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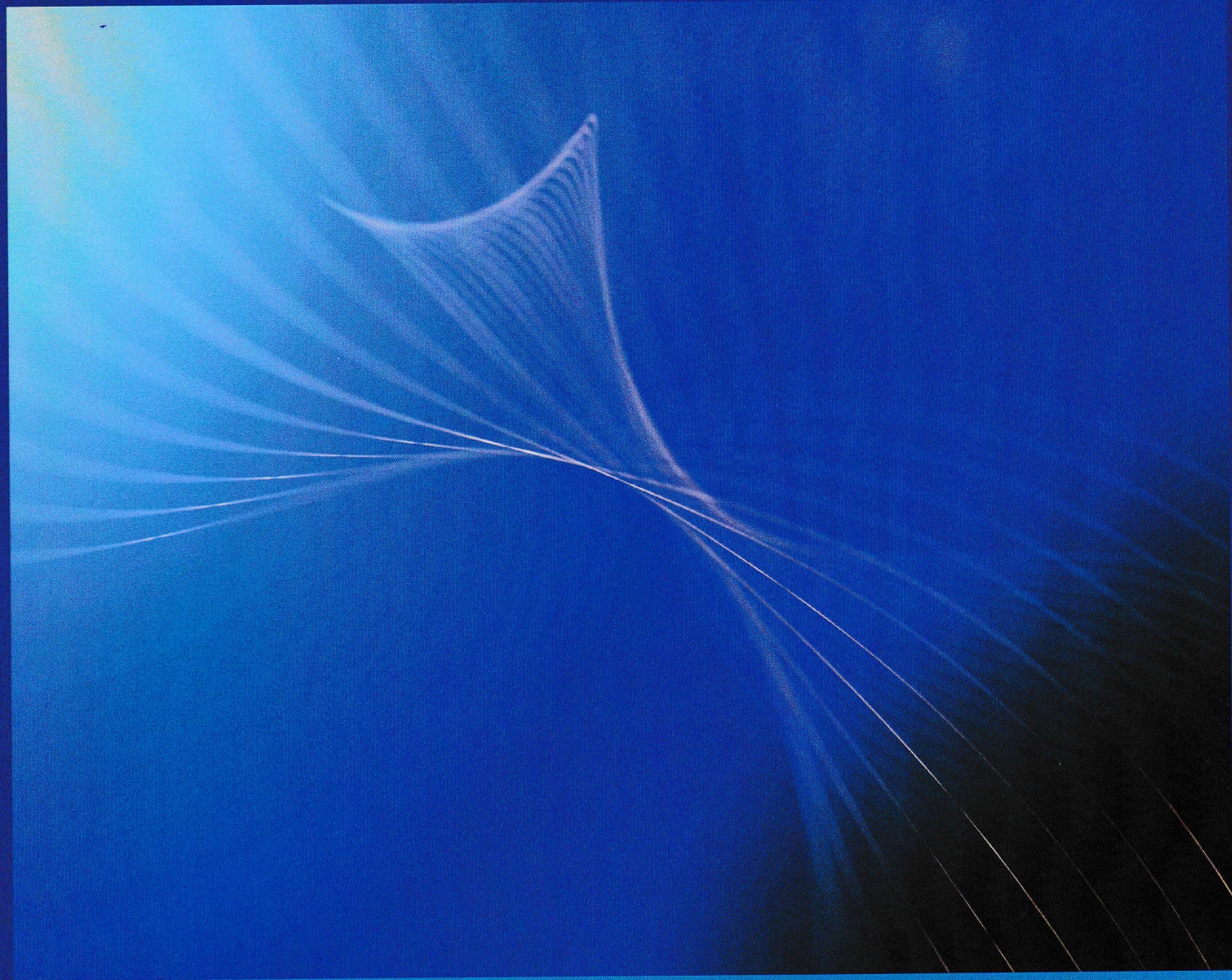

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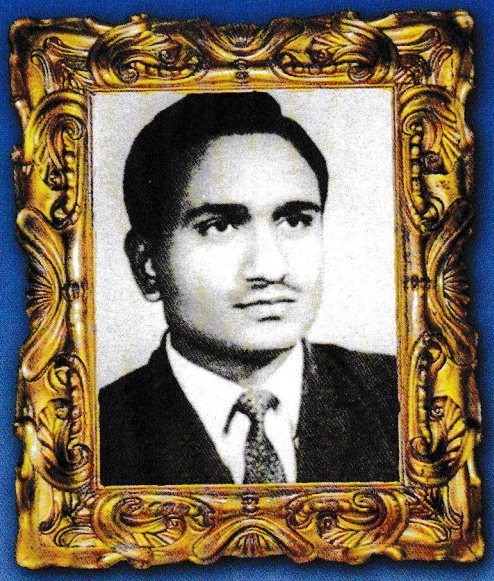
A TRUE VISIONARY

"You see things and you say **Why***? But I dream of things that never were and say* **Why** *not?"*

- George Bernard Shaw



Shri Jagannath Gupta
(1950 - 1980)

Also a true visionary...who dared to dream!
He lives no more but his dreams live on....and on!

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And more dreams to come!

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Editor's Desk

Dear Reader,

"Wisdom is to know that we don't know."— —Socrates, 469–399 BC

It is with much joy and anticipation that we celebrate the launch of "JIMS JOURNAL OF SCIENCE &TECHNOLOGY"(JJST) with this inaugural issue. On behalf of the JJST Editorial Team, I would like to extend a very warm welcome to the readership of JJST. I take this opportunity to thank our authors, editors and anonymous reviewers, all of whom have volunteered to contribute to the success of the journal. An enormous amount of work has done into the development of this journal and I believe you will see that effort reflected in this edition and in the impact it will have on the field. It has been an interesting journey in many aspects.

JJST is dedicated to the rapid dissemination of high quality research papers on how advances in Science and Technology can help us to meet the challenges of the 21st century, and to capitalize on the promises ahead. We welcome contributions that can demonstrate near-term practical usefulness, particularly contributions that take a multidisciplinary / convergent approach because many real world problems are complex in nature.

In science, as in most human endeavors, quality is more important than quantity. As stewards of JJST, the editors have a fiduciary responsibility to the leadership to ensure that only the very best science appears in the journal. In a very real sense, the editors work for the readers; their charge is to select papers rigorously, publishing only truly new or novel information that constitutes an important conceptual advance vis-à-vis existing knowledge, so that the readers' time is spent wisely. In an increasingly busy and competitive environment, the readers' decision to look at our journal must be worth the effort.

Peer review is the actual pillar of a journal's success and it depends on the quality and inspiration of its reviewers. The performance of the referees is also important to the authors, who have the right to a rapid and fair review. Thus, we have selected our Editorial Board carefully on the basis of their scientific proficiency, scholarly figure, rational integrity and commitment to the journal.

Besides frequent informal contacts, once a year we will conduct a survey of all Board members to solicit their candid feedback regarding the direction, philosophy, and operation of the journal. I am committed to personally responding to all email/phone/letter messages from them.

We encourage submission of articles in the fields of interest. Our interest in promoting these topics/themes as important features of JJST is clearly reflected in the makeup of the editorial team.

Finally, we wish to encourage more contributions from the scientific community to ensure a continued success of the journal. Authors, reviewers and guest editors are always welcome. We also welcome comments and suggestions that could improve the quality of the journal.

DR. R. K. RAGHUWANSHI

As an active practitioner and scholar in the field of science & technology, you must have experienced the need for a journal with conceptual richness, which is normally missing in various engineering magazines. In response to this need, a team of competent and dynamic professionals, at JIMS Engineering Management Technical Campus, Gr. Noida, publishes a journal titled **JIMS JOURNAL OF SCIENCE & TECHNOLOGY.**

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CONTANTS

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EXPLOITATION OF DATA MINING TO ANALYSE REALISTIC FACTS FROM ROAD TRAFFIC ACCIDENT DATA

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Abstract

Accident data are often kept just for record keeping purposes rather than using it as a source of intelligence. However, most of the previous studies focused on a few risk factors, some specific road users or certain types of crashes; and so the important factors affecting injury or crash severity have not been yet completely recognized. The prerequisite to improve road safety is to have a comprehensive road accident database and analysis system.

Advanced road accident analysis system is needed to help strategize road safety initiative as well as inculcate better understanding of road accident causation. Data mining has the potential to eliminate road traffic accidents data related deficiencies as well as statistical limitations. In this paper we analyse data mining methods, that can be applied to come up with some novel, unsuspected, and reasonable facts from road traffic accident data.

Keywords: RTA, accident Analysis, Data Mining, Traffic Analysis

1. Introduction

Road traffic accidents are a major public health concern, resulting over 1.2 million deaths and between 20 and 50 million non-fatal injuries worldwide each year.

Various studies comprising on-site field investigations, systematic safety checks and audits, comprehensive analyses of accident reports, eyewitness and victim interviews, drivers' observations and opinion surveys, and expert opinion surveys, have been conducted by different organizations to identify the causative factors of road accidents[1].

These studies reveal that the principal contributing factors to accidents are deficiencies in land-use and road network planning, adverse roadway and roadside environments, absence of or inappropriate pedestrian facilities, defective bridges and bridge approaches, inappropriate intersection designs, reckless driving, vehicle defects, presence of non-standard informal vehicles on main roads and unauthorized vehicle modifications. In addition, driver incompetency, road users' low level of awareness of the safety problem, and inadequate traffic law enforcement and sanctions were also among the major causes of accidents. However, it is difficult to quantify which factors are responsible for how many accidents due to the fact that a large number of contributory factors are not covered by the current accident reporting system. In the field of transportation engineering large amounts of data may need to be handled, specially during studies on accident analysis and when general traffic accident data are heterogeneous.

Statistics tables and ordinary charting techniques are not sufficient for present day requirements and this causes difficulties in the effective visualization of results and patterns. So, it is unrealistic to draw conclusions based on these data. Another disadvantage is that ordinary methods limit human involvement in the exploration tasks due to large sample, missing data, computational difficulty, etc.

Accident data are critical to monitor and evaluate the effectiveness of road safety interventions introduced by the government and road authorities.

Advanced data analysis system has the potential to take advantage of the available accident data. Better structured data will create conditions for deeper analysis, aiding in the formulation of evidence-based research on road safety and enabling better road safety interventions as well as performance monitoring. The system will use the road accident database as the source of intelligence, to help determine accident causation and provide a clearer picture of the issues and potential intervention to improve the road safety condition. Data mining is such an approach that focuses on searching for new and interesting hypotheses than confirming the present ones. It includes various tools, techniques and applications that can be applied to eliminate the road accident data related deficiencies as well as statistical limitations. Therefore, it has been utilized for finding yet unrecognized and unsuspected facts especially in the field of road safety[3].

2. Data Mining

Data Mining, also referred as knowledge discovery in databases, is a process of nontrivial extraction of implicit, previously unknown and potentially useful information (such as knowledge rules, constraints, regularities) from data in databases.

The ultimate goal of Data Mining is prediction - and predictive Data Mining is the most common type of Data Mining and one that has the most direct business applications.

The process of Data Mining consists of three stages.

a) Exploration - It is the first stage of Data Mining process. It performs data preparation which includes data cleaning, data transformations, selecting subsets of records. If the size of the data set is large containing large number of variables ("fields") then it also performs preliminary feature selection operations to reduce the number of variables to a manageable range based on the statistical methods. Depending on the nature of the analytic problem, exploration stage may involve a simple choice of straightforward predictors for a regression model, or elaborate exploratory analyses using a wide variety of graphical and statistical methods to identify the most relevant variables and determine the complexity and/or the general nature of models. Information processed in this stage is then used in the next stage.

b) Model building and validation – In this stage various models are considered and the best model is chosen based on its predictive performance (i.e., which can explain the variability in question and can produce stable results across samples). Variety of techniques are developed that can be applied on different models using same data set to compare their performance to choose the best. These techniques often called as —competitive evaluation of models‖ are considered the core of predictive Data Mining and include Bagging (Voting, Averaging), Boosting, Stacking (Stacked Generalizations), and Meta-Learning.

c) Deployment – In this model, new data is applied to the best model selected in the previous stage in order to generate predictions or estimates of the expected outcome.

3. Data Mining in Transportation Engineering

In the field of transportation engineering large volume of data are generated during the studies of traffic management, accident analysis, pavement conditions, roadway feature inventory, traffic signals and signal inventory, bridge maintenance, road characteristics inventory, etc. Based on these data decision makers arrive at a decision to solve a respective problem. Decision makers are always on lookout for ways to ease the pain in obtaining access to and applying disparate datasets. The basic requirements include the ability to identify what data are available, determine the characteristics of the data, extract the data of interest, and transform the data into formats necessary for applications. In real life situation

of transportation domain, diverse fields of data need to be collected to integrate and to arrive at solutions. Data mining approaches have opened a new horizon for decision makers in transportation engineering .

There is a broad spectrum of engineering problems where computational intelligence is becoming an essential part in many advanced systems. Hence new techniques for extracting important knowledge from raw data are required to handle the components efficiently. Data mining is a step in this knowledge process. Basic steps of data mining and knowledge discovery are depicted in Figure 1

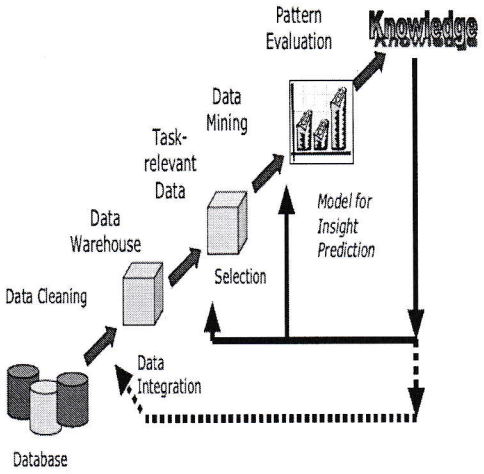

Figure 1: Data mining and knowledge discovery process

4. Literature Review

Jang *et al.* [4] extended the study horizon by introducing a real-time collision warning system for the intersections where conditions related to vulnerable line of site and/or traffic violation can be observed. Christoforou *et al.*[5] in their studies have determined crash probability along with associated crash severity. However, these studies were focused on improving the prediction capability rather than providing insight into crash phenomena. Among the studies related to identifying the traffic variables leading to crash, Abdel-Aty *et al.*[6] ascertained that crashes occur in high speed and low speed scenarios. While the former is caused by quick formation and subsequent dissipation of queues causing a backward shock wave, the latter is due to a disruption in the downstream that propagates a shock wave to the upstream impending driving errors.

Dias *et al.*[7] introduced level of congestion rather than the aggregated speed of vehicles as a predictor and affirmed a positive correlation between congestion and crash risk. Zheng *et al.* [8] considered only congested traffic condition and used matched control logistic regression to prove that traffic oscillations contribute to crash. Christoforou *et al.* [5] utilized real-time traffic data to associate different traffic parameters with various crash types. Xu *et al.* [9] suggested that traffic characteristics leading to crash vary substantially between congested and uncongested situations.

Hossain and Muromachi [10] in their study employed high resolution detector data to identify the traffic patterns impending hazardous driving conditions. Unlike the previous studies, their study separated the road sections of the urban expressways into five groups – the basic freeway segments (BFS) and areas near downstream (d/s) and upstream (u/s) of the on (entrance) and off (exit) ramps and attempts to identify generic crash prone traffic patterns for each of these groups. They came up with the fact that the high risk clusters in all the five groups of the road sections had substantially high differences in their congestion indexes which indicated either the downstream or the upstream traffic conditions were at least partially congested. Thus, it was easier to explain the crash mechanism under low speed operation. This was also logical to believe that many high speed crashes might be associated with unsafe driving rather than traffic condition which was hazardous and thus hard to explain with traffic flow variables. Therefore, education and enforcement related interventions are required as well.

5. Data mining methods for Road traffic analysis

Three data mining methods can be been applied to come up with some novel, unsuspected, and reasonable facts from road traffic accident data.

5.1 Hierarchical Clustering (HC)

Selection of a clustering methodology depends on data type. The data used in cluster analysis can be categorical/nominal (e.g. name/category i.e. data cannot be added, subtracted, multiplied or divided), ratio (data can be added, subtracted, multiplied or divided),

interval (difference meaningful but cannot be multiplied or divided), and ordinal (e.g. good, very good, excellent). However, having a mixture of different types of variable makes the analysis more complicated. This is because in cluster analysis we need to have some way of measuring the distance between observations, and the type of measure used will depend on what type of data we have. Accident data is usually mixed type i.e. a single accident event is recorded with different types (categorical, ratio, interval and ordinal) of variable, and essentially in this research, the mixed attribute type is being considered

HC constructs the clusters by recursively partitioning the instances in either a top-down or bottom-up fashion. These methods can be subdivided as follows:

- Agglomerative hierarchical clustering: each object initially represents a cluster of its own i.e. subjects start in their own separate cluster. The two 'closest' (most similar) clusters are then combined and this is done repeatedly until all subjects are in one cluster. Finally, the desired cluster structure is derived.

- Divisive hierarchical clustering: all objects initially belong to one cluster. Then the cluster is divided into sub-clusters, which are successively divided into their own sub-clusters (i.e. the previous strategy is applied but in reverse order). This process continues until the desired cluster structure is obtained.

However, agglomerative methods are used more often than divisive methods, so this dissertation will concentrate on the former rather than the latter. The result of the hierarchical methods is a dendrogram, representing the nested grouping of objects and similarity levels at which groupings change. A clustering of the data objects is obtained by cutting the dendrogram at the desired similarity level.

Merging or division of clusters is performed according to some similarity measure, chosen so as to optimize some criterion (such as a sum of squares). HC methods could be further divided according to the manner that the similarity measure is calculated. These methods are elucidated in the following:

Single-link clustering: in this method the distance between two clusters is defined to be the distance between the two closest members, or neighbors (Figure 2). This method is relatively simple but is often criticized because it does not take account of cluster structure and can result in a problem called chaining whereby clusters end up being long and straggly. However, it is better than the other methods when the natural clusters are not spherical or elliptical in shape.

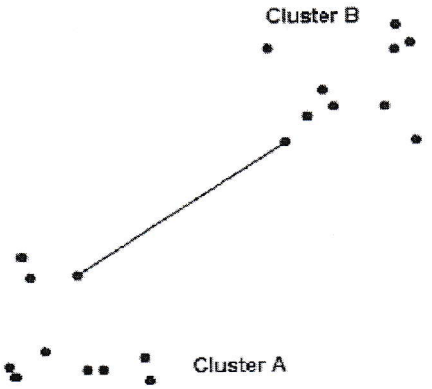

Figure 2. Single-link clustering.

Complete-link clustering: in this case the distance between two clusters is defined to be the maximum distance between members — i.e. the distance between the two subjects that are furthest apart (Figure 3). This method tends to produce compact clusters of similar size but, as for the nearest neighbor method, does not take account of cluster structure. It is also quite sensitive to outliers.

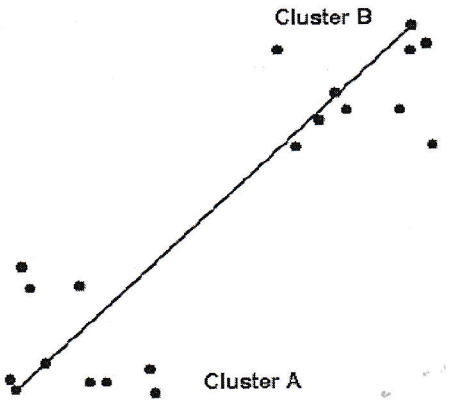

Figure 3. Complete-link clustering.

Average-link clustering: in this method the distance between two clusters is calculated as the average distance between all pairs of subjects in the two clusters (Figure 4). This is considered to be a fairly robust method.

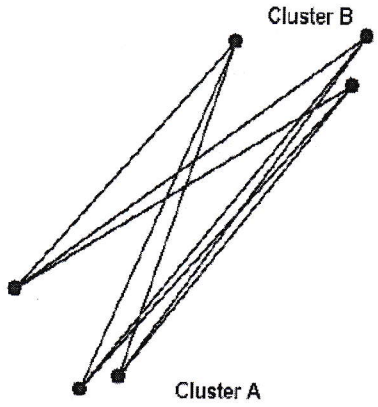

Figure 4. Average-link clustering.

5.2 Random Forest (RF)

Random forest (RF) is one of the new methods in ensemble learning that can perform classification and regression as well as numerically rank the importance of the predictors in the model. Currently, RF is considered as one of the latest and most efficient methods in evaluating and ranking variable importance [10]. It has demonstrated high capability in handling multicolinearity issue of large feature spaces by using two well-known methods in ensemble learning and bagging coupled with the idea of random variable selection. In case of boosting, the successive trees associate extra weight to points misclassified by earlier predictors. Finally, a weighted vote is taken for prediction. Whereas in bagging the earlier trees do not influence the successive trees and each is independently constructed based on a bootstrap sample (bootstrapping constructs a number of re-samples of the original dataset, each equal to the size of the original dataset, where each re-sample is produced by random sampling with replacement from the original dataset) of the dataset. Lastly, prediction is performed by conducting a simple majority voting. RF adds an additional layer of randomness to bagging. To elaborate more, RF generates a given number of CART trees with a different bootstrap sampling for each tree. However, it differs slightly in the process of growing the tree through splitting. Instead of finding the best splitter at each node from all the available variables, it calculates the best splitter from a subset of variables randomly chosen from complete variables space [10]. The study employed 'random forest' package of R program to implement random forest.

The major steps of the RF algorithm are [10]:

(i) Let L be the complete dataset with M predictors and N records and B the total number of CART trees in the RF. Let L_b be the b-th bootstrap sample created by randomly selected n samples with replacement from L. Rest of the data, i.e., L-L_b, are called the out of bag data (OOB) of b-th bootstrap sample.

(ii) Next, for the b-th tree T_b, instead of growing a CART tree with M predictors, m predictors are randomly selected from M predictor space ($M > m$) at every node and the best splitter among m capable of producing two maximum pure nodes is used to split the node at each level.

(iii) Predicting from new data: run down the new data through each and every (here B number of trees) tree and the class of the new data is the class of the leaf of each tree where it ended up. The final class of the data is calculated by aggregating the predictions of the B trees. In case of classification trees, it is achieved by majority voting.

(iv) Estimating OOB error rate: at each and every bootstrap iteration the L-L_b datasets are used to calculate the misclassification rate r_b of tree T_b (this misclassification rate r_b is used for calculating the variable importance as well). This is achieved by running down the L-L_b dataset into T_b grown in step (ii). The

class of each of the data points are decided based on majority voting (can be weighted). This majority voting is required only for estimating the OOB error rate (not for variable importance). In another way it can be said that lastly the r_b of all the B trees are aggregated to calculate the OOB error rate.

(v) Variable importance: the idea of variable importance in RF differs from conventional statistical approaches. Here, it is measured by permuting the values of each variable (one variable at a time) and then calculating the new error rate. The permuted variable with the highest error rate is considered as the most important variable as any error in measuring its value has the highest impact on the classification performance of RF.

5.3 Classification and Regression Tree (CART)

As explained by Gey and Nédélec [12] Classification and Regression Trees (CART) is a robust decision-tree tool for data mining, pre-processing and predictive modelling tasks. CART can analyze complex data for patterns and relationships and uncovering hidden structures. Moreover, CART is a nonparametric technique that can select variables from a large data set and their interactions that are very important in determining the outcome variable to be analyzed. Some of the major advantages of CART, as described by Salford Systems [13], includes faster training time, its ability to use raw data (no need to transform or prepare the data), automatic handling of missing values, automatic handling of categorical (nominal) predictors, handling very large numbers of predictors, and ability to handle very large training data files.

An important feature of a CART analysis include a set of rules for splitting each node in a tree; deciding when a tree is complete; and assigning each terminal node to a class outcome. CART always base on - questions that have a 'yes' or 'no' answer to split a node into two child nodes; the yes answers to the left child node and the no answers to the right child node to grow trees [14].

6. Conclusion

In this paper we studied data mining methods that can be been applied to come up with some novel, unsuspected, and reasonable facts from road traffic accident data. Hierarchical clustering methodology was employed to form natural data groups and to identify hazardous clusters; then random forest was applied to identify, rank, and thus select a subset of variables from a large variable space. Finally, classification and regression trees have been allowed to investigate the accident severity mechanism of the hazardous clusters.

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Analysis of Impeller Blade through CFD software

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Abstract

Due to excessive stress development mixed flow pump impeller blades generally fails. To avoid the failure under such situation impeller should be designed, taking into consideration the von mises stress & deformation due to rotation force on the rotor which makes it rotate. In the present research work design and stress analysis has been carried out on mixed flow pump impeller under applied torque due to rotational angular velocity. On the meridional annulus of the impeller two different positions of blade is considered and maximum Von Mises stress distribution was calculated and compared among them. The inlet inclined blade position impeller under applied rotational force was found to be more suitable than the regular trapezoidal blade position.

Keywords: Mixed flow pump impeller, ANSYS,meridional annulus, Von Mises stress,Rotational force.

Nomenclature

B	width, m	T	Torque, N-m
I	moment of inertia, m^4	y	distance, m
H	fluid pressure head, m	w	surface density force, N/m^2
L	length, m	β	blade angles, degree
H	fluid pressure head, m	w	surface density force, N/m^2
N	rotational speed, rev./min.	σ	Von Mises stress, N/m^2
P	power input, kW	σ_B	bending stress, N/m^2
Q	volumetric discharge, m^3/sec	τ	shear stress, N/m^2
H	fluid pressure head, m	w	surface density force, N/m^2

1. Introduction

Many mechanical devices are used as energy conversion device, in which one mechanical device is used to convert mechanical energy to hydraulic energy. This device plays a major role in various irrigation and cooling systems. These devices are a combination of axial and radial characteristics. To design a radial flow impeller many well-established empirical methods are used. These methods are used to design mixed flow pump impellers under high specific speed, which stimulates the axial flow pump impeller techniques under diagonal flow. In industries

design starts with usual industrial design methodology, i.e. using the empirical methods. In this type of design methods the meriodinal annulus is divide by equal area method (Hao et al.(2013)).Empirical co-efficient depends on the specific speed is used to fix the inlet and outlet blade angles and to determine overall impellers layout
before the meridional streamlines are calculated. After the inlet and outlet angles being fixed blade sections are laid out on the developed stream surfaces.

Industries uses designs thumb rule and ignores the actual happening of pump flow passage and uses empirical co-relations and design constants, this is the poor guide for a new pump design initiative. In this design method designer has less control over the desirable result. Thus to overcome these types of difficulty rational basis of design is to be used, which basically initiated from by minimizing the turbo-machineries co-relation. Thus this rational method enhances the controllability over the outcomes of the design by constantly viewing the physical principle. This method helps to rectify the faults if any, in the performance of the pump.

The recognised research work on mixed flow impeller has been carried out by various scientists and researchers. The initiation in design of mixed flow impeller by Wislicensus (1965) whereas his

design was modified by Myles (1965).Later Busemann (1928) established the concept and relationship to evaluate slip velocity in mied flow impeller. In mixed flow pump impeller meridional plane streamline was calculated by Senoo and Nakase (1972), Inoue et al. (1980).Finally A.J. Stepanoff (1967) gave the step by step design procedure for mixed flow pump impeller. Similarly, Neumann's (1991), Gahlot and Nyiri (1993) also suggested the design procedure to design Mixed flow pump impeller. A three dimension inverse design approach given by Yumiko Takayama and Hiroyoshi Watanabe (2009) to optimize the mixed flow pump impeller design. To enhance the efficiency of mixed flow pump impeller Jim- Hyuk Kim & Kwang-Yong Kim (2011) developed an optimization procedure. Later Hao et al. (2013), Mehta and Patel(2013) studied the effects on hydraulic performance of mixed-flow pump impellers from meridional flow passage shapes.

K. Sham Sunder (1981) using FEM techniques presented a three-dimensional method of stress analysis for determining the stress distribution in centrifugal impellers. Ramamurti and Balasubramanian (1987), Jonker and Van Essen (1997), Jonker and Van Essen (1997), Samir Lemeš and Nermina Zaimović-Uzunović (2002), Bhope and Padole (2003), Arewar and Bhope(2013) done stress analysis on complex blades of mixed flow pump in turbo machinery.

In the present research work design and stress analysis has been carried out on mixed flow pump impeller under applied torque due to rotational angular velocity using ANSYS 11.0 software with optimum mesh size 4.25mm(FEM CONVERGENCE test result). On the meridional annulus of the impeller two different positions of blade is considered and maximum Von Mises stress distribution was calculated and compared among them.

2. Research methodology

In this research work a mixed flow pump impeller has been developed for two different blade positioning in the meridional annulus for specific speed of 1.998 rad. /sec., Discharge (Q) = 0.125 m3/sec., Pressure head (H) = 5 m and Rotation (N) = 1000 rpm. This design is based on Free vortex theory. Basic fundamental relations were based on principles of turbo-machinery and fluid mechanics .Design and development was carried out for two different blade positioning, inlet inclined (case-I) and trapezoidal (case-II) which are shown in Fig. 1(a-b) respectively

(a) Case-I: Forward

(b) Case-II: Trapezoidal

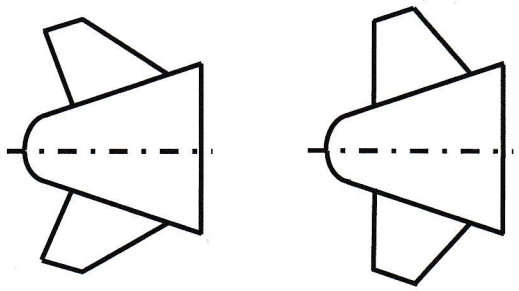

Fig. 1: Two different positions of the mixed flow pump impeller blades in the meridional annulus

2.1. Modelling of pump impeller blades

The development of complex aerofoil shaped blades were carried out by stacking the various blade sections one over another after the design parameters such as, blade chord length ,blade stagger angle, blade solidity, blade angle were calculated. So that blade stagger angle on the conical surface of the pump impeller satisfied. An aerofoil structure NACA 10C4 (circular arc profile) is used for the blades.

2.3 Stress analysis of the impeller blades

To get an accurate estimation of the stresses in the blades to accomplish this FEM CONVERGENCE test is performed by replacing the aerofoil (NACA 10C4) stacked twisted blades with an equivalent rectangular cross-section plate having, which acts like a cantilever beam. It is assumed that each blade of the mixed flow pump impeller acts as a cantilever beam fixed to the hub and due to torque under 1000rpm applied on the impeller; a surface force acts on the blade. The volume and material properties of both the plate and the blade during the calculation were kept identical. The manual calculation of Von Misses stress on the equivalent plate was carried out using the Eqs. (1-6) and convergence test is performed to get the mesh size on ANSYS 11.0.

Torque applied on the plate:

$$T = w \,.\, L \,.\, b \,.\, \frac{L}{2} \,.\, N$$

(1)

Also, torque applied:

$$T = \frac{P.(60).(1000)}{2.\Pi.\,N} = 191 \text{ N-m}$$

(2)

Where,

P = 20 Kw, N = 1000 rev. /min., n = number of blades in the impeller = 8

L = span of each plate= 58 mm, b = mean width of each plate= 162 mm, t = thickness of each plate = 17 mm

So from the above equation,

$$w = \frac{2T}{L^2.b.n} = \frac{(2).(191000)}{(58^2).(162).(8)} = 0.088 \text{N/mm}^2 = 88000 \text{N/m}^2$$

(3)

Bending stress is given by the relation:

$$\sigma_B = \frac{M}{I}.y$$

(4)

where ,

M=bending moment=w . b N-m, I=moment of inertia=(b . t^3)/12 m^4 , y=varying distance from neural axis ,m.

and shear stress can be written as:

$$\tau = \frac{6.(w.b.l).}{b.t^3} \cdot \frac{(t^2)}{(4 - y^2)}$$

(5)

So, Von Mises stress is given by the relation:

$$\sigma' = \sqrt{(\sigma_B{}^2 + 3\tau^2)}$$

(6)

So, the calculated value of the Von Misses stress at the root of the plate is 3.07299 10^6 N/m^2.

While calculating the Von Misses stress the following material properties were taken into consideration.

Material	: Bronze
Young Modulus	: 1.1 x 10^5 MPa
Poisson Ratio	:0.341
Density	:8.86 x 10^{-9} kg/mm^3
Thermal Expansion	:1.78x 10^{-5}/°K
Yield Strength	:5.2 x 10^8 N/m^2

Once the value of the Von Misses stress was calculated for the equivalent rectangular plate, Finite Element convergence test was carried on it with different mesh sizes to find out the optimum size of the element using ANSYS i.e. 4.25 mm .Using the optimum element sizes obtained from ANSYS 11.0, numerical stress analysis for the pump impellers under applied rotational force were carried out under rotational speed of 1000 rpm.

3. Results and discussion

In this research work, two different positions of blade is considered two different positions of blade on the meridional plane of impeller have been selected for the detailed design and optimization. The simulation is carried out using the software ANSYS 11.0 for the regular trapezoidal blades and inlet inclined blades separately. Firstly simulation of regular trapezoidal blades is carried out and then in the second phase, simulation of blade second blade which is inclined towards the inlet direction is carried out as shown in the Figure by using ANSYS 11.0.The impeller blades are subjected to a rotational force, which make the rotor rotate at its required speed i.e. 1000 rpm. With these loading conditions at the specified angular velocity, the directional deformation and stresses of the two types of blades are investigated.

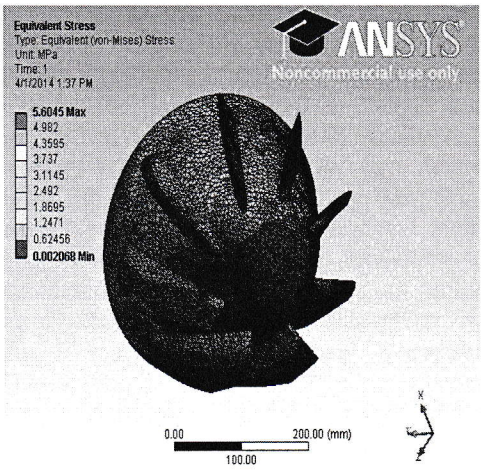

Figure 2 : Von Mises stress distribution of the impeller with inlet inclined section blades (Case-I)

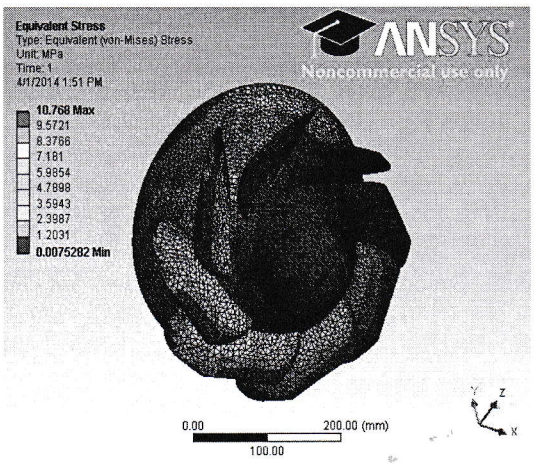

Figure 3: Von Mises stress distribution of the impeller with regular trapezoidal section blades (Case-II)

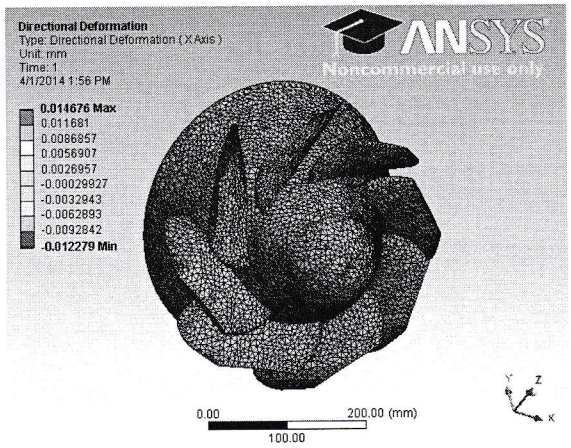

Figure 4 : Direction Deformation of the impeller with inlet inclined section blades (Case-I)

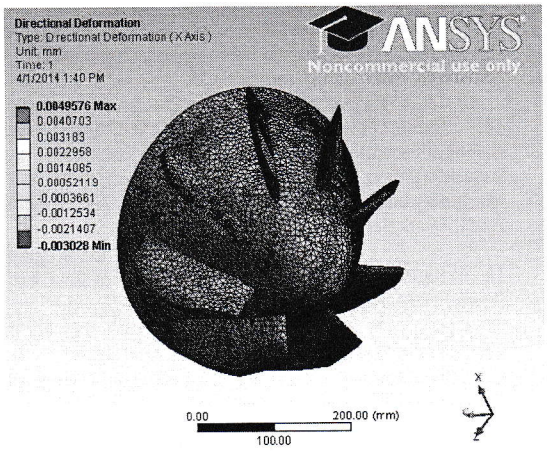

Figure 5: Direction Deformation of the impeller with regular trapezoidal section blades (Case-II)

From figure 2 and 3 it is observed that maximum von mises stress in inlet inclined positioned impeller blade is 5.605 MPa & wheras in regular trapezoidal impeller blade it is 10.769 MPa. This evidences that the inlet inclined impeller von mises stress is less as compared to trapezoidal blade. After the Von misses, Directional deformation of both the impellers the analysed the same i.e. directional deformation of case-I is less as compared to case-II.

4. Conclusion

From the above result bar under applied torque, the Von Misses stress and Directional Deformation of the mixed flow pump impeller for inlet inclined blade position under applied rotational force was much lower than that for trapezoidal positioned blade in the meridional annulus. This clearly indicates that the inlet inclined blade position in mixed flow pump impeller is a better option than the earlier calculated trapezoidal blade. Hence the conclusion drawn from the above results and calculations is to choose the inlet inclined positioned blade over the regular trapezoidal blade over the applied torque of 191 N-m.

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Technical necessities and progressive improvement in Aerospace Composite materials in the light of PMMA

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ABSTRACT: ***Composites as a different class of materials have discovered numerous applications in aviation ventures where strength and lightweightness are a prime concern. A study has been done so as to give an extensive throughput on different kinds of composites utilized in the airplane industry, accentuating on the highlights, properties, points of interest, constraints, and developing patterns in the field. Fiber-reinforced polymer composite materials are quick making strides as favoured materials for development of flying machines what's more, space creates. Specifically, their utilization as essential auxiliary materials as of late in a few innovation demonstrator cutting edge aviation ventures worldwide has given certainty prompting their acknowledgment as prime materials for aviation vehicles. This paper gives an audit of a portion of these improvements with a dialog of the issues with the present age composites and prospects for further improvements. Albeit a few applications in the aviation vector are referenced, the accentuation of the audit is on uses of composites as auxiliary materials where they have seen a noteworthy development in use. A short audit of composites use in aviation part is first given. The idea of composite materials conduct and uncommon issues in structuring and working with them are then featured. The issues examined identify with the effect harm and harm resilience when all is said in done, natural debasement and long haul solidness.***

Keywords: Aerospace, Composite Materials, Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Fibre Reinforced composites (FRPs)

1.1 Introduction

Composite materials have grabbed vougishness (paying little heed to their all around stunning cost) in unrivalled things that ought to be lightweight, yet adequately ready to take high loads, for instance, flying structures (tails, wings and fuselages), vessel improvement, bicycle housings and hustling vehicle bodies. Distinctive uses fuse limit tanks and calculating bars. Ordinary composites (wood and surfaces) have found applications in flying machine from the key trek of the Wright Brothers' Flyer 1, in North Carolina on December 17, 1903, to the a lot of occupations right now valued by man-made (assembled) composite materials on both military and regular flying machine, despite continuously charming applications on unmanned airborne vehicles (UAVs), space launchers and satellites. Their apportionment as a vital pledge to flying machine structures

sought after on from the disclosure of carbon fiber at the Royal Aircraft Establishment at Farnborough, UK, in 1964. Regardless, not until the moment that the late 1960s did these new composites start to be associated, on a display preface, to military flying machine. Occurrences of such demonstrators were trim tabs, spoilers, rudders and portals. With extending application and experience of their use came upgraded strands and system materials (thermosets and thermoplastics) achieving CFRP composites with improved mechanical properties, empowering them to remove the more standard materials, aluminium and titanium amalgams, for basic structures. In the going with fragments, the properties and structure of carbon fibers are discussed together with thermoplastic and thermoset saps and the centrality of the interface between the fiber and the system.

1.1.1 Carbon fibers types and properties

Brilliant, high modulus carbon strands are about 5-6 μm in estimation and involve little crystallites of 'turbostratic' graphite, one of the allotropic sorts of carbon. The graphite structure contains hexagonal layers, in which the holding is covalent and strong (->525 kJ/mol) and there are fragile vander Waal powers (<10 kJ/mol) between the layers [1,2]. This infers the essential crystal units are exceedingly anisotropic; the in-plane Young's modulus parallel to the α-axis is around 1000 GPa and the Young's modulus parallel to the c-axis run of the mill to the basal planes is only 30 GPa. Game plan of the basal plane parallel to the fiber turn gives solidified strands, which, in light of the relative low thickness of around 2 Mg/m3, have incredibly high estimations of unequivocal immovability

(- 200 GPa/(Mg/m3)). Imperfections in game plan displayed in the midst of the collecting method result in complex-shaped voids stretched parallel to the fiber turn. These go about as weight raisers and motivations behind deficiency inciting a decline in strength properties. Distinctive wellsprings of deficiency, which are consistently associated with the amassing strategy, join surface pits and full scale crystallites. The strategy of the layer planes in the cross-fragment of the fiber is similarly basic since it impacts the transverse and shear properties of the fiber. Thusly, for example, the standard polyacrylonitrile-based (PAN-based) Type I carbon strands have a thin skin of circumferential layer planes and an inside with subjective crystallites. Strangely, some mesophase pith based fibers show radially arranged layer structures. These differing structures result in some gigantic differentiations in the most ideal ties of the fibers and clearly those of the composites. Refinements in fiber process development throughout ongoing years have provoked consider-fit updates in inflexibility (-4.5 GPa) and in strain to split (over 2%) for PAN-based strands. These would now have the capacity to be given in three key structures, high modulus (HM, -380 GPa), midway modulus (IM, -290 GPa) and top notch (HS, with a modulus of around 230 GPa and tensile strength of 4.5 GPa). The later upgrades of the excellent strands have provoked what are known as high strain fibers, which have strain estimations of 2% before fracture. The tensile stresses train response is elastic up to failure, and a large amount of energy is released when the fibres

break in a brittle manner. The decision of the fitting fiber depends especially on the application. For military carrier, both high modulus and high strength are appealing. Satellite applications, curiously, advantage from use of high fiber modulus upgrading soundness and solidness for reflector dishes, gathering mechanical assemblies and their supporting structures.

Rovings are the basic structures in which strands are given, a meandering being different strands or bundles of filaments bent into a package or creel, the length of the winding being up to a couple of kilometres, dependent upon the package measure. Rovings or tows can be woven into surfaces, and an extent of surface advancements are open fiscally, for instance, plain weave, twills and distinctive silk weave styles, woven with a choice of meandering or tow gauge dependent upon the heap or areal thickness of surface required. Surfaces can be woven with different sorts of fiber, for example, carbon in the weft and glass in the curve course, and this manufactures the extent of properties available to the originator. One good position of surfaces for strengthening purposes behind existing is their ability to wrap or consent to twisted surfaces without wrinkling. It is as of now possible, with specific sorts of sewing machine, to convey fiber performs exclusively fitted to the condition of the conceivable portion. Generally speaking, regardless, the more significantly tangled each fiber advances toward getting to be, as at crossover centers in woven surfaces, or as circles in weaved surfaces, the lower its strengthening limit.

1.1.2 Fibre-grid interface

The fibers are surface treated in the midst of create to prepare bond with the polymer organize, on account of thermosetting (epoxy, polyester, phenolic and polyimide saps) or thermoplastic (polypropylene, Nylon 6.6, **PMMA**, PEEK). The fiber surface is disagreeable ended by blend scratching and after that secured with an appropriate size to help appending to the foreordained system. While composite flexibility is on a very basic level a part of fiber properties, the limit of the network to both help the fibers (required for good compression strength) and give out-of-plane strength is, all around, likewise basic. The purpose of the material supplier is to outfit a structure with a respectable game plan of properties. While overhauls in fiber and structure properties can provoke upgraded lamina or overlay properties, the hugely fundamental field of fiber-cross section interface must not be neglected.

The load following up on the system must be traded to the help by methods for the interface. Thusly, fibers must be unequivocally clung to the system if their high strength additionally, stiffness are to be presented to the composite. The fracture behaviour is also dependent on the nature of the interface. A feeble interface results in a low robustness and strength yet high assurance from break, however a strong interface makes high immovability and strength anyway as often as possible a low insurance from split, i.e., brittle behaviour. Conflict therefore exists and the designer must select the material most nearly meeting his requirements. Distinctive properties of a composite, for instance, resistance to creep, fatigue and environmental degradation, are in like manner

affected by the characteristics of the interface. In these cases the association among properties and interface characteristics are generally complex, and logical/numerical models maintained by expansive preliminary confirmation are required.

1.1.3 Resin materials Thermoplastic materials are twisting up progressively available, in any case, the more standard matrix materials right currently used are thermosetting epoxies. The cross section material is the Achilles affect purpose of the composite system and limits the fiber from showing its most extreme limit similarly as cover properties. The structure plays out different limits among which are settling the fiber in weight (providing lateral support), making an understanding of the fiber properties into the cover, constraining damage on account of impact by indicating plastic deformation and giving out-of-plane properties to the overlay. Lattice overpowered properties (Interlaminar strength, compressive strength) are decreased when the glass advance temperature is outperformed, and keeping in mind that with a dry cover this is close to the fix temperature, the unavoidable moistness maintenance reduces this temperature and thus compels the usage of most high-temperature-settle thermoset epoxy composites to under 120 C.

Standard epoxy avionics resins are expected to settle at 120 to 135 C or 180 C as a rule in an autoclave or quiets depression gadget at loads down to 8 bar, on occasion with a post settle at higher temperature. Systems expected for high temperature applications maybe encounter re-establishing at temperatures up to 350 C. The resins must have a room temperature life past the time it takes to lay up a segment and have time/temperature/consistency sensible for dealing with. The resultant gum traits are frequently an exchange off between certain appealing characteristics. For example, improved damage opposition execution when in doubt causes a decline in hot-wet weight properties, and in case this is practiced by an extended thermoplastic substance, the sap thickness can augment essentially. Extended thickness is especially not needed for a resin transfer moulding (RTM) sap where a consistency of 50 cPs or less is every now and again required, but toughness may also be imparted by the fabric structure such as a stitched non-crimped fabric (NCF).

The original of composites acquainted with flying machine development during the 1970s utilized weak epoxy pitch frameworks prompting covered structures with a poor resistance to low vitality affect caused by runway trash hurled via airplane wheels or the effects happening amid make and resulting adjusting activity. In spite of the fact that the more current toughened epoxy frameworks give upgrades in this regard, they are still not as harm tolerant as thermoplastic materials. A proportion of harm resistance is the cover compression after effect (CAI) and the overlay open hole compressive (OHC) qualities. The perfect arrangement is to give a composite displaying level with OHC and CAI qualities, and keeping in mind that the thermoplastics are harder they have not profited by this by yielding higher scored pressure properties than the thermoset epoxy composites. Polyetheretherketone (PEEK) is a moderately exorbitant thermoplastic with great mechanical properties. Carbon fiber-strengthened PEEK is a contender with carbon fiber/epoxies and Al-Cu

and Al-Li amalgams in the airplane business. On effect at generally low energies (5-10 J) carbon fiber-PEEK covers demonstrate just a space on the effect site while in carbon fiber-epoxy frameworks ultrasonic C-examines demonstrate that delamination expands an impressive separation influencing all the more drastically the lingering quality and firmness properties of the composite. Another vital favourable position of carbon fiber-PEEK composites is that they have boundless time span of usability at surrounding temperature; the fabricator does not need to be worried about proportioning and blending tars, hardeners and quickening agents as with thermosets; and the reversible warm conduct of thermoplastics implies that parts can be created all the more rapidly in light of the fact that the long fix plans for thermosets, at times stretching out more than a few hours, are wiped out. It very well may be seen that in the push to enhance the through-the-thickness quality properties and effect opposition the composites business has moved far from fragile tars and advanced to thermoplastic saps, toughened epoxies, through harm tolerant approach, Z-fiber (carbon, steel or titanium pins driven through the z-bearing to enhance the through-thickness properties), sewed textures, sewed performs and the emphasis is presently on reasonableness. The present stage is being coordinated toward moderate preparing strategies, for example, non-autoclave handling, non warm electron bar relieving by radiation and financially savvy creation [3]. NASA Langley in the United States asserts a 100% enhancement in harm resistance execution with sewed textures in respect to customary materials (allude to Advanced Composites Technology program where NCF covers are handled by sap film imbuement). It is basic that if composites somehow managed to wind up reasonable they should change their essential procedures to make tracks in an opposite direction from pre-preg material innovation, which as of now results in a costly arrangement and henceforth item. Notwithstanding, autoclaved ceaseless fiber composites will even now rule for the abnormal amounts of basic proficiency required.

1.2 Analysis and plan Flying machine structure from the 1940s has been founded principally on the utilization of aluminum compounds, and in that capacity, a colossal measure of information and experience exists to encourage the plan procedure. With the presentation of overlaid composites that show anisotropic properties the approach of configuration must be checked on and as a rule supplanted. It is acknowledged that plans in composites ought not simply supplant the metallic compound but rather should exploit remarkable composite properties if the most productive structures are to develop. Obviously the plan should represent through-thickness impacts that are not experienced in the examination of isotropic materials. For example, in an overlaid structure since the layers (laminae) are flexibly associated through their faces, shear stresses are produced on the essences of every lamina. The transverse stress (σz, τxz,τyz)in this manner delivered can be very expansive close to a free limit (free edge, cut-out, an open gap) and may impact the disappointment of the overlay [4]. The cover stacking succession can essentially impact the extent of the interlaminar typical and shear stresses, and along these lines the stacking grouping of utilizes can be imperative to an originator. It has been accounted for that the

weariness quality of a (15/45)s Boron fiber/epoxy overlay is around 175 MPa lower than a (45/15)s cover of a similar framework. The interlaminar ordinary pressure, σzz, changes from strain to pressure by changing the stacking arrangement, and consequently represents the distinction in qualities. For this situation dynamic delamination is the disappointment mode in exhaustion. Surmised diagnostic strategies and numerical methodologies, for example, limited distinction and limited component (FE) systems [5] can be utilized to dissect the interlaminar push appropriations close free edges, open gaps, darted joints and help to recognize the ideal fiber introduction and cover stacking succession for the given stacking and kinematic limit conditions. By and large, the assurance of neighborhood stretch circulation in a shot joint is a three-dimensional issue because of bowing impacts and clasping of the latch. The pressure state in the region of a shot opening relies upon numerous mind boggling elements, for example, grating properties of the individuals, contact issue, geometry and firmness of the joined individuals, joint setup, clipping power and stacking conditions. To correctly incorporate every one of these variables in a pressure examination of a joint dependent on ordinary explanatory techniques is to a great degree bulky [6-8]. Figure 1.1 represents a finite element model used to analyse a single bolt fastener in a double lap joint and simulate the clamping force in the joint [8]. The lay-up geometry of a composite unequivocally influences break commencement as well as split proliferation, with the outcome that a few covers show up exceedingly indent delicate though others are absolutely harsh to the nearness of stress concentrators [9-11]. The choice of filaments and gums, the way in which they are consolidated in the lay-up, and the nature of the produced composite should all be cautiously controlled if ideal sturdiness is to be accomplished. Moreover, materials prerequisites for most noteworthy elastic and shear qualities of covers are regularly contrary with necessities for most noteworthy strength. Contrasted and break in metals, examination into the crack conduct of composites is in its early stages. A great part of the important hypothetical structure isn't yet completely created, and there is no straightforward formula for anticipating the sturdiness all things considered. We are not capable yet to plan with sureness the structure of any composite in order to create the ideal blend of solidarity and sturdiness.

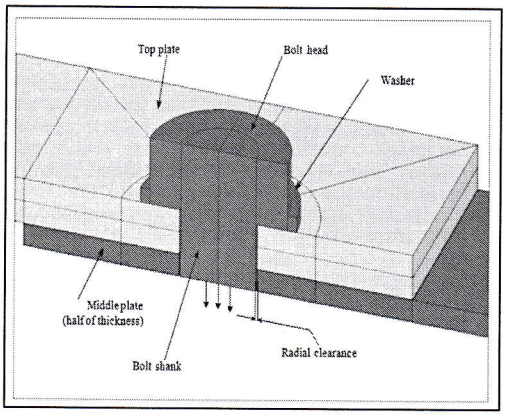

Figure 1.1 A limited component strong bolt show where the clasping power is represented by a negative dislodging at base surface of bolt shank In metallic and plastic materials, even generally fragile ones, vitality is disseminated in non-elastic twisting systems in the district of the split tip. This vitality is lost in moving separations in a metal and in viscoelastic stream or rage development in a polymer. In composites focused on parallel to the fiber hub, the filaments meddle with break development; however their impact relies upon how firmly

they are attached to the lattice (pitch). For instance, if the fiber/lattice security is solid, the break may go through the two strands and grid without deviation, in which case the composite durability would be low and around equivalent to the aggregate of the different part strength. Then again, if the security is powerless the break way turns out to be exceptionally mind boggling, and many separate harm instruments may then add to the general crack work of the composite. For instance, a weak polymer or epoxy tar with a crack energy G = 0.1 KJ/m and fragile glass strands with

G =0.01 KJ/m can be consolidated together in composites some of which have break energies of up to 100 kJ/m. For a clarification of such an extensive impact we should look past basic expansion [12,13]. In the event that the break is arranged parallel to the filaments and is oppressed either to elastic anxieties opposite to the strands or shear stresses parallel to them, the strands have little impact on split engendering. In these conditions a frail fiber-matrix bond can make the split proliferate quickly along the fiber/framework interface. On the off chance that the interface bond is more grounded than stresses required to fizzle the network in either shear or direct pressure, split development is to a great extent an element of framework quality and strength. Crack in composite materials only from time to time happens calamitously all of a sudden, however will in general be dynamic, with significant harm broadly scattered through the material. Pliable stacking can create lattice splitting, fiber crossing over, fiber haul out fiber/grid debonding and fiber crack, which give additional sturdiness and defer disappointment [12]. The crack conduct of the composite can be sensibly very much clarified as far as some summation of the commitments from these systems, however as said prior, it isn't yet conceivable to structure a covered composite to have a given strength.

Another imperative demonstrating issue is the exhaustion life of the composite. As opposed to homogeneous metallic materials, in which weakness disappointment by and large happens by the commencement and proliferation of a solitary split, the exhaustion procedure in composite materials is extremely unpredictable and includes a few harm modes, including fiber/lattice debonding, framework splitting, delamination and fiber break (tractable or compressive disappointment as fiber miniaturized scale clasping or crimping); Figure 1.2 demonstrates a run of the mill fiber smaller scale locking disappointment saw in right now utilized carbon fiber/epoxy frameworks [14,15]. By a mix of these procedures, broad harm creates all through the main part of the composite and prompts a changeless corruption in mechanical properties, remarkably overlay firmness and remaining quality [16,17]. In spite of these complexities the in-plane weariness quality of both glass and carbon fiber overlays is altogether better than most metallic amalgams, to such a degree, to the point that in-plane exhaustion strength is never again a structure issue. As in the static stacking case, it is the out of plane weakness properties that can restrict configuration strains. Despite the fact that these complexities (free edge impacts, affect harm, joints, and feebleness) extend the plan procedure, they are more than adjusted for by the mass investment funds and upgrades in streamlined effectiveness that outcome. The limited component investigation is likewise an essential segment, and the greatest efficient

steps have been in the easy to use improvements in making the information and deciphering the outcomes utilizing present day complex graphical UIs. The key is utilizing parametric programming to create the geometry and the cross sections. Evidently it used to take Boeing (Phantom Works) in St. Louis, Missouri, over a half year to play out the underlying FE component firmness and quality investigation for a total air ship, and this presently takes under three weeks with a bunch of designers, so composites can turn out to be progressively appealing.

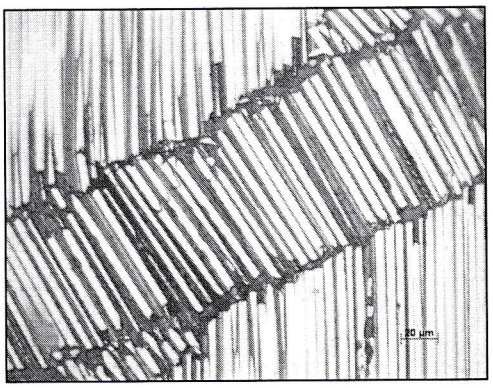

Figure 1.2 Fibre crimping incited by fibre precariousness or fibre small scale locking saw in a carbon fibre/epoxy cover; fibre distance across is around 6 mm

Figure 1.3 V22-Osprey tiltrotor plane .

The greater part of flying machine control-lift surfaces delivered has a solitary level of bend because of restriction of metal creation procedures. Enhancements in streamlined proficiency can be acquired by moving to twofold ebb and flow permitting, for instance, the creation of variable camber, wound wings. Composites and current form apparatuses enable the shape to be custom fitted to meet the required execution focuses at different focuses in the flying envelope. A further advantage is the capacity to tailor the air flexibility of the surface to additionally enhance the streamlined execution. This fitting can include embracing cover designs that permit the cross-coupling of flexure and torsion with the end goal that wing turn can come about because of twisting and the other way around. Limited component examination permits this procedure of air flexible fitting, alongside quality and dynamic firmness (ripple) necessities to be performed naturally with at least post-investigation designing yielding a base mass arrangement. Early composite structures were reproductions of those, which utilized metallic materials, and thus the high material expense and man-hour-escalated cover generation risked their acknowledgment. This was intensified by the expansion in gathering costs because of introductory challenges of machining and opening generation. The expense is specifically relative to the quantity of parts in the gathering, and, as a result, plans and fabricate methods must be altered to incorporate parts, along these lines decreasing the quantity of related clasp. Various roads are accessible for lessening the parts check, among which are the utilization of indispensably solidified structures, co-relieving or co-holding of substructures onto lift surfaces,

for example, wings and stabilizers and the utilization of honeycomb sandwich boards.

Hand lay-up systems and traditional gathering brings about assembling costs 60% higher than the datum, and just with the dynamic presentation of robotized lay-up and propelled get together strategies composites contend with their metallic partners. Likewise, the presentation of augmented reality and virtual assembling will assume a gigantic job in further lessening the general expense. The utilization of computer generated reality models in building preceding production to distinguish potential issues is generally new yet has officially exhibited incredible potential. Chime Textron in the United States made a huge utilization of IT amid the item definition stage (for the V22 Osprey Tilt-rotor, Figure 1.3) to guarantee 'right first-time' approach. Other assembling devices that can decrease generation cost and make composites progressively appealing are Virtual Fabrication (making parts from crude materials), Virtual Assembly (making of get together from parts) and Virtual Factory (assessment of the shop floor). Virtual assembling approves the item definition and streamlines the item cost; it decreases modify and enhances learning.

1.3 Manufacturing method

The biggest extent of carbon fiber composites utilized on essential class-one structures is created by setting endless supply of unidirectional (UD) material to the de-underwriter's prerequisite regarding handle profile and fiber introduction. On less basic things, woven textures all the time supplant the prime unidirectional frame. Various procedures have been produced for the exact situation of the material, going from work serious hand lay-up strategies to those requiring high capital interests in programmed tape layers (ATLs). Tape-laying machines working under numerical control are right now constrained underway applications to level lay-up, and huge exertion is being coordinated by machine producers at beating these issues related with laying on molded surfaces. The width of UD tape connected differs extensively from around 150 mm down to a solitary tow for complex structures. The expense of hardware is high and statement rates low. In 1988 the primary Cincinnati tape layer was introduced in the Phantom Works, and in 1995 a 7-pivot Ingersol fiber position machine was introduced. This gave the capacity to control filaments inside an envelope of 40 20 ft with a 32-tow ability. An over-wing board had been produced where it had the capacity to control around patterns. Cooperation with DASA on worldwide improvement programming was to be finished toward the finish of 1998. This product is professed to have created a 13% weight sparing. Different applications incorporate a motor cowling entryway, ducting with a perplexing structure, FA18 E/F and T45 level stabilizer skins. Its ability was stretched out to take a 6-in-wide tape and Boeing 777 has been changed over from hand lay-up to fiber put (consecutive at that point split) fights with a sparing of $5000 per set. Ringer Textron has a 10-pivot Ingersol, shaped programmed tape laying machine for the B609 skin lay-up, which is setting a 6-in wide T300 tape onto an inward form line Invar instrument with pre-introduced cap stringers. Fiber arrangement and fiber winding advancements are likewise being utilized to make parts for the V22 [3].

When the segment is laid up on the form, it is encased in an adaptable sack custom fitted roughly to the ideal shape and the get together is encased for the most part in an auto-clave, a weight vessel intended to contain a gas at weights by and large up to 1.5 MPa and fitted with a methods for raising the inner temperature to that required to fix the tar. The adaptable sack is first emptied, subsequently evacuating caught air and natural vapours from the composite, after which the chamber is pressurized to ace vide extra combination amid fix. The procedure produces structures of porosity, under 1%, and high mechanical honesty.

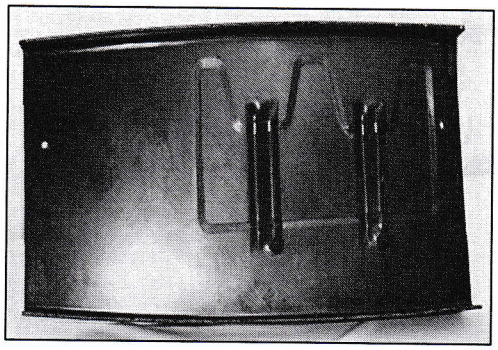

Figure 1.4 An average air ship composite wing rib component delivered by RTM.

Vast autoclaves have been introduced in the airplane business fit for lodging complete wing or tail segments. Then again, minimal effort non-autoclave preparing techniques can be utilized like the vacuum forming (VM), RTM, Figure 1.4, vacuum-helped RTM (VARTM) and tar film implantation (RFI). The vacuum shaping procedure makes utilization of barometrical strain to combine the material while restoring, in this manner blocking the requirement for an autoclave or a water powered press. The overlay as pre-impregnated filaments or texture is put on a solitary form surface and overlaid by an adaptable layer, which is fixed around the edges of the shape by a reasonable clipping course of action. The space between the shape and the layer is then emptied, and the vacuum is kept up until the point when the sap has relieved. Very vast, thin shell mouldings can be made along these lines requiring little to no effort. The larger part of frameworks appropriate for vacuum-just handling are relieved at 60e120 C and after that post-restored ordinarily at 180 C to completely create properties. In 1991 the assessment of this technique began at the Phantom Works utilizing the sap sys-tem LTM10 (low temperature trim) and they made a little allowable database for their X36 warrior inquire about air ship ponder. In 1996, McDonnell Douglas described LTM45 EL for the Joint Strike Force (JSF) model and produced structure suitable information. In 1998, Boeing additionally delivered LTM45 EL information. LTM10 applications showed for complex parts with a 140 F fix under vacuum incorporate a snake delta conduit. A container utilizing LTM10 was appeared at the 1998 Farnborough Air-appear. An examination program at NASA Langley is taking a gander at the improvement of 180 C material properties utilizing low temperature restoring gums. The primary points of interest of LTM frameworks are the possibility to utilize sans autoclave fixes, the utilization of less expensive tooling and decreased spring back of parts.

RTM and RFI are the transcendent restoring forms being created today of which there are a few varieties. In conventional pre-preg innovation, the sap has just invaded the filaments, and handling for the most part expels air and volatiles, merges and fix. RTM in its least complex frame includes a texture preform

being set in an encased pit and sap constrained into the form to fill the holes under strain and fix. The RFI technique uses precast tar tiles with thickness extending from 0.125 in to 0.25 in. This methodology diminishes the quantity of consumables utilized however is exceptionally process touchy, depending on the pitch being of adequately low porousness to completely impregnate the texture before fix propels excessively far. The utilization of an autoclave or press to apply weight changes. The RFI procedure is being connected inside the Advanced Composites Technology (ACT) Program related to customary autoclave handling. Warmth is the vitality source to enact the tar fix, however some gum frameworks can be initiated by radiation. Wright Patterson guarantee that warm broiler handling could spare 90% of autoclave genius cessing time and vitality and subsequently half expense. There is additionally a radiation relieving process grew mutually by NASA and ACG (Advanced Composites Group) and of creative electron bar restored structures being produced by Foster Miller, Lockheed Martin and Oakridge National Laboratories in the United States [3]. The VARTM is a fluid pitch mixture process and is as of now considered by the air ship industry to be the favoured minimal effort producing process for what's to come. It is a sans autoclave process that has been recognized as decreasing the expense of segment handling. It is accounted for that dimensional resilience and mass estimations are com-illustration with sewed RFI autoclave boards. A regular sharp edge solidified test board (3 2 ft with 4-in-high edges 0.5 in thick) has been fabricated as of late at NASA by utilizing the VARTM strategy, accomplishing a sensible quality. Further cost decrease when fabricating with composites will be accomplished by diminishing the get together expense, by moving far from securing (penetrating of thousands of gaps pursued by latch addition and fixing) toward holding and to get together with less or no costly jigging. Chime Textron among others are building and building up various structures (for the V22 and B609) where they are applying cutting edge composites innovation/procedures to accomplish a unitised way to deal with assembling and get together. There are obviously critical accreditation challenges with an adhesively reinforced joint without latches for an essential flying machine structure application that should be tended to. 1.4

Applications in flying machine development In the spearheading long periods of flight, air ship structures were composite being manufactured to a great extent of wood (normal composite), wire and texture. Aluminum combinations assumed control during the 1930s and have overwhelmed the business from that point forward. Wooden structures did, how-ever, endure until World War II, and the de Havilland Mosquito flying machine (DH98) built of a compressed wood balsa-pressed wood sandwich overlay most likely speaks to the high purpose of building plan with wood. The DH91 Albatross aircraft in 1937 was shaped as a handle balsa-utilize sandwich development, and the Spitfire fuselage in 1940 was planned and worked of Gordon Aerolite material that was a phenolic gum joining untwisted flax filaments that could be viewed as the forerunner of present day fiber strengthened plastics. Current common airplane applications have focused on supplanting the optional structure with sinewy composites where the support media have either been carbon, glass, Kevlar or cross breeds of these.

The grid material, a thermosetting epoxy framework, is either a 125 C or 180 C restoring framework with the last getting to be predominant due to its more prominent resistance to ecological corruption. Regular instances of the broad utilization of composites thusly are the Boeing 757, 767 and 777 and from Europe the Airbus A310, A320, A330 and A340 aircrafts. The A310 conveys a vertical stabilizer (8.3 m high by 7.8 m wide at the base), an essential streamlined and auxiliary part manufactured completely from carbon composite (presently £10-20/kg for huge tow HS fiber) with an aggregate weight sparing of very nearly 400 kg when contrasted and the Al compound unit recently utilized. Furthermore, the CFRP blade box com-prises just 95 sections barring clasp, contrasted and 2076 sections in the metal unit, accordingly making it simpler to create. The A320 has stretched out the utilization of composites to the even stabilizer notwithstanding the plenty of boards and optional control surfaces, prompting a load sparing of 800 kg over Al combination skin development. As a sign of the advantage of such weight sparing, it has been evaluated that 1 kg weight decrease spares more than 2900 L of fuel for each year. Bigger measures of FRPs are utilized in the greater A330, A340 models and obviously in the A380 excessively large carrier worked by the European Airbus consortium.

The wing-trailing edge boards are made of glass and carbon fiber-strengthened plastics utilizing another RFI strategy in which pitch film, between leaved among glass and carbon texture layers, when the cover is laid up, liquefies when warm is connected. Softened low consistency sap relocates effortlessly through the thickness of the cover where it fixes to shape the last segment. A half and half aluminum/glass rein-constrained plastic framework (GLARE) is utilized for the A380 fuselage crown, Figure 1.5, that outcomes in diminished weight, expanded harm resilience and enhanced exhaustion life.

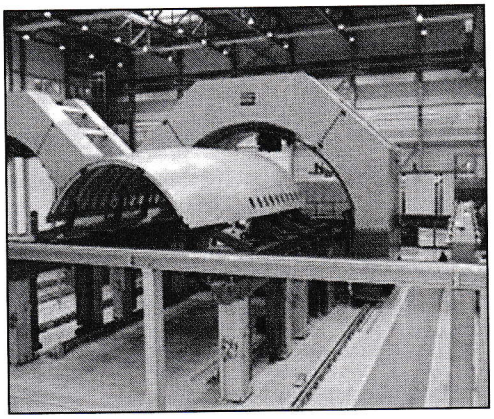

Figure.1.5 A380 Glare fuselage crown. Presentation: building necessities for aviation composite materials

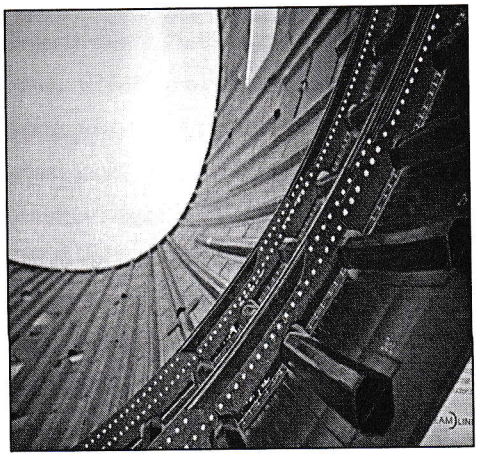

Figure 1.6 A typical modern carbon fibre/epoxy fuselage section.

The new Boeing 787 Dreamliner structure including the fuselage, wings, tail, entryways and inside is made of over half by weight composite materials (80% by volume). The all-composite fuselage, Figure 1.6, makes it the

main composite aircraft underway. Every fuselage barrel is produced in one piece (around 45 ft long) dispensing with the need of in excess of 50,000 clasp utilized in customary air ship building. Nonetheless, real get together issues with the composite fuselage segments were experienced that caused long deferrals in conveying the air ship to the client, and there were issues with what was leaving the autoclave, which is surely an exorbitant ordeal. Other specialized issues that must be settled were on the wellbeing side with electromagnetic perils like lightning strikes, since the polymer material does not direct away electric vitality. Another real stress, however generally for the administrator, will be harm identification, which as it was said before happens principally inside and ends up hard to recognize. Soutis and colleagues [18e22] have exhibited the likelihood of utilizing a straight cluster of piezoelectric transducers for the recognition of delaminations and different methods of harm in composite plates. So as to distinguish low speed affect harm in multidirectional overlays, they utilized the essential enemy of symmetric A0 Lamb mode at frequencies of 15e20 kHz; Figure 1.7 delineates a ultrasonic C-filter picture of the whole and harmed setup together with time-of-flight strategy used to identify the area of harm; its area was determined with a mistake of only 2.3% from the genuine position [20]. Some achievement, however further innovative work here, is required, particularly on fix [23,24] and auxiliary wellbeing observing of fixed setups [25,26]. Figure 1.8 represents a bended fuselage composite board where fortified fix fixes have been performed effectively, yet for them to be ensured by the Civil Aviation Authority an ongoing harm checking framework will be required.

Composites have been utilized in Bell helicopters (Dallas Fort Worth, Texas) since the 1980s after their propelled composites airframe program when they were capable 14 to accomplish a 20% decrease in load on metallic airframes. All cutting edges on their more up to date vehicles (412, 407, 427, 214, 609, OH58D, V22) are for the most part composite. The V22 Osprey tiltrotor has a composite fuselage hardened skin, Figure 1.9, and an all-composite wing, decided for its solidness basic structure, which was just conceivable in composites at low enough weight. The skins of the V22 wing are I-hardened with co-reinforced competes and rushed on ribs (the common 609 variant will utilize fortified ribs). It ought to be noticed that buck-ling can create extreme worries in the bond line among skin and stiffeners. Early demonstrators (from 1960s onwards) did not meet desires until the point that composites were accessible. The arch help axle is presently fiber twisted, yet it is intended to be made by utilizing the propelled fiber arrangement technique. Over 60% of the entire vehicle weight is carbon composite, in addition to a further 12% in glass fortified plastic. The V22 utilizes tape laying, hand lay-up and fiber twisting for the greater part of the composite development however is moving to fiber position for the 609 common rendition [3]. Mechanical attaching highlights vigorously in the composite structure, some 3000each side of the wing, is presented by manual boring with layouts, however they are looking toward the utilization of mechanized boring, presumably including water stream cutting. Different models where composites will be broadly connected are the new military freight Airbus A400M and the tail of the C17 (USA). A 62-ft C-17 tail demonstrator has been effectively

finished yielding 4300 less parts (counting latches), weight diminished by 20% (260 kg) and cost by half contrasted and the current metal tail. No matter what all deft warrior air ship at present being planned or worked in the United States and Europe (e.g., JSF, EFA, Figure 1.10) contain in the locale of 40% composites in the auxiliary mass, covering some 70% of the surface zone of the airplane. The basic nimbleness of the a/c would be lost if this measure of composite material was not utilized in view of the noteworthy mass increment.

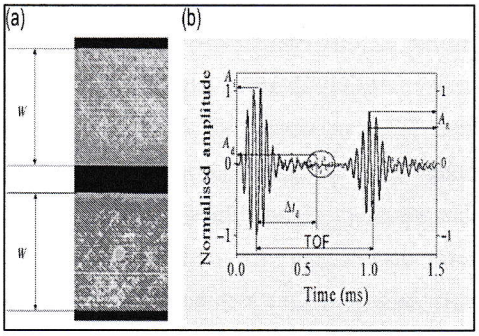

Figure 1.7 (an) A ultrasonic C-examine picture (over the width, W) of unharmed and 2 J affect harmed cover and (b) reaction of flawless and harmed composite plate [20].

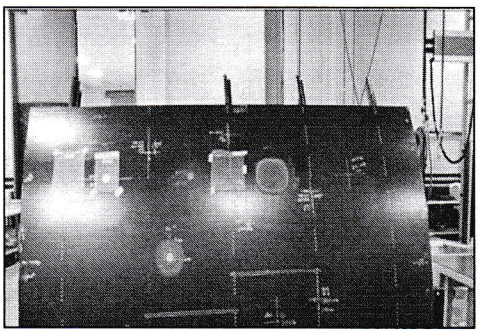

Figure 1.8 A composite fuselage board with fortified fix fixes.

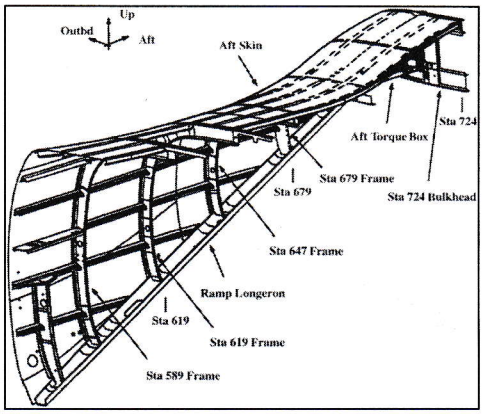

Figure 1.9 Composite fuselage solidified skin of V-22 Osprey tiltrotor air ship.

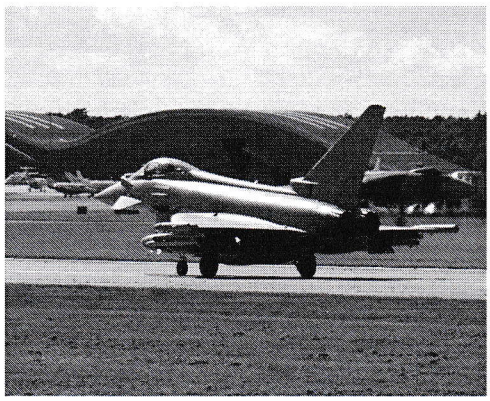

Figure 1.10 The Typhoon jet fighter, Eurofighter.

Huge numbers of the materials, procedures and assembling techniques examined before in the section have been executed in their development. Another fascinating moderately new field of advancement in the military flying machine circle is that of 'stealth', an idea that requires the originator to accomplish the littlest conceivable radar cross-area to decrease the odds of early location by protecting radar sets. The fundamental compound bend of the airframe with steady difference in range is a lot simpler to shape in composites than in metal, while radar permeable material can be successfully delivered in composites.

1.5 Conclusion

The utilization of carbon fiber has created from little scale innovation demonstrators during the 1970s to huge structures today. From being an over the top expensive intriguing material when previously grew generally couple of years prior, the cost of carbon fiber has dropped to about £10/kg, which has expanded applications to such an extent that the aviation advertise represents just 20% of all creation [27,28]. The principle points of interest given by CFRP incorporate mass and part decrease, complex shape make, diminished piece, enhanced weariness life, plan advancement and for the most part enhanced consumption opposition. The principle challenges limiting their utilization are material and handling costs, harm resilience, fix and examination, dimensional resistance and conservatism related with vulnerabilities about generally new and at times factor materials. Cases of 100% enhancement in harm resilience execution with sewed textures (3D woven textures) in respect to ordinary pre-preg materials are made; be that as it may, autoclaved ceaseless fiber composites will at present overwhelm for the abnormal amounts of auxiliary productivity required in essential air ship structures.

Carbon fiber composites are digging in for the long haul as far as future air ship development since huge weight investment funds can be accomplished. For auxiliary structures, weight investment funds moving toward 40% are attainable by utilizing composites rather than light metal compounds, while for essential structures, for example, wings and fuselages 20% is progressively sensible. These figures can generally enhance however advancement is the way to making composites increasingly moderate. Some ongoing advancement on composites disappointment investigation and structure, where current limited components procedures have been utilized to reproduce shoot conduct of fiber metal overlays and model pitch splitting and delamination created amid an effect occasion or a catapulted joint are accounted for in references [29-31]. The pursuer will be educated in the accompanying parts of this book of the most recent advancements in new materials, 2D and 3D woven models, manufacture procedures, natural impacts (temperature and mugginess), crack and weakness, plan and investigation of effect, crash (at overlay and segment level) and impact vitality ingestion, joints, notwithstanding fix, non ruinous assessment and ongoing basic wellbeing checking.

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A STABLE ELECTION PROTOCOL FOR CLUSTERING IN POWER CONSTRAINED WIRELESS MESH NETWORKS

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Abstract: The Wireless Mesh Network (WMN) is a collection of Mesh Routers (MR) and Mesh Clients (MC) which are organized in a mesh topology. Each device is directly connected to other devices in the same network and constitute what is called mesh topology. Wireless Mesh Network is a dynamic and Infrastructure less network. Due to its dynamic nature, it has many constraints like CPU, Battery, Mobility and Bandwidth. To efficiently manage some of those constraints in wireless mesh network, we use clustering technique. Clustering makes the network fast, more efficient and reliable. We will use Stable Election Protocol for clustering and to select a cluster head on the basis of battery power, the battery power is defined by the user. Only the cluster heads are allowed to connect and communicate with other nodes, which significantly reduces the extra computation on nodes in connection.

Keywords: *Wireless Mesh Networks, Mesh Topology, Stable Election Protocol, Clustering*

1. INTRODUCTION

A wireless mesh network is a form of Ad hoc networks. A WMN consists of two types of components -wireless mesh routers (MR) and mesh clients (MC). A WMN is also typically interconnected with the Internet through a gateway, which is an MR that performs the gateway or bridge function. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may need not connect to the Internet[1][2]. Wireless Mesh Networks, an emerging technology, are considered as the promised choices for wireless Internet communications since they allow fast, easy, and low-cost network deployment. Wireless Mesh Networks represent a good solution to provide wireless Internet connectivity in a sizeable geographic area. This new and promising network allows network deployment at a much less cost than with classic wireless networks. In WMNs, it is possible to cover the same area, as

compared to Wi-Fi, with less wireless routers, which makes the use of WMNs a compelling economical case[3][4]. WMNs are thus suitable for areas that do not have existing data cabling or for the deployment of a temporary wireless network.

WMNs are extremely reliable, as each node is connected to several other nodes. If one node drops out of the network, due to hardware failure or any other reason, its neighbors simply find another route. Extra capacity can be installed by simply adding more nodes. Mesh networks may involve either fixed or mobile Devices. The basic high level security issues in wireless mesh network have, such as availability, authenticity, integrity and confidentiality. We plan to use a Stable Election Protocol for clustering and to select a cluster head in each cluster on the basis of energy levels in a typical wireless mesh network. The cluster head avoids the extra computation on each node and also saves the battery power of the nodes. The cluster head increases the connection time [5]. The simplest meaning of clustering is grouping. Grouping the similar or different types of nodes by applying proper and appropriate techniques or methods. There are many types of clustering techniques used in networks[9].Cluster analysis is an unsupervised process that divides a set of objects into homogeneous groups.There have been many clustering algorithms scattered in publications in very areas such as Pattern Recognition,AI,Computer Science, Networks, Image processing, Biology, Psychology, and Marketing[8] Basically clustering is divided into two types

1.1. Hard Clustering

Basically hard clustering has each document belongs to exactly one cluster. In hard clustering, we make a hard partition of the data set Z.

$$\cup_{i=1}^{e} Ai = Z and Ai \cap Aj = \emptyset for all i \neq j$$

Also none of the set Ai may be empty.

1.2. Fuzzy Clustering

Fuzzy Clustering also called soft clustering. In fuzzy clustering, we make a fuzzy partition of the data set. Fuzzy clustering uses membership function in partition data set.

$$\sum_{i=1}^{c} u_{ij} = 1, \forall j = 1, \ldots \ldots, n$$

This function is called membership function and its value between 0 and 1

Clustering advantages

Clustering has many advantages [9]. Some of these are:

- By the Clustering reduces the size of routing tables which are stored at the individual nodes by localizingring and soft clustering.
- Clustering can conserve communication bandwidth since it limits the scope of inter cluster interactions to Cluster Heads (CHs) and avoids redundant exchange of messages among nodes.
- The Cluster Head can increase the battery life of the individual nodes and the network lifetime as well by implementing optimized management strategies.
- Clustering reduces the topology maintenance overhead. Nodes would care only for connecting with their CHs.
- A Cluster Head can perform data aggregation in its cluster and decrease the number of unnecessary packets.
- A Cluster Head can reduce the rate of energy consumption by scheduling activities in the cluster

2. Working Steps of Stable Election Protocol for Clustering

It is a clustering protocol to create clusters of nodes and it is a heterogeneity aware protocol. This process involves selecting cluster head on the basics of their battery and computation power. The whole mesh network is composed into clusters and those clusters are connected to other clusters by using the cluster head. [7]Steps to create cluster and cluster Head -

Step 1-Select number of nodes randomly in wireless mesh network and make clusters of those nodes on the basis of cut off frequency of the nodes.

Step 2-In a cluster cut off frequency selected by the user. The frequency is divided into three levels, Higher, Middle and Lower levels.

Step 3-Select the cluster head on the basis of battery power. Selection of cluster head in energy efficient techniques generally depends on the initial energy, residual energy, and the average energy of the network or energy consumption rate or a combination of these.

Step 4-Afetr selection of cluster head, for the communication between two cluster heads or other nodes. Established the connection between new cluster head to other nearest cluster heads in wireless mesh network.

3. THE STABLE ELECTION PROTOCOL

In a wireless mesh network, the data are sent in the form of digital signals between one cluster head to another cluster head. To send any types of signal some energy is required. The distance from one cluster head to another is d. Energy consumption formula for sending an r bit message to a distance s is

$$E_{Tx}(r,s) = E_{Tx-elec}(r) + E_{Tx-amp}(r,s)$$

$$E_{Tx}(r,s) = E_{elec} \times r + E_{amp} \times r \times s^2$$

In a wireless mesh network, if the cluster head receives data that also require some energy. The distance from one cluster head to another is s. The energy consumption formula for receiving a r bit message to a distance is d.

$$E_{Rx}(r) = E_{Rx-elec}(r)$$

$$E_{Rx}(r) = E_{elec} \times r$$

To calculate consumption of energy,following parameters are defined. The average energy used by a node in a cycle includes energy from cluster head plus energy from leaf nodes, as given below

$$E_{avg} = pE_{head} + (1-p)E_{leaf}$$

The number of nodes is given, then creates a cluster and calculates the energy of all nodes for selection of cluster head on the basis of energy level of nodes. The expected number of nodes in a cluster with every node has the same probability p to become a cluster head, given by:

$$\mathbf{M} = \frac{1}{p}$$

Subsequently, the stable probability of a node to become a cluster head is derived from a function of P_{Rate} Assume that all the nodes have data to send in each cycle P_{Rate}, the stable cluster head election probability (p) becomes

$$p = \sqrt{\frac{E_{amp} K_{data} L^2}{N(3E_{elec} K_{inter} + 2E_{amp} L^2 k_{data})}}$$

With the help of these equations, we can create a mesh network having various cluster heads selected on the basis of node energy.

4. DISCUSSION AND RESULT

We use Stemplot to track all the data in from of 1's and 0's that is called sub carrier indexing because all the data is sent in digital form. By Placing data in empty vector and thus creating different size of sub carriers. Here we show the Random bits graph between Bit Index and Binary Values Fig 1 shows the all signal sources :

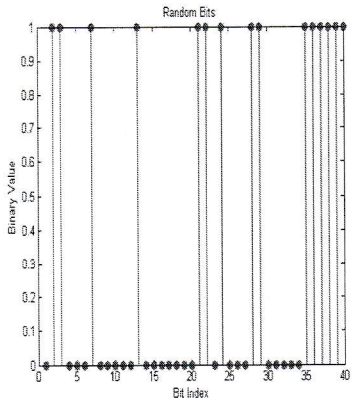

FIG 1: **Signal Processing Symbol Index**

A stemplot in statistics is a device for presenting quantitative data in a graphical format, similar to a histogram, to assist in visualizing the shape of a distribution. A basic stemplot contains two columns separated by a vertical line. The left column contains the stems and the right column contains the leaves.

Here we Plot first 10 symbols in a stem plot out of all signals of symbols. It is a Random Symbols graph between the Symbol Index and Integer
Values

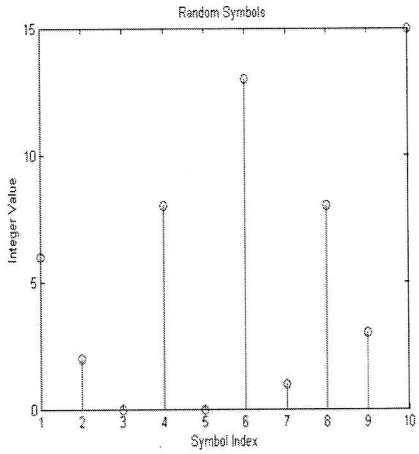

FIG 2: **Shown Binary Value Of Bit Index**

The data are displayed as a collection of points, each having the value of one variable determining the position on the horizontal axis and the value of the other variable determining the position on the vertical axis. This kind of plot is also called a scatter chart, scatter diagram or scatter graph. Here we show received signals and check the peak to average power ratio (PAPR) for each symbol and select cluster head on the basis of power.

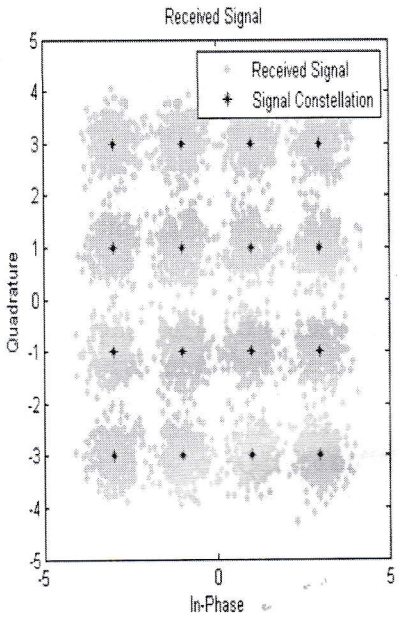

FIG 3: **Scatter Plot Diagram For Choosing The Cluster Heads**

5. CONCLUSION AND FUTURE WORK

In a wireless mesh network we used a stable election protocol for clustering and to select a cluster head, which reduced overhead and also saved the battery power. Only the cluster heads are responsible for establishing connections and communicate with other cluster heads. In the future, the link heterogeneity of networks will be considered. Also the impact of location and size of the cluster to cluster heads election algorithm will be our further research.

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Production of Hydrogen (H_2) From Uric Acid Through Electrolytic Approach

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ABSTRACT

Our long term goal is to design an economical means of hydrogen gas production which can be provided at the grass –root level of rural inhabitation. Our objective in this application is to determine the optimum way of producing hydrogen using Nickel electrode to address cost reduction in energy utilization at the community level. This proposed research is potentially innovative because our design of small scale urine production with the help of electrolysis process will determine the optimum conditions for production of hydrogen using a small setup of 20 litre capacity of urine and using nickel and cadmium rod as an electrode and borax as an catalyst for producing hydrogen from urine.

Key words: Electrode, Nickel, Sodium Borax, Potassium Hydroxide

INTRODUCTION

Sanitation issues related to urination are a common problem in India especially in rural areas. So far no efficient means of coping up with the urinal waste have been devised. Thus there is a critical need of addressing the accumulation of such wastes by utilizing these for some beneficial purposes. Urine comprises of inorganic constituents such as ammonia, sulphate, phosphate, chloride, magnesium calcium, potassium, sodium, creatinine, uric acid and urea. The urea is 2.5% of the total urine. The urea from urine can be used for the production of hydrogen by three different methods i.e. by direct electrolysis of urine or by chemical means using aluminium and sodium hydroxide or by microbial means using microbes extracted from the soil obtained from open urinals. Of all these methods, microbial method is the least viable method which is costly to use the microbial consortia (urea positive bacteria and cyan bacteria) to produce hydrogen from urine in a photo bioreactor while the electrolysis methodis the most economically feasible one. So, we would be utilizing the electrolysismethod in our current project. Using urine as the starting material would not only help reduce the pollution due to human excreta but would also help cutting down the prices of fossil fuels that have put enormous burden on the world economy. Availability of urine is not a problem especially in our campus where there are more than 5000 students. Moreover, the location of college is surrounded by many villages around so urine can also be collected from nearby regions. Some preliminary studies have already been conducted by us in laboratory using animal urine now we want to move the technology from lab scale to pilot scale through this project.

MATERIAL REQUIRED

- **Nickel Rod**: Nickel rod is used as an electrode in the electrolysis of urine. It is also act as a catalyst which accelerated the reaction rate in the container and also helps in the dissociation of hydrogen, carbon and nitrogen bonds.

- **Borex**: It is used to absorb the moisture content from the hydrogen gas which comes out as a product after the electrolysis.
- **Potassium Hydroxide**: It is mixed with the urine during electrolysis, it with help in dissociation of H_2O molecule bond in OH^- and H^+ molecules. These bonds get combined together and form H_2 atom.
- **Connecting Wires**: These wires are used for completing the circuit to ensure flow of current and proper electrolysis of urine.
- **Battery**: It is used as driving potential for the whole setup and provides the required amount of current for urine electrolysis.
- **Container**: It is used for storing the hydrogen gas which is coming out from electrolysis process. We will take a simple aluminium container because the amount of hydrogen produced is very low.
- **Separator**: The separator is a simple thin metal sheet which retards the mixing of different gas inside the main container during electrolysis process.
- **Metal Bar**: It is a simple cast iron bar about 50 cm long which is used to support the electrodes inside the main container.
-
- **Top Cover**: It is also a simple steel cover which is to pack the whole container proper so that the gases coming out from electrolysis process will not mixed with the atmosphere.
- **Nozzles, Pipes and Connecting Clips**: Nozzles are placed at the top cover so that the gas produced inside the main container can pass to the storage container through the pipes without any leakage in atmosphere. Connecting Clips are used for connecting the battery terminals and wires.
- **Sealant and Adhesive**: They are used for making the whole setup leak proof and ensure that our system will not come in contact with surrounding.

METHODOLOGY

Working: The system actually consist of an electrolytic container, water filter, an empty gas can, borax, and an engine. Urine is placed in the container where it undergoes and release hydrogen-oxygen gas. This mixture then passes into the, water filter. The water filter removes any impurities that might have come in contactwith the gas. Then H_2 gas comes into an empty gas cylinder which serves as the gas storage. The gas cylinder pushes hydrogen into a cylinder of borax, used to remove the moisture from the hydrogen gas. Borax serves as a drying agent. Also, borax helps to remove any other impurities that might have come with the gas. The purified hydrogen gas is then pushed into the engine where it is used as a fuel for combustion. Methodology is mainly divided into three parts.

1. Electrolysis of urine

2. Purification

3. Transferring the Hydrogen to the engine.

Electrolysis of Urine: An efficient way of producing hydrogen from urine that could not only fuel the cars of the future, but could also help to clean up the municipal waste water. Using hydrogen to power engine has become an increasingly attractive transportation fuel, as the only emission produced is water - but a major stumbling block is the lack of a cheap, renewable source of the fuel. Using an electrolysis approach to produce hydrogen from urine is the most abundant waste on Earth at a fraction of the cost of producing hydrogen from water. Urine's major constituent is urea, which incorporates four hydrogen atoms per molecule - importantly, less tightly bonded than the hydrogen atoms in water molecules. Electrolysis process is used to break the molecule apart, developing an inexpensive new copper -based or nickel based electrode to selectively and efficiently oxidize the urea. To break the molecule down, a voltage of 0.37V needs to be applied across the cell - much less than the 1.23V needed to split water. Here we have considered nickel as the catalyst for this reaction as it is cheap, economically feasible and shows high activity for urea electrolysis. Currently, high concentrations of alkali potassium hydroxide (KOH) are being used in the reaction. The use of KOH would present a significant improvement for the process by eliminating the need for aqueous KOH resulting in a system that is cheaper, safer, easier to contain, and more adaptable application. Typical concentration used is 5 M (280 g L-1).During the electrochemical process the urea gets adsorbed on to the copper electrode surface, which passes the electrons needed to break up the molecule.

Pure hydrogen is evolved at the cathode, while nitrogen plus a trace of oxygen and hydrogen were collected at the anode. While carbon dioxide is generated during the reaction, none is found in the collected gasses as it reacts with the potassium hydroxide in the solution to form potassium carbonate. Urea is oxidized at the anode at a standard electrode potential of 0.46 V. Nitrogen is generated from the anode demonstrating nitrate remediation of wastewater while water is reduced at the cathode producing valuable hydrogen for the impending hydrogen economy. An electrolytic cell potential of only 0.38 V is thermodynamically required to electrolysis of urea at standard conditions. This is significantly less than the 1.20 V required for electrolysing water to generate 75% cheaper hydrogen. Urea naturally hydrolyses into ammonia before generating gas phase ammonia emissions. These emissions lead to the formation of ammonium sulphate and nitrate particulates in the air, which cause a variety of health problems including chronic bronchitis, asthma attacks.

Table of Urine Chemical Composition

Chemical	Concentration in g/100 ml urine
water	95
urea	2
sodium	0.6
chloride	0.6
sulfate	0.18
potassium	0.15
phosphate	0.12
creatinine	0.1
ammonia	0.05
uric acid	0.03
calcium	0.015
magnesium	0.01
protein	--
glucose	--

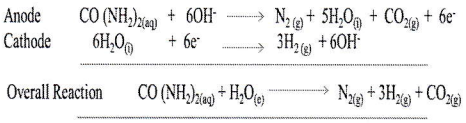
Reaction:

Urea Electrolysis

There are two possible cases:

1. Chemical Decomposition – Urea dissociate naturally to NH_3 (ammonia) and NH_2CaoH (carbonates)

2. Electrochemical oxidation as follows:



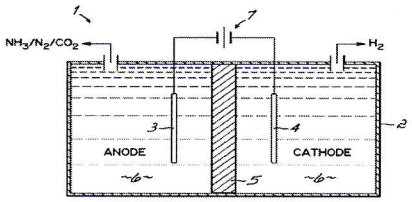
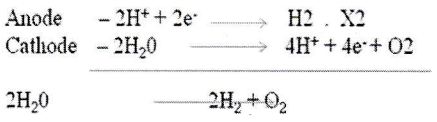


Fig. 1 Block Diagram of System

Procedure

Some Additional Equations to Understand the Process

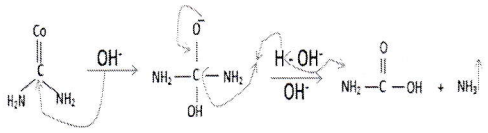
Water Electrolysis:



Exothermic reaction with heat output $T\Delta S$ = 48.7 KJ mol^{-1}

Chemical decomposition of urea with base like (KOH, NaOH)

For Urea



Now electrolysis of ammonia (Electrochemical decomposition)

Anode $-2NH_3 + 6OH^- \longrightarrow N2 + 6H_2O + 6e^-$

Cathode $-2H_20 + 2e^- \longrightarrow H_2 + 2OH^-$ X 3

$2NH_3 \longrightarrow N_2 + 3H_2$

PROCEDURE

Step1- Collect the Urine in a container in the proper amount. We have taken 10L of urine at once.

Step2- After this add the Sodium Borax and Potassium Hydroxide approx. 10 grams each in the urine and left the solution for a period of time approx. 3 hours so that saturation can be achieved in the solution.

Step3-Make two holes at the upper part of the container make a hole at the upper centre of the thin metal plate which act as a separator and avoid the mixing of gases which are generated on cathode and anode

Step4-Insert the metal bar in the hole which is made on upper surface of container used for holding the separator and nickel rods. Put the rods and separator at the desired location in the container.

Step5-Done the proper insulation of the metal bar to avoid the short circuiting when current is flowing for electrolysis

Step6-Connect the thick nickel rod to the positive and thin rod to the negative terminals of the battery.

Step7-Cover the top of the container using the metal cover and seal the edges of the container and the cover using sealant and adhesives.

Step8-Make the two holes in the top cover at both anode and cathode side so that gases can be come out from the container. It is estimated that hydrogen is come at anode and other gases (carbon dioxide and nitrogen) come at cathode.

Step9-Insert the pipe through nozzles at anode and cathode for the removal of gases inside the container. Pipe at anode is connected to the storing container for hydrogen and pipe at cathode is left open in atmosphere.

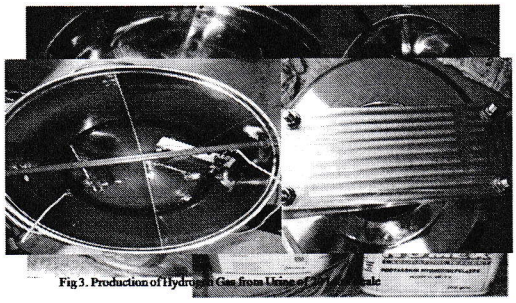


Fig 2. Production of Hydrogen Gas from Urine of 20 Litre Scale

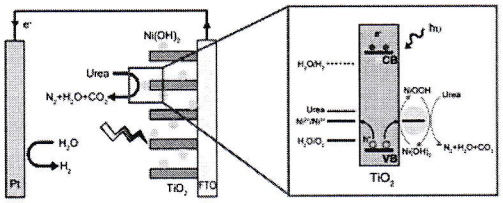


Fig 4 Reactions at Anode and Cathode during the process

RESULTS AND DISCUSSION

This experimental study was strongly indicative of the fact that the concentration of KOH plays a significant role as a catalyst to oxidation reaction. The maximum current density obtained at 5 M KOH supports the argument that a higher concentration of KOH is more favourable towards the oxidation reaction. However, as can be seen from the oxidation peak and the rapid decrease of current from potentials of 0.55V to 0.7V, which is uncharacteristic of rotating disk electrode experiments, it is an indication of an adsorption-desorption reaction occurring on the electrode surface. There is a possibility of adherence of CO_2 or the OH- onto the NiOH surface which causes this rapid rise and fall of the electrode current. The set of experiments performed initially to determine the lower set point of KOH concentrations. 4 concentrations of KOH were tested starting with 0.1 M. There was no response peak at 0.1 M. The lowest concentration of KOH that gave a response was 0.25 M. Prelim in different concentrations of KOH at 20g L^{-1} urea to determine lower set point. The peaks were obtained for different concentrations of KOH at different urea concentrations. Baseline KOH represents a solution with 1M KOH with no urea present. It is evident that the

current density corresponding to the peak is the highest in the case of 5M KOH. There is not a significant increase in the current density in case of 1 M, 2 M and 3 M KOH for all three concentrations of urea used.

World population=7.063 billion

India population= 1,224,260,000

Voltage required for electrolysis of Urine (Urea) per molecule= 0.37 V

Voltage required for electrolysis of water per molecule= 1.23 V

Approx. daily single person urine production **=1-2 lit**

Let be taken as 1.5lit

So total urine production in India = 1224260000*1.5

= 1836390000 lit

Amount of hydrogen produced per litre of urine= **2 grams**

Hence, total potential of hydrogen from urine **= 1836390000* 0.002 = 3772780 kg per day**

Efficiency of fuel cell is about 60 %. Hence, it is about 2-3 times more efficient than petrol and diesel internal combustion engine.

Calorific Value of hydrogen = 142 KJ/ kg. Hence, it has 3 times more calorific value than petrol (48 KJ/kg).

Hence, this results into multiplication factor of 2*3= 6.

Thus, petrol equivalent of hydrogen = 3772780*6 kg=22036680 kg

Dividing this amount with the density of petrol (0.75 kg/ltr) = 22036680 / 0.75 = 29382240 litres

Amount of oil consumption in India= 3,182,000 bbl / day = 3182000*158.987295 =505897573 lit/day

If we take the efficiency to be 60% over a period of time, amount of hydrogen collected is equivalent to 29382240*0.6 litres = 17629344 litres taking in consideration, the profits which can be obtained.

Now considering the case of Delhi city,

Population of Delhi compared to total population of India=**1.23%**

Petrol equivalent which can be produced in Delhi = 17629344*1.23% = **216840.93 lit per day**

Cost of 216840.93 litre petrol = 216840.93*60 (price of petrol) = **1.30 crore**

Now hydrogen which can be produced in Delhi = 3772780 *1.23% = **46405.194 kg per day**.

Power required for electrolysis of 2 gms hydrogen = **22 WH**

CONCLUSION

Using an electrolytic approach to produce hydrogen from urine is the most abundant waste on Earth at a fraction of the cost of producing hydrogen from water. The hydrogen gas gives many more application in all the fields such as in cars, vehicle. But it required special arrangement. It is used to drive turbine, in internal combustion engines for motive and electrical power. Urea naturally hydrolyses into ammonia and carbonate before generating gas phase ammonia emissions. These emissions lead to the formation of ammonium sulphate and nitrate particulates in the air, which cause a variety of health problems including chronic bronchitis, asthma attacks and premature death.

The energy is required for urea electrolysis is 35% less, which generated 40% cheaper hydrogen compared to water electrolysis. For this system, the exhaust gas is the water vapour. It does not emit carbon monoxide like the normal fuel-based engine so this ensures clean environment for people. The source of urine is naturally available from human being and cattle so there is availability of hydrogen easily. System using hydrogen generated from urine is 46.15% more efficient than the petrol fuel. Running cost nearly turns to half as compared to petrol and thus this is a solution to the increasing demand of the oil fuel which is eco-friendly and reduces the burden on the fuels.

- **Amount of Carbon- 6.87G/L**
- **Amount of Nitrogen- 8.12G/L**
- **Amount of Oxygen- 8.25G/L**
- **Amount of Hydrogen- 1.51G/L**

Initially we have taken 20L of urine is our container for performing the experiment and at the end we got approx. 9.2 gram of gas in the storage container outside the main container

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Thesis

[1] **Analysis of urea electrolysis for generation of hydrogen***by Deepika Singh,*

Department of chemical & Bimolecular Engineering, Russ college of engineering & technology, 2009

Patent search Reports

[1] US Patent : 6,689,259-Mixed gas generator

[2] US Patent : 6,866,756-Hydrogen generator for uses in a vehicle fuel system

[3] US Patent: 7,191,737- Hydrogen generator for uses in a vehicle fuel system

[4] US Patent: 4,936,961-Method for the Production of a Fuel Gas

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Application of Photochemical Gradation Technologies for Waste Water Treatment

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Abstract: ***The control of waste water pollution has become a trust area of research in the recent years. Waste water generated from various industries creates the major environmental detrimental effects leading to imbalance of bio-system. Waste water now-a-days has become more complicated because of the contamination with industrial discharge, agrochemicals, surfactants, dyes etc. Advanced oxidation degradation processes are based on the concept of green chemistry may lead to clean industrial revolution.***

Currently, the main methods of waste water treatment is by physico-biological means but they are time consuming & can lead to sludge disposal problems & moreover most of the organic compounds are found to be non-biodegradable & hence the methods are unable to reduce the power of contaminant. Advanced oxidation processes such as photo-oxidation, chemical oxidation technologies (H_2O_2, O_3) & Fenton's oxidation holds great promise to provide alternative for better treatment. These methods generally break-up pollutants molecular bonds into harmless & non-toxic by-products like CO_2, water & mineral acids.

This paper mainly aims at the break down of organic & inorganic molecules by advanced oxidation techniques & also alternative hybrid oxidative techniques such as the combination of UV/H_2O_2, UV/O_3, H_2O_2/O_3, $O_3/H_2O_2/UV$ with their advantages & disadvantages along with their operating mechanism which generally involves the use of free radicals.

Keywords: **Oxidation, Photo-oxidation, Ozone, UV, Hydrogen peroxide.**

1. INTRODUCTION.

Due to the restrictive effluent quality of waste water, natural ecosystems are no longer neutralizing the contaminants effectively & this cause irreparable change in environment. Major part of pollutants in waste water comes from textile industry, distillery, and agricultural waste & municipal sites. The main content of pollution is complex organic compounds. The removal of these organic compounds from waste water represents a major environmental concern.

Various conventional oxidation treatment oxidize the various organic compounds to some extent but if the structure of compound is quite complex, it become difficult to degrade them at low concentration. To ease the above problem, advanced oxidation technology [1] comes into focus & they are found to be very effective for removing contaminants from waste water by generating hydroxyl radical. They are more effective than conventional techniques like flocculation, coagulation, adsorption, etc. [2] Advanced oxidation techniques are alternative & very useful for the degradation of non-biodegradable organic pollutants to non-toxic by-products. These processes lead to complete mineralization of pollutants as the process is based on generation &

use of hydroxyl radicals as primary oxidants which helps in the degradation to produce biodegradable by-products.

II. CONSITUENTS OF WASTE WATER.

Waste water is characterized by various parameters like physical, chemical, biological composition. The various sources are listed below:

Table 1: CONTAMINANTS & SOURCES

Colour	Domestic & industrial waste
Odour	Decomposing waste water
Surfactants	Domestic, commercial, industrial waste
Heavy Metals	Industrial waste
Pesticides	Agricultural waste
Organic Compounds	Industrial ,commercial waste.

III. OXIDATION TECHNIQUES.

Oxidation [3] of pollutants in waste water requires various techniques to convert them into non-toxic products. Oxidation is the commonly used chemical process to degrade the pollutants. Generally, the aromatic cleavage takes place. Chemical oxidation has two major dimensions;

1. Conventional oxidation techniques(ozone, H_2O_2)

2. Advanced oxidation techniques (combination with UV).

Table 2: OXIDISING AGENTS

Agents	**Characteristics**
Chloride	Strong, cheap, low selectivity
Oxygen	Moderate oxidizing agents, low cost
H_2O_2	Strong, highly recommended
Ozone	Strong, highly recommended.

The ability of these agents to oxidize the pollutants depends on their potential values of the agents. It is also listed in the table below:

Table 3: OXIDATION POTENTIAL VALUES [4]

Agents	**Oxidation potential**
Hydroxyl radical	2.80 V
Oxygen	2.42 V
Ozone	2.07 V
H_2O_2	1.77 V
Chlorine	1.36V

By studying the E° values of various agents, it is clearly understood that hydroxyl radical has the strongest oxidizing power among all the species. There are huge amount of organic compounds which can be easily converted into the biodegradable substance by the hydroxyl compounds.

Individual attacks of O_3 & H_2O_2 [5] are also very much effective but face some of the limitations also. Ozone is the powerful oxidizing agents & can react with many species containing double bond.

H_2O_2 although a weak acid but is effective in degrading various compounds. Moreover, their mechanism is very simple as they only require

efficient contact with the pollutants. Ozone can be used for waste water generated from paper & pulp industry, pesticides, textile & dye industry,etc.

The major problem encountered is low rate of reaction, cost generation, stability of H_2O_2.

So this makes use of hybrid systems of O_3 & H_2O_2 with ultraviolet (UV) radiations. The principle includes the addition of energy in the form of radiation to the molecule. UV lamps have the principle wavelength of 254nm & ozone gets adsorped at 253.7nm.

IV. ADVANCED OXIDATION TECHNIQUES.

The treatment [6,12] process involves the generation of highly reactive hydroxyl radical which acts as strong oxidants to degrade pollutants in waste water. In these processes, no toxic compounds are formed. There are varieties of techniques for producing radical.

Table 4: STRONG OXIDISING REAGENTS

O_3/UV (Also applicable in gas phase)
O_3 / H_2O_2
UV/ H_2O_2
UV/O_3 / H_2O_2

In photochemical reactions, the main step is the generation of hydroxyl radical by photolysis.

$$H_2O \rightarrow H + OH^\circ$$

This process can be accelerated easily by adding various additives.

a) **O_3/UV:** Ozone [7] is a powerful oxidizing agents. But alcohols, coloured compounds, carboxylic acids are difficult to degrade by ozonation so the process is enhanced by UV(254 nm) to generate more hydroxyl radicals.

$$H_2O + O_3 \rightarrow 2\ OH^\circ + O_2$$

b) **H_2O_2/ UV:** Hydrogen peroxide alone is found to be ineffective for many organic compounds degradation while under UV radiations, it forms two hydroxyl radicals. Process is more effective under acidic medium (pH =3) in terms of decolourization of textile waste water. The process involves the photolysis of H_2O_2 where rupturing of O-O bond takes place by action of UV.

$$H_2O_2 \rightarrow 2\ OH^\circ$$

c) **O_3/H_2O_2:** The combinations of both to waste water accelerates the decomposition of ozone [8] & enhances the production of **OH°** radicals. At higher pH even small concentration of H_2O_2 [9] dissociates into HO_2 that can initiate the ozone decomposition.

$$H_2O_2 + 2\ O_3 \rightarrow 2\ OH^\circ + 3\ O_2$$

d) **$UV/H_2O_2/O_3$:** This system [10] is potent & quick mineralization of pollutants takes place. The hybrid combination of all three accelerates the decomposition of ozone & results in faster generation of hydroxyl radical. It is most efficient way of decolourization of waste water.

$$H_2O_2 + 2\ O_3 \rightarrow 2\ OH^\circ + 3\ O_2$$

The hydroxyl radical can react in 3 ways with the reactants [11].

1.Hydrogen abstraction	**OH° + RH → $R^\circ + H_2O$**
2.Electrophilic addition	**OH° + PhX → HOPhX°**
3.Electron transfer	**OH° + RX → $RX^{\circ -} + OH^-$**

V. CONCLUSION.

Advanced oxidation treatment is t powerful treatment for toxic pollutants waste water which are not degrade b any other conventional treatments.. E the proper combinations of all the agent more than 95% pollutants can be degrad into CO_2, H_2O & non-toxic salts. Th efficiency of process depends upon th rate of generation of free radicals.

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Analysis of Asynchronous Sigma-Delta Modulation Scheme for Real and Reactive Power Control in Grid Connected Single Phase Inverters

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Abstract—***This paper presents the analysis of asynchronous sigma-delta modulation scheme for the control of real and reactive power in grid connected single phase inverters. To investigate the suitability of this modulation scheme, three different current reference generation schemes, such as scalar, modified scalar and simplified real and reactive power control schemes, are considered. The performance of the inverter with the considered asynchronous sigma delta modulation scheme is analyzed and its compatibility with the existing current reference schemes and as an alternative to conventional PWM technique is established.***

Index Terms— **Asynchronous modulation, current reference generation techniques, PWM technique, real and reactive power control, Single phase inverters.**

INTRODUCTION

Due to emergence of distributed generation technologies, it has become a common practice to interconnect the small capacity generators to the already existing grid utility services. As the rating of most of these distributed generators (DGs) is in the range of kWs and of voltages of 100V-250V they will be connected to single phase utility grid available at every electricity access point [1]. The main objective of these DGs is to supply the desired real power to the system. However, as these DGs are mostly inverter based and are usually interfaced to the distribution system feeders along the line; reactive power can also be supplied to support the load voltage whenever necessary [2]. On the other way, the continuous reactive power demand of modern loads during islanding mode can be met from the DG, thereby avoiding need of extra reactive compensating device. Even in grid connection mode, the reactive power supply from the DG can considerably reduce the burden on feeders [3]. Enabling the reactive power supplying capability to the DGs can address the aforementioned problems along with several power

quality issues [4]. So far the commercial inverters used for integration of DGs to the grid, are mainly aimed at control of active power, it is not only due to application area but also due to restrictions from grid codes. Due to inevitable emergence of DGs and the advantages of reactive power control by DG systems, the grid codes are expected to allow the reactive power control from the DGs as well [5].

The interconnection of single phase DG inverter with utility grid becomes difficult due to the inherent pulsating nature of

single phase powers at double the grid frequency. However, with the introduction of proper current control scheme the active and reactive powers can be controlled at the desired values subjected to stability, speed & accuracy of the overall scheme. In general, for distributed power inverters, two loop control strategy will be adopted using a pulse-width modulation (PWM) scheme [6]. The inner control loop is used to give the duty ratio/modulation index for the generation of sinusoidal output current which will be in phase with the grid voltage. The second or outer control loop is implemented to minimize the error in real and reactive powers [6].

In order to regulate the active and reactive power with well-established PWM technique,PI controllers are used to generate the modulating signal in three phase systems. However, the controller design for single

phase inverter is not an easy task as the powers vary

with double the fundamental frequency. To overcome this problem the synchronous sinusoidal currents can be transformed into α, β domain so as to

obtain stationary references and variables. As mentioned earlier, the production of stationary variable from sinusoidal one is different in single phase system from that in three phase system. Thus the stationary frame transformation brings considerable delay, adversely affecting control dynamics. In addition, the performance of grid connected DG based inverters affected by nonlinear behaviors and most of the nonlinearities are due to nonlinear switching functions of power electronic converters [7, 8]. If the system is linearized over an equilibrium operating point, the linear controllers can perform satisfactorily over a set of operating points even though the switching functions of the inverter are nonlinear. The restrictions of operating points can be addressed by implementing nonlinear controllers for DG based inverters. In this regard, the sigma-delta modulation (SDM) has drawn attention in various power electronics applications. It has the merits of quick response, simple circuitry and reduced harmonic content [9]. In asynchronous SDM (ASDM), there is no need of synchronization clock which makes it an attractive choice for the control of power converters [9, 10]. The ASDM can be easily realized with simple analog components and hence it has further simplified circuitry when compared with SDM. In addition, owing to its fast dynamic response, low harmonic distortion and low electromagnetic interference [9], ASDM is one of most attractive control techniques for single phase grid connected inverter applications. Recent literature [11], confirms the potential and advantages of ASDM over other control techniques. In this connection this paper considers ASDM for the generation of switching signals whose performance has been verified with three different current generation schemes for the compatibility, quickness and accuracy.

Most of the literature has adopted either of the instantaneous reactive power (IRP) theory and synchronous reference frame (SRF) theory [12, 13], among the different current reference schemes. In three phase system, the active and reactive powers can be easily controlled by employing IRP and SRF reference generation schemes [11]. The application of these two theories to single phase systems needs some modification due to availability of only one phase. In order to achieve this, two orthogonal variables are created by synthesizing an imaginary variable from an already available variable [12-13]. Synthesis of such an imaginary variable is usually done by 90° phase shift operation. The process of obtaining two variables from one takes considerable time and introduces considerably long delays which further affects the system dynamics [12-14], as aforementioned. To overcome the limitation associated with IRP and SRF theories in single

phase systems, few other current reference generation schemes based on discrete Fourier Transform phase locked loop (PLL) [15], sinusoidal signal integrator (SSI) have been developed [16]. Although these modified methods are effective to overcome the problem associated with IRP and SRF but due to increased complexity, a powerful computer platform is needed to realize the sophisticated functions, transforms and associated signal processing, resulting in higher cost of manufacturing with less commercial viability. Alternatively, three new simple current reference generation schemes viz. scalar reference [17, 18], modified scalar reference [19] and simplified real and reactive power control (SRPC) reference [11] have been evolved. In all these mentioned schemes the complexity and cost is considerably reduced.

In this connection, this paper discusses the ASDM scheme and its control design for switching pulse generation in Section II. The considered three different current reference techniques are briefed in Section III. The performance analysis of the single phase grid connected inverter controlled by ASDM with different current reference generation techniques is given in Section IV. Section V concludes this paper.

I. ASYNCHRONOUS SIGMA-DELTA MODULATION

The block diagram of the single phase grid connected inverter along with the ASDM switching scheme is shown in Fig. 1. The DG is interfaced to the grid through inverter after filtering out the harmonics as depicted in Fig. 1. The P_{ref} and Q_{ref} are the two set point powers for which the reference current i_{ref} is generated by the respective current generation techniques. The i_{ref} is compared with actual current fed by the inverter, i_{ac} to generate the current error, i_{err}. This i_{err} is fed to the first order current controller to generate reference voltage V_{ref}. The basic operation of ASDM to modulate the current and produce PWM signals for the inverter switches is depicted in Fig. 2. The ASDM consists of an error amplifier, a band comparator with an integrator. The difference (Delta) between the

input reference V_{ref} and the output pulsating voltage train is considered as error signal, V_{err}. The integrated signal V_{int} is the sum (Sigma) of the error signal which will be processed by the comparator in order to generate the output pulsating voltage train for inverter switches. To understand the operation of ASDM, the reference signal can be assumed constant during a switching period as the frequency of the

reference voltage is much smaller as compared to the switching frequency. The waveforms of V_{ref}, V_{err} and train of ASDM pulses can be shown in Fig. 3 for a particular frame of time.

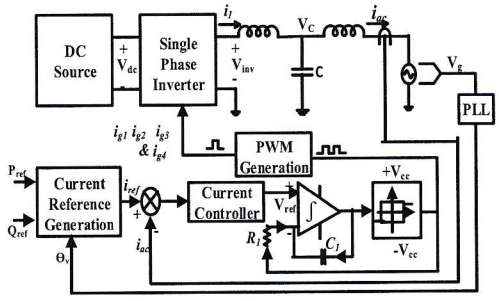

Fig. 1 Block diagram of single phase grid connected inverter with ASDM

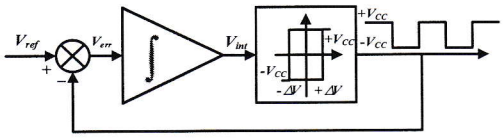

Fig. 2 Implementation of ASDM

At the end of the time period T_1 and just before the starting of the time period T_2, it can be seen that V_{err} is a negative constant hence the integral signal V_{int} decreases with a negative slope, S_{int}^-. The S_{int}^- and T_1 can be given as in (1)

$$S_{int}^{-} = \frac{V_{ref} - V_{cc}}{\tau}; \quad T_1 = \frac{-2\Delta V}{S_{int}^{-}} \tag{1}$$

where $\tau = R_1 C_1$ is the time constant of the integrator. The output of ASDM is changed from $+V_{cc}$ to $-V_{cc}$, upon V_{int} reaches the hysteresis band's lower limit $-\Delta V$, hence, changing the V_{err} from negative to positive value. With this, the slope will be changed from negative to positive. The slope S_{in}^+ and T_2 can be expressed as

$$S_{int}^{+} = \frac{V_{ref} + V_{cc}}{\tau}; \quad T_2 = \frac{2\Delta V}{S_{int}^{+}} \tag{2}$$

As soon as V_{int} with positive slope reaches the upper limit of hysteresis band, $+\Delta V$ the output of ASDM changes from $-V_{cc}$ to $+V_{cc}$, completing one switching cycle. The duty ratio and switching frequency can be expressed as in (3).

$$d = \frac{1}{2} + \frac{V_{ref}}{2V_{cc}}; \quad f_s = \frac{(V_{cc})^2 - (V_{ref})^2}{4R_1C_1\Delta V V_{cc}} \tag{3}$$

where V_{cc} is the DC train voltage of the op-amps, ΔV is the hysteresis band of the comparator, and τ is the time constant of the integrator. From, (3), it can be understood that the duty ratio d of the PWM signal is independent of circuit parameters, such as ΔV or τ, however, linearly proportional to

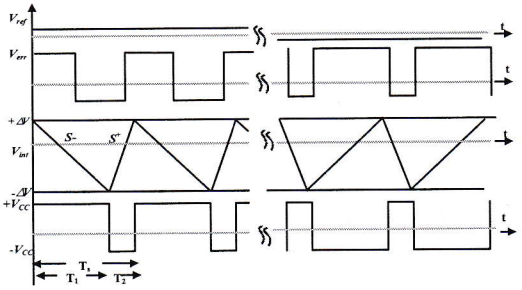

Fig. 3 Switching pulse generation in ASDM

the reference signal which indicates the controllability of ASDM. Secondly, as ASDM operates at various switching frequencies, the switching noise will be spread over a wider frequency spectrum and its electromagnetic interference is less. However, the switching frequency is affected by other variables like, V_{ref}, ΔV, and τ. Hence to regulate the switching frequency under the range of permissible values, a careful selection of ΔV and τ is a must. To design the controller parameters, the ASDM current control technique can be modeled in frequency domain [11] as shown in Fig. 4. It shows the individual transfer functions of inverter $G_{inv}(s)$, sigma-delta modulation $G_{asdm}(s)$ and current controller $G_c(s)$. The open loop transfer function of overall system is

$$T(s) = G_c(s).G_{inv}(s).G_{asdm}(s).G_{LCL}(s) \tag{4}$$

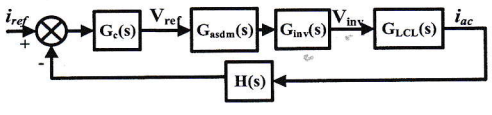

Fig. 4 Frequency domain model of ASDM control technique

A. $G_{asdm}(s)$

The block diagram of ASDM for duty ratio d for different $+V_{cc}$ and $-V_{cc}$ can be represented by the equivalent circuit shown in Fig. 5. The respective dynamic equations of ASDM can be written as (5).

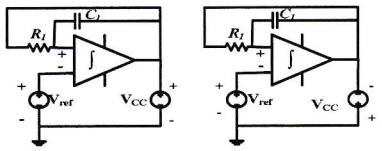

Fig. 5 Equivalent circuit of ASDM

$$\frac{dv_c}{dt} = \frac{V_{cc} - V_{ref}}{R_1 C_1}.d \quad \& \quad \frac{dv_c}{dt} = \frac{-(V_{cc} + V_{ref})}{R_1 C_1}.(1-d) \tag{5}$$

By state space averaging method above equations can be represented as (6).

$$\frac{dv_c}{dt} = \frac{(2d-1)V_{cc} - V_{ref}}{R_1 C_1} \tag{6}$$

Further, perturbing the variables around its average values,

$$\frac{dv_c}{dt} = \frac{2dV_{cc} - V_{ref}}{R_1 C_1} \tag{7}$$

Hence, the transfer function of ASDM can be deduced as (8).

$$G_{asdm}(s) = \frac{d(s)}{V_{ref}(s)} = \frac{sR_1C_1 + 1}{2V_{cc}} \tag{8}$$

$G_{inv}(s)$

The equivalent circuit of a grid connected inverter for positive and negative half cycles can be represented as Fig. 6.

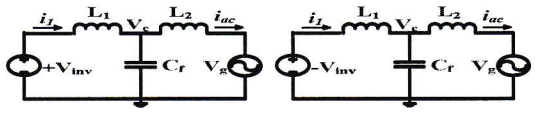

Fig. 6 Equivalent circuit of single phase inverter connected to grid

For bipolar switching the inverter voltage V_{inv} takes two values of voltages, $+V_{dc}$ and $-V_{dc}$ which can be written as

$$v_{inv}(t) = +V_{dc}.d \quad \& \quad v_{inv}(t) = -V_{dc}.(1-d) \tag{9}$$

By state space averaging method (9) can be represented as:

$$v_{inv}(t) = (2d-1).V_{dc} \tag{10}$$

Further, perturbing the variables around its average values (10) can be written as (11)

$$v_{inv}(t) = 2d.V_{dc} \tag{11}$$

Hence, the transfer function of grid connected inverter is

$$G_{inv}(s) = \frac{V_{inv}(s)}{d(s)} = 2V_{dc} \tag{12}$$

B. $G_{LCL}(s)$

The Fig. 7 shows the frequency domain model of LCL, wherein the $Z_{1L}(s)$, $Z_{2L}(s)$ and $Z_{Cf}(s)$ are the impedances offered by L_1, L_2 and C_f, respectively. The transfer function of filter is

$$G_{LCL}(s) = \frac{i_{ac}(s)}{v_{inv}(s)} = \frac{1}{s(L_1L_2C_f.s^2 + L_1 + L_2)} \tag{14}$$

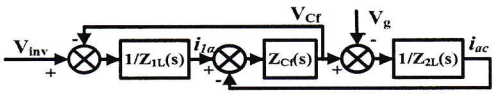

Fig. 7 Frequency domain model of LCL filter

C. $G_C(s)$

The open loop transfer function of system without controller is given by (15).

$$G_{ol}(s) = G_{asdm}(s).G_{inv}(s).G_{LCL}(s) = \frac{i_{ac}(s)}{V_{ref}(s)} = \frac{V_{dc}}{V_{cc}} \frac{sR_1C_1 + 1}{s(L_1L_2C.s^2 + L_1 + L_2)} \tag{15}$$

The typical values of R_1, C_1 and V_{cc} are 10kΩ, 10nF and 15V, respectively. The filter inductors of 5mH and 5mH are selected, respectively for L_1 and L_2 to limit the THD in current to 5% and C_f of 3μF to limit the voltage ripple to 10%. For a 230V grid voltage, 400V is considered as dc voltage. Since, the magnitude's attenuation at the switching frequency region is limited, a controller with a dc gain K = 8, has been adopted to implement the current controller as (16).

$$G_c(s) = \frac{K}{sR_cC_c + 1} \quad (16)$$

Hence, the compensated open loop gain is

$$T(s) = G_c(s).G_{ol}(s) = \frac{V_{dc}}{V_{cc}} \frac{K}{s(L_1L_2C.s^2 + L_1 + L_2)} \quad (17)$$

2- Current Reference Generation Schemes

This section describes three different generation schemes, namely: scalar, modified scalar and SRPC, as follows.

D. Scalar current reference generation scheme

The schematic of this scheme is shown in Fig. 8. It is the simplest of all reference generation schemes developed so far and it directly converts power reference to the current reference almost in no time, as depicted in Fig. 8. Though the generated current reference could be of an exact magnitude and phase, but due to lack of error correction arrangement, it could suffer from steady state errors. Occasionally, error could be very large, making entire grid connected DG inefficient.

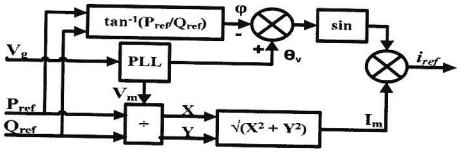

Fig. 8 Schematic of Scalar current reference generation scheme

E. Modified scalar current reference generation scheme

The scalar current reference scheme can be modified by introducing the error correction mechanism as shown in Fig. 9.

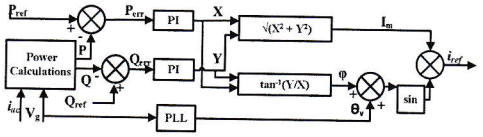

Fig. 9 Schematic of modified scalar current reference scheme

The errors generated by comparing the references with the actual power feedings will be processed by respective PI controllers to ensure zero steady state errors. The rest of the scheme is similar to the scalar current reference generation scheme. As the PI controllers are involved in this scheme, the current dynamics are quite different from that of scalar current reference which makes the power calculations a daunting task and tuning of controllers is also a tedious task.

SRPC current reference generation scheme

The errors, generated by comparing actual and reference powers, are modulated into reference current by using two hysteresis controllers, namely, current magnitude generator and phase angle generator as shown in Fig. 10. The current reference and phase angle reference are generated as (18) and (19), where the subscripts H and L denote upper and lower bounds. Since, this method has iterative changes in current magnitude and phase angle, P_{err} and Q_{err} can be adjusted to make the steady state error zero. However, care has to be taken while deciding the magnitudes of these perturbs along with hysteresis band to achieve satisfactory dynamic performance.

$$\text{if } P_{err} > \Delta P_H \text{ then } k = 1; \quad \text{else if } P_{err} < \Delta P_L \text{ then } k = -1; \text{ else } k = 0;$$
$$I_m(n+1) = I_m(n) + k\Delta I \quad (18)$$

$$\theta(n+1) = \theta(n) + k\Delta\theta \quad (19)$$

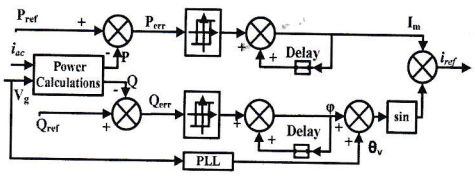

Fig. 10 Schematic of SRPC current reference generation scheme

Results and Discussions

The performance of ASDM as modulation scheme for switching pulse generation in single phase inverter has been investigated with three different current generation schemes. The reference real power is considered as 2500W till 0.5s, whereas the reference reactive power is considered as 1250VA (0.9 p.f.) till 1s as shown in Figs. 11 and 12. It is assumed that these set points are changing to 3000W at 0.5s and to 1500VA at 1s, respectively. From Figs. 11 and 12, it can be concluded that the scalar reference generation scheme is quickest among the schemes considered. However, as it lacks the error correction mechanism, it delivers a non-zero steady state error performance as depicted in Figs. 11 and 12.

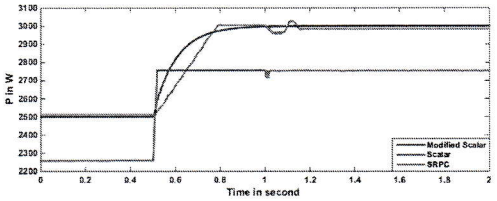

Fig.11Real power nbwith ASDM for different current generation schemes

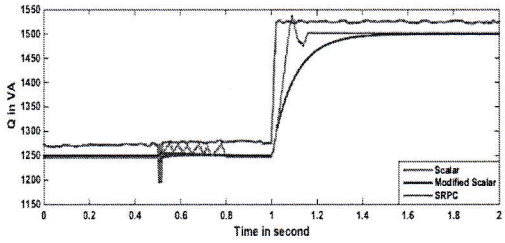

Fig. 12 Reactive powers with ASDM for different current generation schemes

The modified scalar reference generation scheme consists of error correction mechanism with PI controllers, hence it delivers zero steady state error as shown in Figs. 11 and 12, in both real and reactive power control. However, as it involves power calculations blocks and PI controller, the response is sluggish when compared with the scalar current reference generation scheme. From Figs. 11 and 12, it can be deduced that the SRPC scheme is quick enough when compared with the modified scalar scheme and is resulting reduced steady state error without using any PI controller.

The following Figs. 13 and 14 depict the performance of single phase inverter controlled by ASDM with SRPC of different parameters such as hysteresis bands in powers and perturbations ($\Delta I, \Delta\theta$). For the bands of 20W and 20VAr in real and reactive powers, 0.1A as current perturb and 0.01rad as angle perturb which are considered as Set-1, the reference tracking is smooth, delivering ripple free steady state performance. However, for the Set-2 (10W, 10VAr, 0.1A, 0.01rad, respectively), the reference tracking smooth, however resulting ripples in steady state powers. It can be inferred from the Figs. 11 to 12, even though the SRPC is superior to scalar and modified scalar current reference generation schemes; its performance (steady state errors and ripple in power output) is dependent of its parameters. However, once the proper choice of parameters is made, it can render very good performance as its operation is independent of system parameters, like filters and other associated devices, operating points and the disturbances.

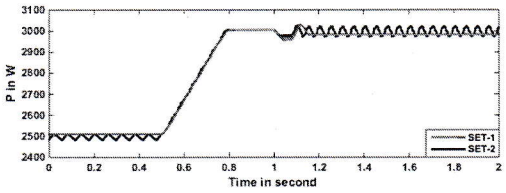

Fig. 13 Real powers with ASDM for changes in SRPC parameters

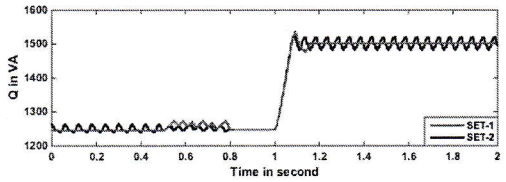

Fig. 14 Reactive powers with ASDM for changes in SRPC parameters

From the above discussions, it can be understood that the performance of inverter depends on the current reference generation scheme used, but not on the ASDM technique. As it is depicted, ASDM technique is compatible with all the considered/established current reference generation schemes for single phase inverter control and it can render very good performance, as an alternate to the conventional PWM techniques.

Conclusion

The suitability of ASDM for control of real and reactive power control of single phase grid connected inverter is established. The performance of the ASDM scheme is verified

with three different current generation techniques and it is deduced that the ASDM can deliver superior performance which is independent of system parameters and other disturbances. From the analysis, it is concluded that the ASDM is compatible to the existing current generation schemes and is a potential alternate to the existing PWM schemes for the control of single phase inverters.

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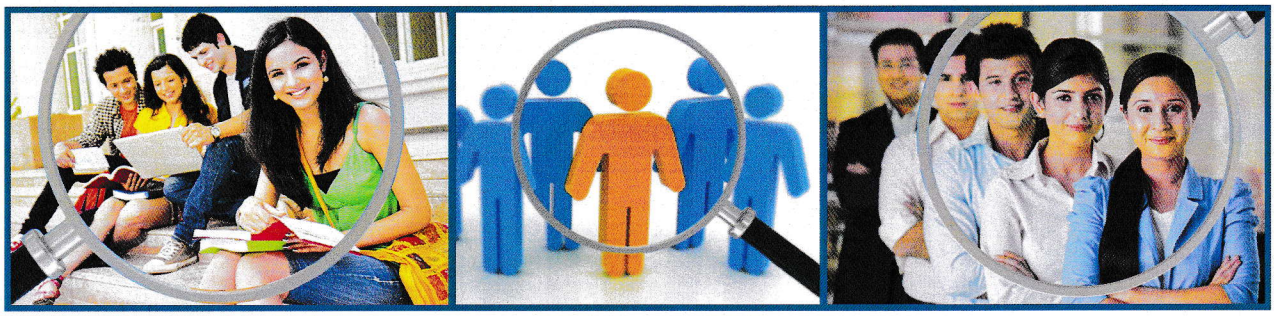

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