HIGH PERFORMANCE ADAPTIVE FIR FILTER SYSTEMS DESIGN BASED ON FPGA ARCHITECTURES USING RLS ALGORITHM

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ABSTRACT

A Filter in its most basic sense is a device that enhances or rejects certain components of a signal. An adaptive filter is a filter that self-adjusts its transfer function according to an optimization algorithm driven by an error signal. The adaptive filter uses feedback in the form of an error signal to refine its transfer function to match the changing parameters. There are several algorithms to achieve the calculation of coefficients in a given system, which vary in complexity. The most common algorithms are LMS and RLS algorithms.

In this project high performance Adaptive FIR filter architecture is designed. In particular, the Recursive Least Square (RLS) algorithm for adaptive signal processing is explored based on QR decomposition, which is accomplished by using the Givens Rotation algorithm, since Rotations are the basic operation in many high performance adaptive filtering schemes as well as many other advanced signal processing algorithms relying on matrix decompositions. The Givens Rotation algorithm is implemented using CORDIC based architecture. This architecture is suitable for high-speed FPGAs or ASIC designs. It also solves the tradeoff between throughput and latency issues. This system identification model is tested and verified using the following 4-tap FIR filter . Error output between the desired signal and the estimated signal is found using Matlab.

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Keywords: RLS , QR Decomposition, Givens Rotation, CORDIC

I. INTRODUCTION

An adaptive filter is a filter that self-adjusts its transfer function according to an optimization algorithm driven by an error signal (Simon Haykin, 1996). Because of the complexity of the optimization algorithms, most adaptive filters are digital filters. By way of contrast, a non-adaptive filter has a static transfer function. Adaptive filters are required for some applications because some parameters of the desired processing operation (for instance, the locations of reflective surfaces in a reverberant space) are not known in advance. The adaptive filter uses feedback in the form of an error signal to refine its transfer function to match the changing parameters.

Adaptive filtering techniques have applications in different fields, such as wireless communication, noise cancelling techniques, channel estimation and medical signal processing. However, the implementation of adaptive filtering is very complex.

The standard RLS algorithm for Adaptive filtering requires a direct matrix inversion operation which may cause numeric stability problems, and QR decomposition with back substitution method is able to solve this issue(J. E.

Volder,1959). QR Decomposition Recursive Least Square (Karkooti et al., 2005) (QRD-RLS) offers the most robust numerical properties and hardware specific accelerator architecture.

Today adaptive systems have found their way into many applications where learning capacity of the system is an important factor. There are several algorithms to achieve the calculation of coefficients in a given system, which vary in complexity. Among the most simple is the Least Mean Square algorithm (LMS). This algorithm is widely used because of its ease of implementation and low utilization of computer resources.

If LMS algorithms represent the simplest and most easily applied adaptive algorithms, the recursive least squares (RLS) algorithms (J. G. McWhirter,1992) represents increased complexity, computational cost, and fidelity. In performance, RLS approaches the Kalman filter in adaptive filtering applications, at somewhat reduced required throughput in the signal processor. Compared to the LMS algorithm, the RLS approach (Aslan S et al.,2012) offers faster convergence and smaller error with respect to the unknown system, at the expense of requiring more computations. In contrast to the least mean squares algorithm, from which it can be derived, the RLS adaptive algorithm minimizes the total square error between the desired signal and the output from the unknown system (Sufeng Niu et al.,2013).

II. QR DECOMPOSITION BASED RLS ALGORITHM

2.1 The Least-Squares Problem

In this chapter, the QR-RLS algorithms based on Givens rotations are presented together with stability considerations. These algorithms are related to the tapped delay line FIR filter realization of the adaptive filter.

The RLS algorithm provides in a recursive way the coefficients of the adaptive filter which lead to the minimization of the following cost function

$$x_D(k) = \sum_{i=0}^{k} \lambda^{k-i} e^2(i) = \sum_{i=0}^{k} [d(i) - w^T x(i)]^2 \quad (1)$$

Where,

$$y(k) = w_0 x(k) + w_0 x(k-1) + \ldots\ldots + w_0 x(k-N)$$

is the input signal vector,

$$w(k) = [w_0(k) w_1(k) \ldots\ldots w_N(k)]^T$$

is the coefficient vector at instant k, $\varepsilon(i)$ is the a posteriori error at instant i, and λ is the forgetting factor.

Forgetting Factor λ , determines how the algorithm treats the value of past inputs. If $\lambda = 1$, all previous error is considered to be of equal weight. As λ reduces the past errors play a smaller role. The parameter λ is an exponential weighting factor that should be chosen in the range.

$$1 - \frac{1}{10L} < \lambda \leq 1 \quad (2)$$

2.2 Rls Algorithm

Error function :

$$x^d(k) = \sum_{i=0}^{k} \lambda^{k-i} e^2(i) = \sum_{i=0}^{k} \lambda^{k-i} [d(i) - x^T(i)w(k)]^2 \quad (3)$$

Input signal vector :

$$X(k) = [x(k) \lambda^{1/2} x(k-1) ..... \lambda^{k/2} x(0)] \quad (4)$$

Coefficient vector:

$$w(k) = [w_0(k) w_1(k) ..... w_N(k)]^T \quad (5)$$

Then,

$$y(k) = X(k)w(k) = \begin{bmatrix} y(k) \\ \lambda^{1/2} y(k-1) \\ . \\ . \\ . \\ \lambda^{k/2} y(0) \end{bmatrix} \quad (6)$$

$$d(k) = \begin{bmatrix} d(k) \\ \lambda^{1/2} d(k-1) \\ . \\ . \\ . \\ \lambda^{k/2} d(0) \end{bmatrix} \text{ and } e(k) = \begin{bmatrix} e(k) \\ \lambda^{1/2} e(k-1) \\ . \\ . \\ . \\ \lambda^{k/2} e(0) \end{bmatrix} = d(k) - y(k) \quad (7)$$

2.1.1 Initialization Process

$$w_i(k) = \frac{-\sum_{j=1}^{i} x(j) w_{i-j}(k) + d(i)}{x(0)} \quad (8)$$

The above equation represents the back-substitution algorithm. During the initialization period, *i.e.*, from k=0 to k=N, the solution of equation can be found.

After the instant k=N, the equation for $w_i(k)$ is no longer valid. The matrix can be triangularized through an orthogonal triangularization approach such as Givens rotations. Since here the interest is to iteratively apply the triangularization procedure to each new data vector added, the Givens rotation seems to be the most appropriate approach.

In the Givens rotation approach, each element of the first line of equation can be eliminated by premultiplying the matrix by a series of Givens rotation matrices given by

$$\tilde{Q}(N+1) = Q'_N(N+1) Q'_{N-1}(N+1) ..... Q'_0(N+1) \quad (9)$$

In this manner, after the last Givens rotation the input signal information matrix will be transformed in a matrix with null first row the resulting equation is given by

$$Q_q(k) \begin{bmatrix} x^T(k) \\ \lambda^{1/2} U(k-1) \end{bmatrix} = Q'_{qN}(k) Q'_{qN-1}(k) ..... Q'_{qi}(k) \begin{bmatrix} x'_i(k) \\ U'_i(k) \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ U(k) \end{bmatrix} \tag{10}$$

Where $Q_{q_i}(k)$ is derived from $Q'_i(k)$ by removing the I_{k-N-1} section of $Q'_i(k)$ along with the corresponding rows and columns.

The updating is performed through below equations

$$d(k) = \begin{bmatrix} e_{q1}(k) \\ d_{q1}(k) \end{bmatrix} = Q_q(k) \begin{bmatrix} d(k) \\ \lambda^{1/2} d_{q2}(k-1) \end{bmatrix} \tag{11}$$

$$= Q'_{q_N}(k) Q'_{q_{N-1}}(k) \ldots\ldots Q'_{q_i}(k) \begin{bmatrix} d'_i(k) \\ d'_{q2i}(k) \end{bmatrix} \tag{12}$$

$$e_q(k) = d_q(k) - \begin{bmatrix} 0 \\ U(k) \end{bmatrix} w(k) \tag{13}$$

Another important relation can be derived from equation

by premultiplying both sides by $Q^T(k)$ transposing the result, and post-multiplying the result by pinning vector,

$$e_q^T(k) Q(k) \begin{bmatrix} 1 \\ 0 \\ \vdots \\ 0 \end{bmatrix} = e^T(k) \begin{bmatrix} 1 \\ 0 \\ \vdots \\ 0 \end{bmatrix} = e(k) \tag{14}$$

Then, from the definition of $Q(k)$ in equations (4.33) and (4.34), the following relation is obtained.

$$e(k) = e_{q1}(k) \prod_{i=0}^{N} \cos\theta_i(k)$$

$$= e_{q1}(k) \gamma(k) \tag{15}$$

This relation shows that the a posteriori output error can be computed without the explicit calculation of $w(k)$. The only information needed is the Givens rotation cosines. In applications where only the a posteriori output error is of interest, the computationally intensive back-substitution algorithm of equation (8) to obtain $w_i(k)$ can be avoided.

Now, all the mathematical background to develop the QR-RLS algorithm has been derived. After initialization, the Givens rotation elements are computed using their rotation cosines. These rotations are then applied to the information matrix and the desired signal vector respectively as indicated in equations (10) and (12). The next step is to compute the error signal using equation (15)

III. GIVENS ROTATION

The orthogonal triangularization process may be carried out using various techniques such as Gram–Schmidt orthogonalization, Householder transformation, or Givens rotations. Particularly, Givens rotations leads to an efficient algorithm whereby the triangularization process is updated recursively.

Considering a two-element vector of the form $[x \quad y]^T$.

Where, $\cos q = \frac{x}{\sqrt{x^2 + y^2}}$ and $\sin q = \frac{y}{\sqrt{x^2 + y^2}}$

The transformation using this matrix results in

$$\tilde{Q}\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \sqrt{x^2 + y^2} \\ 0 \end{bmatrix} \tag{16}$$

The above transformation is said to annihilate y by rotating it into x. This transformation is known as Givens rotation .The variable q is known as the angle of rotation

Similarly For i^{th} term in the algorithm Therefore

$$\tilde{Q}_i(k) = Q'_N(k).....Q'_1(k)Q'_0(k) \tag{17}$$

IV. CORDIC ALGORITHM

The CORDIC (COordinate Rotation DIgital Computer) algorithm is an iterative technique and consists of two modes of operation called rotation mode and vectoring mode. In the rotation mode, the co-ordinate components of a vector and an angle of rotation are given and the co-ordinate components of the original vector, after rotation through the given angle are computed. In the vectoring mode, the co-ordinate components of a vector are given and the magnitude and angular argument of the original vector are computed.

CORDIC, also known as the digit-by-digit method and Volder's algorithm, is a simple and efficient algorithm to calculate hyperbolic and trigonometric functions. It is commonly used when no hardware multiplier is available (e.g., simple microcontrollers and FPGAs) as the only operations it requires are addition, subtraction, bit shift and table lookup.

4.1 Applications

CORDIC uses simple shift-add operations for several computing tasks such as the calculation of trigonometric, hyperbolic and logarithmic functions, real and complex multiplications, division, square-root calculation, solution of linear systems, eigen value estimation, singular value decomposition, QR factorization and many others. As a consequence, CORDIC has been utilized for applications in diverse areas such as signal and image processing, communication systems, robotics and 3-D graphics apart from general scientific and technical computation.

4.2 Mathematical Basis of the algorithm

Vector rotation is the first step to obtain the trigonometric functions. It can also be used for polar to rectangular and rectangular to polar conversions, for vector magnitude ,and as a building block in certain transforms such as the DFT and DCT. The aim of the Algorithm is to compute the Sine and Cosine of a given angle, which we will call q (Theta). Suppose that we have a point on a unit circle, which may be illustrated as follows:

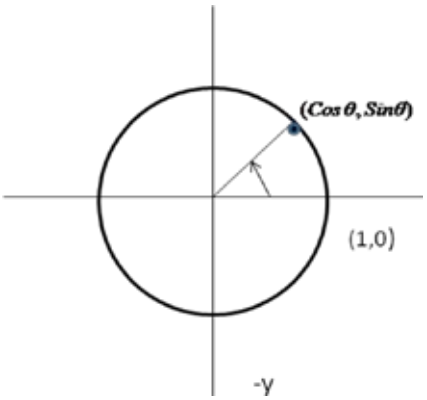

Fig 1 A point on the unit circle rotated by an angle θ

The point on the unit circle that has a rotation of θ has co-ordinates of (Cos θ, Sin θ). This implies that if a point on the x-axis is rotated by an angle θ then the Sine and Cosine of the angle of rotation may be read directly off the x and y axes. The rotation may be achieved by rotating the point on the unit circle in a series of steps, which are smaller than θ. In addition these steps may be either in an anti-clockwise direction (increase in θ) or in a clockwise direction (decrease in θ).

The co-ordinates of a point in a two dimensional space may be represented as a vector. If the coordinates of the point are (x, y) then the point may be equally well represented as (x, y)' where the inverted comma indicates a matrix transpose function. The rotation of a point in two dimensional space may be effected by multiplying the co-ordinates of that point by a rotation matrix. Thus:

$$\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x' \\ y' \end{bmatrix} \quad (18)$$

Where (x', y') are the co-ordinates of (x,y) rotated by an angle of θ .This matrix operation may be expressed as follows:

$$\begin{aligned} x' &= x\cos\theta - y\sin\theta \\ y' &= y\cos\theta + x\sin\theta \end{aligned} \quad (19)$$

For CORDIC, the final angle θ_n the angle whose sine or cosine we want to calculate and initial angle θ_1 is set to a convenient value such as 0. Rather than rotating from θ_1 to θ_n in one full sweep, we move in steps with careful choice of step values. Rearranging (3) gives us:

$$\begin{aligned} x' &= \cos\theta[x - y\tan\theta] \\ y' &= \cos\theta[y + x\tan\theta] \end{aligned} \quad (20)$$

By restricting the rotation angles such that $\tan(\theta) = \pm 2^{-i}$, the multiplication by the tangent term is reduced to simple shift operation. Arbitrary angles of rotation are obtainable by performing a series of successively smaller elementary rotations. If the rotation at each iteration, i, is the direction to rotate rather than whether or not to rotate, then the $\cos(\theta_i)$ term becomes a constant (because of $\cos(\theta_i) = \cos(-\theta_i)$). The iterative rotation can now be expressed as:

$$x_{i+1} = K_i\left[x_i - y_i * d_i * 2^{-i}\right]$$
$$y_{i+1} = K_i\left[y_i + x_i * d_i * 2^{-i}\right] \quad (21)$$

Where,

$$K_i = \cos(\tan^{-1} 2^{-i}) = 1/\left(\sqrt{1+2^{-i}}\right)$$
$$d_i = \pm 1$$

Removing the scale constant from the iterative equations yields a shift-add algorithm for vector rotation. The product of the $K_i's$ can be applied elsewhere in the system or treated as a part of a system processing gain. That product approaches 0.6073 as the number of iterations goes to infinity. Therefore rotation algorithm has a gain, A_n of approximately 1.647. The exact gain depends on the number of iterations, and obeys the relation.

$$A_n = \tilde{O}\sqrt{1+2^{-i}} \quad (22)$$

The angle of a composite rotation is uniquely defined by the sequence of the directions of the elementary rotations. That sequence can be represented by a decision vector. The set of all possible decision vectors is an angular measurement system based on binary arctangents. Conversions between this angular system and any other can be easily accomplished using a LUT. A better conversion method uses an additional adder-subtractor that accumulates the elementary rotation angles post iteration. The angle accumulator adds a third difference equation to the CORDIC algorithm:

$$z_{i+1} = z_i - d_i * \tan^{-1}(2^{-1}) \quad (23)$$

when the angle is in the arctangent base, this extra element is not needed.

4.3 Pre-computation of $\tan(a_i)$

Finding a_i such that $\tan(a_i) = 2^{-1}$: (or, $a_i = \tan^{-1}(2^{-1})$)

TABLE I- Pre-computation of $\tan(a_i)$

i	a_i	$Tan(a_i)$	
0	45.0^0	1	$=2^{-0}$
1	26.6^0	0.5	$=2^{-1}$
2	14.0^0	0.25	$=2^{-2}$
3	7.1^0	0.125	$=2^{-3}$
4	3.6^0	0.0625	$=2^{-4}$
5	1.8^0	0.03125	$=2^{-5}$
6	0.9^0	0.015625	$=2^{-6}$
7	0.4^0	0.0078125	$=2^{-7}$

8	0.2^0	0.00390625	$= 2^{-8}$
9	0.1^0	0.001953125	$= 2^{-9}$

The CORDIC algorithm as defined will only converge (work) across a limited range of input values. For circular configurations of CORDIC algorithms, convergence is guaranteed for the angles below the sum of the angles in the lookup table – that is, between –99.7 and 99.7 degrees.

V. EXPERIMENTS AND RESULTS

5.1 RTL Schematic and simulation of Fir Filter

Xilinx ISE 14.3 software was chosen to design the Filter blocks used in the Filter design used in Matlab Simulink model .The ISim P.40xd function simulation is used to verify the functionality correctness of the design.

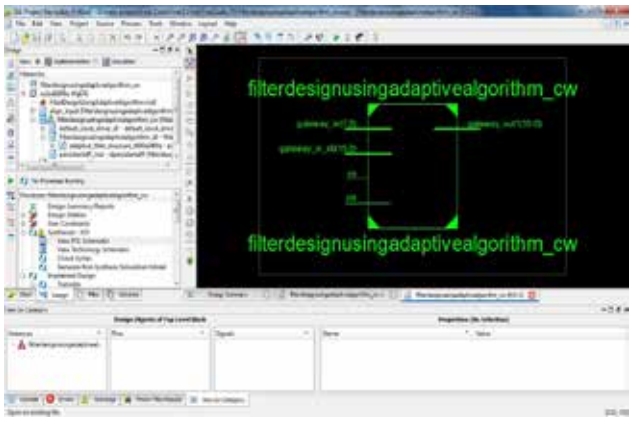

Fig 2 RTL Schematic of FIR Filter

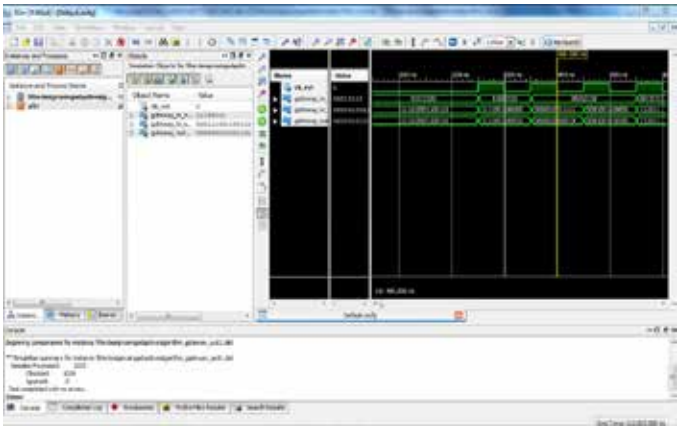

Fig 3 Simulation results for CORDIC based FILTER

The simulation results shows 1025 bit patters generated from the Uniform Random number Generator tool from Matlab for generating bit patterns, and the input and the output bit patterns.

Xilinx ISE 14.3 is used to design the filter blocks used in the filter and Matlab Simulink tools are used for filter design. System Generator enables the use of Simulink for designing designs.

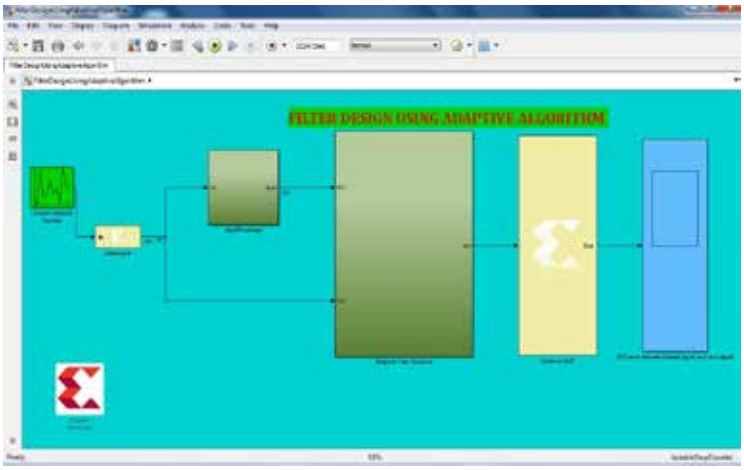

Fig 4 Adaptive filter design

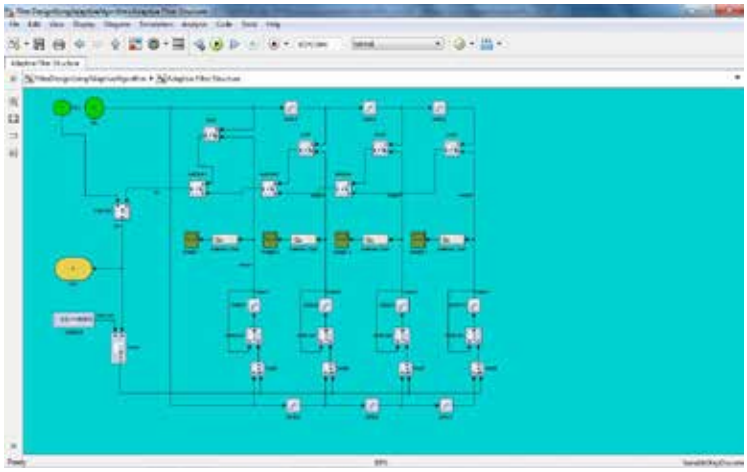

Fig 5 Adaptive filter structure

The Simulink Model is built using Matlab R2012b, Fig 5.1 shows the filter design using Matlab Simulink model and Fig 5.2 shows the Adaptive filter structure of the Filter design.

The filter weights adapted by the algorithm is as shown for the 4-tap filter

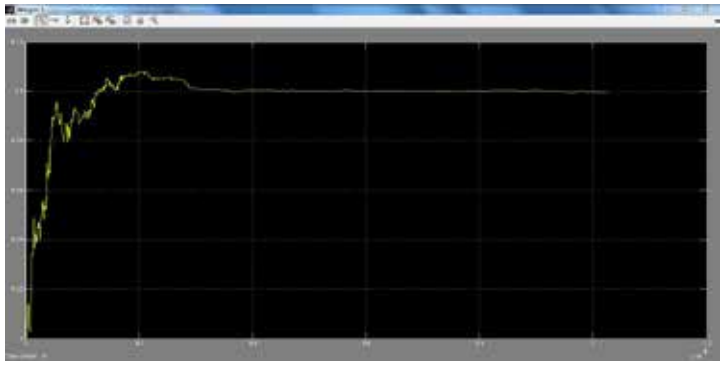

Fig 6 Filter weight 1

Fig 7 Filter weight 2

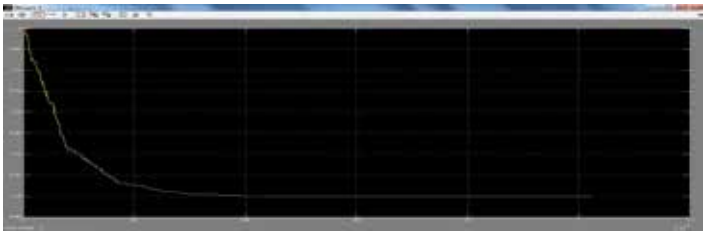

Fig 8 Filter weight 3

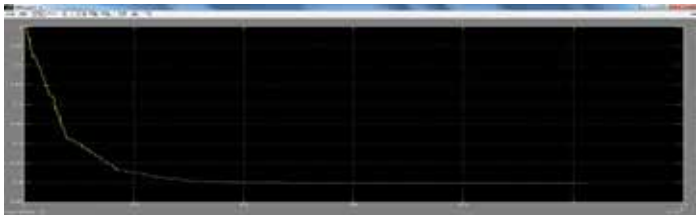

Fig 9 Filter weight 4

5.2 ERROR ANALYSIS

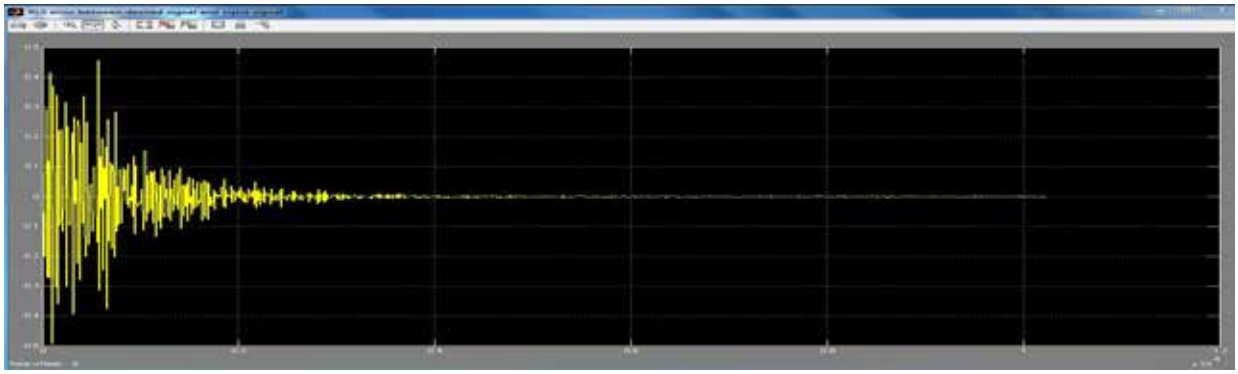

Fig 10 RLS Error between desired and input signal

The graph shows the error getting reduced with the adaptive filter, the error values peaks initially and later it reduces by proper use of weights and the adaptive algorithm.

VI. CONCLUSION AND FUTURE WORK

An Adaptive FIR filter architecture is designed using Matlab tool where the Recursive Least Square (RLS) algorithm for adaptive signal processing is done based on QR decomposition which is accomplished by using the Givens Rotation algorithm. These rotations are the basic operation in many high performance adaptive filtering schemes as well as many other advanced signal processing algorithms relying on matrix decompositions. The Givens Rotation algorithm is implemented using CORDIC based architectures, these architectures are suitable for high-speed FPGAs or ASIC designs.

Xilinx ISE 14.3 is used to design the Filter blocks used in the Filter design which is used in Matlab Simulink model. The simulation results are shown in the Fig 2 and 3. The simulink model is tested with input samples generated from the Matlab Uniform Random Number generator block from the design. A total of 1025 number of samples are generated for testing the adaptive algorithm. The error analysis shows the error value peaks initially and later it reduces by proper weight adaptation by the adaptive algorithm.

The implementation of CORDIC algorithm for adaptive signal processing can be done using pipelined Coordinate Rotation Digital Computer (CORDIC) unit and pipelined multiplier to get high system throughput in each of the pipelined stage. Also FIR filters have higher orders than IIR filters, hence number of coefficients increases and hence require larger processing time, this time can be reduced by using FFT algorithms.

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QUANTITATIVE STRUCTURE–ACTIVITY RELATIONSHIP MODELING OF BIOCONCENTRATION FACTORS OF POLYCHLORINATED BIPHENYLS

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ABSTRACT

Polychlorinated biphenyls (PCB) are now of concern as prevalent, persistent, and toxic pollutants. PCB contamination of water and soil and bioaccumulated in food chains due to their high hydrophobicity and chemical stability. PCB `s are chemicals that persist for a very long time in the environment and consequently may concentrate to a high level (10^6) in the food chain. They may also cause toxic effects on the animal and human reproduction, development and immunological function. That's why it is essential to determine the value of BCF for 58 PCB`s. The bioconcentration factors (BCFs) of 58 polychlorinated biphenyl (PCB) congeners were modeled by quantitative structure–activity relationship (QSAR) based on physicochemical & topological descriptors derived solely from molecular structure and calculated using Chem Sketch 12.0 & Dragon 6.0 software to calculate all kinds of descriptors. Descriptors utilized for the general model were selected by various statistical validation techniques. Multilinear models were developed using the best Multiple linear regression analysis (MLRA) followed by statistical evaluation by SPSS software (IBM) to corelate experimental BCF to a set of molecular descriptors. The proposed parameter model satisfactorily describes the relationship between observed and calculated values in terms of statistical parameters. Comparison with Alan R. Katritzky et al in their result have reported R^2 for best parameteric modeling is as R^2=0.931. We have observed that in our case R^2 for models with one, two, three, four five and six molecular descriptors are 0.8444, 0.9108, 0.9242, 0.9389, 0.9484 and 0.9503 Our results are much more superior then the result reported by Alan R. Katritzky et al. Therefore simple 2D QSAR reported by us is much betters then the 3D QSAR modeling of Alan R. Katritzky et al.

Keywords: Bioconcentration Factors (BCF) ; Multiple Linear Regression Analysis (MLRA) ; Polychlorinated Biphenyls (PCB); Quantitative Structure Activity Relationship (QSAR) ; SPSS.

I. INTRODUCTION

Polychlorinated biphenyls (PCB) formerly widely used industrially as dielectric fluids in transformers and capacitors, as hydraulic and heat transfer fluids, and as plasticizers, are now of concern as prevalent, persistent, and toxic pollutants.[1-2] Bioaccumulation of chemicals is quantitatively expressed in terms of BCF, defined as the equilibrium of its concentration inside an organism (or in a certain tissue of the organism, usually in the fat) to that in the ambient environment.[3] The concentrations in tissues and in the environment are measured at

steady-state after chronic exposure. However, the real test period may be too short to achieve steady-state. In addition, metabolism and chemical degradation may occur and large molecules may not permeate sufficiently through membranes into the organism, often lowering BCF values. Thus, experimental determination of BCF may underestimate the environmental risk.[4].The measured value of BCF should be strongly related to the high complexity of bioaccumulation process, taking into account such factors as metabolism, organ-specific bio concentration, irreversible binding onto proteins, incomplete depuration, and kinetic effects.[5] Bioaccumulation is a thermodynamically driven partitioning process between aquatic environment and the lipid tissues of fish, thus, n-octanol is often a satisfactory surrogate for biological lipids.[6] As demonstrated earlier, it is important to know the BCF of all PCB congeners. The literature data on experimental BCF of PCB are limited and their measurement is difficult and expensive. Thus, quantitative structure-property relationship (QSPR) methods based on the descriptors derived directly from the molecular structure are vital to supply the missing data independently of experimentation. The BCF of a chemical is most commonly estimated from established correlations between logBCF and logKOW[7-8]. molecular connectivity indices and polarity correction factors[9], theoretical molecular descriptors[10-11], and molecular electro negativity distance vector. The QSPR model development techniques utilized included genetic algorithms and artificial neural networks[12], fragment constant method[13] the heuristic method and support vector machine.[14] The present study was devoted to determining the bioaccumulation process (in terms of BCF) of 58 PCB congeners by means of multilinear QSAR approach in attempt to construct a statistically significant model. The main focus is on the selection of appropriate descriptors and investigation of how those selected descriptors are in fact related to the studied property elucidating the physical nature of the bioaccumulation phenomenon.

II. MATERIALS AND METHODS

2.1. Data Set

All data of the present investigation were obtained from the reference *(* Alan R. Katritzky *et al)*. The data set for this investigation consisted of 58 PCBs.The geometry of biphenyl template is depicted along with atom numbering (Fig. 1).

2.2. Molecular Descriptor Generation

To obtain a QSAR model, compounds are often represented by the molecular descriptors. The calculation process of the molecular descriptors was described as below: The two-dimensional molecular structures of 58 PCBs were drawn by Chem Sketch 12.0 then calculated some parameters. Then optimize molecular structure this optimize structure files were exported into software Dragon 6.0 to calculate all kinds of descriptors. The software Dragon 6.0 can calculate Physicochemical parameters, constitutional, topological, geometrical, descriptors and has been successfully used in various QSAR researches.Then value of all parameters put into SPSS statistical and data analysis software or NCSS (We can also use MSTAT instead of SPSS & NCSS) statistical and data analysis software to get data regression and correlation. Constitutional descriptors are related to the number of atoms and bonds in each molecule. Topological descriptors include valence and non-valence molecular connectivity indices calculated from the hydrogen-suppressed formula of the molecule, encoding information about the size, composition, and the degree of branching of a molecule. The topological descriptors

describe the atomic connectivity in the molecule. The geometrical descriptors describe the size of the molecule and require 3Dcoordinates of the atoms in the given molecule. The electrostatic descriptors reflect characteristics of the charge distribution of the molecule. The quantum chemical descriptors offer information about binding and formation energies, partial atom charge, dipole moment, and molecular orbital energy levels etc.

III. RESULTS AND DISCUSSION

By using the multiple linear regression analysis (MLRA) method of 2D-QSAR, regression models were developed for 58 PCBs. To select the sets of descriptors that are most relevant to logKBCF values and effectively show the relation between descriptors and logKBCF values of these compounds, six subsets with the descriptors from one to six were determined to establish the QSAR models. The initial decision concerning the optimal number of parameters describing the LogBCF of the PCB for the current set of structures was based on the application of the so-called breaking point criterion (Katritzky et al., 2006). An increase of the R^2 value less than 0.02 was chosen as a threshold. Multi-linear regression method for descriptor selection proceeds with a reselections of descriptors by sequentially eliminating descriptors which do not match any of the following criteria: (i) the F-test greater than one unit; (ii) R^2 value less than a value defined at the start (default 0.01); (iii) the student's t-test less than that defined (default 0.1); and (iv) duplicate descriptors having a higher squared inter-correlation coefficient than a predetermined level (usually 0.8). The next step involves correlation of the given property with (i) the top descriptor in the above list with each of the remaining descriptors, and (ii) the next one with each of the remaining descriptors, etc. The goodness of the correlation is tested by the correlation coefficient (R^2) and The stability of the correlations was tested against the cross-validated coefficient (R^2CV). Descriptors assigned a lower index number have a higher *t*-test value i.e. they are of higher significance in the derived model. Besides, it will demonstrate which descriptors have bad or missing values, which descriptors are insignificant, and which descriptors are highly intercorelated .This information will be helpful in reducing the number of descriptors involved in the search for the best QSAR/QSPR model. The statistical parameters of the derived model are as follows: (N= 58, Se=0.0420, R^2=0.9503, R^2A=0.9444, F-Ratio=162.4790, Q=23.2103) where R^2 is the squared correlation coefficient, N is the number of data points. Comparison to other models indicated advantages of the proposed model over previously reported ones. Derived parameter regression equation has improved statistics and is based on theoretical descriptors with a definite physicochemical meaning; it is easier to use and interpret due to the mathematical simplicity of the linear QSAR approach. Internal validation and scrambling procedure confirmed the stability and reliable predictive ability of the general model and indicated the absence of chance correlations. External validation demonstrated that the presented model can be applied to structurally similar sets of compounds, thus extending the domain of applicability of the model. A plot representing the observed vs predicted LogBCF values is given in Figure 2. Comparison with Alan R. Katritzky *et al* in their result have reported R^2 for best parameteric modeling is as R^2=0.931. We have observed that in our case R^2 for models with one, two, three, four five and six molecular descriptors are 0.8444, 0.9108, 0.9242, 0.9389, 0.9484 and 0.9503 Our results are much more superior then the result reported by Alan R. Katritzky *et al*. Therefore simple 2D QSAR reported by us is much betters then the 3D QSAR modeling of Alan R. Katritzky *et al*.The data was subjected to regression analysis and the result obtained is discussed below.

3.1 Best Mono-Parametric Model

When topological indices were taken as independent parameter then we found that no single parameter is applicable is obtaining statistically significant mono-parametric model. The one which is the best model contain 2χ having R^2 value 0.8444. The model is as given below.

LogBCFexp= 0.7545(±0.0433)2χ -0.6967

N= 58, Se=0.0708, R^2=0.8444, F-Ratio=303.9296, Q=12.9789

3.2 Best Bi-Parametric Model

Many bi-parametric models have been obtained. The best model contains the R^2 value of two models with BAC and 0χ and BAC with 0χv has a similar value 0.9108. The model is as given below.

LogBCFexp=-0.0483(±0.0063)BAC 0.8016(±0.0611)0χ -3.2294

N= 58, Se=0.0541, R^2=0.9108, R^2A=0.9076, F-Ratio=280.9630,Q=17.6406

In above model the BAC have negative coefficient and 0χv has positive coefficient suggesting that the compound having high value of 0χv and low value of BAC will favor LogBCFexp activity.

3.3 Best Tri Parametric Model

When three parameters are taken together five tri- parametric models have been obtained. The best tri-parametric model contains BAC, 2χ, 3χv. The R^2 value of best model is 0.9242. The model is given below.

LogBCFexp=-0.0514(±0.0070)BAC 1.0786(±0.1117)2χ, 0.6405(±0.1519)3χv -4.1838

N= 58, Se=0.0504, R^2=0.9242, R^2A=0.9200, F-Ratio=219.3830, Q=19.0744

In above model the BAC have negative coefficient and 2χ and 3χ have positive coefficient suggesting that the compound having high value of 2χ and 3χv and low value of BAC will favor LogBCFexp activity.

3.4 Best Tetra-Parametric Model

When four parameters are taken together five tatra- parametric models have been obtained. The best tetra-parametric model contains W, J, Jhetz and 0χv. The R^2 value of best model is 0.9389. The model is given below.

LogBCFexp=-0.0453(±0.0064)W 93.1302(±20.1162)J, -60.4452(±12.4157)Jhetz 5.0308(±0.7117)0χv -26.7280

N= 58, Se=0.0457, R^2=0.9389, R^2A=0.9342, F-Ratio=202.4640, Q=21.2028

In above model the W and Jhetz have negative coefficient and J and 0χv have positive coefficient suggesting that the compound having high value of J and 0χv and low value of W and Jhetz will favor LogBCFexp activity.

3.5 Best Penta Parametric Model

When five parameters are taken together five penta- parametric models have been obtained. The best penta-parametric model contains W, J, Jhetz, 2χand 3χv.The R^2 value ranging from 0.9460 to 0.9484. The R^2 value of best model is 0.9484. The model is given below.

LogBCFexp= -0.0360(±0.0044)W 71.7677(±15.2845)J, -44.4263(±9.0550)Jhetz 5.5883(±0.6915)2χ 2.3125(±0.2994)3χv -30.5554

N= 58, Se=0.0423, R^2=0.9484, R^2A=0.9434, F-Ratio=191.0870, Q=23.0226

In above model the W and Jhetz have negative coefficient and J , 2χ and 3χv have positive coefficient suggesting that the compound having high value of J , 2χ and 3χv and low value of W and Jhetz will favor LogBCFexp activity.

3.6 Best hexa Parametric Model

When six parameters are taken together two hexa- parametric models have been obtained. The best tetra-parametric model contains W, J, Jhetz, Jhetm, 2χ and 3χv. The R^2 value of best model is 0.9503. The model is given below.

LogBCFexp= -0.0358(±0.0044)W 78.1359(±15.8176)J, -144.3091(±72.0558)Jhet 95.6271(±68.4487)Jhetm 5.5205(±0.6870)2χ 2.3110(±0.2967)3χv -30.2199

N= 58, Se=0.0420, R^2=0.9503, R^2A=0.9444, F-Ratio=162.4790, Q=23.2103

In above model the W and Jhetz have negative coefficient and J , Jhetm, 2χ and 3χv have positive coefficient suggesting that the compound having high value of J , Jhetm, 2χ and 3χv and low value of W and Jhetz will favor LogBCFexp activity.

IV. CONCLUSION

The relationship of the BCF to molecular structure of 58 PCB congeners was investigated using molecular descriptors calculated by Chem Sketch 12.0 & Dragon 6.0 software to calculate all kinds of descriptors. Multiple linear regression analysis (MLRA) followed by statistical evaluation by SPSS software (IBM) software we can also use MSTAT & NCSS instead of SPSS. The 6-parameter regression equation provided insight into the structural features that influence BCF. In above best hexa parameteric model the W and Jhetz have negative coefficient and J , Jhetm, 2χ and 3χv have positive coefficient suggesting that the compound having high value of J , Jhetm, 2χ and 3χv and low value of W and Jhetz will favor LogBCFexp activity. The stability of the model was demonstrated by applying internal validation techniques. By comparison to other reported models, it was demonstrated that QSAR models utilizing descriptors of topological can be advantageously used for modeling of BCF of PCB. The ability of the proposed model to predict accurately BCF of structurally similar to PCB compounds was also demonstrated.

IV.1 CO-RELTION

(1.) The LogBFCexp has moderate correlation with Balaban and Balaban type's indices and good correlation with Randic and Kier and Hall connectivity indices.

(2.) 0χ, 0χv, and 1χv has very good correlation with all topological indices.

(3.) Balaban and Balaban type's indices have a very good correlation among themselves and with topological indices.

(4.) 0χ has 100 % correlation with 0χv and 1χv and very good correlation with all the indices used.

(5.) All the Randic and Kier Hall connectivity indices has good correlation among themselves and with all the others parameters used.

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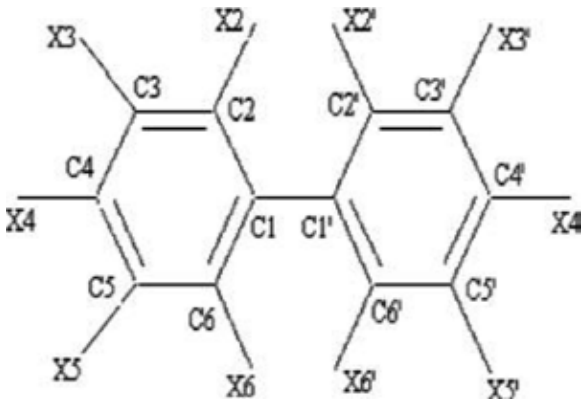

Fig.1 Geometry of biphenyl template with atom numbering

Table-1 Details of compounds with their activity used in the present study.

S.N.	COMPOUND NAME	LogBCFexp
1	Biphenyl	2.64
2	Biphenyl, 4-chloro-	2.77
3	Biphenyl, 2,2'-dichloro-	3.38
4	Biphenyl, 2,3-dichloro-	4.11
5	Biphenyl, 2,3'-dichloro-	3.80
6	Biphenyl, 2,4-dichloro-	3.55
7	Biphenyl, 2,4'-dichloro-	3.57
8	Biphenyl, 2,5-dichloro-	3.89
9	Biphenyl, 3,5-dichloro-	3.78
10	Biphenyl, 4,4'-dichloro-	3.28
11	Biphenyl, 2,2',5-trichloro-	4.11
12	Biphenyl, 2,4,4'-trichloro-	4.20
13	Biphenyl, 2,4,5-trichloro-	4.26
14	Biphenyl, 2,4',5-trichloro-	4.23
15	Biphenyl, 2,2',3,3'-tetrachloro-	4.23
16	Biphenyl, 2,2',3,5'-tetrachloro-	4.84
17	Biphenyl, 2,2',4,4'-tetrachloro-	4.85
18	Biphenyl, 2,2',4,5-tetrachloro-	5.00
19	Biphenyl, 2,2',4,5'-tetrachloro-	4.84
20	Biphenyl, 2,2',5,5'-tetrachloro-	4.63
21	Biphenyl, 2,2',6,6'-tetrachloro-	3.85
22	Biphenyl, 2,3,4',6-tetrachloro-	4.60
23	Biphenyl, 2,3',4',5-tetrachloro-	4.77
24	Biphenyl, 3,3',4,4'-tetrachloro-	4.59
25	Biphenyl, 2,2',3,4,5'-pentachloro-	5.38
26	Biphenyl, 2,2',3,4',5-pentachloro-	5.00
27	Biphenyl, 2,2',3',4,5-pentachloro-	5.43
28	Biphenyl, 2,2',4,4',5-pentachloro-	5.00
29	Biphenyl, 2,2',4,5,5'-pentachloro-	5.40
30	Biphenyl, 2,3,3',4,4'-pentachloro-	5.00
31	Biphenyl, 2,3,3',4,6-pentachloro-	5.00
32	Biphenyl, 2,3',4,4',5-pentachloro-	5.00
33	Biphenyl, 3,3',4,4',5-pentachloro-	5.81
34	Biphenyl, 2,2',3,3',4,4'-hexachloro-	5.77
35	Biphenyl, 2,2',3,3',6,6'-hexachloro-	5.43
36	Biphenyl, 2,2',3,4,4',5-hexachloro-	5.88
37	Biphenyl, 2,2',3,4,4',5'-hexachloro-	5.39
38	Biphenyl, 2,2',3,4,5,5'-hexachloro-	5.81
39	Biphenyl, 2,2',3,4',5,6'-hexachloro-	5.39
40	Biphenyl, 2,2',3,5,5',6-hexachloro-	5.54
41	Biphenyl, 2,2',4,4',5,5'-hexachloro-	5.65
42	Biphenyl, 2,2',4,4',6,6'-hexachloro-	4.93
43	Biphenyl, 2,3,3',4,4',5-hexachloro-	5.39
44	Biphenyl, 2,3,3',4,4',5'-hexachloro-	5.39
45	Biphenyl, 3,3',4,4',5,5'-hexachloro-	5.97
46	Biphenyl, 2,2',3,3',4,5,6'-heptachloro-	5.80
47	Biphenyl, 2,2',3,4,4',5,5'-heptachloro-	5.80
48	Biphenyl, 2,2',3,4,4',5,6'-heptachloro-	5.80
49	Biphenyl, 2,2',3,4,4',5',6-heptachloro-	5.84
50	Biphenyl, 2,2',3,4',5,5',6-heptachloro-	5.80
51	Biphenyl, 2,3,3',4,4',5',6-heptachloro-	5.84
52	Biphenyl, 2,2',3,3',4,4',5,5'-octachloro-	5.81
53	Biphenyl, 2,2',3,3',4,4',5,6-octachloro-	5.92
54	Biphenyl, 2,2',3,3',4,4',5,6'-octachloro-	5.92
55	Biphenyl, 2,2',3,3',4,5,5',6-octachloro-	5.88

56	Biphenyl, 2,2',3,3',5,5',6,6'-octachloro-	5.82
57	Biphenyl, 2,2',3,3',4,5,5',6,6'-nonachloro-	5.71
58	Decachlorobiphenyl	5.44

Table-2 Values of calculated topological parameters for the compounds used in the present study.

Comp.no.	W	J	JhetZ	Jhetm	Jhetv	Jhete	Jhetp	BAC
1	198.0000	1.8000	2.7000	2.7000	2.7000	2.7000	2.7000	0.0000
2	252.0000	1.7890	2.7280	2.7300	2.6400	2.6680	2.6650	2.0000
3	287.0000	1.9630	3.0470	3.0520	2.8470	2.9070	2.9020	5.0000
4	291.0000	1.9330	2.9990	3.0040	2.8050	2.8640	2.8590	5.0000
5	294.0000	1.9110	2.9610	2.9650	2.7760	2.8320	2.8270	5.0000
6	298.0000	1.8880	2.9250	2.9290	2.7430	2.7990	2.7940	5.0000
7	301.0000	1.8670	2.8890	2.8930	2.7150	2.7680	2.7640	5.0000
8	293.0000	1.9210	2.9770	2.9820	2.7890	2.8460	2.8410	5.0000
9	298.0000	1.8820	2.9140	2.9180	2.7350	2.7900	2.7850	5.0000
10	315.0000	1.7800	2.7460	2.7500	2.5950	2.6420	2.6380	5.0000
11	346.0000	1.9940	3.1300	3.1370	2.8610	2.9420	2.9350	10.0000
12	368.0000	1.8720	2.9250	2.9310	2.6960	2.7650	2.7590	10.0000
13	354.0000	1.9470	3.0530	3.0590	2.7960	2.8730	2.8670	10.0000
14	362.0000	1.9030	2.9760	2.9820	2.7380	2.8100	2.8040	10.0000
15	408.0000	2.0420	3.2370	3.2450	2.9020	3.0010	2.9930	17.0000
16	410.0000	2.0330	3.2210	3.2290	2.8910	2.9890	2.9800	17.0000
17	426.0000	1.9580	3.0930	3.1010	2.7910	2.8810	2.8730	17.0000
18	414.0000	2.0140	3.1880	3.1970	2.8650	2.9610	2.9530	17.0000
19	419.0000	1.9910	3.1480	3.1560	2.8350	2.9280	2.9200	17.0000
20	412.0000	2.0240	3.2050	3.2130	2.8800	2.9760	2.9680	17.0000
21	394.0000	2.1250	3.3790	3.3880	3.0110	3.1190	3.1100	17.0000
22	418.0000	1.9980	3.1610	3.1690	2.8440	2.9380	2.9300	17.0000
23	426.0000	1.9520	3.0810	3.0890	2.7840	2.8720	2.8650	17.0000
24	440.0000	1.8840	2.9670	2.9740	2.6940	2.7760	2.7690	17.0000
25	486.0000	2.0500	3.2690	3.2780	2.8960	3.0050	2.9960	26.0000
26	488.0000	2.0420	3.2560	3.2650	2.8860	2.9950	2.9860	26.0000
27	486.0000	2.0490	3.2670	3.2760	2.8940	3.0040	2.9940	26.0000
28	496.0000	2.0090	3.1980	3.2070	2.8420	2.9470	2.9380	26.0000
29	488.0000	2.0410	3.2540	3.2630	2.8850	2.9940	2.9840	26.0000
30	502.0000	1.9790	3.1470	3.1560	2.8030	2.9050	2.8960	26.0000
31	482.0000	2.0700	3.3050	3.3150	2.9210	3.0340	3.0240	26.0000
32	504.0000	1.9710	3.1330	3.1420	2.7940	2.8940	2.8850	26.0000
33	510.0000	1.9430	3.0840	3.0930	2.7560	2.8530	2.8450	26.0000
34	569.0000	2.0690	3.3180	3.3290	2.9080	3.0280	3.0170	37.0000
35	537.0000	2.2020	3.5510	3.5640	3.0800	3.2160	3.2050	37.0000
36	568.0000	2.0750	3.3290	3.3400	2.9160	3.0360	3.0260	37.0000
37	571.0000	2.0620	3.3050	3.3160	2.9000	3.0180	3.0080	37.0000
38	559.0000	2.1080	3.3860	3.3970	2.9590	3.0830	3.0720	37.0000
39	555.0000	2.1270	3.4190	3.4310	2.9840	3.1100	3.0990	37.0000
40	545.0000	2.1680	3.4910	3.5030	3.0360	3.1680	3.1570	37.0000
41	573.0000	2.0550	3.2930	3.3030	2.8910	3.0080	2.9980	37.0000
42	555.0000	2.1320	3.4280	3.4400	2.9890	3.1160	3.1060	37.0000
43	577.0000	2.0380	3.2640	3.2740	2.8680	2.9840	2.9740	37.0000
44	578.0000	2.0320	3.2520	3.2620	2.8600	2.9750	2.9650	37.0000
45	587.0000	1.9960	3.1890	3.1990	2.8140	2.9240	2.9150	37.0000

46	632.0000	2.1870	3.5380	3.5510	3.0510	3.1910	3.1790	50.0000
47	652.0000	2.1170	3.4130	3.4250	2.9610	3.0920	3.0810	50.0000
48	642.0000	2.1540	3.4790	3.4920	3.0080	3.1440	3.1330	50.0000
49	644.0000	2.1480	3.4680	3.4800	3.0000	3.1350	3.1240	50.0000
50	636.0000	2.1750	3.5160	3.5290	3.0360	3.1740	3.1630	50.0000
51	652.0000	2.1160	3.4120	3.4230	2.9600	3.0910	3.0800	50.0000
52	738.0000	2.1730	3.5210	3.5340	3.0250	3.1680	3.1560	65.0000
43	726.0000	2.2150	3.5970	3.6110	3.0780	3.2270	3.2140	65.0000
54	729.0000	2.2040	3.5780	3.5910	3.0650	3.2120	3.2000	65.0000
55	717.0000	2.2430	3.6470	3.6610	3.1140	3.2670	3.2540	65.0000
56	702.0000	2.2950	3.7390	3.7540	3.1800	3.3390	3.3260	65.0000
57	800.0000	2.3230	3.7980	3.8130	3.2090	3.3760	3.3620	82.0000
58	907.0000	2.3480	3.8480	3.8640	3.2360	3.4100	3.3950	101.0000

Table-3 Values of calculated connectivity indices for the compounds used in the present study.

Comp.no.	***0 χ***	***1χ***	***2χ***	***3χ***	***0χv***	***1χv***	***2χv***	***3χv***
1	8.2260	5.9660	4.7960	3.9660	6.7740	4.0710	2.7320	1.8810
2	9.0960	6.3600	5.4180	4.3770	7.8300	4.5490	3.3090	2.2030
3	9.9660	6.7880	5.8510	4.9060	8.8870	5.0390	3.7740	2.6970
4	9.9660	6.7880	5.8290	5.0250	8.8870	5.0390	3.7530	2.8550
5	9.9660	6.7710	5.9570	4.7600	8.8870	5.0330	3.8340	2.5740
6	9.9660	6.7710	5.9570	4.7530	8.8870	5.0330	3.8340	2.5640
7	9.9660	6.7710	5.9460	4.8440	8.8870	5.0330	3.8300	2.6110
8	9.9660	6.7710	5.9570	4.7760	8.8870	5.0330	3.8340	2.5780
9	9.9660	6.7540	6.0760	4.5310	8.8870	5.0270	3.8970	2.4060
10	9.9660	6.7540	6.0400	4.7880	8.8870	5.0270	3.8870	2.5260
11	10.8370	7.1820	6.4850	5.2480	9.9430	5.5160	4.3550	2.9870
12	10.8370	7.1650	6.5790	5.1640	9.9430	5.5100	4.4110	2.8860
13	10.8370	7.1820	6.4650	5.3450	9.9430	5.5160	4.3340	3.1300
14	10.8370	7.1650	6.5790	5.1860	9.9430	5.5100	4.4110	2.9000
15	11.7070	7.6090	6.8620	6.0900	11.0000	6.0060	4.7730	3.8310
16	11.7070	7.5920	6.9910	5.8400	11.0000	6.0000	4.8540	3.5540
17	11.7070	7.5750	7.1190	5.5460	11.0000	5.9940	4.9360	3.2480
18	11.7070	7.5920	6.9930	5.8180	11.0000	6.0000	4.8550	3.5380
19	11.7070	7.5750	7.1190	5.5680	11.0000	5.9940	4.9360	3.2620
20	11.7070	7.5750	7.1190	5.5900	11.0000	5.9940	4.9360	3.2760
21	11.7070	7.6090	6.9260	5.7110	11.0000	6.0060	4.8220	3.4350
22	11.7070	7.5920	6.9880	5.8440	11.0000	6.0000	4.8540	3.5480
23	11.7070	7.5750	7.0870	5.7640	11.0000	5.9940	4.9110	3.4630
24	11.7070	7.5750	7.0550	5.9440	11.0000	5.9940	4.8870	3.6510
25	12.5770	8.0030	7.4960	6.4280	12.0560	6.4830	5.3540	4.1120
26	12.5770	7.9860	7.6360	6.0690	12.0560	6.4770	5.4390	3.7820
27	12.5770	8.0030	7.4980	6.4100	12.0560	6.4830	5.3540	4.1050
28	12.5770	7.9860	7.6260	6.1380	12.0560	6.4770	5.4360	3.8140
29	12.5770	7.9860	7.6260	6.1600	12.0560	6.4770	5.4360	3.8280
30	12.5770	8.0030	7.4640	6.6020	12.0560	6.4830	5.3290	4.2980
31	12.5770	8.0030	7.5180	6.2560	12.0560	6.4830	5.3600	4.0230
32	12.5770	7.9860	7.5950	6.3340	12.0560	6.4770	5.4110	4.0140
33	12.5770	7.9860	7.5730	6.4500	12.0560	6.4770	5.3900	4.1730
34	13.4470	8.4300	7.8730	7.2650	13.1130	6.9730	5.7720	4.9480
35	13.4470	8.4300	7.9370	6.9230	13.1130	6.9730	5.8210	4.5760

36	13.4470	8.4140	8.0140	6.9230	13.1130	6.9670	5.8570	4.6230
37	13.4470	8.4140	8.0040	6.9970	13.1130	6.9670	5.8540	4.6640
38	13.4470	8.4140	8.0140	6.9460	13.1130	6.9670	5.8570	4.6370
39	13.4470	8.3970	8.1850	6.3780	13.1130	6.9610	5.9660	4.1040
40	13.4470	8.4140	8.0450	6.7680	13.1130	6.9670	5.8810	4.4490
41	13.4470	8.3970	8.1340	6.7300	13.1130	6.9610	5.9360	4.3800
42	13.4470	8.3970	8.2170	6.1690	13.1130	6.9610	5.9910	3.8930
43	13.4470	8.4140	7.9820	7.1200	13.1130	6.9670	5.8320	4.8240
44	13.4470	8.4140	7.9820	7.1070	13.1130	6.9670	5.8320	4.8200
45	13.4470	8.3970	8.0900	6.9550	13.1130	6.9610	5.8920	4.6950
46	14.3170	8.8410	8.4230	7.6090	14.1690	7.4570	6.3000	5.2870
47	14.3170	8.8240	8.5210	7.5150	14.1690	7.4510	6.3570	5.1890
48	14.3170	8.8240	8.5630	7.2320	14.1690	7.4510	6.3840	4.9450
49	14.3170	8.8240	8.5530	7.3190	14.1690	7.4510	6.3810	4.9890
50	14.3170	8.8240	8.5530	7.3370	14.1690	7.4510	6.3810	5.0010
51	14.3170	8.8240	8.5310	7.4230	14.1690	7.4510	6.3600	5.1440
52	15.1880	9.2520	8.9080	8.3010	15.2260	7.9400	6.7780	5.9980
43	15.1880	9.2690	8.8100	8.3840	15.2260	7.9460	6.7210	6.0850
54	15.1880	9.2520	8.9400	8.1050	15.2260	7.9400	6.8020	5.7980
55	15.1880	9.2520	8.9500	8.0480	15.2260	7.9400	6.8050	5.7690
56	15.1880	9.2520	8.9720	7.9500	15.2260	7.9400	6.8270	5.6230
57	16.0580	9.6790	9.3590	8.7290	16.2820	8.4300	7.2480	6.4230
58	16.9280	10.1070	9.7460	9.5080	17.3390	8.9190	7.6690	7.2230

Table-4 Regression parameters and quality of correlation with topological Parameters

Model No.	Parameter used	Ai=(1…6)	B	Se	R^2	R^2a	F Ratio	Q=R/Se
1	**2χ**	0.7545(±0.0433)	-0.6967	0.0708	0.8444	-	303.9296	12.9789
2	**BAC** **0χv**	-0.0483(±0.0063) 0.8016(±0.0611)	-3.2294	0.0541	0.9108	0.9076	280.9630	17.6406
3	**BAC** **2χ** **3χv**	-0.0514(±0.0070) 1.0786(±0.1117) 0.6405(±0.1519)	-4.1838	0.0504	0.9242	0.9200	219.3830	19.0744
4	**WJ** **Jhetz** **0χv**	-0.0453(±0.0064) 93.1302(±20.1162) -60.4452(±12.4157) 5.0308(±0.7117)	-26.7280	0.0457	0.9389	0.9342	202.4640	21.2028
5	**WJ** **Jhetz** **2χ** **3χv**	-0.0360(±0.0044) 71.7677(±15.2845) -44.4263(±9.0550) 5.5883(±0.6915) 2.3125(±0.2994)	-30.5554	0.0423	0.9484	0.9434	191.0870	23.0226
6	**WJ** **Jhetz** **Jhetm** **2χ** **3χv**	-0.0358(±0.0044) 78.1359(±15.8176) -144.3091(±72.0558) 95.6271(±68.4487) 5.5205(±0.6870) 2.3110(±0.2967)	-30.2199	0.0420	0.9503	0.9444	162.4790	23.2103

Table-5 Observed and calculated activity for the compounds using model-6 (Table N.- 4)

Comp.no.	Observed LogBCFexp	Calculated LogBCFexp	Residual
1	2.6400	2.7210	-0.0810

2	2.7700	2.9360	-0.1660
3	3.3800	3.5680	-0.1880
4	4.1100	3.6610	0.4490
5	3.8000	3.6460	0.1540
6	3.5500	3.4360	0.1140
7	3.5700	3.4880	0.0820
8	3.8900	3.7900	0.1000
9	3.7800	3.7940	-0.0140
10	3.2800	3.4730	-0.1930
11	4.1100	4.2000	-0.0900
12	4.2000	4.0500	0.1500
13	4.2600	4.1140	0.1460
14	4.2300	4.2360	-0.0060
15	4.2300	4.6500	-0.4200
16	4.8400	4.7260	0.1140
17	4.8500	4.5240	0.3260
18	5.0000	4.7750	0.2250
19	4.8400	4.7080	0.1320
20	4.6300	4.7950	-0.1650
21	3.8500	4.2570	-0.4070
22	4.6000	4.5960	0.0040
23	4.7700	4.9600	-0.1900
24	4.5900	4.8570	-0.2670
25	5.3800	5.1710	0.2090
26	5.0000	5.1180	-0.1180
27	5.4300	5.1850	0.2450
28	5.0000	5.0950	-0.0950
29	5.4000	5.1880	0.2120
30	5.0000	5.2430	-0.2430
31	5.0000	5.1360	-0.1360
32	5.0000	5.2950	-0.2950
33	5.8100	5.5240	0.2860
34	5.7700	5.5050	0.2650
35	5.4300	5.3840	0.0460
36	5.8800	5.5010	0.3790
37	5.3900	5.5860	-0.1960
38	5.8100	5.6590	0.1510
39	5.3900	5.4880	-0.0980
40	5.5400	5.5690	-0.0290
41	5.6500	5.5170	0.1330
42	4.9300	5.1300	-0.2000
43	5.3900	5.6450	-0.2550
44	5.3900	5.7150	-0.3250
45	5.9700	5.9540	0.0160
46	5.8000	5.7710	0.0290
47	5.8000	5.8900	-0.0900
48	5.8000	5.6900	0.1100
49	5.8000	5.6360	0.1640
50	5.8000	5.8180	-0.0180
51	5.8400	5.7160	0.1240
52	5.8100	6.0320	-0.2220
43	5.9200	5.7990	0.1210
54	5.9200	5.7160	0.2040
55	5.8800	5.9180	-0.0380
56	5.8200	5.9180	-0.0980
57	5.7100	5.7120	-0.0020
58	5.4400	5.4830	-0.0430

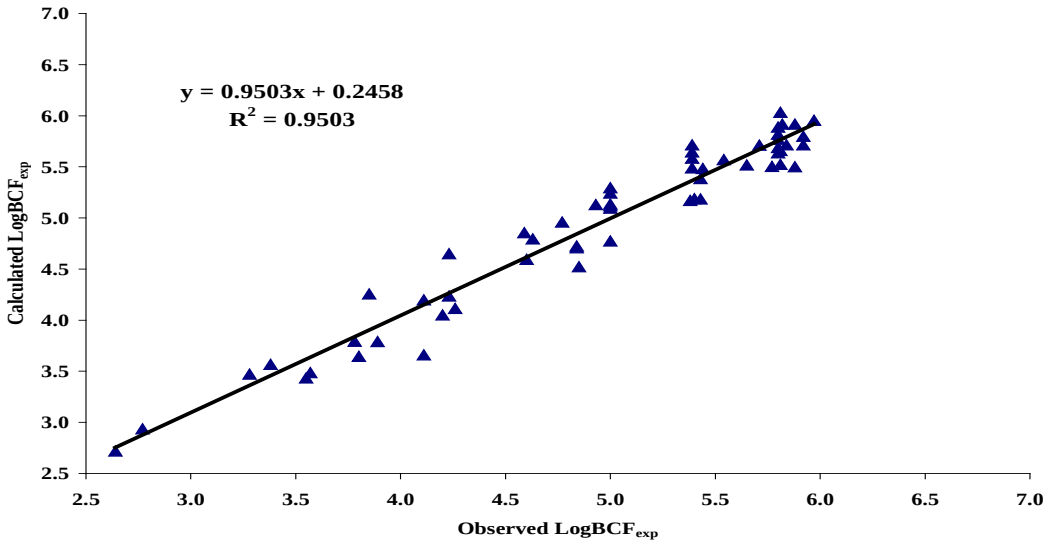

Fig-2 Correlation between Observed and Calculated activity using model No.-6 (Table- 4).

Table-6 Cross validated values for Topological parameters

S.no.	Parameters used	PRESS	SSY	PRESS/SSY	R^2cv	PSE	S_{PRESS}
1.	2χ	6.8667	37.2679	0.1842	0.8158	0.3440	0.3501
2.	BAC,0χv	3.9346	40.2000	0.0978	0.9022	0.2604	0.2674
3.	BAC,2X,3χv	3.3465	40.7881	0.0820	0.9180	0.2402	0.2489
4.	W,J,Jhetz,0χv	2.6984	41.4362	0.0651	0.9349	0.2156	0.2256
5.	W,J,Jhetz,2χ,3χv	2.2780	41.8566	0.0544	0.9456	0.1981	0.2093
6.	W,J,Jhetz,Jhetm,2χ,3χv	2.1940	41.9406	0.0523	0.9477	0.1944	0.2074

Table-7 Correlation matrix showing inter-correlation among all the parameters with the activity.

	Jhetv	*Jhete*	*Jhetp*	*BAC*	0χ	1χ	2χ	3χ	0χv	1χv	2χv	3χv
Jhetv	1.0000											
Jhete	0.9960	1.0000										
Jhetp	0.9966	1.0000	1.0000									
BAC	0.8746	0.8976	0.8962	1.0000								
0χ	0.8617	0.8998	0.8973	0.9665	1.0000							
1χ	0.8666	0.9038	0.9013	0.9692	0.9999	1.0000						
2χ	0.8380	0.8805	0.8777	0.9470	0.9957	0.9942	1.0000					
3χ	0.8451	0.8800	0.8776	0.9723	0.9839	0.9858	0.9655	1.0000				
0χv	0.8617	0.8998	0.8973	0.9665	1.0000	0.9999	0.9957	0.9839	1.0000			
1χv	0.8632	0.9011	0.8986	0.9674	1.0000	0.9999	0.9953	0.9845	1.0000	1.0000		
2χv	0.8485	0.8894	0.8867	0.9545	0.9982	0.9972	0.9994	0.9729	0.9982	0.9979	1.0000	
3χv	0.8469	0.8801	0.8779	0.9758	0.9806	0.9828	0.9602	0.9994	0.9806	0.9813	0.9681	1.0000

	LogBCFexp	*IR*	*ST*	*D*	*POL*	*W*	*J*	*JhetZ*	*Jhetm*
LogBCFexp	1.0000								
IR	0.9328	1.0000							
ST	0.9308	0.9996	1.0000						
D	0.9359	0.9998	0.9993	1.0000					
POL	0.9037	0.9907	0.9936	0.9887	1.0000				
W	0.8775	0.9723	0.9772	0.9693	0.9935	1.0000			
J	0.7702	0.8974	0.9006	0.8934	0.9152	0.8884	1.0000		
JhetZ	0.8082	0.9275	0.9299	0.9242	0.9401	0.9135	0.9972	1.0000	
Jhetm	0.8098	0.9286	0.9310	0.9253	0.9410	0.9145	0.9970	1.0000	1.0000
Jhetv	0.6940	0.8339	0.8385	0.8287	0.8618	0.8362	0.9915	0.9791	0.9785
Jhete	0.7475	0.8790	0.8826	0.8746	0.8999	0.8734	0.9992	0.9933	0.9930
Jhetp	0.7439	0.8760	0.8797	0.8715	0.8974	0.8709	0.9989	0.9926	0.9922
BAC	0.7950	0.9236	0.9317	0.9181	0.9667	0.9827	0.9062	0.9199	0.9203
0χ	0.9038	0.9907	0.9936	0.9888	1.0000	0.9935	0.9152	0.9401	0.9410
1χ	0.8999	0.9892	0.9923	0.9871	0.9999	0.9939	0.9186	0.9428	0.9436
2χ	0.9189	0.9942	0.9961	0.9933	0.9957	0.9853	0.8979	0.9265	0.9276
3χ	0.8731	0.9640	0.9683	0.9608	0.9840	0.9877	0.8939	0.9167	0.9175
0χv	0.9038	0.9907	0.9936	0.9888	1.0000	0.9935	0.9152	0.9401	0.9410
1χv	0.9027	0.9903	0.9932	0.9883	1.0000	0.9936	0.9163	0.9410	0.9418
2χv	0.9143	0.9942	0.9963	0.9929	0.9982	0.9888	0.9060	0.9332	0.9342
3χv	0.8636	0.9571	0.9620	0.9536	0.9806	0.9867	0.8932	0.9148	0.9155

STRESS ANALYSIS OF AN INFINITE PLATE WITH DIFFERENT SHAPED CUTOUTS IN COMPOSITE PLATE

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ABSTRACT

In engineering structures and machine components holes and openings are provided for the purpose of reducing weight, easy access of equipment's or for any other requirement. These discontinuities are weakening agent for the structure or machines. In order to predict failure of component the stress field around such discontinuity must be known under different loading conditions. In present work attempt is made to obtain generalized solution for determining stress concentration around different shaped holes in isotropic material as well as composite laminates. General solutions are coded in MATLAB 7.8 and results are obtained. The results are well matched with that of ANSYS 11.0 results.

Keywords : Analysis, Composites, Cutouts, Complex Variable, Infinite Plate, Stress Concentration

1. INTRODUCTION

Now a days composites laminates are widely used in aircrafts, space vehicles, under water transportation, transportation equipment, construction applications, and other light weight properties can be tailored to meet design requirements. Sometimes cutouts are made in the composites for various practical reasons such as access to system equipment, maintenance of hydraulic piping, electric wiring, to reduce weight etc. High stresses are produced around such holes when subjected to various working loads and may lead to the failure of the structure/machine. In order to predict the structural behavior of these laminates, it is necessary to know the stresses around the cutouts.

Simha and Mohapatra (1998) [1] used complex variable method to find stress concentration around irregular holes and considered remote loading at hydrostatic tension, uniaxial tension and pure shear state. Ukadgaonker and Rao(2000) [2], and Ukadgaonker and Kakhandki(2005) [3] presented stress analysis of infinite anisotropic plate with irregular shaped holes. They adopted Savins formulation for inplate loading problems and general solution is developed by introducing mapping function and an arbitrary biaxial loading condition into boundary conditions. Results are obtained for various shaped holes, loading conditions and laminate geometry. Yi Yang et al (2008) [4] presented an analytical solution for the stress concentration problem of an infinite plate with a rectangular hole under biaxial tensions. Zhang et al (2009) [5] used Schwarz's alternating method and the Muskhelishvili's complex variable function techniques and obtain accurate stresses in a plate containing two elliptic holes subjected to uniform normal tensions and tangential shears on the hole boundaries and any uniform loads applied at

infinity.NageswaraRao et al (2010) [6] found stress concentration around square and rectangular holes using Savins formulation. Rezaeepazhand and M.Jafari (2010) [7] presented the accurate and simple method for stress analysis of plates with central cutout and studied the varying parameters, such as cutout shape and bluntness, load direction or cutout orientations, which affect the stress distributions and SCF in the perforated plates. Milan Batista (2011) [8] presents a modified Muskhelishvili method by which one may efficiently calculate the stress distribution around holes of relatively complex shapes in infinite plates subjected to a uniform load at infinity. The method is illustrated by several examples of stress distribution around polygonal holes of a complex geometry utilizing the Schwartz–Chistoffel mapping function. Dharmendra Sharma (2011) [9] determine the stress concentration around circular, elliptical and triangular cutouts in laminated composite infinite plate subjected to arbitrary biaxial loading at infinity by using Muskhelishvili's complex variable method. DharmendraS.Sharma (2012) [10] used Mushkhelishvili's complex variable approach and presented the stress field around polygonal shaped cutouts in infinite isotropic plate. The effect of cutout shape, corner radius, load angle and hole orientation on stress pattern is studied for triangular, square, pentagonal, hexagonal, heptagonal and octagonal cutout shapes.

In this paper Mushkhelishvili's complex variable approach is adopted to obtain generalized stress function. The effect of hole geometry fiber orientation, loading factor and loading angle on stress field around cut out is studied. Isotropic and Glass/Epoxy materials are considered.

II FORMULATION

2.1 SCHEME OF SOLUTION FOR SINGLE HOLE

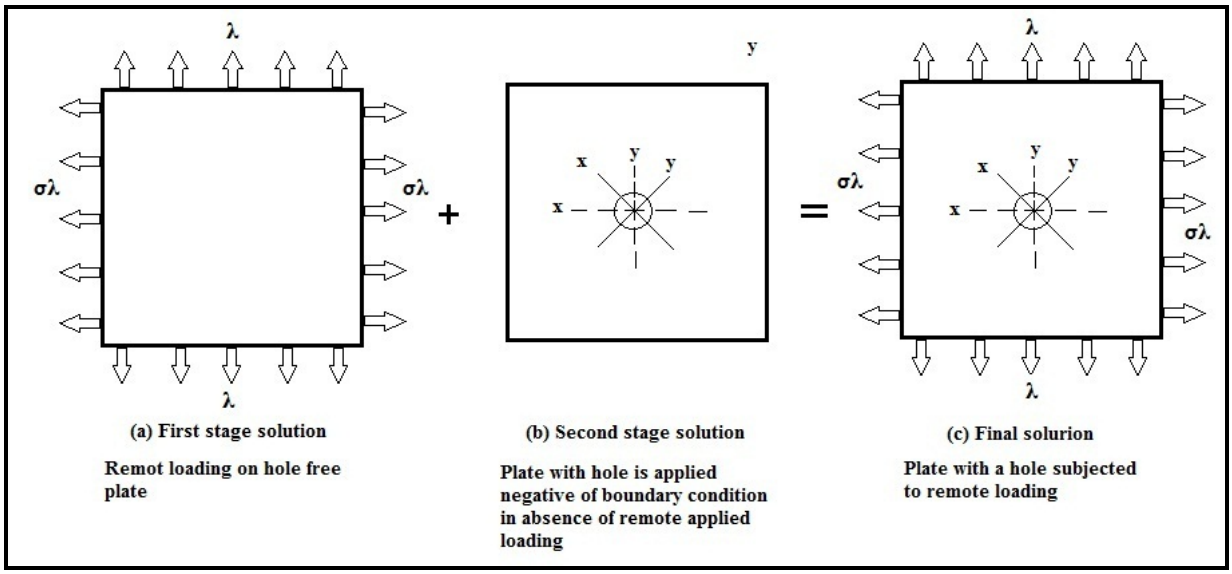

Fig.1 Scheme of Solution for Single Hole

The anisotropic plate containing the hole is subjected to re-motely applied load is shown in Fig. 1. The edges of the hole are free from loading. To determine the stresses around the hole, the solution is split into two stages.

2.1.1 First Stage

The stresses functions $f(z_1)$ and $y(z_2)$ are determined for the hole free plate under the application of remotely applied load. The boundary conditions f_1 and f_2 are found for the fictitious hole using stress functions $f(z_1)$ and $y(z_2)$.

The stress function $f(z_1)$ and $y(z_2)$ are obtained for hole free plate due to remotely applied load $s_x^{\infty}, s_y^{\infty}$

$$f_1(z_1) = B^* z_1 \tag{1}$$

$$y_1(z_2) = (B'^* + iC'^*) z_2 \tag{2}$$

Where,

$$B^* = \frac{s_x^{\infty} + (a_2^2 + b_2^2) s_y^{\infty} + 2a_2 t_{xy}^{\infty}}{2((a_2 - a_1)^2 + (b_2^2 - b_1^2))}$$

$$B'^* = \frac{(a_1^2 - b_1^2 - 2a_1a_2) s_y^{\infty} - s_x^{\infty} - 2a_2 t_{xy}^{\infty}}{2((a_2 - a_1)^2 + (b_2^2 - b_1^2))}$$

$$C'^* = \left[\frac{[(a_1 - a_2)] s_x^{\infty} + [a_2(a_1^2 - b_1^2) - a_1(a_2^2 - b_2^2)] s_y^{\infty} + [(a_1^2 - b_1^2) - (a_2^2 - b_2^2)] t_{xy}^{\infty}}{2b_2[(a_2 - a_1)^2 + (b_2^2 - b_1^2)]} \right]$$

C is taken zero, because no rotation is allowed.

The boundary conditions f_1, f_2 on the fictitious hole are determined from these stress functions as follows.

$$f_1 = \left[(K_1 + \overline{K_2}) \left(\frac{1}{z} + \sum_{k=1}^{N} m_k z^k \right) + (K_2 + \overline{K_1}) \left(z + \sum_{k=1}^{N} \frac{m_k}{z^k} \right) \right] \tag{3}$$

$$f_2 = \left[(K_3 + \overline{K_4}) \left(\frac{1}{z} + \sum_{k=1}^{N} m_k z^k \right) + (K_4 + \overline{K_3}) \left(z + \sum_{k=1}^{N} \frac{m_k}{z^k} \right) \right] \tag{4}$$

Where,

$$K_1 = \left(\frac{R}{2} \right) \left[B^* a_1 + (B'^* + iC'^*) a_2 \right] \qquad K_3 = \left(\frac{R}{2} \right) \left[s_1 B^* a_1 + s_2 (B'^* + iC'^*) a_2 \right]$$

$$K_2 = \left(\frac{R}{2} \right) \left[B^* b_1 + (B'^* + iC'^*) b_2 \right] \qquad K_4 = \left(\frac{R}{2} \right) \left[s_1 B^* b_1 + s_2 (B'^* + iC'^*) b_2 \right]$$

2.1.2 Second Stage

For the second stage solution, the stress functions $f_0(z_1)$ and $y_0(z_2)$ are determined by applying negative of the boundary conditions $f_1^0 = -f_1$ and $f_2^0 = -f_2$ on its hole boundary in the absence of the remote loading.

The stress functions of second stage solution are obtained using these new boundary conditions (f_1^0, f_2^0) into Schwarz formula:

$$y_0(z) = \frac{i}{4P(s_1 - s_2)} \int_g \left[(s_1 f_1^0 - f_2^0)\left(\frac{t+z}{t-z}\right)\frac{dt}{t}\right] \quad (5)$$

$$j_0(z) = \frac{i}{4P(s_1 - s_2)} \int_g \left[(s_2 f_1^0 - f_2^0)\left(\frac{t+z}{t-z}\right)\frac{dt}{t}\right] \quad (6)$$

By evaluating the integral the stress functions are obtained as

$$f_0(z) = \left(\frac{a_3}{z} + b_3 \sum_{k=1}^{N} \frac{m_k}{z^k}\right) \quad (7)$$

$$y_0(z) = -\left(\frac{a_4}{z} + b_4 \sum_{k=1}^{N} \frac{m_k}{z^k}\right) \quad (8)$$

Where

$$a_3 = \left(\frac{1}{s_1 - s_2}\right)\left[s_2(K_1 + \overline{K_2}) - (K_3 + \overline{K_4})\right]$$

$$b_3 = \left(\frac{1}{s_1 - s_2}\right)\left[s_2(K_2 + \overline{K_1}) - (K_4 + \overline{K_3})\right]$$

$$a_4 = \left(\frac{1}{s_1 - s_2}\right)\left[s_1(K_1 + \overline{K_2}) - (K_3 + \overline{K_4})\right]$$

$$b_4 = \left(\frac{1}{s_1 - s_2}\right)\left[s_1(K_2 + \overline{K_1}) - (K_4 + \overline{K_3})\right]$$

2.1.3. Final Solution

The stress function $f(z_1)$ and $y(z_2)$ for single hole problem, can be obtained by adding the stress functions of first and second stage.

$$f(z_1) = f_1(z_1) + f_0(z_1) \quad (9)$$

$$y(z_2) = y_1(z_2) + y_0(z_2) \quad (10)$$

III RESULTS AND DISCUSSION

The generalized solutions for stress functions obtained in previous chapter are coded using MATLAB 7.8 and stress fields are obtained for different hole geometries and loading patterns. The plane stress models for some of the cases

are prepared and analyzed using FEA software (ANSYS 11.0). Here attempt is made to obtain the stress concentration around different shaped holes. For this plate with different loading condition, loading angle, fiber orientation angle is considered. The numerical results are obtained for Glass/Epoxy material. Some results are obtained for Isotropic material also for the sake of comparison.

The following loading conditions have been considered.

1. Plate subjected to Uniaxial tension at infinity
2. Plate subjected to Biaxial tension at infinity

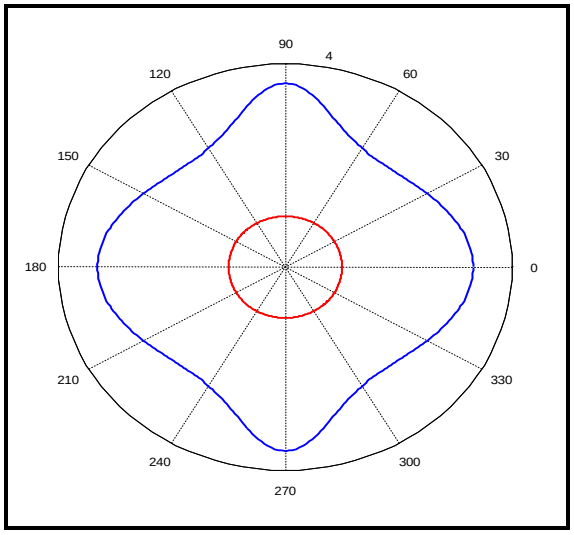

Fig.2 Stress Analysis of Plate with Isotropic Material Biaxial Loading (Present Method)

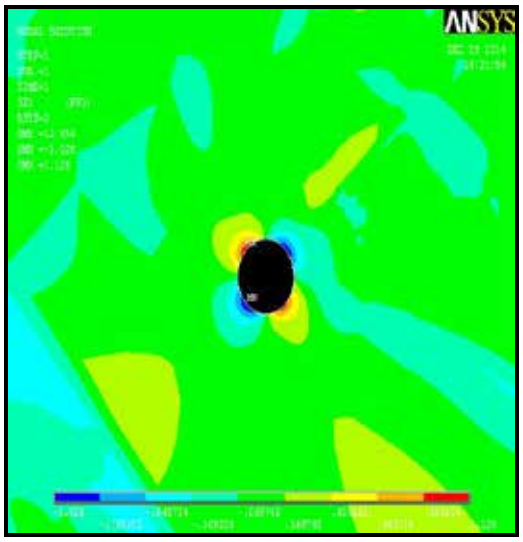

Fig.3 Stress Analysis of Plate with E-Glass/Epoxy Material Biaxial Loading (Ansys)

Table.1 Comparison of results of ISOTROPIC material obtained in present method and ANSYS in an infinite plate with CIRCULAR hole subjected to uniaxial and biaxial load

Fiber orientation angle θ	Max. Stress	Uniaxial Load (λ=0)		Biaxial Load (λ=1)	
		Present method	ANSYS	Present method	ANSYS
	X – direction	0.5624	0.4654	2.0000	2.0120
	Y – direction	3.0000	2.9940	2.0000	2.0130

Table.2 Comparison of results of E-Glass/Epoxy material obtained in present method and ANSYS in an infinite plate with CIRCULAR hole subjected to uniaxial and biaxial load

Fiber orientation angle θ	Max. Stress	Uniaxial Load (λ=0)		Biaxial Load (λ=1)	
		Present method	ANSYS	Present method	ANSYS
[0]	X – direction	0.6539	0.5898	2.6125	2.5190
	Y – direction	2.8121	2.9370	2.3085	2.1640
[0/90]	X – direction	0.3973	0.4595	2.7916	2.9160
	Y – direction	3.3716	3.4880	2.7916	2.8870
[45/-45]	X – direction	0.7955	0.8397	1.6982	2.0400
	Y – direction	2.4329	2.3300	1.6982	1.9800

Table.3 Comparison of results of ISOTROPIC material obtained in present method and ANSYS in an infinite plate with ELLIPTICAL hole subjected to uniaxial and biaxial load

Fiber orientation angle θ	Max. Stress	Uniaxial Load (λ=0)		Biaxial Load (λ=1)	
		Present method	ANSYS	Present method	ANSYS
	X – direction	1.0416	0.8399	1.3330	1.2750
	Y – direction	5.0000	4.9090	4.0000	3.9630

Table.4 Comparison of results of E-Glass/Epoxy material obtained in present method and ANSYS in an infinite plate with ELLIPTICAL hole subjected to uniaxial and biaxial load

Fiber orientation angle θ	Max. Stress	Uniaxial Load (λ=0)		Biaxial Load (λ=1)	
		Present method	ANSYS	Present method	ANSYS
[0]	X – direction	1.1773	1.3720	1.4061	2.1110
	Y – direction	4.6243	4.4920	4.1206	4.0780
[0/90]	X – direction	0.7434	1.7020	1.3958	2.2500
	Y – direction	6.5832	6.1010	5.5832	5.3890
[45/-45]	X – direction	1.4583	1.8940	1.7855	1.8400
	Y – direction	3.8657	3.7000	2.8931	3.0680

Table.5 Results OF CARBON/ EPOXY obtained by present method of an infinite plate with CIRCULAR hole subjected to uniaxial and biaxial load

Fiber orientation angle α	Max. Stress	Uniaxial Load (λ=0)	Biaxial Load (λ=1)
		Present method	Present method
[0]	X – direction	0.9114	2.5152
	Y – direction	2.4011	2.1364
[0/90]	X – direction	0.3016	3.6344
	Y – direction	4.6344	3.6344
[45/-45]	X – direction	1.0455	1.9963
	Y – direction	2.1577	1.9963

Table.6 Results OF CARBON/ EPOXY obtained by present method of an infinite plate with Elliptical hole subjected to uniaxial and biaxial load

Fiber orientation angle α	Max. Stress	Uniaxial Load (λ=0)	Biaxial Load (λ=1)
		Present method	Present method
[0]	X – direction	1.5781	1.7845
	Y – direction	3.8021	3.5374
[0/90]	X – direction	0.5691	1.8172
	Y – direction	8.2687	7.2687
[45/-45]	X – direction	1.9032	2.3021
	Y – direction	3.4105	2.8937

3.1 Effect of Fiber Orientation Angle

Various graphs are plotted for fiber orientation angle of material and corresponding values of stresses. Fig. 4 to 7 shows the values of stress around circular hole for E-Glass/Epoxy and Carbon/Epoxy laminates for uniaxial and biaxial loading. Fig. 8 to 11 shows the values of stress around elliptical hole for E-Glass/Epoxy and Carbon/Epoxy laminates for uniaxial and biaxial loading. For both circular and elliptical hole it is found that the stress in Y – Direction decreases at 90° and the stress in X – Direction increases at 90° in uniaxial loading condition. Fig. 12 to 19 shows the comparison of circular and elliptical holes for E-Glass/Epoxy and Carbon/Epoxy material under Uniaxial and Biaxial loading condition. There is high stress concentration in elliptical shape compare to circular shape.

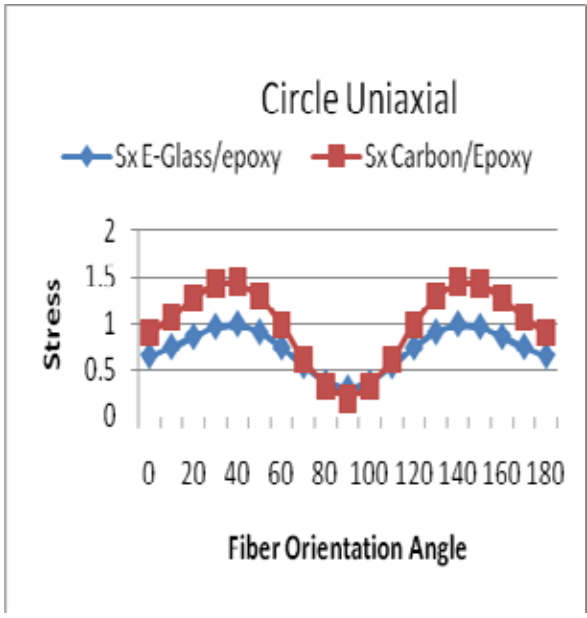

Fig. 4 Effect of fiber orientation angle for circular hole in X-Direction under Uniaxial loading for E-Glass/Epoxy and Carbon / Epoxy

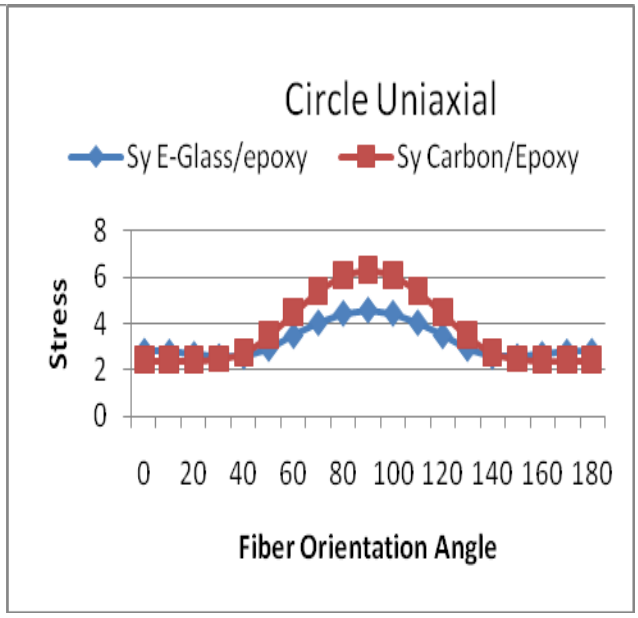

Fig. 5 Effect of fiber orientation angle for circular hole in Y-Direction under Uniaxial loading for E-Glass/Epoxy and Carbon / Epoxy

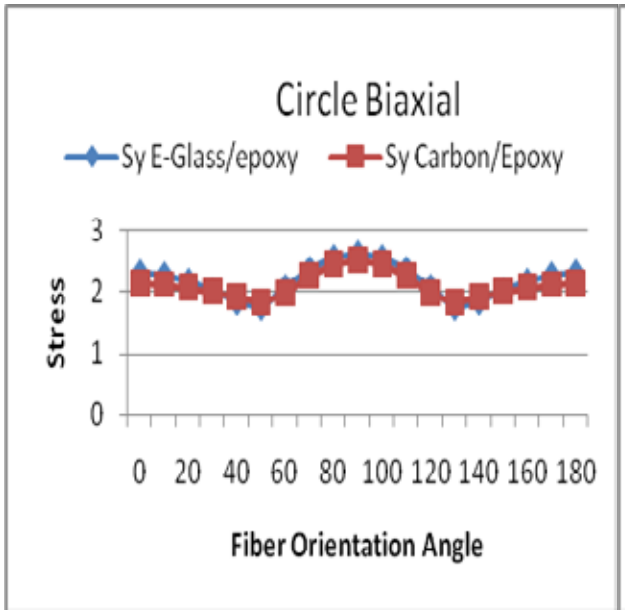

Fig. 6 Effect of fiber orientation angle for circular hole in X-Direction under Biaxial loading for E-Glass/Epoxy and Carbon / Epoxy

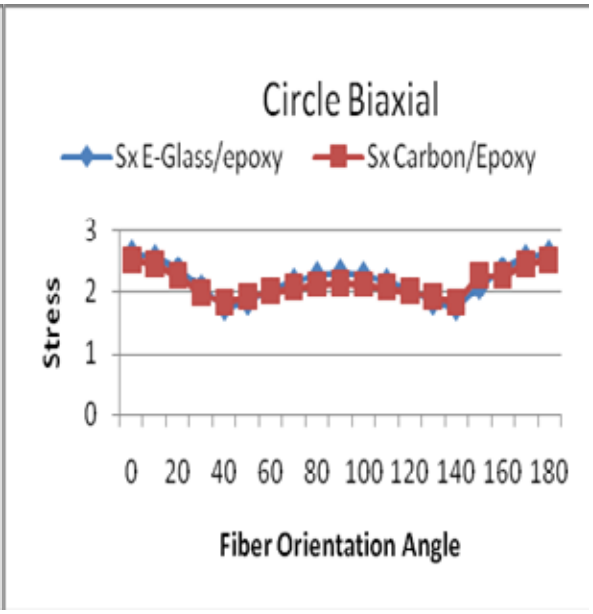

Fig. 7 Effect of fiber orientation angle for circular hole in Y-Direction under Biaxial loading for E-Glass/Epoxy and Carbon / Epoxy

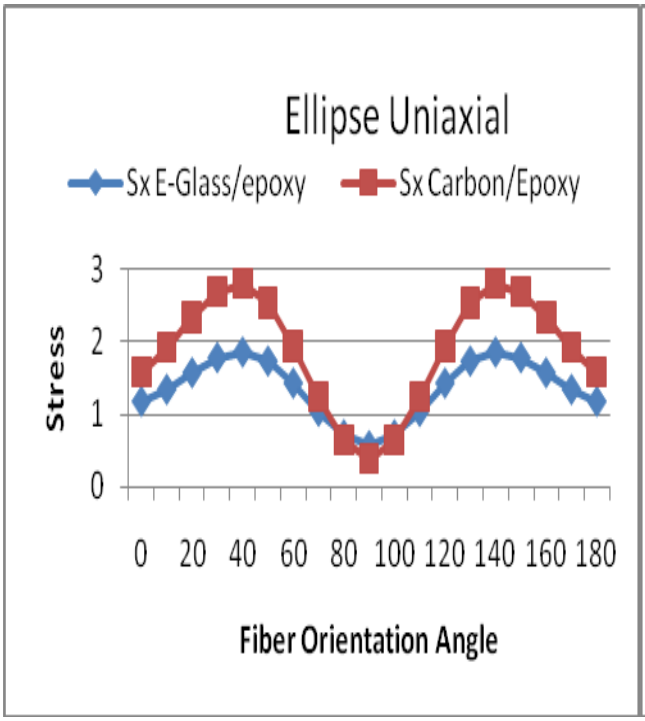

Fig. 8 Effect of fiber orientation angle for elliptical hole in X-Direction under Uniaxial loading for E-Glass/Epoxy and Carbon / Epoxy

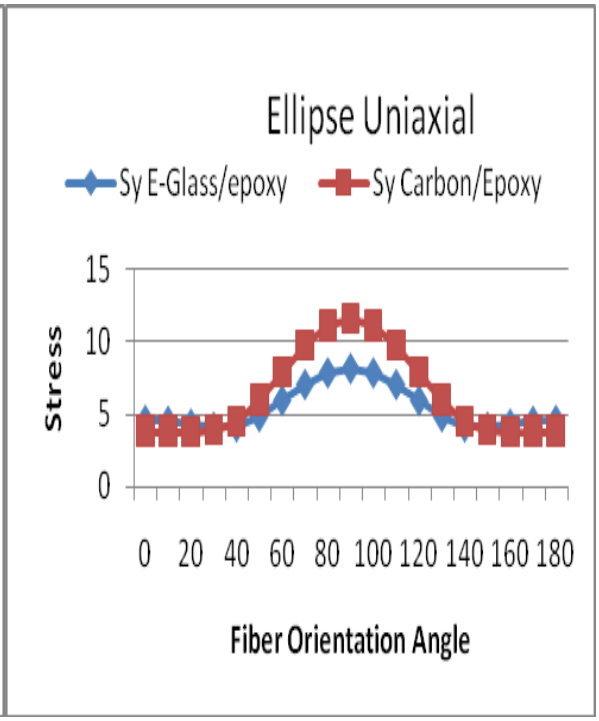

Fig. 9 Effect of fiber orientation angle for elliptical hole in Y-Direction under Uniaxial loading for E-Glass/Epoxy and Carbon / Epoxy

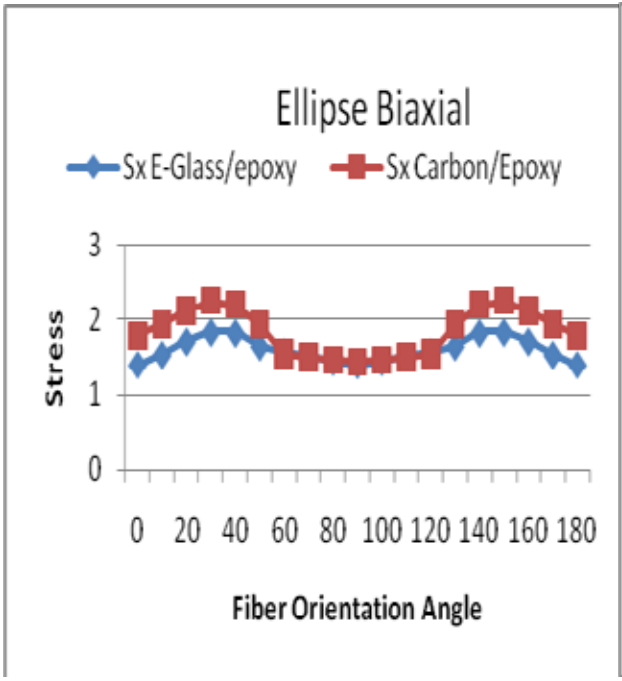

Fig. 10 Effect of fiber orientation angle for elliptical hole in X-Direction under Biaxial loading for E-Glass/Epoxy and Carbon / Epoxy

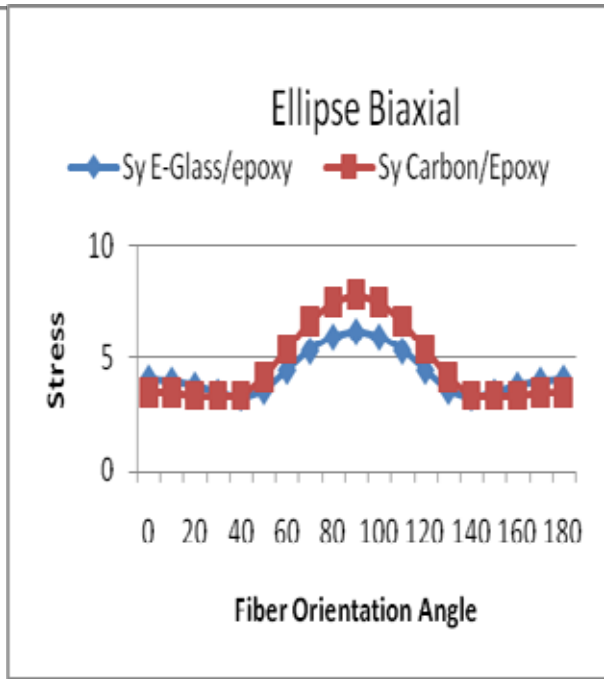

Fig. 11 Effect of fiber orientation angle for elliptical hole in Y-Direction under Biaxial loading for E-Glass/Epoxy and Carbon / Epoxy

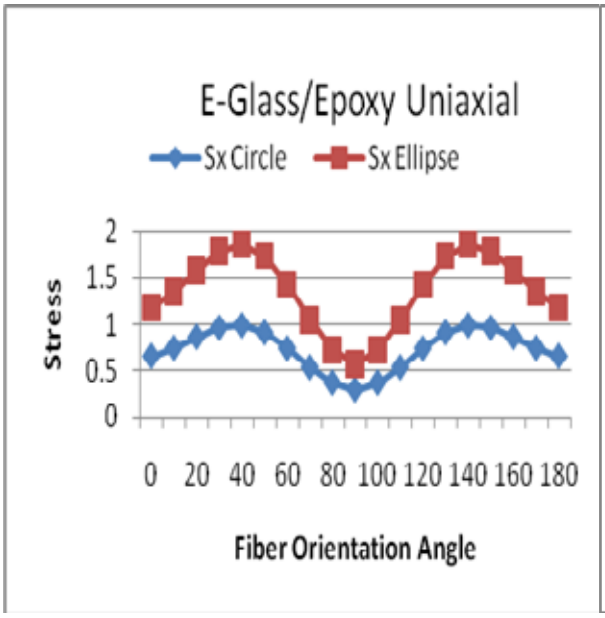

Fig. 12 Effect of fiber orientation angle for circular and elliptical hole in X-Direction under Uniaxial loading

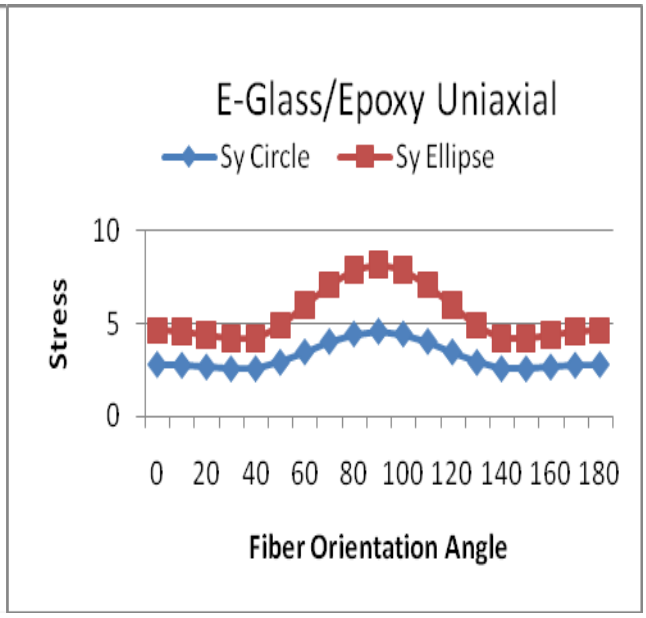

Fig. 13 Effect of fiber orientation angle for circular and elliptical hole in Y-Direction under Uniaxial loading

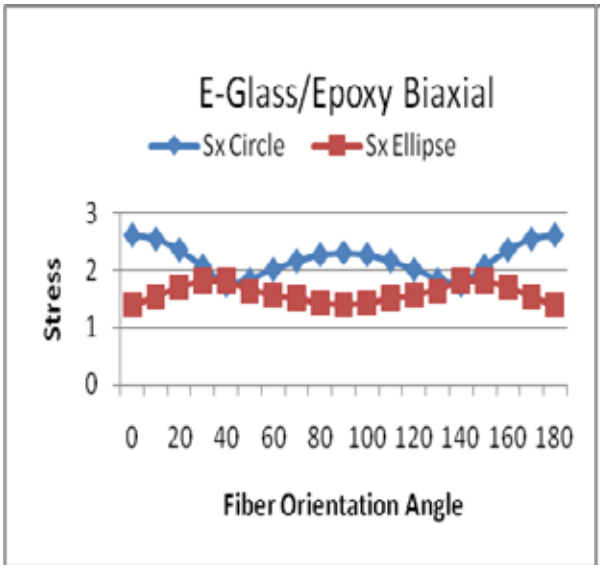

Fig. 14 Effect of fiber orientation angle for circular and elliptical hole in X-Direction under Biaxial loading

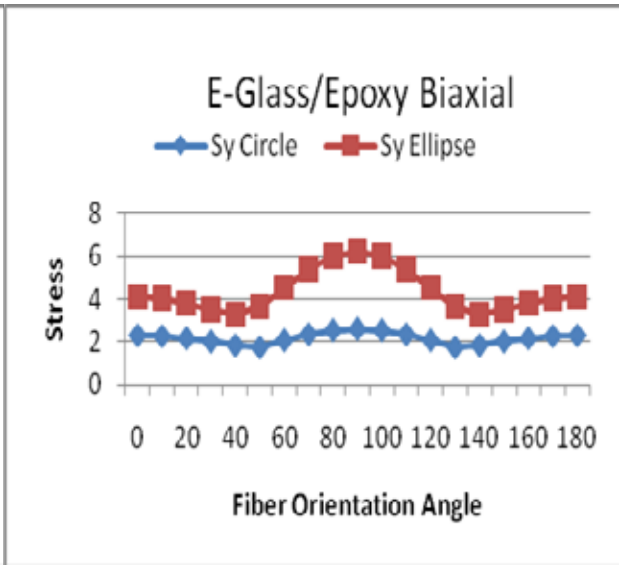

Fig. 15 Effect of fiber orientation angle for circular and elliptical hole in Y-Direction under biaxial loading

IV CONCLUSION

The general solution presented is extremely useful to study the effect of fiber orientation on stress distribution. A detailed parametric study can be easily made using present solution. More stress field found around in Carbon/Epoxy material in both loading condition for circular and elliptical hole.High stress found in elliptical cut out in both X & Y direction under Uniaxial and Biaxial loading for both materials.The stress in X direction least at 90※and maximum at 45※under uniaxial loading condition for both shapes using E-Glass/Epoxy and Carbon/Epoxy. The stress in Y direction is maximum at 90※under biaxial loading condition for both shape using E-Glass/Epoxy and Carbon/Epoxy materials.There is higher stress in elliptical shaped hole compared to circular shaped hole for both uniaxial and biaxial loading condition.It is also observed that there is high stress concentration in Carbon/Epoxy in any loading condition compare to E-Glass/Epoxy.

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CONTROL OF H_2 GAS EVOLUTION AT CATHODE DURING ELECTROCHEMICAL MACHINING OF IRON BY USING PALLADIUM BASED MEMBRANES

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ABSTRACT

A mathematical equation and experimental procedure have been proposed to determine the permeability of H_2 gas during electrochemical machining of iron at higher current density through palladium based membranes (Pd/Ag) which is placed within the reservoir. The permeability can measure in the low pressure range (1–3 bar absolute). The functionalities of the membranes can also measure in terms of the hydrogen gas transport. A relationship between temperature at which process occurs and corresponding transport of the permeate has been established. The membrane does not expose to high pressure and therefore membranes used for the purpose are less prone to damage. The proposed method will be used to optimize the process parameters.

Keywords*: *Electrochemical Machining, Hydrogen Evolution, Membrane

I. INTRODUCTION

Over the years ECM principles have been employed for performing a number of machining operations involving machining of hard and tough materials, at atomic level [1-2] with higher surface finish. Many groups of Researchers and Engineers have been engaged in manufacturing sophisticated and precise parts used in various technologically advanced industries like Aerospace, Automotive and Medical. Which require accurately machined components of complex shapes, of materials [3] which are difficult to machine such as super alloys, tungsten carbide and alloys of titanium. The Electrochemical Machining process is best suited for such operations and thus dominants over several non-conventional processes, but the capabilities of this process have not been exploited to its fullest extent mainly because of the inherent problems associated with tool design, electrolyte, heat transfer and gas development [4-6]. In Electrochemical Machining Process, the effect of Hydrogen gas development include their obstructions of electric current and stirring of electrolyte within the cell H_2 gas bubbles decrease the effective conductivity of the electrolyte [7] that leads to the ohmic losses in the cell and therefore it would affect the local anodic dissolution rate.

In this paper, an attempt has been made to optimize the machining parameters during Electrochemical machining of iron workpiece with respect to transport of hydrogen gas (based on diffusion mechanism) through dense palladium membrane to enhance the local anodic dissolution.

Electrochemical and Chemical Reaction Scheme

In aqueous solution of NaCl following reaction occurs

$NaCl \leftrightarrow Na^+ + Cl^-$

$H_2O \leftrightarrow H^+ + OH^-$

On passing the electric current through the solution, positive ions moves towards cathode and negative ions move towards anode. Each Na^+ ions gain an electron and are converted to Na. Hence Na ions are reduced at the cathode by means of electrons.

Reactions at Cathode

$Na^+ + e^- \leftrightarrow Na$

$Na + H_2O \leftrightarrow NaOH + H^+$

$2H^+ + 2e^- \leftrightarrow H_2$

It shows that only hydrogen gas will evolve at cathode.

$Fe \leftrightarrow Fe^{2+} + 2e^-$

$Fe^{2+} + 2Cl^- \leftrightarrow FeCl_2$

$Fe^{2+} + 2(OH)^- \leftrightarrow Fe(OH)_2$

$FeCl_2 + 2(OH)^- \leftrightarrow Fe(OH)_2 + 2Cl^-$

$2Cl^- \rightarrow Cl_2 + 2e^-$

$2FeCl_2 + Cl_2 \leftrightarrow 2FeCl_3$

$H^+ + Cl^- \leftrightarrow HCl$

$2Fe(OH)_2 + H_2O + O_2 \leftrightarrow 2Fe(OH)_3 \downarrow$

$Fe(OH)_3 + 3HCl \leftrightarrow FeCl_3 + 3H_2O$

$FeCl_3 + 3NaOH \leftrightarrow Fe(OH)_3 + 3NaCl$

Thus, the net effect of hydrogen gas concentrated near the cathode is to decrease the electrolyte's electrical conductivity and hence affects the local anodic dissolution rate also.

Fig one shows a schematic of an electrochemical machining system consists mainly of four sub-systems: power source, electrolyte supply system, device and tool-feed system, and work and work-holding system.

Low voltage DC (2-50 V) capable of giving high current density can be used as the power source. The material removal rate mainly depends upon the current density employed. The electrolyte supply and cleaning system consists of a pump, filters, pipings, control valves, pressure gauges and a reservoir. Electrolyte supply ports (connections) are made in the tool. An anti-corrosive materials for tools with high thermal and electrical conductivity like brass can be used as tool.

Two sides (Feed side and Permeate side) are separated through a dense palladium membrane which is an inorganic dense membrane having capability to separate hydrogen completely from the gaseous mixture. One pressure gauge

and one temperature sensor are also integrated on each side of the rectangular flow chamber in order to measure the pressure and temperature. During electrochemical Machining, the rate of evolution of hydrogen gas bubbles at the cathode surface is governed by current density on its surface. As the current density increases mass concentration of hydrogen also increases and the pressure and temperature on both the sides of the Pd/Ag Membrane will be measured with the help of pressure gauge and temperature sensor which drives the transport phenomena.

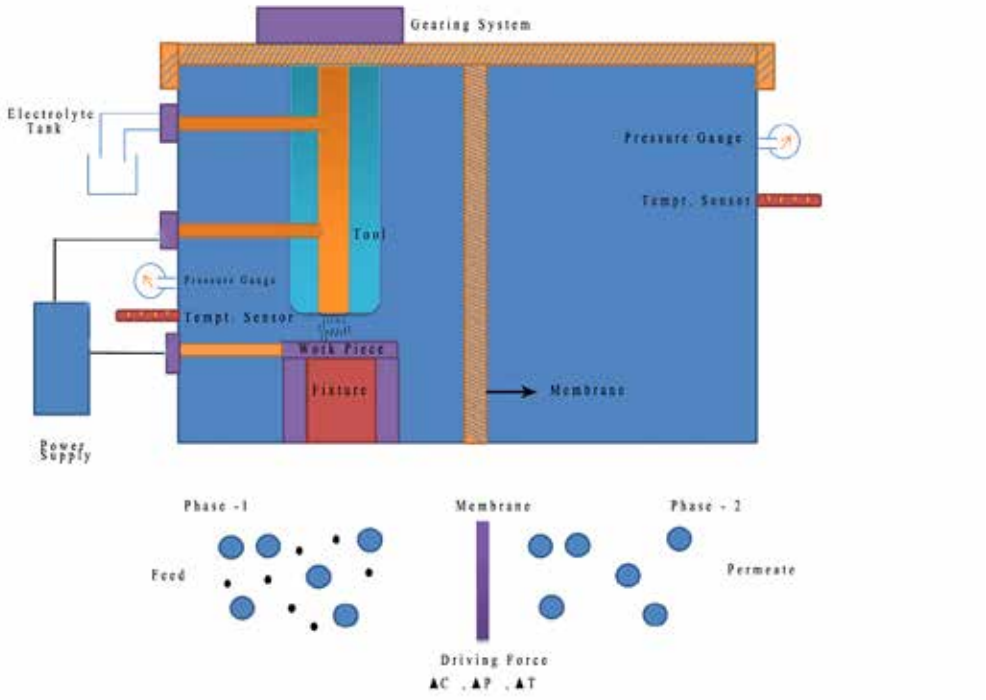

Fig.1 Schematic of Electrochemical Machining set up

II. RESULT AND DISCUSSION

The hydrogen molecular transport in the palladium membrane occurs through a solution diffusion mechanism, which follows the following steps [8]:

1. Dissociation of molecular hydrogen at the gas/ metal interface.
2. Adsorption of the atomic hydrogen on the membrane surface.
3. Dissolution of atomic hydrogen into the palladium matrix.
4. Diffusion of atomic hydrogen through the membrane.
5. Recombination of atomic hydrogen to form hydrogen molecules at the gas/metal interface.
6. Desorption of hydrogen molecules.

Membrane	d_{pore} (nm)	Diffusion mechanism
Macroporous	**>50**	**Poiseuille (Viscous flow)**
Mesoporous	**2–50**	**Knudsen**
Microporous	**<2**	**Activated process**
Dense Pd	**–**	**Fick**

Table 1.1 Diffusion mechanisms in porous and dense membranes

The hydrogen permeating flux can be expressed as following equation [9]:

$$J_{H2} = \frac{Pe_{H2}}{\delta} \left(P^{n}_{H2,\,feed} - P^{n}_{H2,\,perm}\right) \quad \text{.....(1)}$$

Where,

J_{H2}: Flux or permeation rate of hydrogen (mol/m^2s)

P_{eH2} :Hydrogen Permiability (mol m/m^2s Pa)

δ: Membrane Thickness (µm)

n: Dependence factor of the hydrogen flux to the hydrogen partial pressure (0.5 -1)

$P_{H2,feed}$: Hydrogen partial pressure in the feed side (bar)

$P_{H2,perm}$: Hydrogen partial pressure in the permeate side (bar)

When pressure is relatively low, diffusion is assumed to be rate limiting step and factor n is equal to 0.5 [10].

Hence the equation becomes Sievert's Fick law:

$$J_{H2} = \frac{Pe_{H2}}{\delta} \left(P^{0.5}_{H2,\,feed} - P^{0.5}_{H2,\,perm}\right) \quad \text{.....(2)}$$

The relationship between hydrogen permeability and temperature follows an Arrhenius behavior

$$P_{eH2} = P^{0}_{eH2} \exp(-E_a/RT) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where P^{0}_{eH2} is the pre-exponential factor, E_a the apparent activation energy, R the universal gas constant and T the absolute temperature.

Thus by using equation (2) Hydrogen permeating flux can be determine in terms of **mol/m^{2}s**. and once the hydrogen permeating flux for given area is determined, the exact amount of hydrogen transported through the membrane can be obtain for known area of the membrane and time by using the following relation.

$$\textbf{Number of mole} = \frac{Mass}{Molar\ Mass}$$

III. CONCLUSION

A theoretical approach concerning palladium based membranes (Pd/Ag), in order to control hydrogen evolution during Electrochemical Machining is presented. The corresponding mathematical equation and experimental procedure to determine the permeability of H_2 through the same has also been proposed. The hydrogen gas evolution at cathode can be minimizing as the maximum fraction of H_2 will be transported through membrane and hence the local anodic dissolution enhances with better accuracy and high surface finish. Based upon the concept of H_2 gas transported through Pd/Ag membrane mathematical equations are proposed.

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QUALITY MANAGEMENT APPROACHES IN INDIAN AUTOMOTIVE INDUSTRY

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ABSTRACT

This paper highlights the tools and techniques of quality management approaches used by companies in Indian Automobile Industry in their endeavors to match global standards. Content analysis of the Quality management links of respective websites of shortlisted hundred Automobile and Auto ancillary companies has been performed to bring out differences in the implementation of these practices. The paper concludes that there is similarity in the implementation of the practices like Kaizen, Employee Empowerment, Product Design, Statistical Process Control, Total Product Maintenance, PDSA, SMED, Six Sigma, Satisfaction Index and Autophoretic Painting. On the other hand significant differences are observed in the use and practice of Just in time, Computer Numerical Control, laser marking, image analyzer, contour measuring, benchmarking and Poka Yoke.

Key Words: Quality Management Practices, ISO Certifications, Kaizen, Statistical Process Control

I. INTRODUCTION

India has emerged as an Automotive manufacturing hub in the past decade. Competition in Automotive Sector requires the manufacturers and their suppliers to innovate, improve, and increase their efficiency to meet the challenges of globalization. This force the manufacturers to maintain high quality standards in their manufacturing process under strong competitive pressure. Low Labor cost, availability of raw materials, and the emerging automobile market leads the foreign manufacturer to outsource the manufacturing of the automobile component to gain competitive advantage [1]. The relatively stable economic growth and developed infrastructure, low cost manpower, low cost manufacturing and increasing demand for vehicle provides the Indian automotive companies with opportunities to grow at a fast pace. Customer focus and continuous improvement enhances the quality innovation process in an organization. Total Quality Management implementation focuses on continuous improvement and customer focus which leads to the innovation processes in the organization [2]. According to Kaynak, TQM and innovation together integrates organization objectives and functions which ultimately results in Customer Satisfactions [3].

Total Quality management is the management process and set of disciplines which ensures that the organization consistently meets and exceeds customer requirements. It is a combination of Quality and management tools aiming at increasing business and reducing losses due to wasteful practices. TQM is an integral part of Strategy at high level involving all employees at all levels from top to bottom and extends from supply chain to the ultimate customer [4]. TQM is a management philosophy, which operates to fulfill the customer's requirement continuously [5]. TQM practices helps in increasing revenue and market share of the companies by effective use of organizational resources to meet the customer expectation. Most of the companies are constantly working to

improve existing products or to develop new and exciting products that go beyond satisfaction. The Quality Management process can be used to help in the planning process for the products. It helps the company to improve in order to increase customer satisfaction. [6]

Emergence of Indian automotive industry as a global player seeks for understanding the complexity of quality practices required for running the business successfully in the international competitive environment. Today in the competitive world customers seeks for quality products and services at a low cost. In order to achieve this manufacturers have to produce those products which are economical. Saraph (1989) proposed that empirically validated measures to integrate quality management practices helps in understanding these practices with reference to the organization quality environment and quality performance [7]. Researchers have used such measures to understand quality management practice better and to build theories and models that relate the critical factors of quality management to organizational performance to achieve business excellence. According to a study by Ferdows (1997) the reason for the firm to outsource their manufacturing processes is to provide high quality products at comparatively low prices [8]. Consumer now a days are more aware about the quality while purchasing product, it leads the companies to be more focus on developing and updating their technological capabilities [9]. Firms that adopted Quality Certifications tends to implement TQM as the next step towards their quality management journey [10].

II. QUALITY MANAGEMENT PRACTICES AND TECHINIQUES IN INDIAN AUTOMOTIVE INDUSTRY

2.1 Quality Certification

India Automobile Sector requires a lot of certifications for its effective and efficient working. The ISO /TS 16949 certification is provided to the companies that emphasis on the development of process oriented quality management system and seeks for continuous improvement in their process which results in prevention of defects, reduction in variation and elimination of waste in the supply chain. ISO 9001 certification consist of documents containing national standards of the organizations in each country. ISO 9001:2008 replaced and combined the standards of the two quality certification ISO 9002 and ISO 9003 in the year 2000. OHSAS 18000 certification assures that the organisation must meet with the international occupational health and safety management system specifications.

2.2 Quality Control Techniques & Tools

Indian Automobile Industry has been using some general and some industry specific tools and techniques for its Total Quality Management. **Kaizen** refers to continuous and ongoing improvement in all activities of the organization from product development to industrial relation management to total product maintenance and ultimately to customer satisfaction. It is the result of the combination of small changes over a period of time [11].

Employee Empowerment provides incentive to employee to identify the problems and helps the management to solve the problem. It helps the staff to increase creativity, productivity, customer service and learn from their mistakes [12]. **Product Design** is the transformation of new ideas into a new product. It consists of three stages viz. Analysis, Concept and Synthesis. It can be classified into two category either demand pull innovation or invention push innovation. **Six Sigma** is the empirical and statistical technique of process improvement, developed by Motorola in the year 1986 [13]. It stands for six standard deviation from mean. It aims at

maintaining the quality of product near perfection. It defines the number of defects experienced by customer per million opportunities for a defect to occur [14] which allows for only 3.4 defects per million oppurtunities for each product [15]. Automobile manufacturer's demands for zero defect quality from their suppliers. Thus it helps in achieving significant cost reduction and gain competitive advantage.

Poka Yoke is a mistake proofing technique for avoiding simple human error, based on prediction and detection. It uses a bunch of small devices like fixtures, gadgets, warning signals, paper system to detect and prevent defects before additional value is added to the products [15]. **Statistical Process Control** is the statistical technique which uses Statistical equation and graphs to define the range of control limit in which variation in product design can be accepted. **Total Product Maintenance** is the tool that maximises effectiveness of the equipment and maintain the optimum relationship between the people and their respective machines. It aims at making the most effective use of the existing product structure [16].

PDSA CYCLE stands for the plan –do– study – act (PDSA) cycle and is cyclic process based on the fact that continuous improvement is a never-ending process. The application of this principle helps the automotive industry in alignment of the activities with the strategic goals of the organization. **Benchmarking** is a technique by which organization can measure themselves against the best industry practices. It is all about the borrowing ideas and adapting them to gain competitive advantage [17].

Just In Time (JIT) is the Pull System Production strategy where the material is not received from the supplier until it is needed to sustain Production. This technique helps to eliminate unproductive stocks and hence helps in reducing inventory, lead time, re-work, and space. The main purpose of these techniques is to deliver the raw materials or components to the production line to arrive just in time when they are needed. [16]

2.3 Emerging Techiniques of Quality Control in Automobile Sector

There are some new emerging techinique of quality contol used in Automobile Industry. These are Image analyser, Laser marking, Contour measuring, Computer numerical control, Autophhoretic painting and Satisfaction index.

Image Analyzer is the production tool used widely in the automobile industry which assures the required design, safety, comforts and aesthetic appearance of the visible parts of the vehicle. It helps in eliminating the deviations from desired geometry of the product. **Laser Marking** is production quality technique widely used in the automobile industry. The laser-marked code contains serial and lot of numbers, date of manufacturing and further information. Laser, vision system, software and handling system are integrated into the production line in order to achieve high production efficiency.

Contour measuring helps in conforming the shape of the auto ancillary parts based on the two dimension viz. macrostructure which includes form position & dimension and microstructure which includes roughness and waviness of the reference surface. The contour measuring systems are designed in modules and are combined for measuring tasks. **Single Minute Exchange of Die** Technique is the lean production technique aimed at reducing the waste in the manufacturing process. The phrase "single minute" in fact means that it should take less than 10 minutes to start up the next process.

Computer Numerical Control (CNC) Technique is the automation process in which various function of machines are controlled by the help of letters, number and symbols. In this CNC technique the machine

operation is based on the Program feed to it. **Autophoretic Painting** is the process of auto deposition and is the excellent alternative for the traditional electronic coating. **Satisfaction Index** is one of the emerging techniques for getting Customer Feedback. In this technique several categories related to customer satisfaction are measured and reported items are calculated per 1,000 orders to evaluate the percentage of customer satisfaction.

III. RESEARCH OBJECTIVE

The main objectives of this paper are:

i) To identify the prevalent Quality management Tools and Techniques of the Indian Automotive Industry.

ii) To identify the differences between the TQM Practices prevalent in Indian Automobile and Auto Ancillary Industry.

IV. RESEARCH METHODOLOGY

After reviewing the literature on total quality management practices, the Quality tools and Techniques used in Indian Automotive Sector were identified with the help of content analysis of quality policies of 100 automotive Companies (16 Automobile and 84 Auto Ancillary companies) by visiting websites of these companies. The Study is descriptive in nature. The Companies are shortlisted from the data base of Automotive Component Manufacturers Association of India and the database of Society of Indian Automobile manufacturer based on convenience sampling. The data is then tabulated in order to get the in depth understanding of their practices. In order to test the difference between the TQM practices in Automobile and auto ancillary companies Hypothesis were formulated. The data is categorical in nature therefore Hypothesis's were tested using Chi Square Test. The following null hypotheses were formulated in order to test whether there is significant difference between the implementation of the TQM Practices in the Indian Automobile industry and Indian Auto Ancillary Industries:

1. H_0: There is no significance difference in the use of Kaizen as a tool of TQM across both the industries.
2. H_0: There is no significance difference in the use of Employee Empowerment practice as a tool of TQM across both the industries.
3. H_0: There is no significance difference in the use of Product Design as a tool of TQM across both the industries.
4. H_0: There is no significance difference in the use of Six Sigma as a tool of TQM across both the industries.
5. H_0: There is no significance difference in the use of Poka Yoke as a tool of TQM across both the industries.
6. H_0: There is no significance difference in the use of Statistical Process Control as a tool of TQM across both the industries.
7. H_0: There is no significance difference in the use of Total Product Maintenance as a tool of TQM across both the industries.
8. H_0: There is no significance difference in the use of Benchmarking as a tool of TQM across both the industries.
9. H_0: There is no significance difference in the use of PDSA Cycle as a tool of TQM across both the industries.
10. H_0: There is no significance difference in the use of SMED as a tool of TQM across both the industries.

11. $H_{0:}$ There is no significance difference in the use of Contour Measuring as a tool of TQM across both the industries.
12. $H_{0:}$ There is no significance difference in the use of Image Analyzer as a tool of TQM across both the industries.
13. $H_{0:}$ There is no significance difference in the use of Laser Marking as a tool of TQM across both the industries.
14. $H_{0:}$ There is no significance difference in the use of Satisfaction Index as a tool of TQM across both the industries.
15. $H_{0:}$ There is no significance difference in the use of Autophoretic painting as a tool of TQM across both the industries.
16. $H_{0:}$ There is no significance difference in the use of Computer Numerical Control as a tool of TQM across both the industries.
17. $H_{0:}$ There is no significance difference in the use of just in time (JIT) as a tool of TQM across both the industries.

V. ANALYSIS AND FINDING

5.1 Description of Data

As can be observed from Table 1 that out the 100 Indian automotive companies 16 were Indian Automobile Company, while 84 were Indian Automobile Ancillary Companies After studying about a hundred Indian Automobile and Auto ancillary companies, it can be observed from the fig. 1 that all of these companies have **ISO TS 16949 ISO and OHSAS 18001** certification, probably due to the strict government norms. It can also be revealed most of the companies use **Kaizen, Employee Empowerment, Product Design, Six Sigma, Statistical Process Control and PDSA Techniques.** Techniques like **POKA YOKE, Just In Time, Benchmarking, and SMED** are used by more than half of the companies surveyed and targeted by the rest of the companies to be included in their next plans. The emerging techniques of quality control such as **Contour Measuring, The Satisfaction Index Technique, Autophoretic Painting, Laser Marking, and image analysis** are used by few of the companies.

Table 1: Table Showing The Type Of Industry Surveyed

	Frequency	Percent	Valid Percent	Cumulative Percent
Automobile	16	16.0	16.0	16.0
Ancillary	84	84.0	84.0	100.0
Total	100	100.0	100.0	

Table 2: Table Showing The Quality Practices In The Indian Automotive Industry

S. No.	**Name of Quality Management Practices & Techniques**	**Frequency (in %)**
1.	Kaizen	**98**
2.	Employee Empowerment	**94**

3.	Product Design	**95**
4.	Six Sigma	**94**
5.	Poka Yoke	**75**
6.	Statistical Process Control	**92**
7.	Total Product Maintenance	**93**
8.	Benchmarking	**57**
9.	PDSA Cycle	**95**
10.	SMED	**89**
11.	Contour Measuring	**38**
12.	Image Analyzer	**22**
13.	Laser Marking	**12**
14.	Satisfaction Index	**12**
15.	Autophoretic Painting	**14**
16.	Computer Numerical Control Technique	**45**
17.	Just In Time	**67**

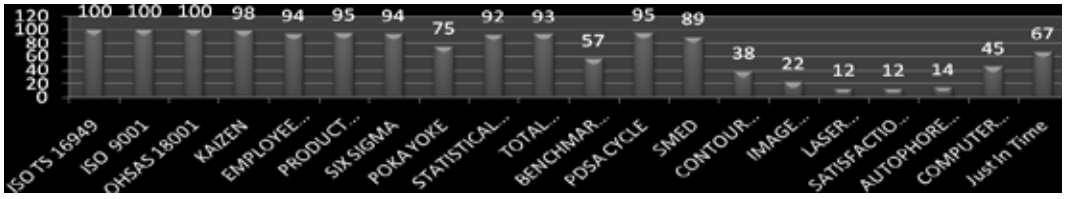

Figure 1: Graph Showing The No. Of Companies (Out Of 100) With Their TQM Practices And Techniques.

5.2 Analysis of Data

Since the Data is categorical in nature, so in order to find out the differences between the TQM Practices across the Automobile and Auto Ancillary Industry, the Hypothesis formulated were tested using the non parametric test i.e. Chi Square Test. The finding of the test is as given below.

Table 3: Interpretation Of Test Of Hypothesis

	Null Hypothesis	**Test**	**Significance***	**Decision**
1	There is no significance difference in the use of Kaizen as a tool of TQM across both the industries.	Chi Square Test	0.581	Retain the null hypothesis
2	There is no significance difference in the use Employee Empowerment as a tool of TQM across both the industries.	Chi Square Test	0.329	Retain the null hypothesis
3	There is no significance difference in the use of Product Design as a tool of TQM across both the industries.	Chi Square Test	0.375	Retain the null hypothesis

4	There is no significance difference in the use of Six Sigma as a tool of TQM across both the industries.	Chi Square Test	0.783	Retain the null hypothesis
5	There is no significance difference in the use Poka Yoke as a tool of TQM across both the industries.	Chi Square Test	0.026	**Reject the null hypothesis**
6	There is no significance difference in the use of Statistical Process Control as a tool of TQM across both the industries.	Chi Square Test	0.254	Retain the null hypothesis
7	There is no significance difference in the use of TPM as a tool of TQM across both the industries.	Chi Square Test	0.289	Retain the null hypothesis
8	There is no significance difference in the use of Benchmarking as a tool of TQM across both the industries.	Chi Square Test	0.001	**Reject the null hypothesis**
9	There is no significance difference in the use of PDSA Cycle as a tool of TQM across both the industries.	Chi Square Test	0.698	Retain the null hypothesis
10	There is no significance difference in the use of SMED as a tool of TQM across both the industries.	Chi Square Test	.588	Retain the null hypothesis
11	There is no significance difference in the use of Contour Measuring as a tool of TQM across both the industries.	Chi Square Test	0.000	**Reject the null hypothesis**
12	There is no significance difference in the use of Image Analyzer as a tool of TQM across both the industries.	Chi Square Test	0.000	**Reject the null hypothesis**
13	There is no significance difference in the use of Laser Marking as a tool of TQM across both the industries.	Chi Square Test	0.000	**Reject the null hypothesis**
14	There is no significance difference in the use of Satisfaction Index as a tool of TQM across both the industries.	Chi Square Test	0.608	Retain the null hypothesis
15	There is no significance difference in the use of Autophoretic painting as a tool of TQM across both the industries.	Chi Square Test	0.104	Retain the null hypothesis
16	There is no significance difference in the use of Computer Numerical Control as a tool of TQM across both the industries.	Chi Square Test	0.000	**Reject the null hypothesis**
17	There is no significance difference in the use of just in time (JIT) as a tool of TQM across both the industries.	Chi Square Test	0.007	**Reject the null hypothesis**
	*Asymptotic significance is displayed. The significance level is .05			

5.3 Findings

5.3.1 The major Quality Certifications viz. ISO TS 16949, ISO 9001, and OHSAS 18001 are implemented by the entire automobile and auto ancillary companies.

5.3.2 About 90% and more of the companies use **Kaizen, Employee Empowerment, Product Design, Six Sigma, Statistical Process Control, TPM and PDSA Techniques.** Techniques like **POKA YOKE, Just In Time, SMED, and Benchmarking** are used by 90% to 50% of the companies and targeted by the rest of the companies to be included in their next plans. **The Satisfaction Index Technique, Autophoretic Painting, Laser Marking, Contour Measuring and image analysis** are used by less than 40% of the companies

5.3.3 It can be seen from the above TABLE 2 that the significant value of the chi square test for Kaizen across both the industry is greater than .05 , i.e. 0.581 so we retain the null hypothesis and can conclude that There is no significance difference in the use of Kaizen as a tool of TQM across both the industries.

5.3.4 It can be seen from the above TABLE 2 that the significant value of the chi square test for Employee Empowerment across both the industry is greater than .05 , i.e. 0.329 so we retain the null hypothesis and can conclude that There is no significance difference in the use Employee Empowerment as a tool of TQM across both the industries..

5.3.5 It can be seen from the above TABLE 2 that the significant value of the chi square test for Product Design across both the industry is greater than .05 , i.e. 0.375 so we retain the null hypothesis and can conclude that There is no significance difference in the use of Product Design as a tool of TQM across both the industries.

5.3.6 It can be seen from the above TABLE 2 that the significant value of the chi square test for Six Sigma across both the industry is greater than .05 , i.e. 0.783 so we retain the null hypothesis and can conclude that There is no significance difference in the use of Six Sigma as a tool of TQM across both the industries.

5.3.7 It can be seen from the above TABLE 2 that the significant value of the chi square test for Poka Yoke across both the industry is less than .05, i.e.0.026 so we reject the null hypothesis and can conclude that There is significance difference in the use of Poka Yoke as a tool of TQM across both the industries.

5.3.8 It can be seen from the above TABLE 2 that the significant value of the chi square test for Statistical process control across both the industry is greater than .05, i.e. 0.254 so we retain the null hypothesis and can conclude that There is no significance difference in the use of Statistical Process control as a tool of TQM across both the industries.

5.3.9 It can be seen from the above TABLE 2 that the significant value of the chi square test for TPM across both the industry is greater than .05 , i.e. 0.289 so we retain the null hypothesis and can conclude that There is no significance difference in the use of TPM as a tool of TQM across both the industries.

5.3.10 It can be seen from the above TABLE 2 that the significant value of the chi square test for Benchmarking across both the industry is less than .05 , i.e. 0.001 so we reject the null hypothesis and can conclude that There is significance difference in the use of Benchmarking as a tool of TQM across both the industries.

5.3.11 It can be seen from the above TABLE 2 that the significant value of the chi square test for PDSA across both the industry is greater than .05 , i.e. 0.698 so we retain the null hypothesis and can conclude that There is no significance difference in the use of PDSA as a tool of TQM across both the industries.

5.3.12 It can be seen from the above TABLE 2 that the significant value of the chi square test for SMED across both the industry is greater than 0.05, i.e. 0.581 so we retain the null hypothesis and can conclude that There is no significance difference in the use of SMED as a tool of TQM across both the industries.

5.3.13 It can be seen from the above TABLE 2 that the significant value of the chi square test for Contour Measuring across both the industry is less than 0.05, i.e.0 .000 so we reject the null hypothesis and can conclude that there is significance difference in the use of Contour Measuring as a tool of TQM across both the industries.

5.3.14 It can be seen from the above TABLE 2 that the significant value of the chi square test for Image Analyzer across both the industry is less than 0.05 , so we reject the null hypothesis and can conclude that There is significance difference in the use of Image Analyzer as a tool of TQM across both the industries

5.3.15 It can be seen from the above TABLE 2 that the significant value of the chi square test for Laser Marking across both the industry is less than 0.05 , i.e. 0.000 so we reject the null hypothesis and can conclude that There is significance difference in the use of Laser Marking as a tool of TQM across both the industries.

5.3.16 It can be seen from the above TABLE 2 that the significant value of the chi square test for Satisfaction Index across both the industry is greater than 0.05 , i.e. 0.608 so we retain the null hypothesis and can conclude that There is no significance difference in the use of Satisfaction Index as a tool of TQM across both the industries.

5.3.17 It can be seen from the above TABLE 2 that the significant value of the chi square test for Autophoretic Painting across both the industry is greater than 0.05 , i.e. 0.104 so we retain the null hypothesis and can conclude that There is no significance difference in the use of Autophoretic Painting as a tool of TQM across both the industries.

5.3.18 It can be seen from the above TABLE 2 that the significant value of the chi square test for Computer Numerical Control across both the industry is less than 0.05, i.e. 0.000 so we reject the null hypothesis and can conclude that There is no significance difference in the use of Computer Numerical Control as a tool of TQM across both the industries.

5.3.19 It can be seen from the above TABLE 2 that the significant value of the chi square test for Just in Time (JIT) across both the industry is less than 0.05, i.e. 0.007 so we reject the null hypothesis and can conclude that There is no significance difference in the use of Just In Time (JIT) as a tool of TQM across both the industries.

VI. CONCLUSION

It concluded that by and large Indian Automotive Industry uses similar tools and techniques for the implementation of TQM practices. There is similarity in the implementation of the practices like Kaizen,

Employee Empowerment, Product Design, Statistical Process Control, Total Product Maintenance, PDSA, SMED, Six Sigma, Satisfaction Index, Autophoretic Painting, but differences were observed in the implementations of some tools and techniques like Just in time, Computer Numerical Control, laser marking, image analyzer, contour measuring, benchmarking and Poka Yoke due to the specific requirements of these segments - Automobile and Auto Ancillary. It can be concluded that despite the different principles, rules, standards etc. followed by most of the automotive companies, they aim for a common result i.e. Quality. Automobile industry by nature is consumer centric. It responds immediately to the emerging technologies and innovations, but with caution. The implementation of TQM practices in the automobile and auto ancillary industry in India were found to be by and large similar, with differences observed in the practices. Quality control and Quality assurance are very important tools in maintaining standards and expectations from the customers and also helps in competing with the global players.

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PERFORMANCE OF FOUR STROKE DIESEL ENGINE, FOCUSING COMBUSTION MODELING AND CYCLE ANALYSIS

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ABSTRACT

In the world, now a day use of various transportation vehicles are drastically increase and also increase the consumption of crude oil so it is very important to improve the fuel consumption and emission in particular area of automobile. Now in the recent Era the diesel engine is most preferable for a transportation system. And the diesel as a fuel is better than another fuel so diesel is more used as a fuel. So it's a challenge for researcher to reduce fuel consumption and increase break power and reduce the exhaust emission. If experimentally investigate the data, it is very laborious, time consuming and expensive. Also cannot detail micro level research study of the engine. For achieving and full fill above concept it is very important to do the combustion modeling and IC engine cycle analysis to detail micro level research study of the combustion process. Here, effort has been made for combustion modeling and simulation of two cylinder four stroke diesel engines and finds the pressure–volume diagram and other relevant combustion diagram with equations and find the various better results for improving the combustion efficiency and brake power in twin cylinder diesel engine. In present study also investigate experimentally performance parameters of diesel cycle with the use of data logger. With the help of data logger it is found that most of the efficiency, brake power, specific fuel consumption, and pressure–volume diagram of each load at each crank angle of diesel cycle. So it is found that from the above study of combustion of diesel engine that modeling is more important for the prediction of combustion behavior characteristic and for the better performance of engine.

I. THEORY OF MODELING

The modeling of I.C engines is a multi-disciplinary subject that involves chemical thermodynamics, fluid mechanics, Turbulence, heat transfer, combustion & numerical methods. I.C engine is a main power plant of transportation systems and are responsible for a substantial fraction of fuel consumption. The scarcity of oil resources and the ever-increasing standards on air pollution & emissions have decide to need for improved, more efficient and less pollution I.C engine. Improvement on engine design has been achieved by traditional method based on extensive experience. The advent of computers & possibility of performing "numerical" experiment may provide a new way of designing I.C engine. In fact, stronger interaction between engine modelers, designers & experimenters may results in improved engine design in the not too-distance future. In model, engine behavior is described with a mathematical model. The optimization does not occur in the real engine but rather is a model, which takes into account all effects relevant for the concrete table of optimization. [1] According to J.B.Heywood engine combustion modeling is a physically based description of the engine combustion process which predicts the mass burning rate and flame geometry as function of engine design & operating variable. The modeling of engine processes continues to develop as our basic understanding of the

physics and chemistry of the phenomena of interest steadying expands and as the capability of computers to solve complex equations continues to increase. Modeling activities can make major contributions to engine engineering at different levels of generality or detail, corresponding to different stages of model development.

The aims of modeling I.C engine processes are:

(1) To predict engine performance without having to conduct tests.

(2) To deduce the performance parameters that can be difficult to measure in tests.[2,3]

It is obviously an advantage if engine performance can be predicated without going to the trouble of first building an engine then incrementing it, testing it and finally analyzing the results. Modeling should lead to saving of both time and money. The models have been classified as zero-dimensional, single-zone to multi-zone and multi-dimensional models. Zero-dimensional and multi-dimensional models have been called as phenomenological or thermodynamic and detailed models; respectively. Multi-dimensional models are based on the numerical solution of a set of governing coupled partial-differential equations, which are integrated in fine (2 or 3 dimensional) geometric grids in the combustion chamber space. Although these models are capable of providing detailed information about both spatial and temporal resolution of the quantities of interest, they require large amounts of computer time and storage capacity. Thus, if it is desired to examine the effects of all parameters on combustion and pollutant emissions more practical methods such as thermodynamic models could be used. Thermodynamic models are based upon a combination of fundamental theory, similarity considerations, direct and indirect experimental data correlations based on various sources. They are widely used to compute whole engine cycles, engine parameters and exhaust emissions, because of their quicker and cheaper application abilities, for generating the information required to support engine design and development studies. The thermodynamic models may be subdivided into two groups such as zero-dimensional single-zone (ZDSZ) and quasi-dimensional multi-zone models (QDMZ).[4,5]

In ZDSZ models, combustion process is modeled simply by assuming it as an empirical heat addition process. Using these models, engine cycles, engine performance parameters and emissions of exhaust gases can be calculated easily and various useful results can be obtained. The QDMZ models are formulated by employing simplified quasi steady equations describing the individual processes that occur in the engine cylinder such as fuel injection, fuel atomization, air entertainment, fuel-air mixing, combustion and heat transfer. In these models, charge in the cylinder is divided into several zones during various processes, especially for combustion process. [6,7]

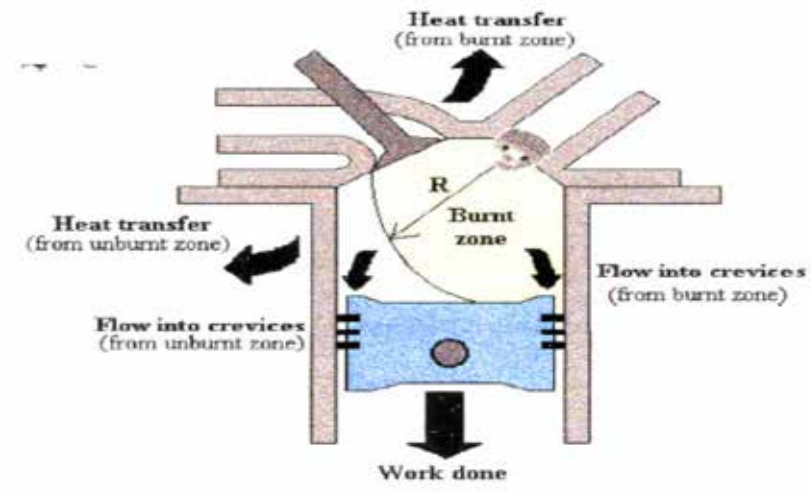

Fig: 1 Two Zone Quasi One Dimensional Thermodynamic Model

Other type is Linguistic model &Mathematical model. In linguistic model rule-based method built upon empirically grounded rules, which can't be grasped by mathematical eq^{n}s. In mathematical model which is resting on mathematical formulism also parametric models & Non-parametric models. Parametric models are represented by compact mathematical formulism for the description of system behavior which rest upon physical & chemical laws & show only relatively few parameters that are to be experimentally determined. These models are typically described by means of a set of partial or normal differential equations and non-parametric models are represented by tables that record the system behavior at specific test input signals with the help of suitable mathematical method, e.g. Fourier transformation the behavior of the system can be calculated at only input signal.[8,9]

The system of ordinary differential equations that is obtained from the first law of thermodynamics and the other basic thermodynamic relations are solved for pressure, temperature and mass in the zones. Although these models are not very detailed, they are used widely as routine simulation exercises and extensive parametric studies of engine operating and emission characteristics. In QDMZ models, the engine cycle and engine characteristics have been computed generally from compression stroke to expansion stoke and indicated engine characteristics have been given from the cycle calculation. In the some research paper two zone quasi one dimensional model is proposed for modeling of combustion process of an I.C. engine as it is readily incorporated complete engine models, is useful for parametric studies associated with engine and tries to predict burn rate information. In two zones quasi one dimensional model, turbulence is eliminated which makes method simple and adaptable from the point of view of programming. The prediction of performance with the help of this model is very much nearer to the actual and available data. [10,11, 12]

II. EXPERIMENTAL PROCEDURE

The experimental was carried out on twin cylinder four stroke vertical water cooled diesel engine made by kirloskar oil engine ltd (TV2/DM 17/DM20 TYPE) with a bore 87.5 mm and stroke 110 mm. the engine is rated for 10.3 (14 hp) and 1800 rpm with a centrifugal governor to control the speed . The engine was connected with an electric dynamometer is used to measure the power output. The engine is instrumented to measure the parameter like fuel consumption, load speed of engine, cooling water temperature, inlet air and exhaust gas temperature. The engine test carried out with constant speed of 1800 rpm and load vary with no load to the maximum load condition. At each operating points variations measured were taken for engine.[13,14]

Table 1: Engine Specification

Engine type : Multi cylinder vertical water cooled self-governed constant speed diesel engine	
Injection pressure = 200bar	I.V.O = 4.5° BTDC
Piston diameter = 87.5 mm	I.V.C = 35.5° ABDC
Compression ratio = 17.5:1	E.V.O = 35.5° BBDC
Power = 10.3 kw = 14 HP	E.V.C = 4.5° ATDC
Lubrication oil = 20w/40.	Injection timing = 26° BTDC
Lubrication oil required = 7 litrs	A/F ratio = 14.89 : 1

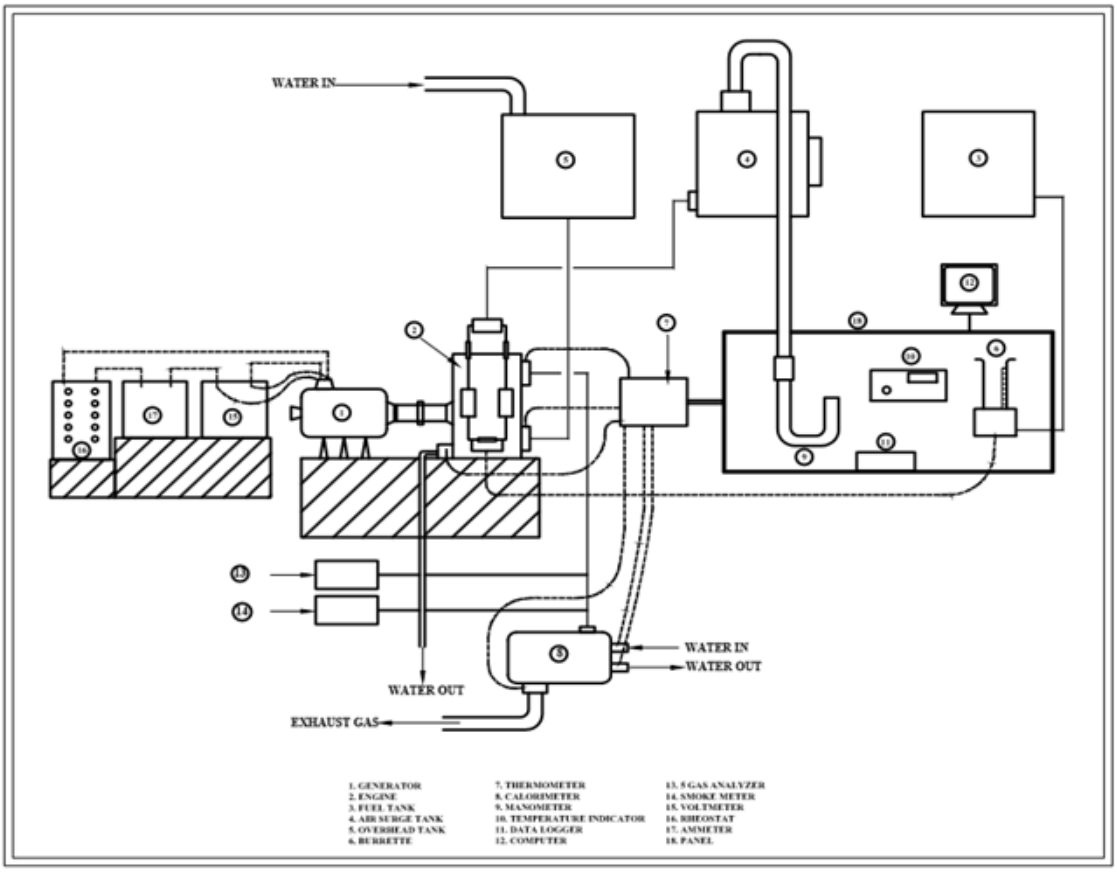

Fig 2: The Block Diagram of Experimental Set-Up

III. RESULT AND DISCUSSION

3.1 Brake Power Vs Volumetric Efficiency

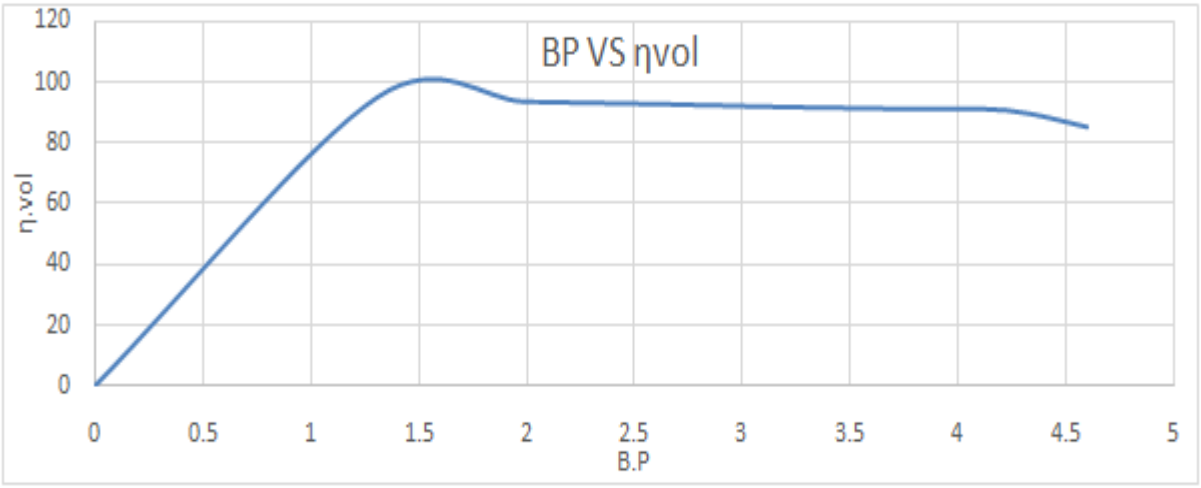

Fig 3: Comparisons of Brake Power (BP) V/S Volumetric Efficiency

It can observe from the above graph; when the brake power is increase volumetric efficiency is increase after it reached at rated power 4.2kw the volumetric efficiency is decrease so at rated power the volumetric efficiency is 90.55 %. At higher operating load the combustion temperature is very higher and engine speed is also very high so less charge of air is admitted in the combustion chamber so after rated power volumetric efficiency is decrease.

3.2 Brake Power Vs Mechanical Efficiency

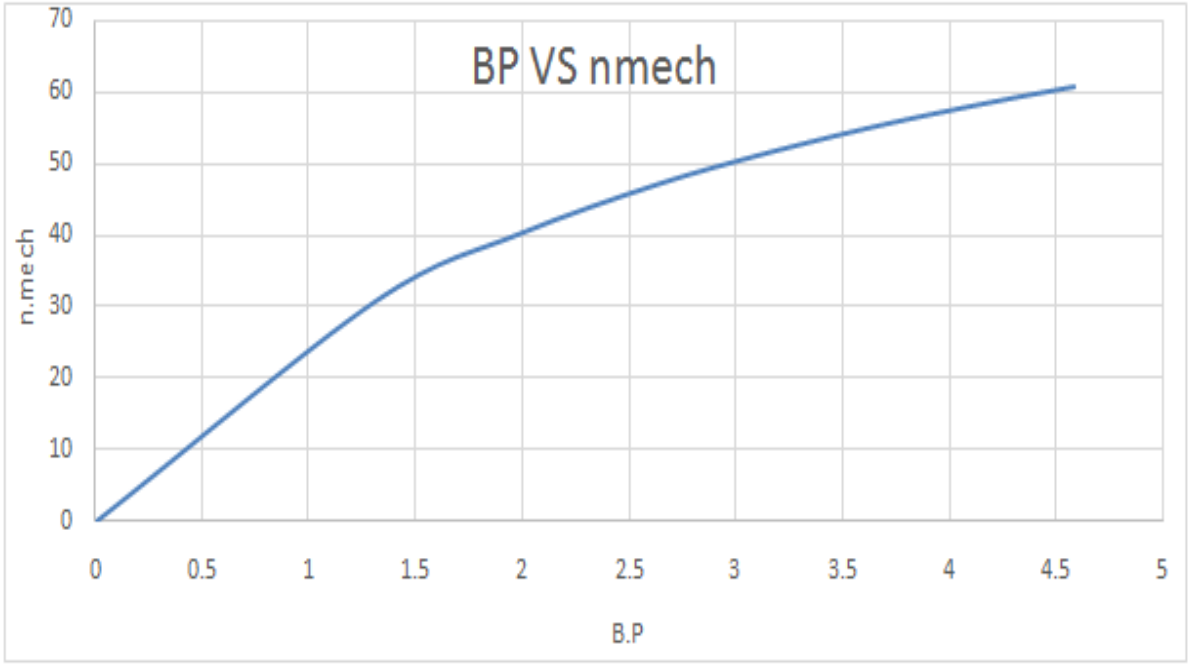

Fig 4: Comparisons Of Brake Power (BP) V/S Mechanical Efficiency

It can found from the above graph; when the brake power is increase mechanical efficiency is increase after it reached at rated power 4.2kw the mechanical efficiency is 58.85 %. At higher operating temperature the lubricant oil temperature also it is high so that viscosity will decrease and friction will also decease.

3.3 Brake Power Vs Brake Thermal Efficiency

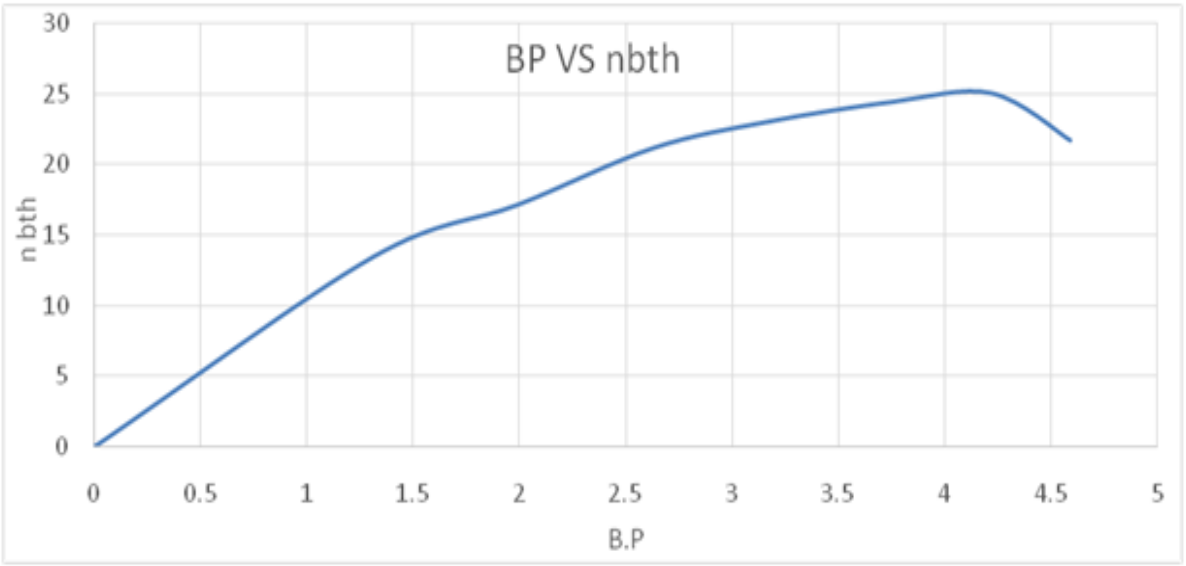

Fig 5: Comparisons Of Brake Power (BP) V/S Brake Thermal Efficiency

It can found from the above graph; when the brake power is increase brake thermal efficiency is increase after it reached at rated power 4.2kw the brake thermal efficiency is 25.08 %. At higher load condition the mixture can lean so the brake thermal efficiency is increase due to lower S.F.C , when at overload condition the mixture become a very rich and incomplete combustion will take place so the efficiency decrease.

3.3 Brake Power Vs Specific Fuel Consumption

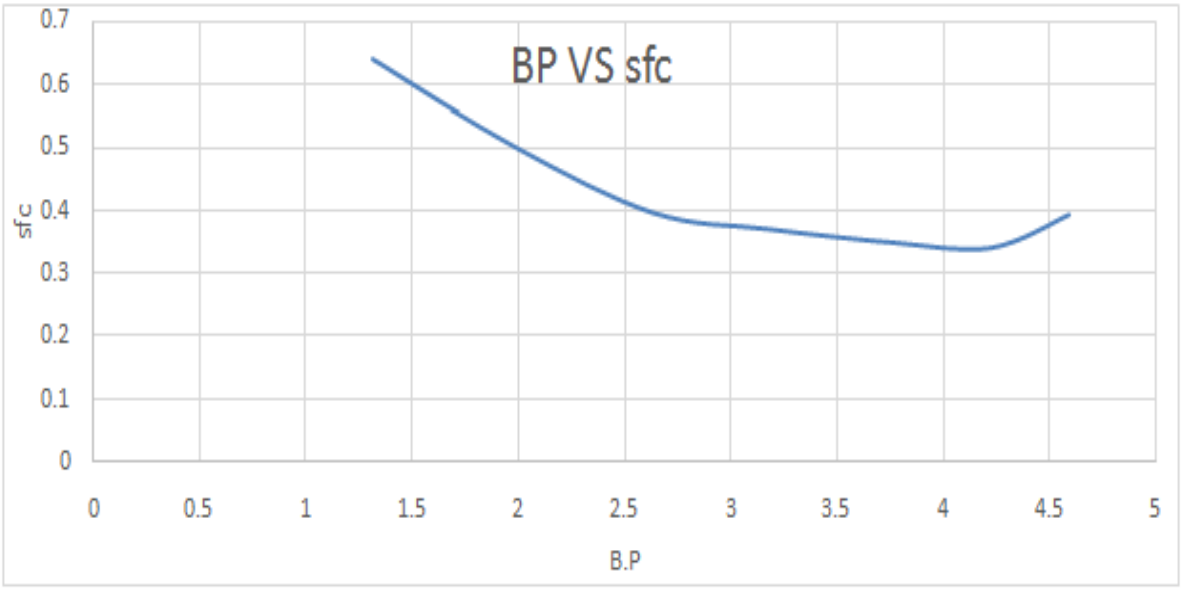

Fig 6: Comparisons of Brake Power Vs Specific Fuel Consumption

It can found from the above graph; when the brake power is increase specific fuel consumption is decrease after it reached at rated power 4.2kw, specific fuel consumption the is 0.344kg/kwhr . After rated power the SFC is now increase. At rated power optimum use of air and fuel so best SFC found among all load condition.

3.4. Heat Balance Sheet at Rated Power

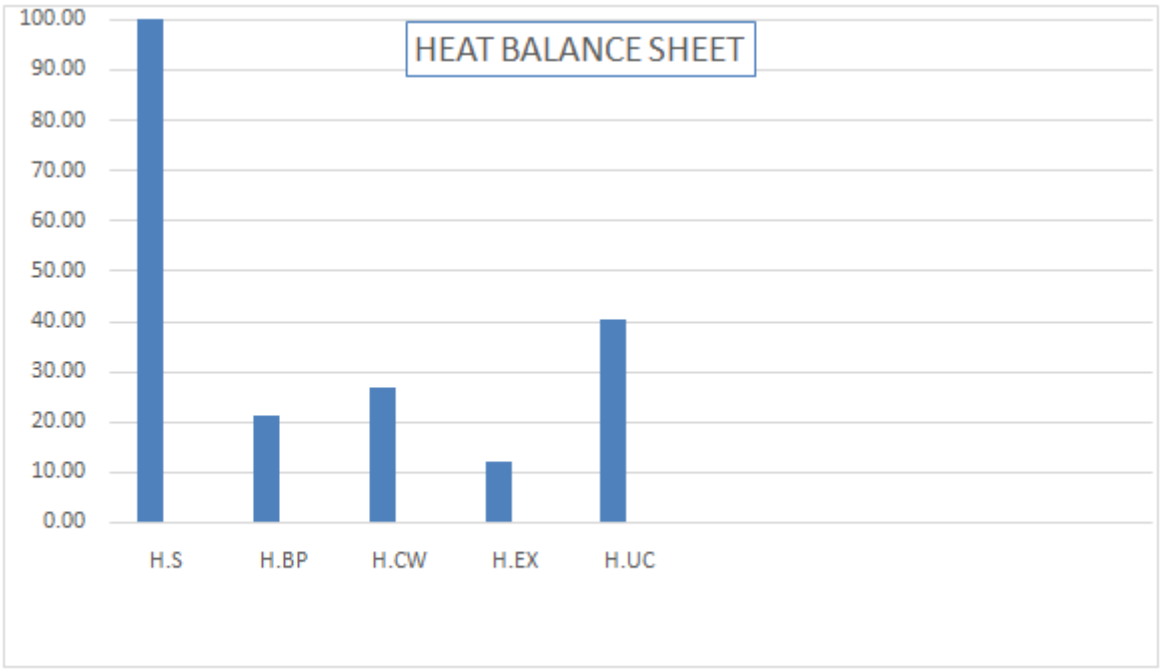

Fig 7: HEAT BALANCE SHEET AT RATED POWER

From the above figure it is found that at rated power 4.2 kw. When100 % heat supply by fuel. 21.02 % Equivalent heat use brake power, 26.78 % heat carried as a loss by jacket cooling water, 12 % heat carried as a loss through exhaust gases. , 40.17 % heat lost by radiation and unaccountable losses.

3.4 Combustion Graph from Data Logger

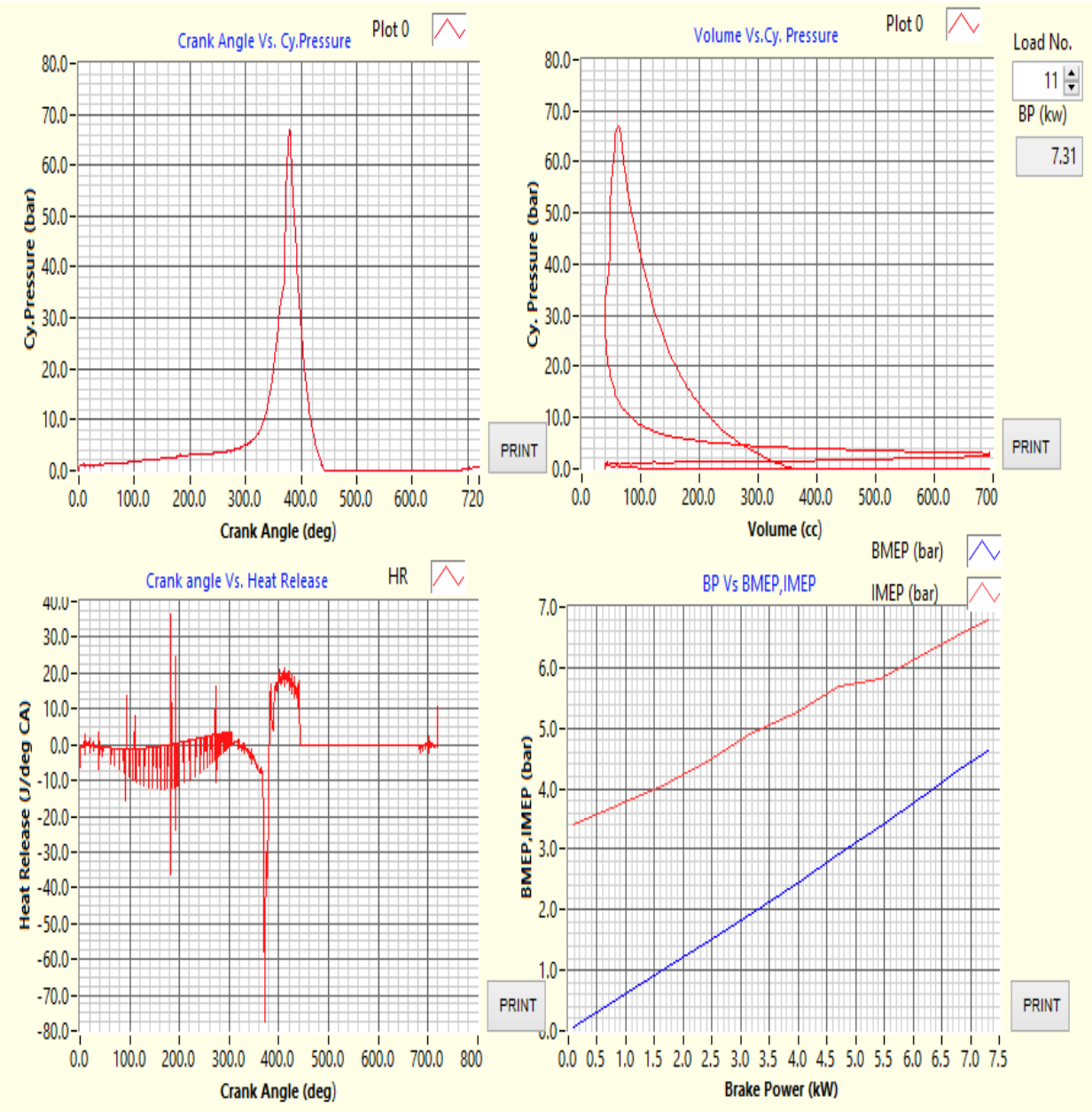

Fig 8: Combustion Graph from Data Logger

From the above combustion figures it can found that of the combustion process at each crank angle and find the pressure and volume at each crank angle and each load which was shows that combustion characteristics useful which will give the clue of improving combustion efficiency. The heat release is increase at combustion period at T.D.C. level of the piston and decrease at expansion at B.D.C condition of the piston. Also the brake mean effective pressure and indicated mean effective pressure is increase gradually with respect to brake power. These graphs are generated with the use of data logger.

3.5 Combustion Graph from Modeling

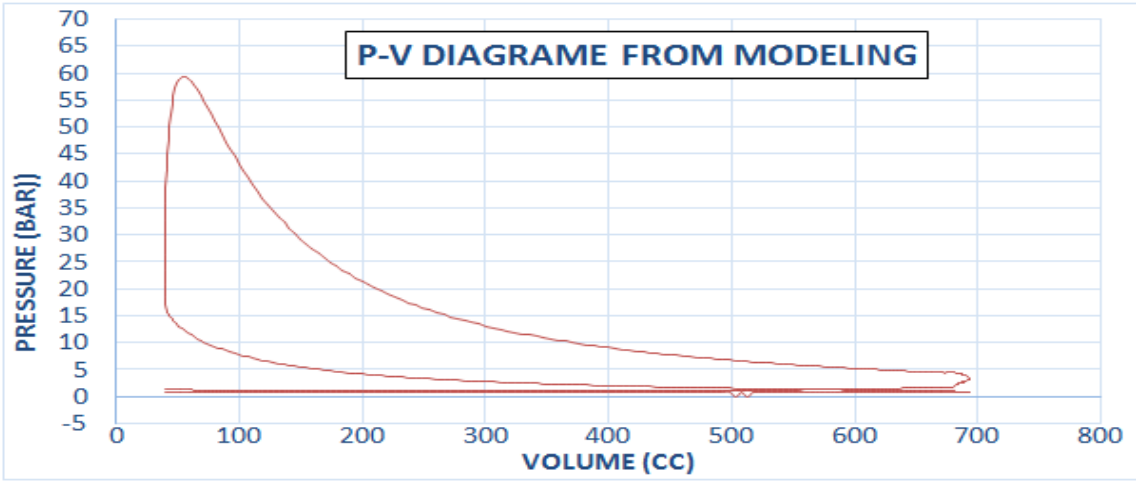

Fig 9: Pressure Vs Volume Graph from Modeling

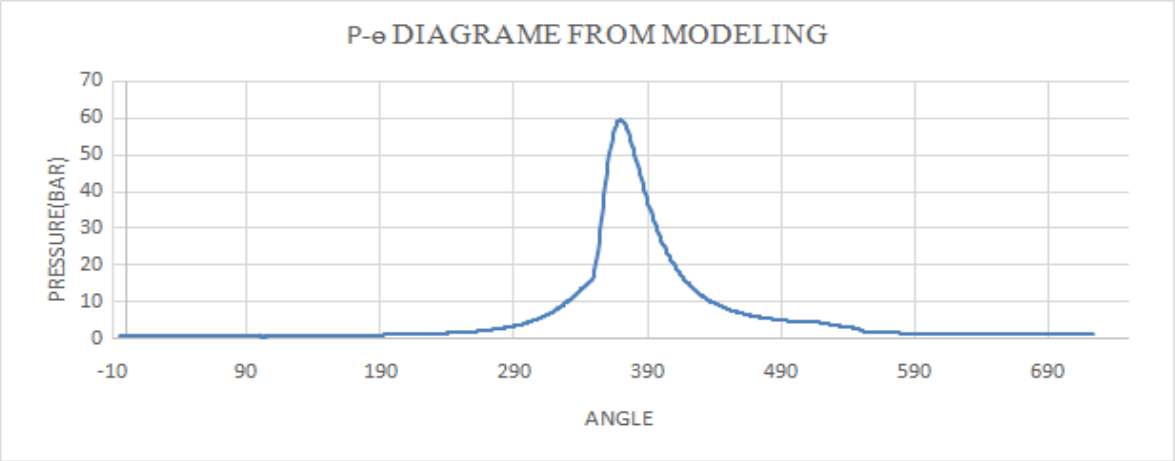

Fig 10: Pressure Vs Angle Graph from Modeling

These Figures are made by mat lab programming with the use of modeling equations and theory. From these graphs can find pressure and volume from the cycle analysis at each crank angle and can predict the performance of engine combustion from this graph without using experimental work and time consuming, laborious work during experiment.

IV. CONCLUSION

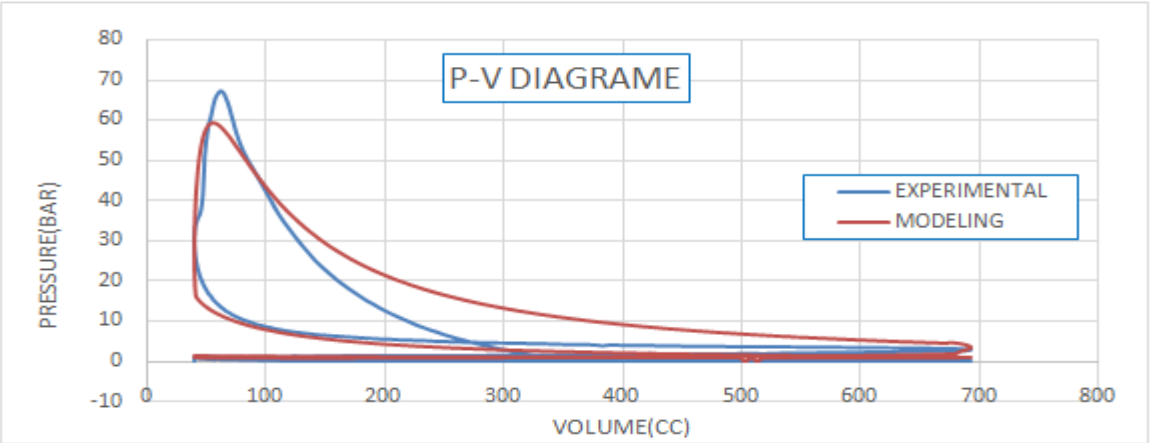

Fig 11: Comparison of Pressure Vs Volume Graph

With the use of data logger find the pressure-volume diagramed at each crank angle and this pressure-volume diagramed is compared with p-v diagramed of modeling shown in figure. From the above validation graph we found the variation in p-v diagramed .experimentally p-v diagram work done is less than the modeling p-v diagram this will be happened due to valve opening and closing in certain time. Also exact valve at TDC and BDC will not be open and close suddenly with zero time variation. The work done is improved by applying optimum advance angle & optimum compression ration required. Also we used some design change in combustion chamber area and design to increase the work done of the engine. From the experiment get the values of efficiency and SFC and heat balance sheet at the rated power of the engine. The volumetric efficiency is 90.55 %, the brake thermal efficiency is 25.08%, the mechanical efficiency is 58.85 %, and SFC is 0.344 kg /kwhr. Also getting the available brake power is 21.03 % and other energy is going in terms of losses.

V. SUGGESTIONS FOR FUTURE SCOPE OF WORK

Make mathematical model universal which is useful for different fuel (CNG, LPG, BIOGAS, BIOMASS, and BIODIESEL) and compare this mathematical model with experimental data. Apply different Batter TBC material on piston, piston head, and piston valve& liner and investigate emission & performance of engine. Make mathematical model of exhaust emission and investigate the exhaust pollution and find how to control the exhaust pollution. Use multidimensional and 3-dimensional mathematical modeling for the combustion chamber analysis. Also investigate vibration and noise condition at different system of the engine and found that what are the effect occur of different component of engine.

VI. ACKNOWLEDGEMENT

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A SURVEY ON OPINION MINING APPROACHES

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ABSTRACT

Opinion mining tasks involve opinion word identification, classification (positive, negative or neutral) and identifying strength of opinion (positive (strong or weak), negative (strong or weak)), target identification on which opinion is given, opinion source identification and opinion summarization. Hence, Opinion Mining tasks require techniques from the field of natural language processing, information retrieval (IR), and text mining. The main concern is how to automatically identify opinion components from unstructured text and summarize the opinion about an entity from a huge volume of unstructured text.

This study presents a systematic literature survey that contains a comprehensive overview of different approaches of opinion mining. The aim of this study is to provide researchers and students access to the works in opinion mining as they frame new ideas and further develop the practice.

Keywords: Aspect Mining, Opinion Classification, Opinion Mining, Opinion Polarity, Opinion Word

I. INTRODUCTION

Opinion Mining needs use of natural language processing tasks for tracking the mood of the public about a particular product or topic. Opinion mining, which involves in building a system to collect and examine and categorize opinions about the product made in blog posts, comments, reviews or tweets. [31]

Opinion mining is the computational treatment of people's opinions, emotions and attitudes toward entities, individuals, events, topics and their attributes. The opinion mining task is technically very challenging and practically very useful. For example, businesses always want to know public or consumer opinions about their products and services. People also want to know the opinions of existing customers before they use a service or purchase a product.

An opinion is the private state of an individual and it represents the individual's ideas, beliefs, judgments and evaluations about a specific subject, topic or item.

Opinion Mining is a procedure used to extract opinion from text. "opinion mining is a recent discipline at the crossroads of information retrieval, text mining and computational linguistics which tries to detect the opinions expressed in natural language texts" [22].

An opinion has three main components, i.e., the opinion holder or source of the opinion, the object (aspect or entity) about which the opinion is expressed and the evaluation, view or appraisal, that is, opinion. For opinion identification, all of these components are important.

Opinion mining tasks involve opinion identification, opinion classification (positive, negative, and neutral), opinion target identification, opinion source identification and opinion summarization. Hence, opinion mining

tasks require techniques from the field of natural language processing, information retrieval (IR), and text mining.

II. OPINION MINING TASKS

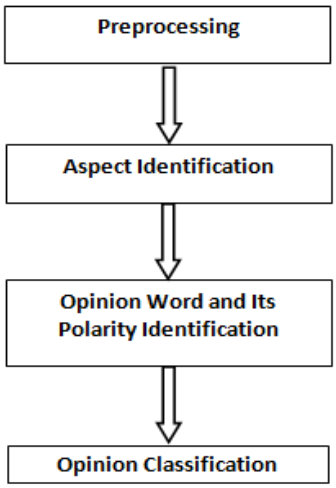

Figure -1 Aspect Based Opinion Mining

2.1 Preprocessing

Preprocessing the text is the process of cleaning text and preparing the text for classification. User-generated reviews require preprocessing to remove noise before the mining process can be performed. This is because these reviews are usually written by non experts and frequently contain mistakes in spelling, grammar, use of non dictionary words such as abbreviations or acronyms of common terms (domain specific), punctuation mistakes, incorrect capitalization, and so forth. The preprocessing involves several steps: spelling check, online text cleaning, white space removal, expanding abbreviation, stemming, stop words removal, tokenization, and sentence boundary detection.

2.2 Aspect Identification

Mining aspect and opinion of products or services commented by customers. Aspects are also called features that are features of some entity or service. In aspect extraction, product or service features (aspects) are extracted from each sentence. Aspects can be frequent or infrequent. Frequent aspects are those which are commented by many people which are most talked about. Infrequent Aspects are not talked by many people. In review, features may be mentioned explicit or implicit. Features which are mentioned in a sentence directly are called as explicit features and features which are not mentioned directly are called implicit features.

For example, “Hotel room was very clean and spacious”

In this sentence reviewer has mentioned about room directly. So it is explicit feature. It is easy to extract such features. Now consider following sentence,

“The elevator was slow”

In this sentence reviewer is talking about speed of elevator but it is not mentioned directly in the sentence. So here speed is implicit feature. It is difficult to understand and extract such features from sentence.

2.3 Opinion word extraction

In opinion word extraction, opinion words mentioned on its related aspect or entity or target are identified. If a sentence contains one or more opinion words and its related targets then the sentence is called an opinion sentence. Opinion words are generally identified by adjectives.

2.3.1 Opinion Word Polarity Identification

In opinion word polarity identification, semantic orientation or polarity (positive or negative) of each opinion word is identified.

2.4 Opinion Classification

The Classification task aims to determine the opinions' polarity (positive, negative or neutral) regarding the features being commented on.
Identifying opinion words in each review and deciding whether each opinion word is positive, negative or neutral.
An opinion is simply a positive or negative view, attitude, emotion or appraisal about an entity or an aspect of the entity from an opinion holder. Positive, negative and neutral are called opinion orientations. Other names for opinion orientation are sentiment orientation, semantic orientation, or polarity. In practice, neutral is often interpreted as no opinion.
It also aims to determine the strength and polarity of the opinions regarding the product's features. Opinion strength may be inferred from adjective choice (e.g., "disappointing" is milder than "awful") or from qualifiers (e.g., "very good" is stronger than "good").

III DIFFERENT APPROACHES FOR OPINION MINING

3.1 Opinion Mining using Machine Learning Approach

Pang et al. [23] tested Naïve Bayes Classifiers, Maximum Entropy, and Support Vector Machines (SVM) to see which would best classify the movie reviews in an earlier 1400 text version of the Polarity Dataset. The answer was fairly conclusive: SVMs outperformed the other two algorithms with most combinations of features, and had the highest scores overall. Based on this result, most of the sentiment analysis research based on machine learning has made use of SVMs. Pang et al. [23] also tested a number of feature types like (one-word) unigrams and (two-word) bigrams, with or without appended part of speech tags or indicators of their position in the text. The optimal SVM classifier did best with only unigram features.

Dave et al. [6] examines product reviews from C|net for classification. The studied corpus consists of reviews from 4 largest categories of C|net (in total, 448 reviews). A review is mentioned as Positive if it is rated in C|net with three or more stars, and as negative for one and two stars. Before aspect extraction, reviews' texts get preprocessed. Preprocessing contains POS tagging, negation words like not and never are identified. The approach also extracts N-grams (unigrams, bigrams and trigrams). The SVM classifier is used for classification and yields the accuracy value of 85.8% using ten-fold cross-validation without stratification. Dave et al. [6] classifier did much better when bigram and trigram features were used instead of Unigrams.

Using the Appraisal Theory of Martin and White (2005), Whitelaw et al. (2005)[33] used features that not only took into account the Orientation (positive or negative) of adjectives in the text, but also their Attitude Type (appraisal, judgment, or affect) and Force (low, neutral, or high). They tested a number of combinations, and got the best results (better than all preceding studies) from a SVM trained on a bag of words plus a set of features that reflected the frequency of "appraisal groups" (adjectives and their modifiers) grouped according to their Attitude Type and Orientation. Not surprisingly, appreciation was the Attitude Type most relevant for predicting sentiment in the movie review corpus. The inclusion of Force features, however, degraded performance.

Esuli and Sebastiani [8] note that this task can be divided into three interrelated subtasks: determining whether a certain unit of language is subjective, determining the orientation or polarity of subjective language, and determining the strength of that orientation. Esuli and Sebastiani [8] use machine learning techniques to classify individual words as positive or negative using their WordNet glosses. The first step is to derive a set of features (positive and negative words) with enough coverage to train a classifier. This is accomplished using two small sets of seed words (e.g., good, nice, etc. and bad, mean, etc., from (Turney and Littman, [27]) that are expanded iteratively using the WordNet synonym, antonym, hyponym, and hypernym relations. When the set of terms was sufficiently large, the glosses and sample sentences were used to train the classifier. The hypernym relation proved too general, and the hyponym relation was only somewhat helpful; the best results were achieved when the synonyms and antonyms of adjectives alone were used to expand the term sets. Having separate features for negated items (e.g., not good) also improved accuracy as compared to the GI lexicon.

Kennedy and Inkpen (2006) [16] used the entire Polarity dataset (2000 reviews) for both semantic and machine learning testing. They tested a number of combinations of options, finding that the use of contextual valence shifters (Polanyi and Zaenen, 2006) boosted the performance of both models (particularly the semantic model), and that, while the semantic model was very sensitive to the dictionary chosen (adding Google PMI dictionaries decreased performance, for instance), the SVM classifier always did best with lemma unigrams and bigrams; limiting unigrams to the ones in previously existing polarity dictionaries (e.g., the GI) was counterproductive. Overall, the SVM classifier outperformed the term-counting (semantic) method by a large margin: the best term-counting model had an accuracy of only 67.8%, as compared to 85.9% for the SVM classifier. A hybrid SVM classifier trained on the output from each model (comparable to Mullen and Collier 2004) did the best of all, reaching 86.2% accuracy. The authors note that this last performance increase was possible in part because the classifiers seems to make different mistakes; the term-counting model is far better at classifying positive reviews correctly, while the SVM classifier does better on average with negative reviews.
Li et al. [17] proposed a machine learning approach to incorporate polarity shifting information into document level sentiment classification. Pang et al. [19] proposed a word between a negation trigger word/phrase. Li et al. used binary classifier to divide sentences in a document into two parts: sentences which contain polarity shifting structure and sentences without polarity shifting structure. They first proposed a machine learning based classifier to detect polarity shifting and then apply two classifier combination methods to perform polarity classification.

Wilson, Wiebe and Hwa [34] used Supervised Machine Learning techniques to classification of intensity of opinions and emotions being expressed in text. Intensity classification detects the absence of opinion and detects

strength of opinion. Authors presented promising results in identifying opinions in deeply nested clauses and classifying their intensities.

3.2 Opinion Mining using unsupervised Approach

Turney [30], which not only attempts to classify full texts, but eschews a unigram (single word) approach in favor of two-word bigrams, extracted according to their part of speech (i.e., adjective/noun pairs, adverb/verb pairs, etc.). The SO values of these bigrams are derived by calculating their Pointwise Mutual Information (PMI).

Another unsupervised approach is the lexicon based method, which uses a dictionary of sentiment words and phrases with their associated orientations and strength, and incorporates intensification and negation to compute a sentiment score for each document (Taboada et al., [29]).

Polanyi and Zaenen [24] focused on how context affects the polarity of a valence (polar) term. They assumed a numerical +2/-2 value (a valence) on positive/negative words in the lexicon (including adjectives, nouns, verbs, and adverbs), and then suggested how this numerical value should change based on the surrounding context. Negation is the case of a contextual valence shifter; the authors proposed that the presence of a negating word (such as not) should switch the sign on the valence, +2 for clever becomes -2 for not clever. The presence of an intensifier (very) or a downtoner (somewhat) affects the valence by increasing or decreasing the absolute value; if good is +2, somewhat good is +1, whereas bad (-2) becomes very bad (-3). Valence shifters, for instance, are probably less useful to an SVM classifier because they require an increase in the number of features, with each feature requiring further independent examples.

3.3 Subjectivity Classification

Subjectivity classification classifies sentences into two classes, subjective and objective (Wiebe, Bruce and O'Hara, 1999). An objective sentence expresses some factual information, while a subjective sentence usually gives personal views and opinions which might not be fact.

In (Wiebe, 2000), Wiebe proposed an unsupervised method for subjectivity classification, which simply used the presence of subjective expressions in a sentence to determine the subjectivity of a sentence. Since there was not a complete set of such expressions, it provided some seeds and then used distributional similarity (Lin, 1998) to find similar words, which were also likely to be subjectivity indicators. However, words found this way had low precision and high recall.

In (Pang and Lee, 2004), a mincut-based algorithm was proposed to classify each sentence as being subjective or objective. The algorithm works on a sentence graph of an opinion document, e.g., a review. The graph is first built based on local labeling consistencies (which produces an association score of two sentences) and individual sentence subjectivity score computed based on the probability produced by a traditional classification method (which produces a score for each sentence). Local labeling consistency means that sentences close to each other are more likely to have the same class label (subjective or objective). The mincut approach is able to improve individual sentence based subjectivity classification because of the local labeling consistencies. The

purpose of this work was actually to remove objective sentences from reviews to improve document level sentiment classification.

Wilson, Wiebe and Hwa [34] pointed out that a single sentence may contain both subjective and objective clauses. It is useful to pinpoint such clauses. It is also useful to identify the strength of subjectivity. A study of automatic subjectivity classification was presented to classify clauses of a sentence by the strength of subjectivity expressed in individual clauses, down to four levels deep (neutral, low, medium, and high). Neutral indicates the absence of subjectivity. Strength classification thus subsumes the task of classifying a sentence as subjective or objective. The authors used supervised learning. Their features included subjectivity indicating words and phrases, and syntactic clues generated from the dependency parse tree.

Benamara et al. (2011)[3] performed subjectivity classification with four classes, S, OO, O and SN, where S means subjective and evaluative (their sentiment can be positive or negative), OO means positive or negative opinion implied in an objective sentence or sentence segment, O means objective with no opinion, and SN means subjective but non-evaluative (no positive or negative sentiment).

3.4 Aspect Extraction Approaches

Lein Zhang and Bing Liu [35] had focused on mining features of an entity. They used unsupervised method “Double Propagation” for feature extraction. It mainly extracts noun features. Dependency Parser was used to find relations between opinion words and features.

Double propagation works well for medium sized corpora. For large and small corpora, it can result in low precision and low recall. Then author introduced “part whole” and “no” patterns to increase the recall. And feature ranking applied to improve precision.

Jorge Carrilo and Laura Plaza has focused on measuring the polarity and strength of opinions. Their approach discovers feature automatically from reviews using unsupervised model. The set of discovered features are small and meaningful enough for the user. And lastly, system estimates the weight of each product feature in the overall user opinion to predict a more precise rating.

Hu and Liu [12] proposed a technique based on association rule mining to extract product features. The idea can be summarized briefly by two points: (1) finding frequent nouns and noun phrases as frequent aspects. (2) Using relations between aspects and opinion words to identify infrequent aspects. The idea is as follows: The same opinion word might be used to describe or modify different aspects. Opinion words that modify frequent aspects may modify infrequent aspects, and thus can be used to extract infrequent aspects.

Jakob and Gurevych (2010) used CRF. They trained CRF on review sentences from different domains for a more domain independent extraction. They also used domain independent features e.g. tokens, POS tag, syntactic dependency, word distance, and opinion sentences.

Li et al [17] used and integrated two CRF variations, i.e., Skip- CRF and Tree-CRF, to extract aspects and opinions. Original CRF, which can only use word sequences in learning, Skip-CRF and Tree- CRF enable CRF to exploit structure features. However, a limitation of CRF is that it only captures local patterns rather than long range patterns. It has been shown in (Qiu et al., [25]) that many feature and opinion word pairs have long range dependencies. Experimental results in (Qiu et al., [25]) indicate that CRF does not perform well.

3.5 Opinion Mining Using Fuzzy Logic

Mita Dalal and Mukesh Zaveri (2014) [5] used fuzzy functions for classification of online user reviews. They proposed an approach to perform fine-grained sentiment classification of online product reviews by incorporating the effect of fuzzy linguistic hedges on opinion descriptors.
Animesh Kar and Deba Mandal [15] introduced fuzzy opinion miner (FOM) a fuzzy approximation system to determine the strength of opinion about product in reviews. FOM outputs a set of opinion phrases which are ranked based on strength and the overall intensity of the product.

Pratik N. Kalamkar and Anupama G. Phakatkar [14] used fuzzy logic algorithmic approach to classify opinion words into different category. Their Proposed approach used conditional random field for aspect extraction. Classification of opinion related to aspect word is done using fuzzy logic algorithmic approach. Ranks Entities based on desired aspect of entities. Their Fuzzy Logic system follows steps like fuzzification and defuzzification. Fuzzification is the process where special degree is associated with each opinion word. Finally, fuzzy results are converted into crisp values using Memdani's defuzzification function.

Nadali and Kadir [27] used fuzzy Logic for classification of reviews. At first fuzzification of inputs is done. Then membership function is defined for finding membership value for each input. Defuzzification is used to get final output.

Shaidah Jusoh and Hejab M. Alfawareh [13] used approach which evaluate sentiment word and sentiment word modifier. Their opinion fuzzy set contains only two types of linguistic variables first is sentiment word and second is sentiment word modifier. Lexicon of sentiment word of positive sentiment, lexicon of negative sentiment word and lexicon of sentiment word modifier are developed. Each word in the list of token are matched with developed lexicons. If they are matched then sentiment word has been recognized and then word in token list is labeled as SenWord Assigns Fuzzy values to fuzzy sets opinion. Fuzzy set operation is conducted on the opinion fuzzy sets to determine sentiment either it is positive or neutral.

IV RESEARCH ISSUES AND CHALLENGES

Despite number of research efforts, the current opinion mining studies and applications still have limitations and margins for improvement. Accordingly, opinion mining suffers from a number of problems, such as accuracy, scalability, quality, standard of data, natural language understanding comprehension, among others.

Some of the major challenges related to natural language processing, such as context dependency, semantic relatedness and ambiguity, have made opinion mining difficult. As practical applications require high accuracy,

some of the work must be performed manually because of the challenging problems with the natural language processing.

Most of the existing research regarding opinion mining is domain dependent, which limits the scope generalization of the information. Machine-learning systems, which are domain dependent, require that data be manually labeled; it is very a difficult task to manage. Hence, there is need for generalized domain independent for the automatic identification and classification of opinion components.

One of the important problems of opinion mining is the identification of opinion targets from unstructured text. The opinion target is defined as the entity or features of an entity about which an opinion is expressed.

Another problem is domain dependency, which can be a problem when the target features that are relevant to a specific domain take on different meanings or interpretations when in a different domain. Accordingly, creating a knowledge base for each domain with relevant features and attributes is a difficult but real concern. Hence, generalized procedures are used to identify and disregard the domain dependency of features (Qiu et al., 2009).

V CONCLUSION

This paper discusses about techniques used by other authors for opinion mining. Opinion mining is the mining of opinions from the text. It can be of document level, sentence level or aspect level. There are different approaches for mining opinions from the text. Supervised techniques need training and testing data. It takes more time in labeling data. Unsupervised Techniques learn from examples. Labeling data is not needed in unsupervised techniques.

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NEW APPROACH OF CONNECTING LEARNERS TO FACULTY AND TO PROFESSIONALS SEEKING DEVELOPMENT

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ABSTRACT

In today's world the market is growing and the people all around need smart-work in all sense. Smart-work is also expected to sharing of knowledge. So, we felt there is need to connect the learners with professionals and professionals with learners and thus, the proposed system will achieve this objective. The current systems like Content Management System, Enterprise Resource Planning, And Web Content Management are content specific but our proposed system integrates all at single place. Everything is online today and is the need to develop a web-portal. So, the proposed system is the creation of a student development website, skill.clubofbelievers.com. This site will provide the academic community in all fields of advance technological education with a central, web-based resource that make it easy for stakeholders (students, alumini, professionals and teachers) of the system to create an interaction medium using the same platform.

Keywords:Content Management System, Web Content Management System, Enterprise Resource Planning

I. INTRODUCTION

Current industry principles for portraying website concentrate on guaranteeing interoperatibility crosswise over assorted stage, however don't give a descent foundation for automating the use of website. In today's world of education, every student is facing problem of quality and accurate information over internet through a single point. But, their expectations are not satisfied wholly. Today, students are addicted towards online usage for their study, that's nice. They always prefer online systems where their requirements get fulfilled. But, it is need to fulfil their need in a effective manner. In order to improve interaction between students, colleges and professionals while looking at the current scenario our system is working towards bridging this gap between stakeholders (alumini, students, industry professionals, teachers) of educational organization using a web-portal that integrates all the features in one single application. The basic idea behind this web-portal is to provide a gateway of useful information to every student.

II. RELATED WORK

A Content Management System (CMS) [1] is a computer program that allows publishing, editing and modifying content as well as maintenance from a central interface. CMS include web-based publishing, format management, revision control (version control), indexing, search and retrieval. A CMS serve as a central repository containing documents, movies, pictures, phone numbers and scientific data. In alumini relationship management [2] , a VIdegree cloud management system was used as a alumini database. VIdegree function that were applied to the alumini database included customizing the fields about the information, a comprehensive data relation mechanism for records, etc. A Web Content management System (WCMS) [3] is a software system that provides website authoring, collaboration and administration tools designed to allow users to create and manage website content with ease. In the world education, we see that every student is facing problem of "Quality & Accurate Information" over Internet. That's why we thought of this system i.e. Web portal which will solve this problem and provide desired information mainly to student of colleges/universities, particularly for rural students. Hence, this web portal will have very simple but dynamic requirements. As it is related to education, it will need continue upgradation in the system. The basic ideas behind this portal are "Provide gateway of useful information to every student" and maintain alumini relationship. According to the best of our knowledge, the above mentioned systems like Content Management System, Enterprise Resource Planning System [4] and Web Content Management System are all content specific as discussed earlier. But, our proposed system provides all these facilities in one single application.

III. MOTIVATION

In the current education system which is manual in nature, considerable time and effort is required to maintain the information of all students of college organization, resulting in a waste of resources. This particular methodology is also unable to properly monitor records and ensure that they are accurate and up to date. The manual process requires that information of all students be stored in filling cabinets or other similar storage location where they can be retrieved later. However, due to the nature of the location of these data, it is accessible to a lot of people, both authorized and unauthorized personnel.

This can lead to a security as well as raise doubts to the integrity and consistency of records. Also, another issue would be the fact that records may be lost due to being misplaced or the disorganized nature of the storage area. The current scenario in rural college organization is that students are not interacting with teachers and professionals due to lack of confidence. Though college is providing necessary resources, but due to lack of proper guidance these resources are not utilized efficiently. The general objective of proposed system aims to design and implement a web portal for stakeholders (students, alumni, teachers) of the system that will provide benefit to organization which will consistently monitor maintained records.

IV. PROPOSED SYSTEM

The main and foremost goal is to create NETWORK of students and professionals to help each other for

their skill development.

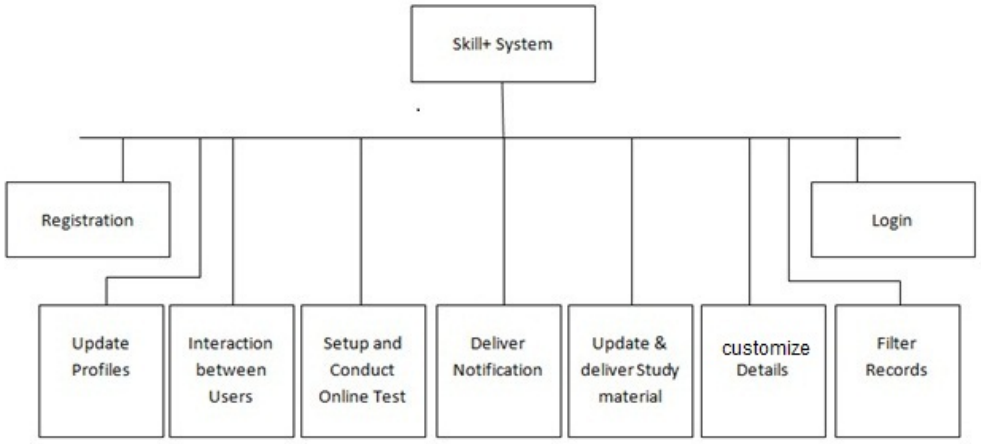

Fig.1 System Architecture

For this purpose, the system will contain the modules as follows:

***1. Registration module*:** This module will provide registration for students, teachers ,experts, company. All the students from approved colleges will registered themselves .Teachers who are experts in particular field will be registered. Company's account will be handled by HR of company. It will include details about company.

***2. Login module*:** This module will provide separate login to every user. All the registered users will be provided with username and password so that only these users will have access to system.

***3. Profile Viewer module*:** This module allows each user to view profile of other users for their purpose. This module will also be used by company's HR to view profiles of all registered students.

***4. Online test module*:** This module will be used if any company will wish to conduct the test to select the students of organization to work for their company. The college, if approved, can conduct the online test of that company. Test will contain timer.

***5. Review Result module*:** This module will contain results of online tests conducted. There will be review of result i.e. result analysis by company experts.

***6. Notification module*:** Notification module will help to send E-mail or Message to registered users and all the related notices will be delivered to students through this module.

***7. Discussion forum module*:** This module will help in interaction between students and experts. Students can ask their queries and experts can give suggestions and also career guidance.

***8. Study Material Delivery module*:** Study material delivery module will allow sharing of PDFs, documents, PPTs, etc. to students.

***9. Customize module*:** Customize module will allow adding new users (expert, HR, administrator). This module will also allow to update the profile if any user wish.

***10. Filtering module*:** This module will be accessed by company's HR. Through the profiles of students, HR will easily able to select the students among college as per company's criteria.

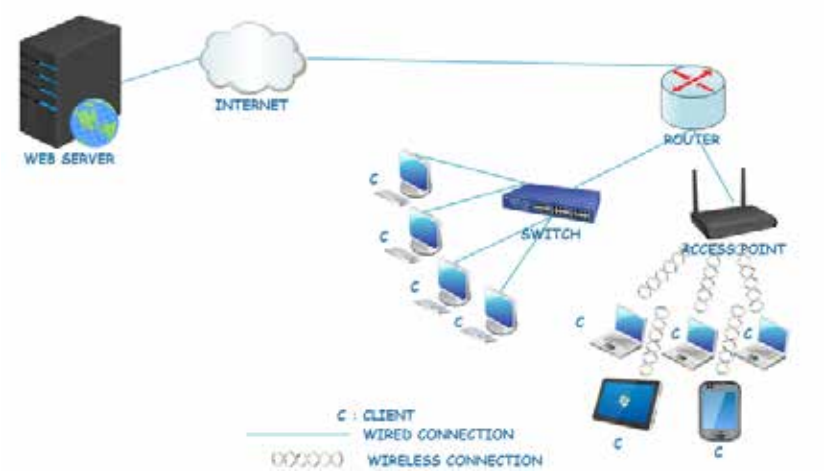

Fig.2 Deployment Diagram of System

The proposed system will be hosted on web server. Router will provide connections i.e. wired and wireless to devices (clients). The router will establish the connection between web server and particular organization (college or company). The end users devices (clients) may be a computer system (wired or wireless), mobile or tablet (wireless) that will be able to access the web portal. Thus, the proposed system will be used by any web enabled device.

V. RESULT ANALYSIS

Our system provides data security in the form of swipe card for the system administrator and proper credentials for the other stakeholders (students, professionals and teachers). The proposed system provides easy access to all stakeholders account and the complete access to his/her profile or expertise. The current system also notifies current updates to the stakeholders and keep them up-to-date. All the functionalities are available in single sign-in. Below figures describes some of the main functionalities of the system. As seen below, the administrator can add new college, its credentials, details of students, teachers and training and placement officer in the form of excel files. And after uploading these credentials, username and passwords will be generated automatically and mailed to particular institutes.

The figure 3 describes the notification module. From this module, the administrator can notify the stakeholders like students, teachers, college representative and professionals individually and multiple also. This provides efficient way for communicating.

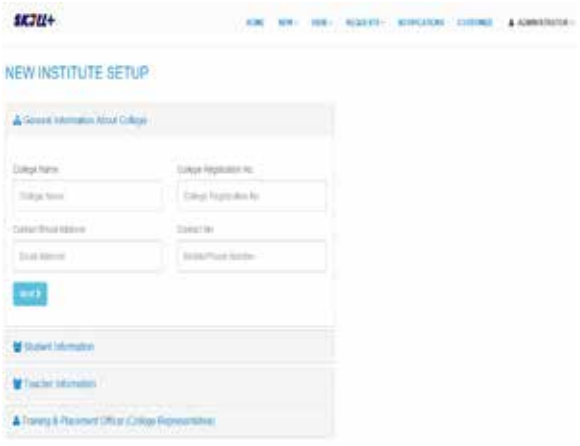

Fig.3 College Registration Module

Fig.4 Notification Module

The figure 4 describes the account creation of particular college in online exam module. Here, database setup is done, account is activated, organization id for that institute is generated along with username and password and all these credentials are mailed to that institute by administrator. While setup, identification string is also mentioned.

Fig.5 Online Examination Setup Module

Fig.6 Online Examination Module

How the actual online examination will be conducted is shown figure 6. The questions for the test can be uploaded in two ways- either by user interface or excel file with questions. The uploading details consists the question, its four options, its right answer, time (in seconds) and marks for that question. And question along with its four options, timer, question number and marks are displayed on top right corner of screen and user can submit their answer. After end of questions result is automatically displayed on screen within few seconds.

Compared to other educational portals the research shown in Table 1 describes that the other portals lag many things as compared to the proposed system which creates a vast difference between proposed system and currently available system. Also the given portal supports modules like Conduction of Online Test, Study materials delivery which were absent in the current systems.

	NAUKRI	MONSTER	SKILL+
EASE OF USE	P	P	P
SECURE REGISTRATION	O	P	P
SUPPORT FROM SALES/SITE	P	P	O
RELEVANCY OF SEARCH	P	P	P
UPDATED PROFILES	P	P	P
CONDUCT ONLINE TEST	O	O	P
DELIVER STUDY MATERIALS	O	O	P
FILTER RECORDS	O	O	P
INTERACTION WITH PROFESSIONAL	O	O	P

Table 1.Comparison with Other Existing Systems

VI. CONCLUSION AND FUTURE WORK

This system is an online system which will connect all students (Rural Areas) with professionals and guide them during their education. System is working towards bridging gap between stakeholders (alumini, students, industry professionals, teachers, etc.) of educational organization. There are many problems in finding jobs for students now, due to lack of skills in the rural students. Our system will provide solution to some of these problems with the help of this portal. The current system allows to interacting with professionals through our web-portal but this can be also implemented in future as a video conferencing. Also, this system can be extended on cloud. Currently this is a web-portal but can also be extended as an android app.

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STUDIES ON THE IMPACT BEHAVIOUR OF FIBER REINFORCED GEOPOLYMER CONCRETE

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ABSTRACT

Mechanical properties of geopolymer concrete with and without fibers were also determined. Comparisons were made in terms of compressive strength, split tensile strength, flexural strength and impact energy. The effect of impact loading on geopolymer concrete was investigated at three different energy levels. Impact response of geopolymer concrete was investigated under three-point bending configuration based on free-fall of an instrumented impact device for notched (25mm) and un-notched prisms. It was observed that reinforcing geopolymer concrete with 0.75% of crimped stainless steel improved the mechanical properties. Experimental investigation have shown that the orientation of fibers play a significant role in the determining the behavior of geopolymer concrete under impact loading.

Keywords : Alkaline Solution, Flyash, Geopolymer Concrete, Impact, Steel Fibers.

I INTRODUCTION

Geopolymers are members of the family of inorganic polymers. Davidovits first proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminum (Al) in a source material of geological origin resulting in a polymerization reaction and coined the term Geopolymer. The Polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals, that results in a three-dimensional polymeric chain and ring structure consisting of Si-O-Al –O bonds. Thus, A geopolymer is essentially a mineral chemical compound or mixture of compounds consisting of repeating units . **Prabir etal** (2012) reported that the peak load of geopolymer concrete (GPC) was higher than that of ordinary Portland concrete (OPC) for similar compressive strength and failure modes of GPC are more brittle than OPC with relatively smooth fracture planes[1]. **Anjan etal (2010)** reported that reducing the size of the flyash particles from 30µm to below 10µm, the flow and strength properties of mortar and concrete were improved [2]. **Redmond etal (2008)** reported that unlike hydroxyl system, silicate activated system enables more homogeneous gelation process to take place throughout the inter-particle volume [3]. **Yip etal (2004)** reported that the formation of CSH gel together with the geopolymeric gel occurs only in a system at low alkalinity[4].**Gum Sung Ryu etal (2012)** reported from the study that the compressive strength increased with use of flyash as binder with higher concentration of NaOH and also with the use of sodium hydroxide to sodium silicate in 1:1 ratio[5].**Dey etal (2013)** reported that dynamic flexural strength under impact was more than 1.5 times higher than the static flexural strength and use of 0.5% volume fraction of polypropylene fibers resulted in more than three times higher flexural toughness[6]. **Bencardino etal (2010)** concluded that

addition of fibers to concrete controls cracking and crack propagation and increase the overall ductility of the material[7]. **Atteshamuddin etal (2013)** reported that inclusion of steel fiber showed excellent improvement in mechanical properties of fly ash based geopolymer concrete[8]. **Ambily etal (2014)** reported that incorporation of steel fibers has improved the compressive strength and flexural strength of ultra high performance geopolymer concrete[9].

In this paper, the mechanical p roperties as well as the impact behavior of plain geopolymer concrete and fiber reinforced geopolymer concrete is investigated. The fiber reinforcement provided are 0.75% of crimped mild steel, 0.75% of crimped stainless steel and 0.75% of both crimped mild steel and crimped stainless steel (Hybrid). The compressive, split tensile and flexural strength of different mixes are investigated and compared. Further, the behavior of plain geopolymer concrete as well as fiber reinforced geopolymer concrete under impact loading is investigated under three – point – bending using instrumented drop weight system. The instrumentation included load cell to record the impact loading from the hammer. In the experiment the rebound of hammer is arrested. The variables in the experiment include the energy level provided and the corresponding drop heights. Time history of the load and energy time details are obtained and discussed in detail.

II EXPERIMENTAL INVESTIGATION

2.1 Materials Used

The fly ash used for the work was obtained from Ennor thermal power plant Tamil Nadu. The Ground granulated blast furnace slag (GGBFS) for the experimental work was from JSW, Vidyanagar, Karnataka. The chemical composition of fly ash and GGBFS are given in the Table 1 and Table 2.

Table 1 : Chemical composition of Fly ash

COMPOUND	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	Mn_2O_3	SO_3	P_2O_5
FLY ASH	49.45	29.61	10.72	3.47	1.3	0.31	0.54	1.76	0.17	0.27	0.53

Table 2 : Chemical composition of GGBFS

COMPOUND	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	Mn_2O_3	SO_3
GGBFS	33.45	13.46	0.31	41.7	5.99	0.16	0.29	0.84	0.40	2.74

The alkaline solution used was a combination of sodium hydroxide and sodium silicate in 1:2 ratio.. River sand passing through 4.75mm sieve was used as fine aggregate and 10mm angular aggregates were used as coarse aggregate. The water used for the entire work was portable water. Crimped mild steel fibers as well as crimped stainless steel fibers of aspect ratio 60 and diameter 19mm were used.

2.2 Synthesis

Sodium hydroxide pellets was mixed with water as per the mix proportion and kept overnight for cooling as the reaction between sodium hydroxide and water is a highly exothermic reaction. About one hour before the casting work the sodium hydroxide solution was mixed with sodium silicate gel and the activator (alkaline) solution of 3.5M was made.

Four different mixes of geopolymer concrete has been prepared for the entire experimental work. The four mixes include a geopolymer control mix, crimped stainless steel fiber geopolymer mix, crimped stainless steel fiber geopolymer mix and a hybrid geopolymer mix.

The fly ash and GGBFS were thoroughly blended along with coarse aggregate and fine aggregate in a drum mixer. The activator solution was then added with the dry mix at small intervals. The complete component materials were made to form a homogeneous mix by thorough mixing in the drum mixer. The mix proportion of the materials used is given Table 3:

Table 3: Mix proportions for geopolymer mix of 3.5M

MIX	FlyAsh (kg/m^3)	GGBS (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	SH (kg/m^3)	SS (kg/m^3)	CSS (kg/m^3)	CMS (kg/m^3)	WATER (kg/m^3)
CM	204	204	635	1113	24	48	-------	-------	175
GP-1	204	204	635	1113	24	48	59	--------	175
GP-2	204	204	635	1113	24	48	---------	59	175
GP-3	204	204	635	1113	24	48	29.5	29.5	175

Where CC is the geopolymer control mix,GP-1 is the geopolymer mix reinforced with 0.75% crimped stainless steel fibers, GP-2 is the geopolymer mix reinforced 0 with 0.75% crimped mild steel fibers and GP-3 is the hybrid geopolymer mix containing both 0.75% crimped stainless steel and crimped mild steel fibers.

2.3 Preparation of specimens

For each geopolymer mix, cubes of size 100*100mm, small cylinders of size 100*200mm, large cylinders of size 150*300mm and prisms of size 100*100*500mm were casted and kept for curing under ambient (room) temperature. The prism specimens for impact test has been provided with a notch of 25mm prior to the test.

III RESULTS AND DISSCUSSION

3.1 Compression test

The compression test was conducted on all the four mixes to determine the 3^{rd}, 7^{th} and 28^{th} day compressive strength. The compression testis done on 100mm*100mm*100mm cubes using Universal Testing Machine (UTM). The compressive strength of the specimen is calculated as:

Compressive strength = load/area = P/A

The 3rd, 7th and 28th day compressive strength of geopolymer is given in Table 4:

Table 4:Compressive strength of geopolymer mixes

MIX	3rd day (MPa)	7th day (MPa)	28th day (MPa)
CM	20.05	34.8	42.25
GP-1	35.98	36.04	51.78
GP-2	33.32	37.48	51.29
GP-3	31.978	37.013	49.01

3.2 Split tensile strength

The split tensile strength of the cylindrical specimen of size 100mm*200mm was tested as per ASTM 109 standard. The split tensile strength of the specimen was calculated as:

$$\sigma sp = 2P / \pi d l$$

The split tensile strength of different mixes is given in Table 5 :

Table 5: Split tensile strength of different geopolymer mixes

MIX	SPLIT TENSILE STRENGTH (MPa)
CM	4.22
GP-1	5.17
GP-2	5.12
GP-3	4.90

3.3 Flexural Strength

Prisms of size 100m*100mm*500mm were tested for flexure. The prisms were tested as per ASTM 109 standard using Universal Testing Machine (UTM). The flexural strength of the specimen was calculated as:

$$\text{Flexural strength} = Pl/bd^2$$

The flexural strength of different mixes is given Table 6:

Table 6: Flexural strength of geopolymer mixes

MIX	FLEXURAL STRENGTH (MPa)
CM	4.55
GP-1	5.03
GP-2	5.01
GP-3	4.90

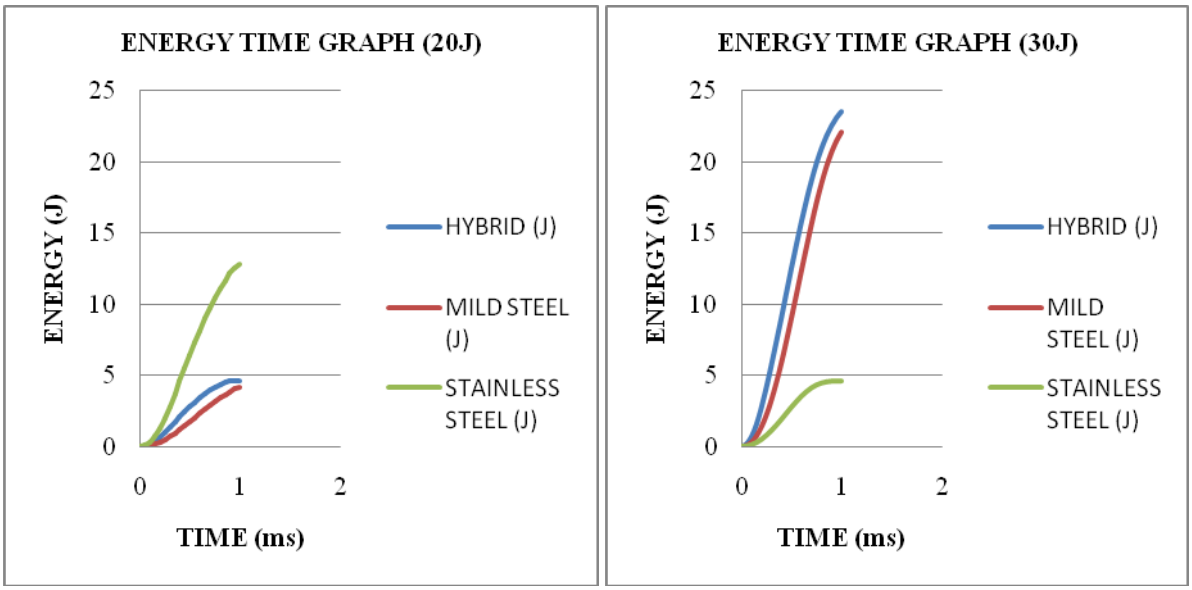
3.4 Instrumented Impact Loading Test

The effect of impact loading on geopolymer concrete is investigated under three – point – bending using an instrumented drop weight system. Geopolymer prisms (both with and without fibers) of size 100*100*500mm were tested for impact. The test was conducted for both notched and un-notched specimens. The total mass of drop (including tup weight) was 20 kg. The variable parameter used is energy level. The different energy levels adopted were 20J, 30J and 40JThe Force – time graph and Energy – time graph were plotted and compared.

Figure 1: Instrumented impact testing machine

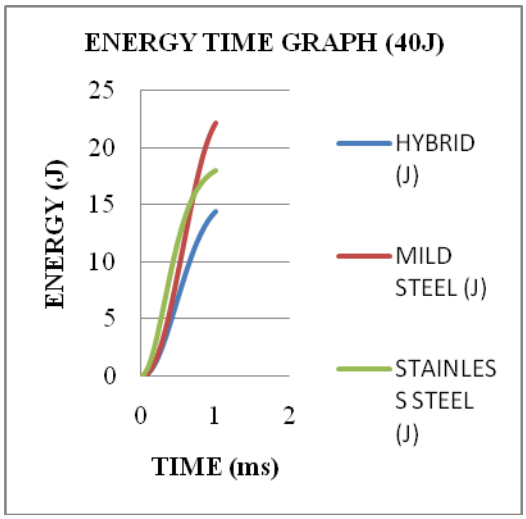
For the impact test, three prisms from each geopolymer mix were tested for each condition (notched and un-notched). Each beam was given a particular energy level and the force time history and energy time history was plotted and compared.

Fig 2(a), 2(b) and 2(c) shows the energy time history for different energy levels for un-notched prisms. From energy time history , it was observed that for energy level of 20J,geopolymer with 0.75% of crimped stainless steel fibers has given higher result, for 30J energy level geopolymer with 0.75% hybrid fibers has given higher result and for 40J energy level, geopolymer with 0.75% of crimped mild steel fibers has given the higher result.



(a)

(b)



(c)

Figure 2:Energy time history of un-notched geopolymer prisms : (a) 20J (b) 30J and (c) 40J

Fig 3(a), 3(b) and 3(c) show the force time history for different energy levels for un-notched prisms. From force time history, it was observed that for 20J and 30J energy level, geopolymer with hybrid fibers has shown highest

energy absorption capacity and for energy level of 40J, geopolymer with 0.75% of crimped mild steel fibers has higher energy absorption capacity.

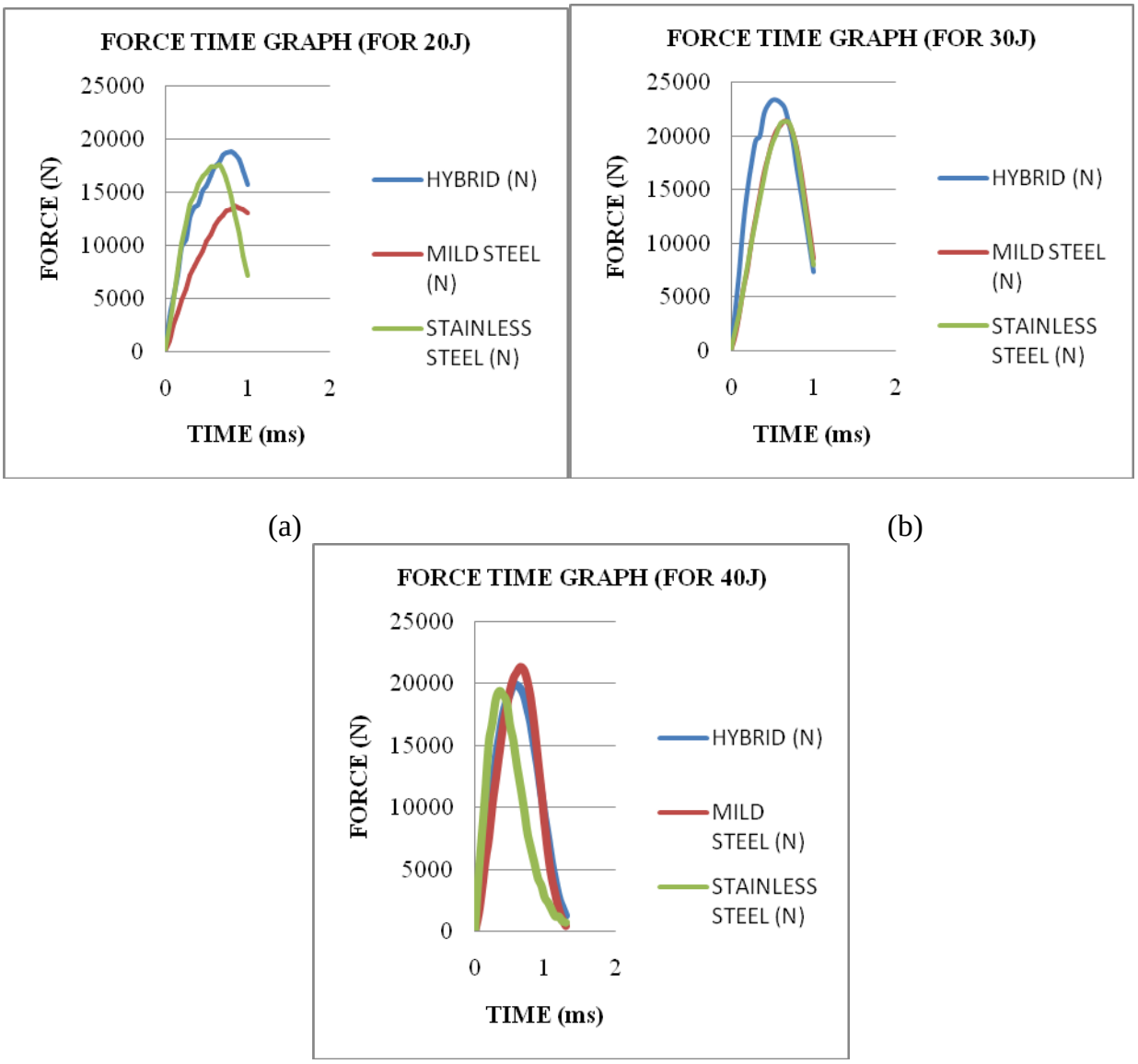
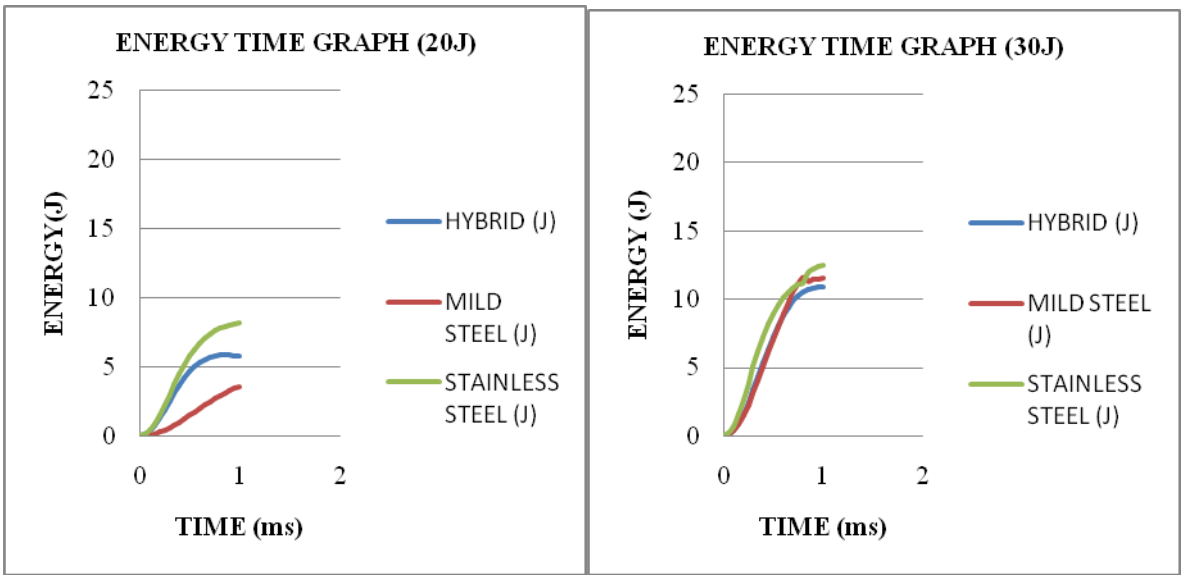


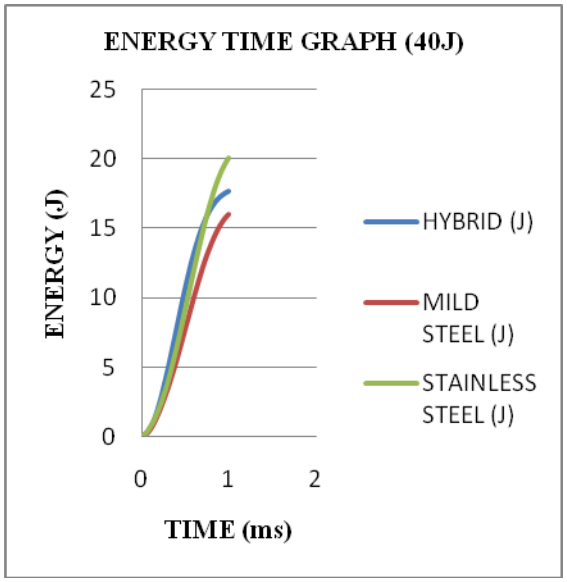
Figure 3:Force time history of un-notched geopolymer prisms (a) for 20J (b) for 30J and (c) for 40J

The time history results obtained from the experiments do not show any particular pattern or consistency. This inconsistency in time history results for un-notched prisms may be due to the random orientation of fibers in the geopolymer mixes. Thus, it can be inferred from the present experimental results that orientation of fibers in the concrete mix plays an significant role. Further experimental studies need to be done to determine which fiber gives higher impact energy taking into account the effect of orientation of fibers.

Fig 4(a), 4(b) and 4(c) shows the energy time history results for notched beams. From the energy time history results it was observed that geopolymer with 0.75% of crimped stainless steel fibers has shown higher energy absorption capacity.



(a) (b)



(c)

Figure 4: Energy time history of notched geopolymer prisms : (a) 20J (b) 30J and (c) 40J

Fig 5(a), 5(b) and 5(c) shows the force time history for different energy levels for notched prisms. From the force time history results it was observed that geopolymer with 0.75% of crimped stainless steel fibers has given higher value.

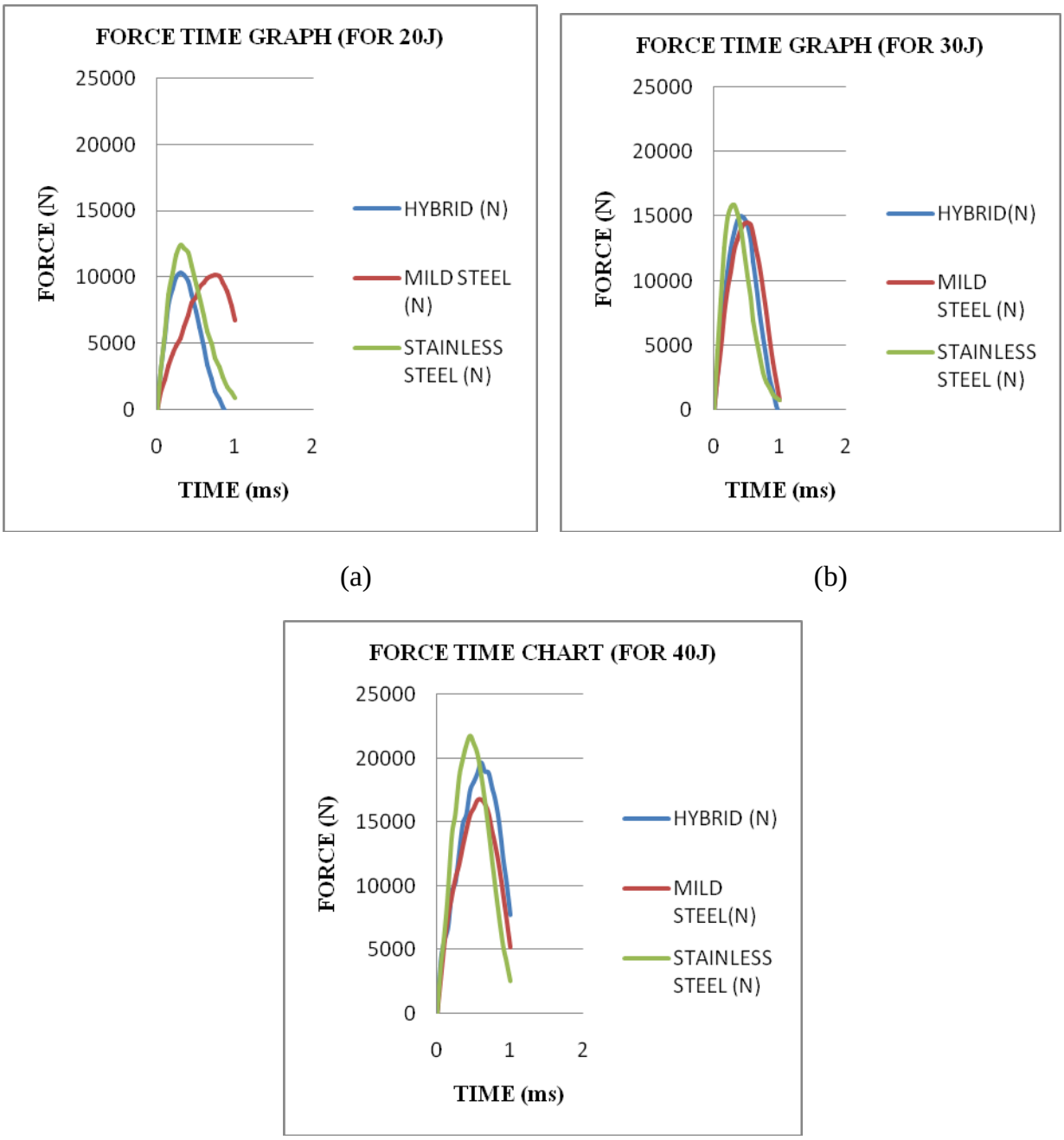
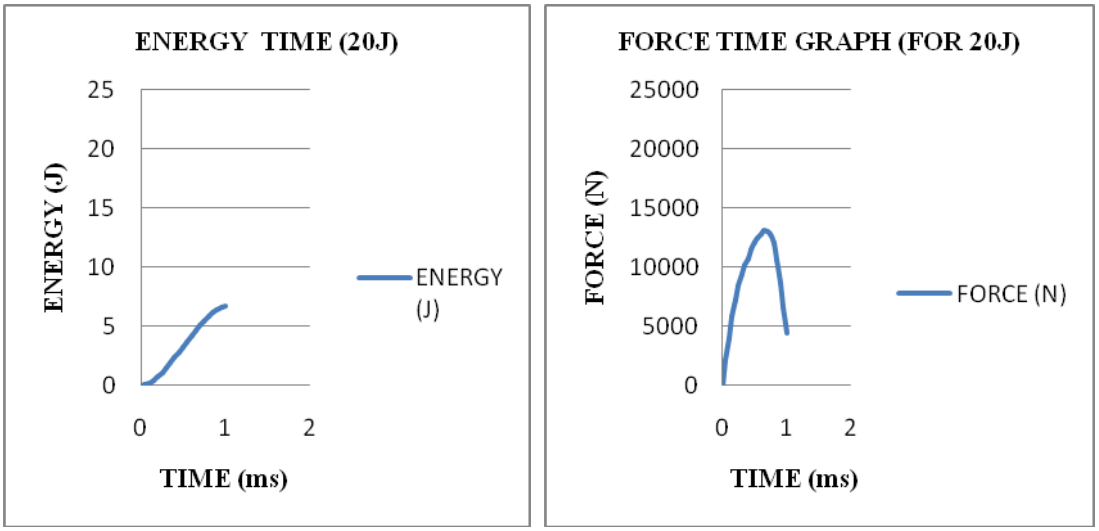


Figure 5: Force time history of un-notched geopolymer prisms (a) for 20J (b) for 30J and (c) for 40J

From the time history results obtained from impact testing of notched geopolymer prisms, geopolymer mix with 0.75% of crimped stainless steel fibers showed higher impact energy. This implies that crimped stainless steel fiber has higher energy absorption capacity and higher bond strength. In case of notched beams the probability of effect of random orientation of fibers is less since by notching the prism the failure is forced to occur at the notch rather than any other part of the specimen.

Fig 6(a) and 6(b) shows the time history result of un- notched prisms without fibers (control mix).



(a) (b)

Figure. 6: Time history results of control mix (un-notched): (a) Energy time graph (b) Force time graph

Fig 7(a) and 7(b) shows the time history result of notched prisms without fibers (control mix).

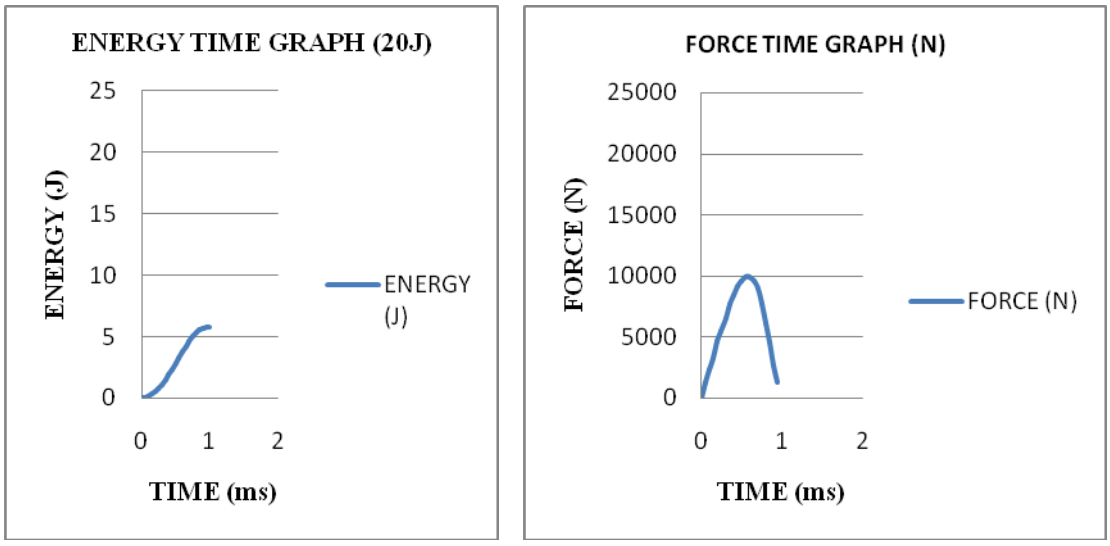


Figure 7: Time history results of control mix(notched): (a) Energy time graph (b) Force time graph

The control specimens which are geopolymer prisms (notched and un-notched) without fibers cannot be compared with the specimens with geopolymer with fibers since the maximum energy level that can be provided to the specimen was only 20J. At an energy level of 20J the complete failure of control mix specimen occurred.

IV CONCLUSIONS

Compressive strength, split tensile strength and flexural strength of geopolymer concrete was determined. It was observed that use of 0.75% of crimped stainless steel fibers in geopolymer concrete increased the mechanical properties of geopolymer concrete due to the higher bond strength characteristics of stainless steel fibers. Impact response of geopolymer concrete was studied for an instrumented test using a three point bending configuration. Time history results are obtained for geopolymer concrete with and without notch at energy levels of 20J, 30J and 40J. It can be concluded from the experimental investigation that for un-notched beams the effect of impact energy mainly depends on the orientation of fibers in concrete. Geopolymer prisms with crimped stainless steel reinforcement have shown higher time history results due to higher energy absorption capacity and bond strength of stainless steel fibers. It was also observed from the experiment that the maximum energy level that can be provided for a geopolymer concrete without fiber reinforcement is 20J. More detailed studies need to be done to determine the effect of orientation of fibers affecting the impact behavior of geopolymer concrete.

V ACKNOWLEDGEMENT

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A CONTENT PROTECTION SCHEME FOR CLOUD CLIENTS THROUGH NETWORK CODING TECHNIQUE IN CLOUD

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ABSTRACT

The real world scenario of cloud is users wish to store massive data in to the cloud database. So, Cloud must store the data without any failure. Sometimes, the data is striped across multiple cloud vendors. If a cloud suffers from a permanent failure and loses all its data, we need to repair the lost data with the help of the other surviving clouds to preserve data redundancy. We present a proxy-based storage system for fault-tolerant multiple-cloud storage with the help of network coding based storage scheme called the functional minimum-storage regenerating (FMSR) codes, which maintain the same fault tolerance and data redundancy as in traditional erasure codes (e.g., RAID-6). One key design feature of our FMSR codes is that we relax the encoding requirement of storage nodes during repair, while preserving the benefits of network coding in repair. With this approach, we may able to safeguard the user's data from the various vulnerabilities.

Keywords: Regenerating Codes, Network Coding, Fault Tolerance, Recovery.

I INTRODUCTION

Cloud storage provides an on-demand remote backup solution. However, using a single cloud storage provider raises concerns such as having a single point of failure and vendor lock-ins. By exploiting the diversity of multiple clouds, we can improve the fault-tolerance of cloud storage. While striping data with conventional erasure codes performs well when some clouds experience short-term transient failures or foreseeable permanent failures, there are real-life cases showing that permanent failures do occur and are not always foreseeable.

In view of this, this work focuses on unexpected permanent cloud failures. When a cloud fails permanently, it is necessary to activate repair to maintain data redundancy and fault tolerance. A repair operation retrieves data from existing surviving clouds over the network and reconstructs the lost data in a new cloud. To minimize repair traffic, regenerating codes have been proposed for storing data redundantly in a distributed storage system (a collection of interconnected storage nodes). Each node could refer to a simple storage device, a storage site, or a cloud storage provider.

Concept of network coding is that nodes can perform encoding operations and send encoded data. During repair,

each surviving node encodes its stored data chunks and sends the encoded chunks to a new node, which then regenerates the lost data. It is shown that regenerating codes require less repair traffic than traditional erasure codes with the same fault tolerance level. One key challenge for deploying regenerating codes in practice is that most existing regenerating codes require storage nodes to be equipped with computation capabilities for performing encoding operations during repair. On the other hand, to make regenerating codes portable to any cloud storage service, it is desirable to assume only a thin-cloud interface, where storage nodes only need to support the standard read/write functionalities. This motivates us to explore, from an applied perspective, how to practically deploy regenerating codes in multiple-cloud storage, if only the thin-cloud interface is assumed.

Our FMSR code implementation maintains double-fault tolerance and has the same storage cost as in traditional erasure coding schemes based on RAID-6 codes, but uses less repair traffic when recovering a single-cloud failure.

II IMPORTANCE OF REPAIR IN MULTI-CLOUD STORAGE

In this section, we discuss the importance of repair in cloud storage, especially in disastrous cloud failures that make stored data permanently unrecoverable. We consider two types of failures:

2.1 Transient Failure.

2.2 Permanent Failure.

2.1 Transient Failure

A transient failure is expected to be short-term, such that the “failed” cloud will return to normal after some time and no outsourced data is lost. Table 1 show several real-life examples for the occurrences of transient failures in today’s clouds, where the durations of such failures range from several minutes to several days.

Cloud Service	Failure Reason	Duration	Date
Google Gmail	Software Bug	3 days	Mar 2-Mar 4,2012
Google Search	Programming Error	28 minutes	Feb 7,2009
Amazon S3	Protocol Blowup	8-9 hours	Jan 20,2008
Microsoft Azure	Malfunction	22 hours	July 13-14,2008

Table I. Examples of transient failures in different cloud services

2.2 Permanent Failure

A permanent failure is long-term, in the sense that the outsourced data on a failed cloud will become permanently unavailable. Clearly, a permanent failure is more disastrous than a transient one. Although we expect that a permanent failure is unlikely to happen, there are several situations where permanent cloud failures are still possible:

1) Data center outages in disasters.
2) Data loss and corruption.
3) Malicious attacks.

III MOTIVATION OF FMSR CODES

We consider a distributed, multiple-cloud storage setting from a client's perspective, where data is striped over multiple cloud providers. We propose a proxy- based design that interconnects multiple cloud repositories, as shown in Figure 1(a). The proxy serves as an interface between client applications and the clouds. If a cloud experiences a permanent failure, the proxy activates the repair operation, as shown in Figure 1 (b)

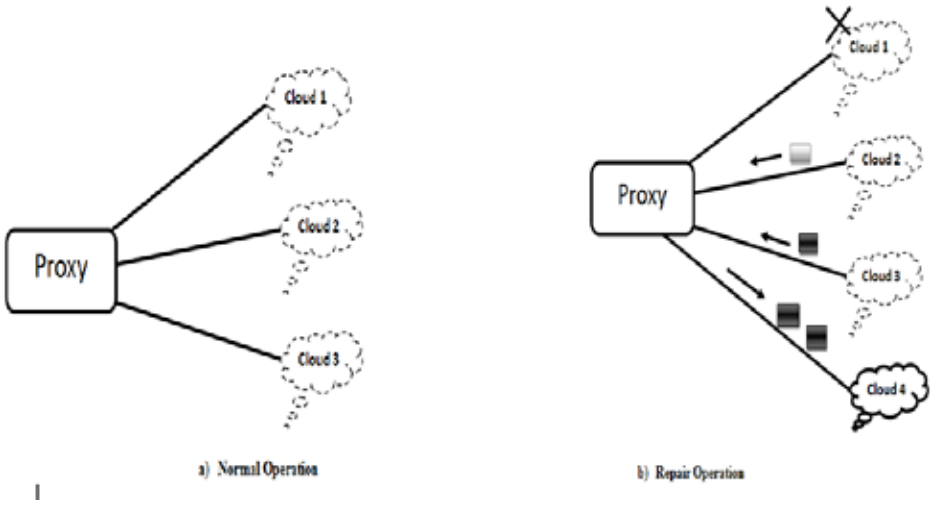

Figure I. Proxy-based design for multiple-cloud storage: (a) normal operation and (b) repair operation when Cloud node 1 fails. During repair, the proxy regenerates data for the new cloud.

That is, the proxy reads the essential data pieces from other surviving clouds, reconstructs new data pieces, and writes these new pieces to a new cloud.

We consider fault-tolerant storage based on a type of maximum distance separable (MDS) codes. Given a file object of size M, we divide it into equal-size native chunks, which are linearly combined to form code chunks. When an (n,k)-MDS code is used, the native/code chunks are then distributed over n (larger than k) nodes, each storing chunks of a total size M/k, such that the original file object may be reconstructed from the chunks contained in any k of the n nodes. Thus, it tolerates the failures of any n − k nodes. We call this fault tolerance feature the MDS property. The extra feature of FMSR codes is that reconstructing the chunks stored in a failed node can be achieved by downloading less data from the surviving nodes than reconstructing the whole file.

IV FMSR CODE IMPLEMENTATION

The details for implementing FMSR codes in multi cloud storage:

First, we specify three operations on file object:

1) File upload.
2) File download
3) Repair.

Each repository in cloud can be seen as a logical storage node. In our implementation, we assume a thin cloud interface, such that storage nodes need to support basic read, write operations.

One feature of FMSR codes is that lost chunks will not be reconstructed exactly, but in each repair operation, code chunks are regenerated which are not identical to those stored in the failed node.

4.1 Basic operations

The basic operations defined by FMSR codes are:

4.1.1 File Upload

To upload a file F, we first divide it into k(n−k) equal- size native chunks, denoted by (Fi)i=1,2,⋯,k(n−k). We then encode these k(n − k) native chunks into n(n − k) code chunks. We let EM = [αi,j] be an n(n−k)× k(n−k) encoding matrix

4.1.2 File Download

To download a file, we first download the corresponding metadata object that contains the ECVs. Then we select any k of the n storage nodes, and download the k(n−k) code chunks from the k nodes. The ECVs of the k(n−k) code chunks can form a k(n−k)×k(n−k) square matrix.

4.1.3 Repairs

The repair of FMSR codes for a file F for a permanent single-node failure is that, given that FMSR codes regenerate's different chunks in each repair; one challenge is to ensure that the MDS property still holds even after iterative repairs. The repair operation is carried out as follows:

Step 1: Download the encoding matrix from a surviving node.

Step 2: Select one ECV from each of the n-1 surviving nodes.

Step 3: Generate a Repair matrix.

Step 4: Compute the ECVs for the new code chunks and reproduce a new encoding matrix.

Step 5: For the given EM, check if MDS property is satisfied.

Step 6: Download the actual chunk data and regenerate new chunk data.

V SIMULATION WORK

We conduct simulations to check the MDS property and can make iterative repairs. Our simulations are carried out in a 2.4 GHz CPU core. First, we consider multiple rounds of node repairs for different values of n, and argue that in addition to checking the MDS property, checking the rMDS property is essential for iterative repairs. Specifically, in each round, we randomly pick a node to fail, and then repair the failed node. We say a repair is bad if the loop of Steps 2 to 5 in our two-phase checking is repeated over a threshold number of times but no suitable encoding matrix has yet been obtained.

Figure 2 shows the number of rounds of repair that can be sustained when the rMDS property is checked or is not checked. It shows that checking the rMDS property enables us to sustain more rounds of repair before seeing a bad repair. For example, suppose that we set the threshold to be 10 loops. Then we can sustain 500 rounds of repair for different values of n (number of nodes) by checking the rMDS property, but we encounter a bad repair quickly (e.g., in 3 rounds of repair for n = 10) if we do not check the rMDS property.

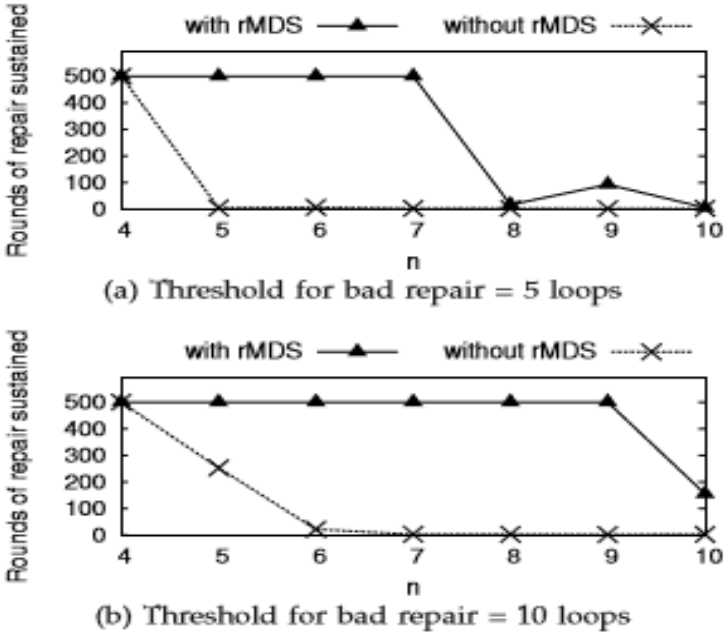

Figure 2. Number of rounds repairs sustainable without seeing bad repair.

Figure 3 plots the cumulative time of two-phase checking for 50 rounds of repair for n = 4 to n=12.It takes negligible time for the repair. For example, when n=6, it takes 0.06 seconds to carry out the repairs. Not only for n=6, but also for n=8 and n=12 it takes only 0.1seconds to carry out the repairs.

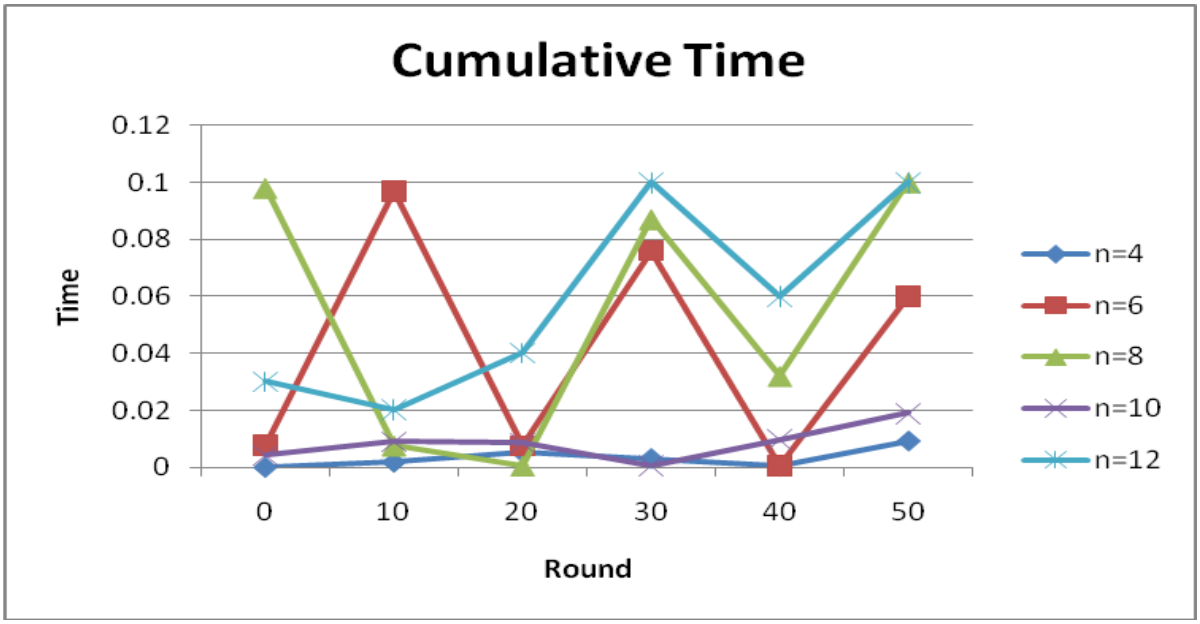

Figure 3: The cumulative time required for checking phase in 50 consecutive rounds of repair from n=4 to n=12.

VI NC CLOUD DESIGN

We now implement NCCloud as a proxy. It acts as a bridge between the user applications and the multi clouds. It has three layers. The three layers are:

1) File System Layer.

2) Coding Layer.
3) Storage Layer.

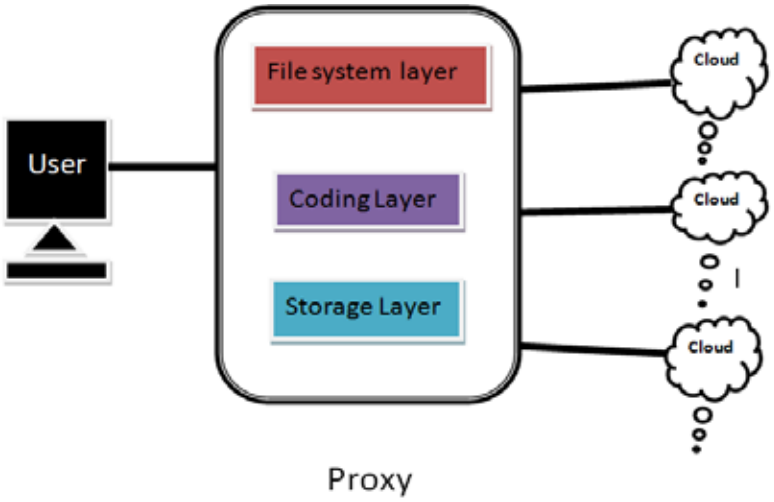

Figure 4. The role of NC Cloud as proxy.

6.1 File System Layer

It presents NCCloud as a mounted drive, which can thus be easily interfaced with the user applications.

6.2 Coding Layer

It deals with the encoding and decoding functions.

6.3 Storage Layer

It deals with the read and writes requests from different clouds.

Each file is associated with a metadata object, which is replicated at each repository. The metadata object holds the file details and the coding information i.e., encoding coefficients for FMSR codes.

VII EXPERIMENTAL RESULTS

In this section we tried to evaluate the NC Cloud implementation by using following three steps:

1) Fie Upload.
2) File Download.
3) Repair.

All the resultant set variables are calculated by using the cloud SLA constraints and need to incorporate the various security implications into the network coding phenomenon. The entire variable is specified in the two level implementation factors such as given below:

1) RAID-6
2) FMSR

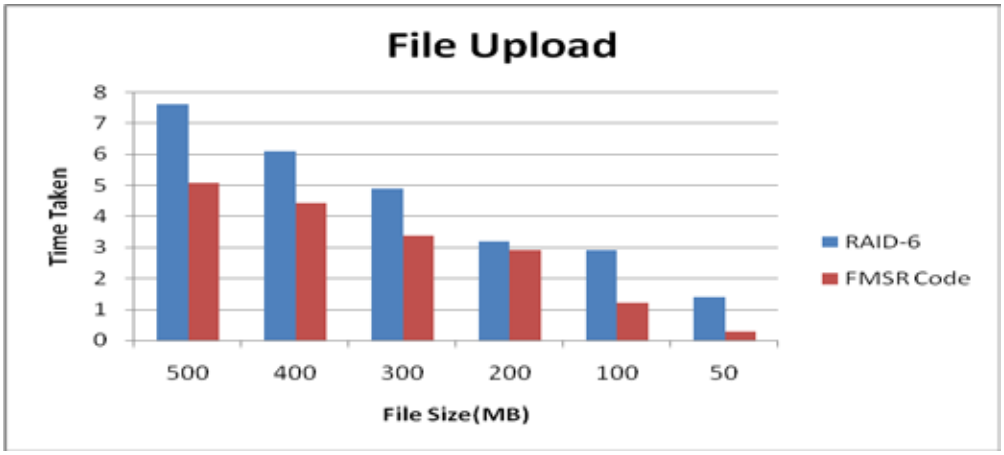

Figure 5. Time taken for File upload in RAID-6 and FMSR Codes

Figure 6Time taken for File download in RAID-6 and FMSR Codes

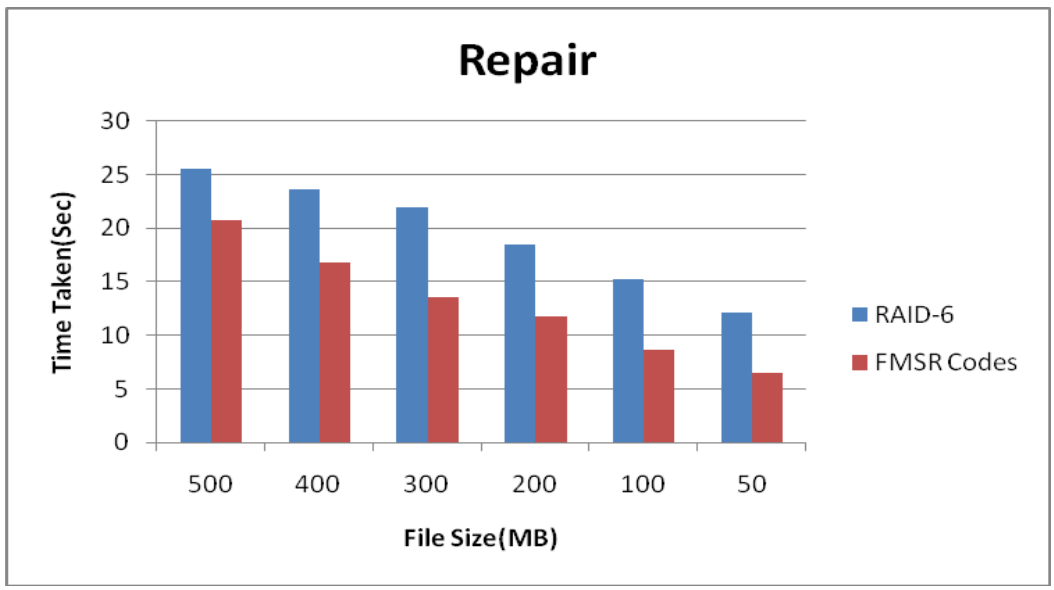

Figure 7. Time taken for Repair in RAID-6 and FMSR Codes

From, the above results it is clearly identified that FMSR is efficient than the previous erasure codes.

VIII CONCLUSION

The implementation of NCCloud, which is a proxy based storage system, addresses reliability issues. It also supports multi cloud storage for backup storage which is opt for today's cloud storage. The implementation of FMSR codes is also very efficient against the previous implementations. The double scheme of checking in steps 2 and 5 verify the MDS property. Even the response time for FMSR code is low.

IX FUTURE ENHANCEMENT

In this paper we studied the relationship between network coding and the cloud storage. In our study we have checked the fault tolerance mechanisms. But still there is scope for auditing the cloud for data integrity.

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