to one-seventh in the total assets composition.

**6.3 GROWTH OF ASSET AND LIABILITIES** Banking sector feeds financial food for the industrial development. Growth of assets and liabilities are essential to cope up the rapid industrialization and expansion. Hence, this study seeks the growth rate of assets and liabilities of the banks. These are presented in table – 4.

**Table – 4: Growth of Assets and Liabilities of SCBs in 2010 and 2011.**

| Items | Public sector banks (as on 31st March) | | Private sector banks (as on 31st March) | | Foreign Banks (as on 31st March) | | All Scheduled Commercial Banks (as on 31st March) | |
|---|---|---|---|---|---|---|---|---|
| | **2010** | **2011** | **2010** | **2011** | **2010** | **2011** | **2010** | **2011** |
| 1. Capital | 0.59 | 40.69 | 7.26 | 5.63 | 19.65 | 15.91 | 12.31 | 21.85 |
| 2. Reserves and Surplus | 16.76 | 19.23 | 20.97 | 15.90 | 12.27 | 18.16 | 17.52 | 18.11 |
| 3. Deposits | 18.61 | 18.44 | 11.74 | 21.87 | 8.42 | 3.70 | 16.83 | 18.32 |
| 4. Borrowings | 21.44 | 25.92 | 8.46 | 24.53 | -11.92 | 35.97 | 12.21 | 26.82 |
| 5. Other liabilities and provisions | 4.15 | 21.36 | 8.51 | 20.89 | -29.68 | 16.94 | -4.63 | 20.36 |
| **Total Liabilities** | **17.93** | **19.21** | **11.97** | **21.50** | **-2.19** | **12.90** | **15.05** | **19.19** |
| 1. Cash and balances with RBI | 20.84 | 30.10 | 31.98 | 13.50 | 22.09 | 6.26 | 23.06 | 25.41 |
| 2. Balances with banks and money at call | -12.87 | 15.58 | 13.91 | -18.24 | -34.24 | 33.10 | -11.65 | 10.12 |
| 3. Investments | 20.04 | 9.29 | 15.52 | 19.18 | 22.20 | 3.90 | 19.28 | 10.82 |
| 4. Loans & Advances | 19.56 | 22.38 | 9.93 | 26.10 | -1.28 | 19.77 | 16.56 | 22.94 |
| 5. Fixed Assets | 2.15 | 4.89 | 3.63 | 26.77 | 2.57 | 2.04 | 2.50 | 9.13 |
| 6. Other Assets | -0.20 | 32.93 | 38.15 | 21.60 | -27.00 | 14.03 | 21.52 | 24.74 |
| **Total Assets** | **17.93** | **19.21** | **11.97** | **21.50** | **-2.19** | **12.90** | **15.05** | **19.19** |

***Source: www.rbi.org.in***

The table 4 presents growth of assets and liabilities for the years 2010 and 2011. Deposit mobilization is the prime source of banks; double digit growth is achieved by public and private sector banks but foreign banks lacked in the accumulation of deposits in both the years. At the same time external commercial borrowing rate is increased to all banks except foreign banks in the year 2010. In 2011, public sector banks are raised capital up to 41% than the previous year position. Reserves and surplus shows handsome increase in both the years. There is mixed trend of increase and decrease in other liabilities and provisions. Lending of resources in the form of loans and advances shows more or less 20% to public sector banks in both the years, but private and foreign banks achieved this rate of growth in 2011. The same kind of progress can be seen to the investments, cash and balances with RBI and other banks. All bankers are concentrating a moderate investment on fixed assets and it ranges from 2% to 26%. The above table strongly evidences that the rate of increase in deposit are equally distributed as loans and advances to the various sectors of the economy. Average growth of scheduled commercial banks are seems satisfactory during the financial year 2010 and 2011. This growth shows the strength of economic prosperity and highest possible industrial development can be possible in coming years.

## 6.4. RESULTS OF CANONICAL CORRELATION ANALYSIS:

**Table - 5: Canonical Correlation Analysis of Assets and Liabilities of Banks**

| Particulars | 2009 | | | 2010 | | | 2011 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Public Sector Bank | Private Sector Bank | Foreign Bank | Public Sector Bank | Private Sector Bank | Foreign Bank | Public Sector Bank | Private Sector Bank | Foreign Bank |
| Squared Canonical Correlation ($R^2$) | 0.9992 | 0.9997 | 0.9999 | 0.9993 | 0.9999 | 0.9996 | 0.9995 | 0.9998 | 0.9999 |
| Canonical Loadings: LIABILITIES | | | | | | | | | |
| Capital | 0.849 | 0.745 | 0.332 | 0.068 | 0.564 | 0.642 | 0.546 | 0.257 | 0.221 |
| Reserves and Surplus | 0.534 | 0.283 | 0.637 | 0.455 | 0.396 | 0.057 | 0.350 | 0.294 | 0.325 |
| Deposits | 0.135 | 0.838 | 0.482 | 0.399 | 0.353 | 0.592 | 0.322 | 0.623 | 0.142 |
| Borrowings | 0.250 | 0.107 | 0.674 | 0.138 | 0.493 | -0.254 | 0.351 | 0.194 | 0.321 |
| Other liabilities and provisions | 0.089 | 0.032 | -0.165 | 0.193 | 0.402 | 0.184 | 0.138 | 0.225 | 0.245 |
| Canonical Loadings: **ASSETS** | | | | | | | | | |
| Cash and balances with RBI | 0.521 | 0.378 | -0.312 | 0.554 | 0.224 | 0.384 | 0.410 | 0.199 | 0.349 |
| Balances with banks and money at call | -0.369 | 0.342 | 0.344 | 0.342 | 0.213 | 0.311 | 0.233 | 0.419 | 0.240 |
| Investments | 0.388 | 0.459 | 0.590 | 0.823 | 0.582 | 0.931 | 0.139 | 0.624 | 0.284 |
| Loans & Advances | 0.149 | 0.228 | 0.391 | 0.399 | 0.563 | 0.627 | 0.524 | 0.329 | 0.595 |
| Fixed Assets | 0.464 | 0.339 | 0.423 | 0.428 | -0.521 | 0.734 | 0.468 | 0.534 | 0.691 |
| Other Assets | 0.235 | 0.582 | 0.526 | 0.234 | 0.642 | 0.592 | -0.204 | 0.263 | 0.169 |
| Redundancy | | | | | | | | | |
| Assets (A) | 0.035 | 0.049 | 0.023 | 0.099 | 0.126 | 0.215 | 0.064 | 0.166 | 0.195 |
| Liabilities (L) | 0.087 | 0.313 | 0.132 | 0.042 | 0.211 | 0.151 | 0.133 | 0.029 | 0.233 |
| Independent Set | A | A | A | L | A | L | A | L | A |
| Dependent Set | L | L | L | A | L | A | L | A | L |

The outcomes of the canonical correlation analysis are furnished in table 5, the bank groups are arranged in the following order that is, public sector banks, private sector banks and foreign banks. The results given in first row ($R^2$) are the measure of the significance of the canonical correlation. The computed values of canonical correlations were to be found significant. The strength of the association is measured with the help of canonical loading. This measures the percentage of variance linearly shared by an original variable with one of the canonical variable, if the loading falls greater than 40% is assumed to be significant. If the loading indicates negatively, it expresses that inverse relationship between original variable and canonical variable. For example, if any assets or liabilities have a loading of more than 0.40 indicates the strong correlation with the canonical variable.

If one set of variable is how and what extent redundant is measured through redundancy factors, information about independent and dependent sets are identified with the other set of variable. This will furnish complete idea about the fact that the bank is whether asset managed or liability managed. The above correlation analysis explains the maximum positive correlation of 0.931 and maximum negative correlation of 0.369. Investments of foreign banks during 2010 shows maximum positive correlation and cash balances with RBI and money at call & short notice is the maximum negative correlation happened in the year of 2009.

Redundancy factors explain the asset and liability management for each class of banks. If the assets are managed properly, it is marked as 'A', whereas liabilities are managed well, it is designated as 'L' in the independent set. The letter 'A' or 'L' noted in the dependent set is assumed as dependent of independent set. The results of canonical correlation analysis shows for the period of three financial years to three different scheduled commercial banks. Public sector banks assets are properly managed in the year of 2009 and 2011. Private sector banks assets are properly managed in the year 2009 and 2010. Similarly assets of foreign banks are properly managed than its liabilities in the year of 2009 and 2011.

While taking liquidity aspect of asset-liability management, the focus on fixed assets and deposits are necessary. Parking investments in the form of fixed assets involves possible liquidity issues and interest rate sensitivity. Fixed assets are bearing low liquidity and interest-rate-neutral whereas deposits and borrowing relatively includes short-term deposits liquidity elements and largely affect interest rate sensitivity. For all banks, fixed assets from the asset side of balance sheet and deposits & borrowings from the liability side of balance sheet expresses significant presence in the canonical loadings. It indicates the proper usage of fixed assets and deposits in the management of assets and liabilities. This trend continued to the three years and for all banks. During this study period, all the banks are actively manages their assets and liability management is dependent upon the how well the assets are managed.

## 7. CONCLUSION

The banking system in India has undergone notable changes over the preceding two decades. Regulatory environments are supports lot for the development of banking habits among common people and have opened up new vistas for banks to enhance its revenues. Simultaneously, global financial turmoil and increased demands for the banking services induces us to study the asset and liability management of banks. Financial stability of commercial banks is largely depends on the effective management of its assets and liabilities. In this study, hardly 81 banks under three classification that is, public sector banks, private sector banks and foreign banks considered to analyze asset-liability management. Performance of scheduled commercial banks are studied for each financial year, while looking liability side of the balance sheet, the growth was driven mainly by borrowings, capital and other liabilities and provisions. The capital accumulation is done through issue of shares and contribution from the Government to the public sector banks. Private sector banks and foreign banks are raised through issue of ownership and credit instruments. The consolidated balance sheet furnishes that acceleration in the growth of deposits enhances the total liabilities position. This could be resulted due to the prevailing higher interest rate in the economy.

Public sector banks leads among the all scheduled commercial banks in the accumulation of deposits. Similar trend can be seen for the borrowings and all other liabilities. Private sector banks and foreign banks and lacked to maintain consistent growth in the deposit mobilization and borrowings accumulation. Disbursement of credit and investment growth rate also consistently maintained for public sector banks than the private and foreign banks. Overall performance shows the public sector banks have rich asset and liability exposure to meet its liquidity and interest rate sensitivity than private and foreign banks. Canonical correlation presents various significant empirical evidences, which explain the dependency involving in asset and liability movements. There is strong canonical correlation between asset and liability movement, indicating high asset-liability dependency. There is consistent trend persists in canonical correlation for public sector banks, private sector banks and foreign banks. There is a positive correlation exists among the different set of assets and liabilities given in the balance sheets of scheduled commercial banks. It is evident from the canonical correlation analysis, scheduled commercial banks were actively managing its asset and liability and liability management is largely depends on the management of assets.

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# A COMPARATIVE ANALYSIS OF SYBIL ATTACK DETECTION TECHNIQUES IN MANET

Aditi Paul*
Asst. Professor, IT
Dronacharya Group of Institutions, Greater Noida.
Tel. No. 09716775691
E-mail. aditi23.mca@gmail.com

Subhrajit Nag
Head of the Department, IT
Dronacharya Group of Institutions, Greater Noida.
Tel. No. 9818171421
E-mail. nag.subhrajit@gmail.com

## ABSTRACT

Mobile Ad hoc Network (MANET) is inherently prone to various security attacks due to its characteristics. The infrastructure-less architecture, mobility of nodes, wireless channel, limited bandwidth and resources and different other characteristics make MANET vulnerable to the intruders to launch various attacks and hence disrupt the network. Sybil attack is one of the network layer attacks in which a malicious node exploits the network by using many fake identities. In this paper we have highlighted the dimensions of Sybil attack and the algorithms which have been proposed to detect those attacks. We have also made a comparative study on these detection techniques which will help future researchers find out a way towards more robust and successful Sybil attack detection mechanism.

***Keywords:*** *MANET, Sybil attack, Sybil Detection technique, Comparative Study*.

## 1. INTRODUCTION

Mobile ad-hoc network (MANET) is characterised as a set of two or more devices having the capabilities of wireless communication and networking. These types of networks do not require any infrastructure or physical backbone. The devices, often known as nodes, are mobile and hence dynamically set up paths among themselves to transmit data packets in the network. Due to the mobility of the nodes MANETs acquire special properties which make them distinguishable from conventional wired and wireless network. MANETs have dynamic topology, i.e., the nodes are spontaneously forming and deforming the network and updating the routing table associated to each node. In MANET the communication between the neighbouring nodes takes place by broadcasting control messages between themselves directly. However, the node away from the radio range of another node has to traverse multiple hops to relay messages. These messages can carry node address, global position info etc. Due to the flexibility of MANET new nodes can enter into the network or existing nodes can leave the network any time which causes route change and link updation. Moreover mobile nodes frequently change their positions inside MANET causing frequent topology change over time. This change in topology should be incorporated so as to keep the routing table updated in each node inside MANET to avoid communication error like link failure etc.

The nodes in MANET have very limited resources such as battery capacity, bandwidth, CPU capacity, storage capacity etc. which cause MANET to face some typical challenges. Moreover mobility of nodes and channel vulnerability causes problems in signal transmission, channel access, routing such as packet loss, route change, increase in control traffic etc. Limited battery power is another crucial challenge in MANET as because battery technology is not progressing as fast as memory or CPU technology. In MANET wireless transmission, routing, retransmission and beaconing consume more power which may not be sufficiently supplied by battery.

All these emerging challenges due the inherent characteristics of MANET are creating significant aspects of research.

Challenges of MANET lead to security issues such as routing security, data forwarding security, link layer security, key management, intrusion detection and so on. To maintain reliable communication in MANET five major

security goals need to be considered. These are as follows:

**CONFIDENTIALITY:** It means that message should be kept secret and not to be exposed to any node other than the recipient. In MANET it is hard to keep message confidential as because in multi-hop communication there are several intermediate nodes in-between which can easily snoop the message.

**AVAILABILITY:** Services should be available when required throughout the network so that the communication remains active. It is important in order to survive against any attack.

**AUTHENTICATION:** It should be confirmed that all the nodes (including the source and the destination node) are legitimate otherwise a malicious node can easily take off the identity of a node and get unauthorised access to the confidential information and consume resources of the network as well.

**INTEGRITY:** It means message sent by the source should reach the destination intact (as it is), i.e., the order of the transmitted message remains unchanged.

**NON-REPUDIATION:** The sender and receiver should never refuse transmission.

Any of the above security goals once violated leads to security attacks among which Sybil attack [1] is the most severe one. Literature review shows that a number of Sybil detection techniques are evolved through decades but most of them have severe constraints in spite of high detection rate. The aim of this paper is to bring forth a quantitative analysis of mainstream Sybil detection techniques in order to clarify their efficiencies. This analytical result is important for the researchers to understand the pitfalls of the detection techniques which are to be avoided next.

## 2. TYPES OF ATTACKS IN MANET

In MANET security attacks can be ***external*** or ***internal***.

**EXTERNAL ATTACKS**: External attacks are similar to the normal attacks in the traditional wired networks in which the attacker can create congestion in the routing path or relay phony routing information or disturb nodes from providing services.

**INTERNAL ATTACKS:** In internal attacks an adversary can directly compromise an existing node and use it to conduct its malicious behaviours or impersonate itself as a new node to get access to the network.
There are several external and internal attacks in MANET which are shown by fig.1 below:

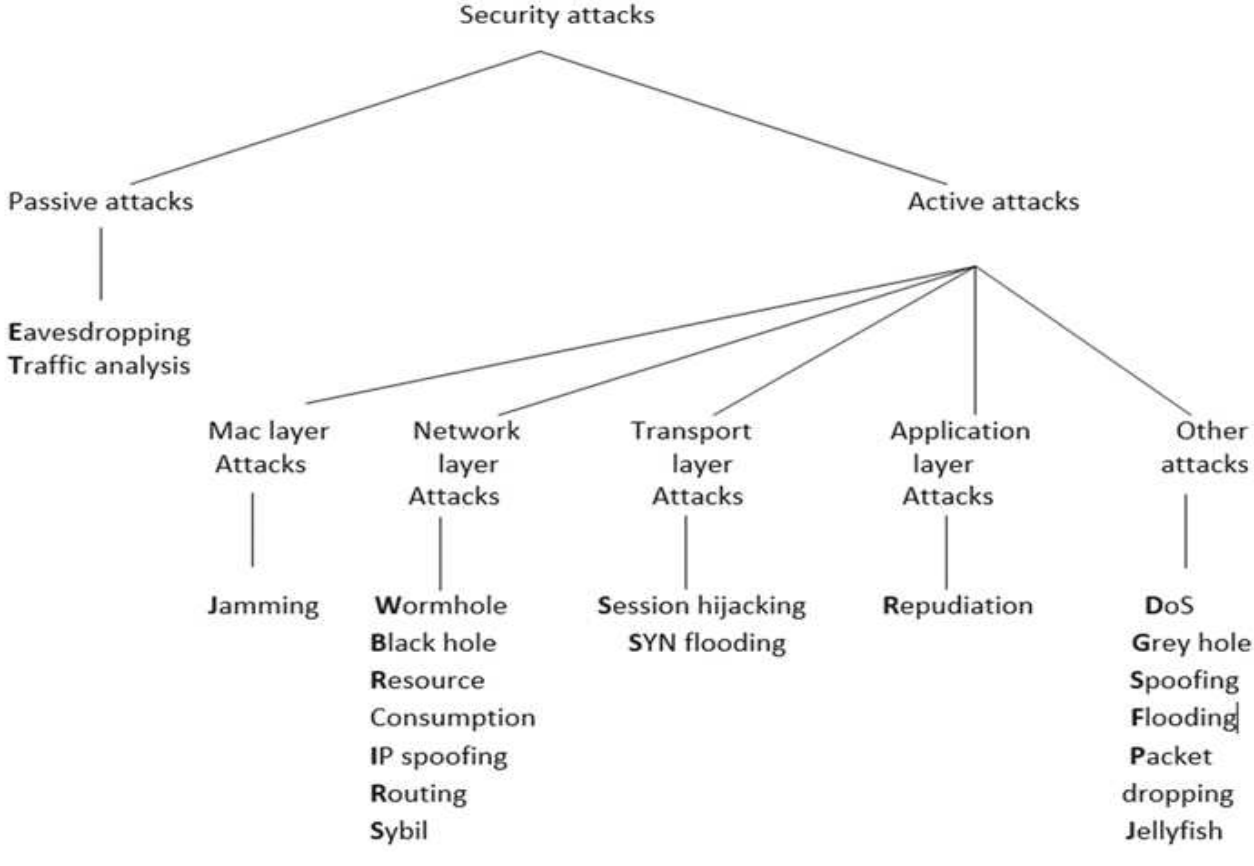


Fig. 1. Different types of attacks in MANET

According to Figure 1 the security attacks in MANET can be broadly classified in two types-passive attack and active attack. In the subsequent section a brief overview of the attacks are discussed.

**PASSIVE ATTACKS** A passive attack does not interrupt the normal operation of the network; the attacker snoops the data exchanged in the network without altering it. Here the property of confidentiality is broken. Revealing passive attack is very difficult as because the network remains unaltered. One of the solutions to this problem is to use powerful encryption mechanism.

***Eavesdropping:*** It aims to obtain some confidential information that should be kept secret during the communication. The information may include the location, public key, private key or even passwords of the nodes.

***Traffic Analysis & Monitoring :*** In this attack enemy nodes monitor packet transmission to gather important information such as a source, a destination and a source-destination pair.

**ACTIVE ATTACKS** In contrast to passive attack, an active attack alters or destroys the data being exchanged in the network; hence interrupting the normal functioning of the network. In active attacks (whether by external means or by an internal) the attacker nodes execute actions such as impersonation, modification , fabrication and replication.

Due the flexibility and openness of MANETs, they are vulnerable to various types of attacks such as wormhole attack, sinkhole attack, selective forward attacks and Sybil attacks. Among these, Sybil attack can significantly reduce the performance of the network by disrupting the routing protocol, resources, bandwidth, communication channel and so on. When a node illegitimately takes on multiple identities and exploits the network, it is called Sybil attack. In this paper we discuss about the various prospective of Sybil attack [3] and their detection techniques. These detection methods have advantages as well as drawbacks. Our aim in this paper is to bring forth the efficiency and limitation of latest techniques of Sybil detection which can help the future researchers in building a view of literature of Sybil detection.

## 3. SYBIL ATTACK

Since MANET is a distributed system data can be sent via one of the multiple nodes which are available. In this case the identity of the source and destination plays an important role in order to maintain data integrity. Thus a distributed system requires to have the ability to determine whether two apparently different entities are actually different. In MANET nodes do not have any physical knowledge about other nodes. The only way to recognize each other is by some informational abstraction (through request/ response message). This type of system must ensure that distinct identities refer to distinct entities; otherwise, when an entity (or node) sends data to multiple identities (or node) it can be deceived into selecting a single entity multiple times. This falsification of multiple identities is termed as **Sybil attack [1].** Thus we can define **Sybil attack** as a **malicious device taking multiple identities (called Sybil nodes) illegally, misleading legitimate nodes in a MANET.**

The Sybil attack can occur in a MANET since it operates without a central authority to verify the identities of each communicating entity. Because the nodes can identify their neighbours by passing messages over a communication channel, a Sybil attacker can assume many different identities and send message to a legitimate node from those identities pretending them as distinct. To defend against Sybil attack it is required to have the knowledge of its different forms. In the next section we briefly discuss the topology of Sybil attack.

## 4. TAXONOMY OF SYBIL ATTACK

1. Direct vs. Indirect Communications
2. Fabricated vs. Stolen Identities
3. Simultaneous vs. non-simultaneous attacks

**DIRECT VS. INDIRECT COMMUNICATIONS:**

In **direct communication** a genuine node sends a radio message directly to a Sybil node from which the message reaches the malicious device without the concern of the sender.

In **indirect communication** the legitimate node does not communicate directly with the Sybil node. Instead there is one or more malicious nodes in between through which the message has to be passed. When the message reaches to the malicious

device, it pretends to pass it to the Sybil node but actually consumes it.

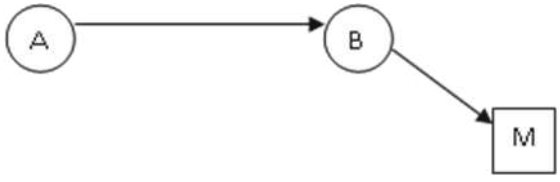


Fig.2. Direct communication: A – Legitimate node; B –Sybil node, M-malicious node

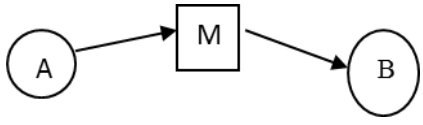


Fig.3. Indirect communication: A- Legitimate node; B-malicious node, C- Sybil identity of B;

**FABRICATED VS. STOLEN IDENTITIES** In fabrication the attacker creates arbitrarily new identities with distinguishable identification. This identification should be compatible with the identification of the existing legitimate nodes of the network. Fabrication can be defeated by introducing some mechanisms like authentication to identify legitimate node's identity. When fabrication fails, the attacker can steal the identification of a legitimate node and assign it to a Sybil node. The attacker may temporarily make the Sybil node inactive so that it remains undetected.

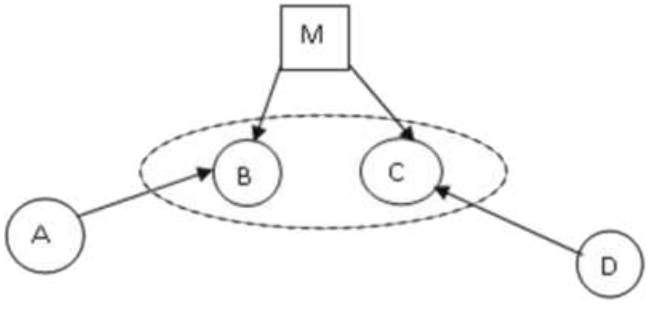


Fig.4. Fabrication: B, C Sybil identities of M

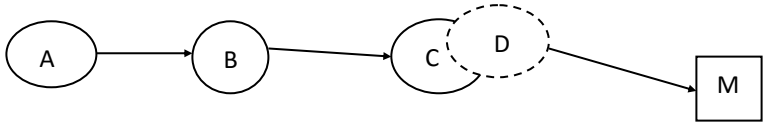


Fig.5. Stolen identity: C - stolen identity of D, M - malicious node, A, B - legitimate nodes.

**SIMULTANEOUS VS. NON-SIMULTANEOUS ATTACK** Attacker makes all its identities participate at a time, i.e., simultaneously in the network. Though it is not possible for a single physical device to represent more than one identity at a time it can cycle through all the identities so rapidly that it appears to be presented simultaneously. In **non-simultaneous** situation an attacker represents large number of identities over a period of time. This can be done in two ways: Either the attacker can represent each identity for once one after another for a period of time or it can use same number of physical devices as the identities to represent them individually by each single physical device.

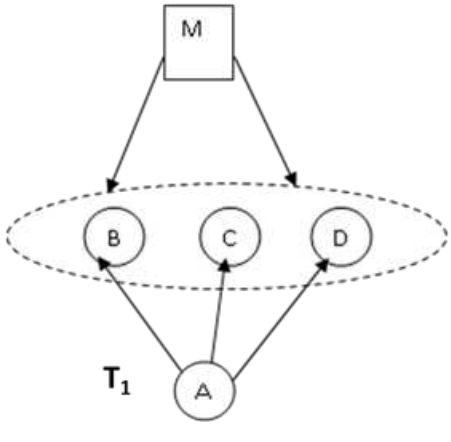


Fig. 6. B,C ,D are the simultaneous (at time $T_1$) identities of the attacker M.

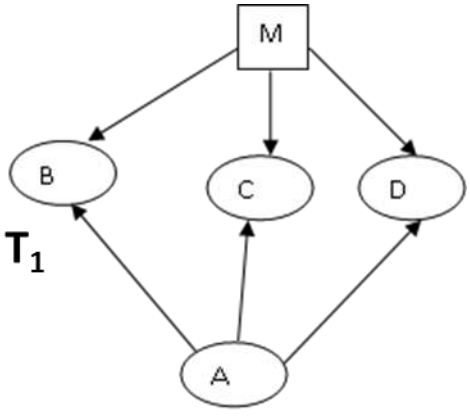


Fig.7. Sybil nodes B,C,D are presented over a period of time (from $T_1$ to $T_3$) by attacker M.

Taxonomy of Sybil attack gives a logical view of how the attacker may launch the attack. In order to impose any defending mechanism against this attack it is important to understand the various prospective of Sybil attack. In the next section we discuss various Sybil detection mechanisms till date and their limitations. Since each of these methods have some disadvantages, it is important to figure them out in order to propose a more robust and stand alone Sybil detection tool. The aim of this paper is to analyse the mainstream Sybil detection techniques in the perspective of their domain, attribute, performance and accuracy.

## 5. COMPARATIVE ANALYSIS OF SYBIL DETECTION METHODS

Still now there is no such well accepted solution to the Sybil attack. A number of methods have been proposed [2] connected with different environments. Some of them are effective to reduce the threat to a satisfactory level. In this section we represent an analytical study of mainstream Sybil detection techniques. We consider the most recent as well as conventional Sybil detection methods and bring out their strengths and weaknesses (table 1.).

**5.1 TRUSTED CERTIFICATION** Douceur in [1] has proved that trusted certification is the only approach that has the potential to eliminate Sybil attack completely. However, this method has a number of drawbacks related to implantation of certification authority as well as implementation of entity-identity mapping. Significant overhead and cost also restrict the use of this method in a dense network.

**5.2 RSS BASED TECHNIQUE** In [4] authors proposed a RSS based technique that can perform attack detection and also localizes adversaries' positions. But this technique requires extra hardware set up and statistical calculation.

**5.3 RECEIVED SIGNAL STRENGTH INDICATOR(RSSI)** Demirbas and Song [5] proposed a method that uses Received Signal Strength Indicator (RSSI) of messages. Upon receiving a message the receiver will attach the RSSI of the message with the sender identity, and later when another message with same RSSI but from a different sender is received, the receiver detects Sybil node. According to this method Sybil attacks can be detected with a100% true positive with a few positive alerts. However, a Sybil node can transmit message with different identities using different transmission power intensity to defeat this scheme.

**5.4 SOCIAL NETWORKS BASED SYBIL DEFENCE** Several designs of trust model are proposed in social networks by using different form of modified random walk [6]. However surveys the social network based Sybil defences states that Sybil defence methods show poor performances while facing some real−world attacks that exhibit a very primitive structure [7]. They identified two main trends of Sybil defence in social networks. The first is based on random walk methods while the second considers community detection. This paper has also showed how the two approaches can go hand in hand to yield more robust Sybil defence protocols that are competitive with the state of the art.

**5.5 FUZZY MULTI-AGENT SECURITY SYSTEM** Authors proposed a fuzzy multi-agent security system for WSN [8] which can differentiate the trusted agents from the untrusted agents on the basis of fuzzy negotiations among agents present in the network. This system is able to recognize different types of attacks such as worm hole, grey hole and Sybil attack. In this system fuzzy logic is used to assign trust values for nodes and every node in the network is considered as agent.

**5.6 INTRUSION DETECTION TECHNIQUES** A review of intrusion detection and protection mechanisms [10] shows that intruders often find new ways of attack and cause damage to computer systems and networks. According to this paper protection mechanism should learn from experience and use the existing knowledge of attacks to infer and detect new intrusive activities. Since the attacker may try to attack an existing protection scheme the protection mechanisms need to be robust enough to protect them and not to introduce new vulnerabilities into the system. Surveys of different trust management schemes in MANETs [11] showed they are much more challenging than the traditional centralized environments due to changes in topology of MANETs.

**5.7 SYBIL TRACKING PROCEDURES** Researcher also represents [12] a Sybil tracking procedure which detect and isolates Sybil node in a p2p network. It uses the concepts of monitoring peers in the network to detect Sybil.

**5.8 ANN BASED SYBIL DETECTION** Haribabu K et al. proposed [13] a Sybil detection that uses CAPTCHA and ANN in a peer-to-peer system where the neural network is trained by Sybil characteristics. In practical applications it is difficult to fabricate Sybil characteristics in a system. Moreover CAPTCHA behaves as an authentication mechanism which again incurs high overhead.

**5.9 REPUTATION BASED SYSTEM** Another Sybil detection scheme [9] is anticipated in reputation based system that uses a non-monetary entry fee (i.e. fee is used as a form of work imposed on every newcomer) per identity to discourage Sybil attackers without using any costly method. This scheme performed better than CONFIDANT protocol in diving evil throughput and evil nodes' utility in the presence of whitewashing nodes. However, the drawback of this approach is that newcomers are not allowed due to the free identities available in the network.

## 6. ANALYSIS AND DISCUSSION

In the previous sections we discuss different types of Sybil attacks and their defences. In this section we analyse the performance of the Sybil detection techniques so far discussed. Here we have done a comparative study of each process on the basis of detection rate, feasibility and requirements. In fig.8 we see that trusted certification and RSSI based Sybil detection techniques have 100% accuracy. However, table.1 shows that these techniques have limitations in detecting all dimensions of Sybil attack. The neural network based Sybil defences, on the other hand, shows a lower detection rate (fig.8). However the performance of these systems increases with time progression as a result of an improved understanding of the existing network topology. The detection accuracy tends to 95% with time. The social network based Sybil detection schemes show a detection rate of up to 98%. Although these results are quite satisfactory, it becomes easier for a more complicated adversary to break this security system and launch a more severe attack. The fuzzy multi agent security system shows a detection rate of 90% but this value is not accurate as because the fuzzy membership values are not exact values and hence may increase false positive.

Table 1. Comparisons of Sybil detection techniques.

| Sl No. | Sybil Detection Techniques | Disadvantages / Limitations | Application Domain | Detection rate |
|---|---|---|---|---|
| 1 | Trusted Certification | (1) In a large mobile network, the scalability problem slows down the performance bottleneck and increase cost in this approach. | General | 100% |
| | | (2) In ad-hoc networks the local CA server may be multi-hops away from a node and may also move which makes the network complicated and creates problem in tracing a local CA server. | | |
| | | (3) Multi-hop communication over the error-prone wireless channel renders the data transmission to high loss rate. This reduces the success ratio and increases the average service latency | | |
| | | (4) CA is prone to DoS attacks. | | |

| Sl No. | Sybil Detection Techniques | Disadvantages / Limitations | Application Domain | Detection rate |
|---|---|---|---|---|
| 2 | Intrusion Detection | The attacker may try to attack an existing protection scheme. The protection mechanisms need to be robust enough to protect them and not to introduce new vulnerabilities into the system | General | 90 to 95% |
| 3 | Social Network Based Sybil Defences | The social network based Sybil defence methods can perform poorly when confronted with some real world attacks that exhibit a very primitive structure | General | 98% |
| 4 | Fuzzy Multi-Agent Security System | This mechanism may not give accurate result as the membership values are not the exact values and hence the false positive may increase. | Social Network Systems | 90% |
| 5 | Reputation Based Detection System | The drawback of this approach is that newcomers are not welcomed due to the free identities available in the network | General | 95% |
| 6 | ANN based Sybil detection techniques with CAPTCHA. | CAPTCHA behaves as an authentication mechanism which again incurs high overhead. Sybils must behave in a malicious manner to be detected by the proposed approach. If Sybil nodes behave legitimately, they cannot be determined using the given solution | Wireless ad hoc networks | 80% |
| 7 | Received Signal Strength Indicator (RSSI) | (1). signal strength varies with distance in the outdoor environment, but not in the indoor environment.<br>(2) In case of open outdoor field, the strength of the signal becomes weaker as the distance between the sender and the receiver increases.<br>However, in the open hallway signal strength does not change with distance. | Sensor Networks | 100% |
| | | (3) In case of long distance, with a small RSSI, it is easy to be affected by surrounding environment, and the fluctuation becomes greater. | | |
| | | (3) Obstructions affect the signal strength | | |

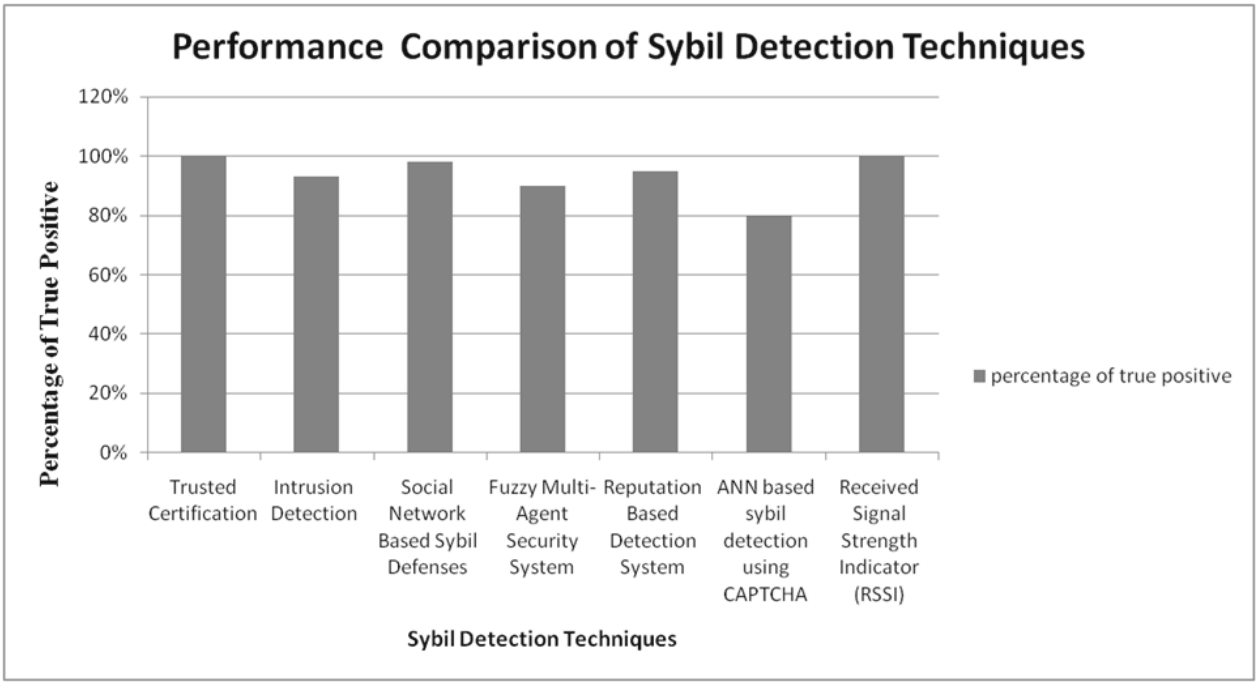


Fig. 8. Performance comparison of mainstream Sybil detection techniques.

## 7. CONCLUSION

From the analysis of Sybil detection techniques so far considered it is observed that in spite of producing high success rate they have a number of limitations. The goal of this paper is to create a scope for the future researchers to propose more improved Sybil detection techniques which can mitigate the real world Sybil attacks in MANET. Each of the defending mechanisms and their limitations will provide the researcher a clear knowledge about what is to be done and what should be eliminated. In future we will extend our study for domain specific Sybil detection technologies such as WSN, VANET and others.

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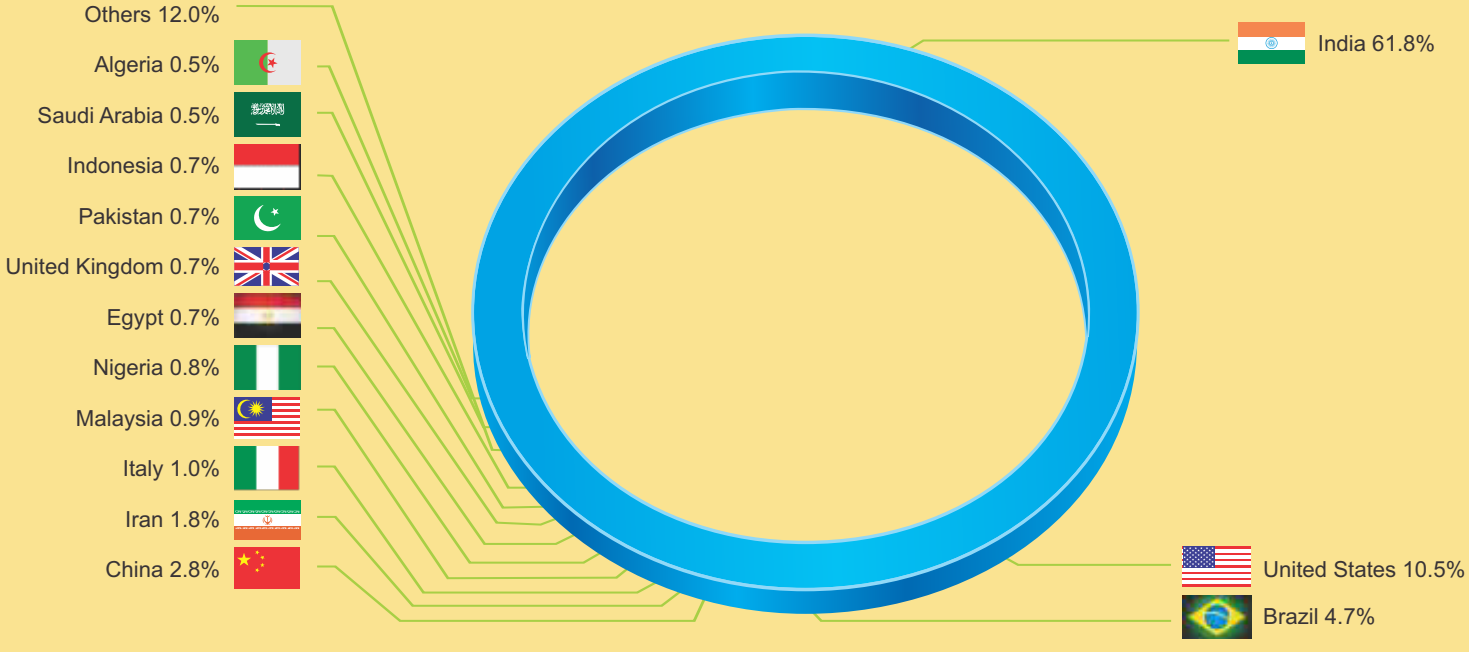


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