# APPLICATION OF NANOFLUIDS IN DIRECT ABSORBING SOLAR COLLECTOR: A REVIEW

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## ABSTRACT

*Miniaturization of devices and energy efficiency are two major driving forces to find new materials and improved designs of solar collectors. Nanofluids are innovative fluids getting worldwide attention due to their inherent characteristics. Nanofluids exhibits enhanced heat absorbing and heat transport ability, credited to nanoparicles suspended in base- fluids. The cardinal factor which is responsible for enhanced heat transfer and absorption ability of Nanofluids is multiplication of surface to volume ratio of nanoparicles.*

*Nanofluids are nanoparicles suspended in a base fluids, it can be considered liquid nano-composites (homogeneous solution of suspended nanoparicles in base fluids).These Nanofluids are now being used as working fluids to absorb solar insolence and transfer it to another fluids at appreciably enhanced rate as reported by many researcher and nano research centers all over the world.*

*Our intention behind writing this review is to comprehensively and thoroughly investigate the research work done for improvement of efficiency in Direct absorbing Solar Collectors Using Nanofluids. Review of previous works based on experimental and model studies have established that nanofluids have great potential for cooling various thermal systems. Recent trends also encouraging towards application of nanofluids in PV/T systems to increase overall efficiency of solar energy conversion.*

***Keywords*: *Nanofluids, DASC, Base-Fluid, Thermal Efficiency, Optical Depth*.**

## I INTRODUCTION

Energy has been major driving force since beginning of civilization. Initially organic and manpower, cattle power were used to fulfill daily basic needs. Conventional resources like coal, water, natural gases, petroleum are being used to propagate the industrial era. Conventional (fossils based) resources still have major role to fulfill huge energy demand for industrial, agriculture and household sector. Conventional resources have its own limitations. These resources will be depleted by 2050 as predicted. These resources are major source of pollution on planet Earth. Since 1970s there has been academic, scientific and technological drive to harness new energy resources, which can replace existing natural resources. Solar energy is the most abundantly and reliable energy resource among all alternative energy resources available. It is also free from pollution and available throughout the year.

It is now generally believed that renewable energy technologies can meet much of the growing demand at prices that are equal or even lower than those of conventional energy. By the middle of 21$^{st}$ century, renewable sources of energy could account for 60% of the worlds electricity market and 40% of the market for fuels used directly[1]. Moreover, making a transition to a renewable energy-intensive economy would provide

environmental and other benefits not measured in standard economic terms. It is envisaged that by 2050 global carbon dioxide ($CO_2$) emissions will be reduced to 75% of their 1985 levels, provided that energy is expected to be competitive with conventional energy [2] Solar radiation, which consists of high amount of energy, can conduct energy of sun to working fluid through photons (quanta of light) [3].

Major shortcoming of solar collectors is its low thermal conversion efficiency. Conventional heat transporting fluids are water or oil based has low heat absorption and heat transfer capacity. Nanofluids are new innovative fluids first postulated by Choi [1]. Nanofluids can be defined as homogeneous solution of nanoparicles of size 1 to 100 nm in base fluid. Nanofluids exhibits enhanced or modified thermo- physical properties. These are thermal conductivity, convective heat transfer coefficient, viscosity and thermal diffusivity compared to base fluids[4].addition of nanoparticle into base fluid can significantly enhances thermo physical[5-8] mass diffusivity [9] and radioactive heat transfer properties of fluid [10]. Volume % of nanoparicles in base fluid remains very small still impact in terms of thermal efficiency observed is very significant. Due to these inherent characteristics, Nanofluids are getting increasing attention among scientific, academic and engineers to develop improved systems and devices which are based on Nanofluids as a heat transporting and absorbing medium. Presently many types of nanoparicles are used to prepare Nanofluids. These are:

- Oxide ceramics ($Al_2O_3$, CuO,ZnO)
- Metal carbides (SiC, AlC)
- Nitrides (AlN. SiN)
- Metals (Al, Cu, Ag, Au, Mg, Zn)
- Nonmetals (Graphite, Carbon Nanotubes, Fullerenes)
- Layered (Al+$Al_2O_3$, Cu+C, Cu+CNT)
- Functionalized Nanoparicles.

## II MATERIALS FOR BASE FLUIDS INCLUDE

- Water
- Ethylene glycol and other coolants
- Oil and other lubricants
- Bio-fluids
- Polymer based solutions

Addition of nanoparicles in very small volume % in a base fluid can amply enhance thermo- physical properties of fluid as reported by many research papers published in recent years [7-9, 11]. According to a recent research[12]. Nanoparticle volume fraction has significant effect on direct solar collector efficiency. Purpose of this review paper is to progressively analyze applications of various Nanofluids and its impacts on enhancement of thermal efficiency of solar collectors**.**

## III PERFORMANCE OF SOLAR COLLECTOR: PARAMETERS

### 3.1 Stability of nanofluids

Stability of nanofluids means that fluid must retain its basic nature during operating period. Its composition (distribution of nanoparticle in base fluid must not vary with time).Though nanofluids are highly stable compare

to micro-fluids still long term stability is an issue of concern for researcher. For commercial use of nanofluids to be applied in heating and cooling systems, long term stability must be addressed.[9]

### 3.2 Convective heat transfer coefficient

convection is a mode of heat transfer in which heat transfer from solid body is affected by fluid flowing in vicinity of body. Convection can be broadly categorized into two modes: forced convection and natural convection.

### 3.3 Optical Properties

Our concern for optical properties of nanofluids is those, which are useful to absorb solar radiation. Nanofluids having higher value of extinction coefficient will be more suitable for solar collectors, particularly in volumetric receivers (DASCs).

Otanicar et al.[13] experimentally investigated the optical properties of four fluids ($H_2O$, propylene glycol, ethylene glycol, and therminol VP-1). These are conventional base fluid for volumetric receiver or DASCs. Measured transmittance spectra of all four fluids exhibits strong absorption bands at 950-1000nm and at 1200 nm for water, EG and PG. A significant amount of solar energy is concentrated in the visible band (300-700nm). In addition it has been observed experimentally that water as base fluid is the strongest solar energy absorber, still not strong enough to absorb more than 13% of incident solar energy. According to researchers findings to increase solar –weighted absorption coefficient to more than 90%, the fluid depth should increase to 1 m or larger.

Based on the literature survey, absorption of the incident radiation increases within the fluid by mixing small particle into the base fluid [13]. If small paricles are nanoparticle, optical properties of base fluid enormously increases[14].

## IV REVIEW OF APPLICATIONS OF NANOFLUIDS IN SOLAR COLLECTORS

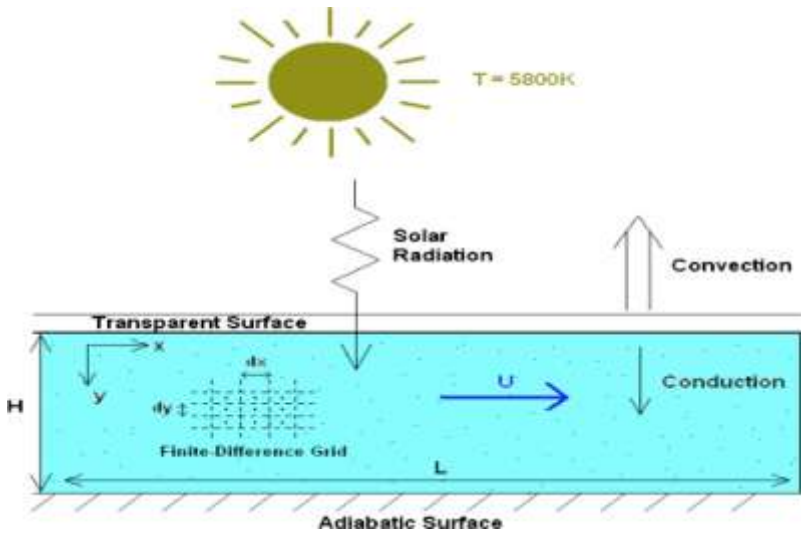


**Fig:1 schematic of DASC based on nanofluid Tyagi et al.[9]**

Thermal performance of the solar collector is determined by getting values of instantaneous efficiency for various combinations of incident radiation, ambient temperature and inlet fluid temperature.

Tyagi et al.[9].performed model study of DASC using two dimensional heat transfer analysis. He selected mixture of aluminum nanoparticles and water. Various parameters which affect thermal efficiency are size, volume fraction, and collector form studied by authors. On the basis of numerical modeling results shows 10% increase in thermal efficiency of nanofluid based DASC compare to conventional solar collectors of same type.

Spectral efficiency decreases as we go from top to bottom of nanofluid as shown in fig below

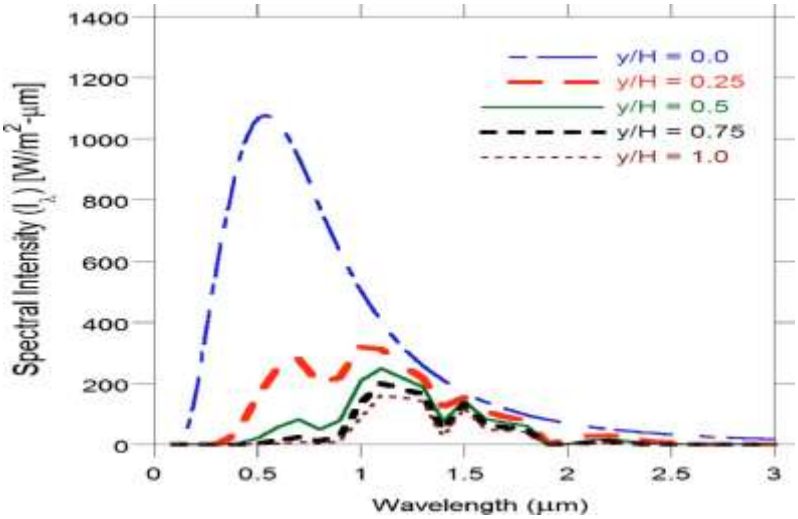


**Fig: 2spectral efficiency v/s depth of nanofluid filled in collector. Tyagi et al.[9]**

Collector efficiency increases with volume fraction Φ up to optimum level around 1% then become saturated.

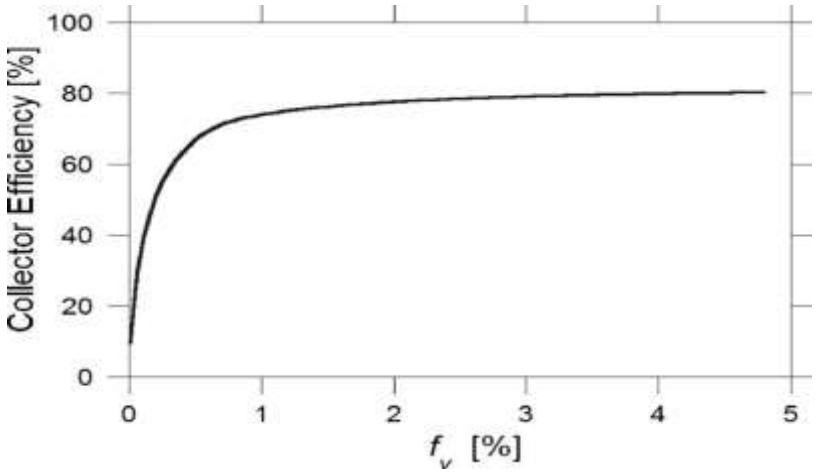


**Fig: 3 graph between volume fraction and collector efficiency. Tyagi et al.[9]**

Taylor et al.[15].Performed both experimental (design of dish collector system) and model study of nanofluid in high flux dish collector. Representative nanofluid selected is Therminol based graphite nanoparticles. ($\varphi$=0.125% to 0.25%). CR for dish collector is 400.Results shows that nanofluid dish collector attained 34% solar-to-thermal conversion efficiency at outlet temperature 250°C, which is 20% higher than when Therminol alone used as heat transfer fluid.

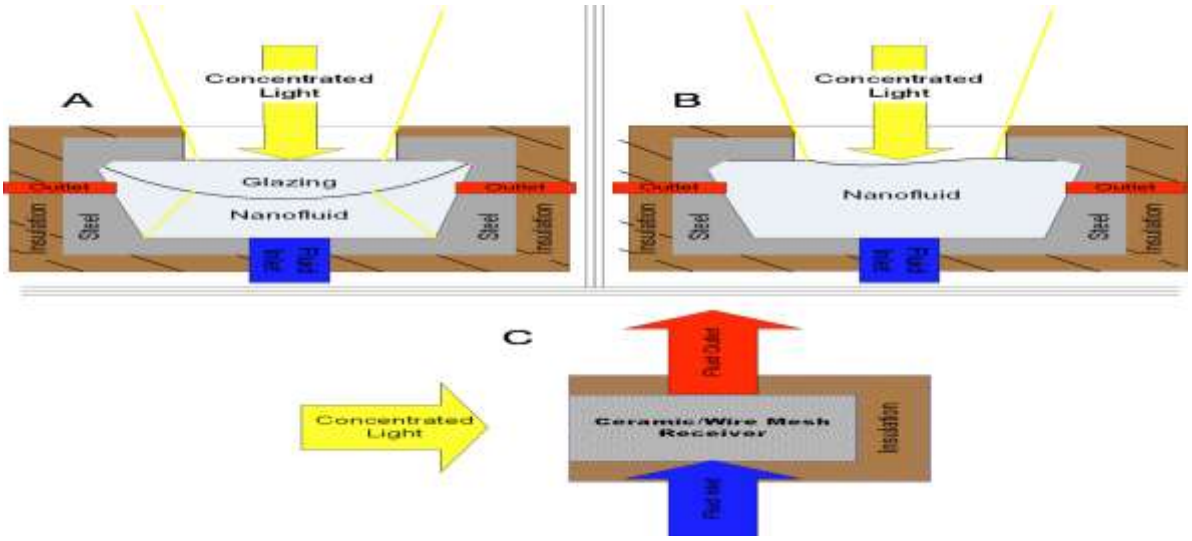


**Fig: 4 A and B conceptual design of solar concentrating collector with glazing and without glazing. C conceptual power tower drawing with solid surface absorber. Taylor et al.[15]**

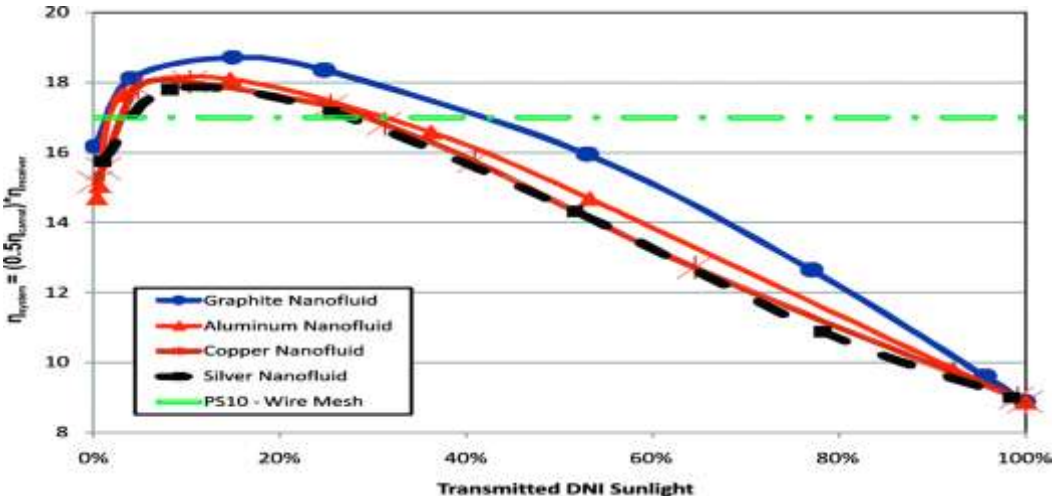


**Fig:5 modeled system efficiencies with graphite,aluminium,copper and silver nanofluid in comparision with PS10 wire mesh.[15]**

Said et al.[16] experimentally analyzed thremophysical properties of $Al_2O_3$ nanofluid and concluded that thermal conductivity significantly enhanced at very small volume fraction and viscosity marginally increased which is not desirable. For low concentration pumping power enhancement and pressure drop have insignificant effect on thermal efficiency. Authors suggest further research to establish thermal conductivity behavior at low temperature range.

Han et al.[17]. Performed experimental study on carbon black nanofluid for solar energy absorption. Results shows that nanofluid of high volume fraction had improved photo- thermal properties in the whole wavelength range from 2000 to25000 A°

Alim et al.[18] analytically applied second law of thermodynamics to analyze formation of entropy due to application of nanofluid in solar collectors. Investigators reported decrease in entropy formation by 4.34% and

enhancement of heat transfer coefficient by 22.15%. There also small penalty in terms of pressure drop by 1.58%.

Ladjevardi et al.[19]performed analytical study on effect of particle size and volume fraction on efficiency of DASC.It has been observed that increase in particle size from 50nm to 300 nm enhances extinction coefficient from 0.4-to 10 in UV and visible ranges. At =0.00025 outlet dimensionless temperature increases from 0.27 to 0.915 compare to pure water.

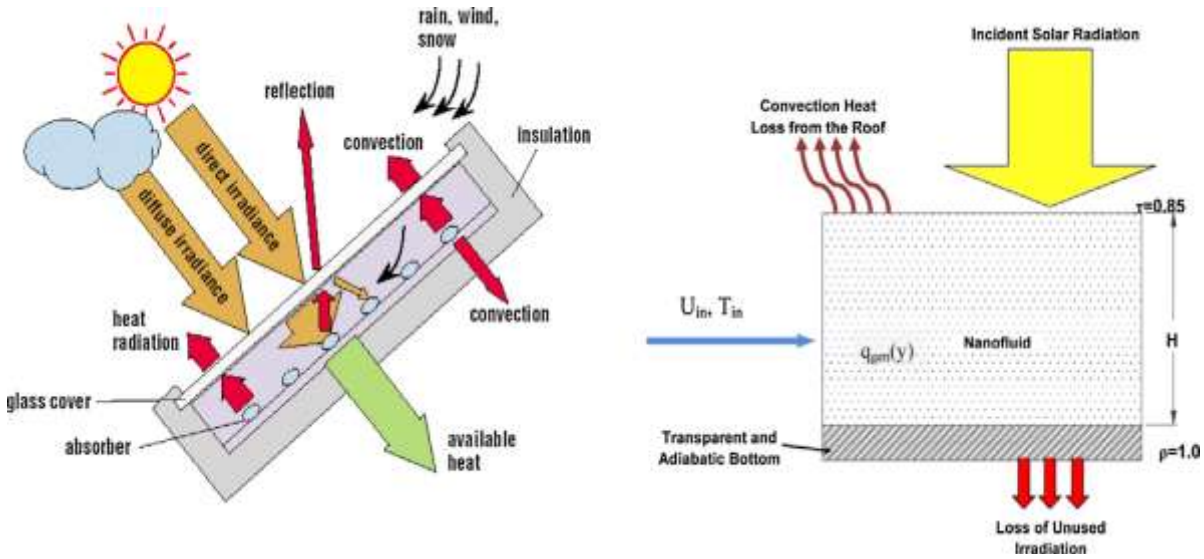


**Fig: 6 conventional (left) and volumetric (right) solar collectors. Ladjevardi et al. [19]**

Parvin et al.[20] have done mathematical modeling and analysis on effect of Cu and Ag nanoparticles on entropy generation and thermal efficiency. Results reveals that Cu nanoparticles with highest $R_e$ and $\varphi$=3% is the most effective fluid to enhance heat transfer rate. The collector efficiency enhances 2 times and more than two times for increasing Reynolds number and solid volume fraction with Ag and Cu nanoparticles.

Karami et al.[21] performed experimental research on application of CNT-fluid as energy absorbing fluid for low temperature DASCs. Nanofluid made of MWCNTs-10nm diameter and 5-10µm length properly dispersed in distilled water. Research findings established that improvement in thermal conductivity is 32.2% for 150ppm of f-CNT.

Lu et al.[22].experimentally performed an open thermosyphon using nanofluid. Nanofluid was based on demonized water and Cu nanoparticles (size mean dia 50 nm).optimum efficiency 30% in terms of heat transfer coefficient enhancement observed at evaporator filling ratio 60% for Φ=1.2%.

Said et al.[23]. Performed experimental analysis on application of SWCNTs base nanofluid on exergy efficiency and pumping power for conventional flat plate solar collectors. Material chosen in experiment is (90% CNT with 60% SWCNTs, 99.5% $TiO_2$, $SiO_2$ 99.5%, and Al2O3 99.8%). Experimental results confirm that SWCNTs may be a good option in laminar flow condition. Analytical results confirm that SWCNT based fluid can arrest entropy generation by 4.34% and augment heat transfer coefficient by 15.53 % theoretically with compare to water. He et al.[24] Experimentally investigated on photo thermal properties of nanofluids for direct absorption solar thermal energy systems. For Cu-$H_2O$ based absorbing fluid, experimental results shows that small addition of nanoparticle in base fluid can widen solar energy absorption spectrum. Nanoparticles exhibit excellent

absorption characteristics. It makes the transmittance of nanofluid lower in the range of 250-1350nm wavelength. The transmittance of Cu-$H_2O$ nanofluid (0.1%) is closer to zero and temperature increase observed 25.3% higher than de-ionized water. Luo et al.[25] performed analytical simulated study on performance improvement of a nanofluid solar collector based on DAC concept. Based on results of simulated study authors concluded increase in outlet temperature 30-100k and efficiency by 2-25%.Filho et al.[26]. Experimentally investigated effect of Ag/water nanofluid in direct absorption solar collectors. Stable formulation of Ag/water was prepared by high pressure homogenizer. Results established that up to 144% enhancement in stored thermal energy can be achieved for an extremely low concentration (6.5ppm). Size of Silver nanoparticle taken 10- 80 nm, average 20nm. Specific absorption rate up to 0.6kw/g obtained during initial heating period for 6.5ppm, but decreases to 0.01 kw/g at 650 ppm due to enhanced particle-particle interaction. Tiwari et al.[27] reported 31.64% enhancement in thermal efficiency when $Al_2O_3/H_2O$ nanofluid used as heat absorbing fluid in place of pure water at $\varphi$ =1.5%. Rahman et al.[28].Investigators has tried to introduce innovative design of quarter circular plate DASC with variable tilt angle and solid volume fraction of CNT nanofluids. Further research needed to establish compatibility of CNT based nanofluid with new design. Rahman et al.[29]performed theoretical model based study of impact of triangular collector design and Φ on convective heat transfer coefficient (h). Nanofluids are based on Cu/Water, $Al_2O_3$/Water and $TiO_2$/Water. Model mathematical solution shows that convective heat transfer increases up to a certain optimum value of $\varphi$ (0.05 to 0.08). $h$ also increases with increase of $G_r$.

Zhang et al.[30].performed experimental study on radiative properties of [HMIM] [NTf2] as base fluid and Cu and Ni nanoparticles (D mean 40nm).observation revealed that for $\varphi$=40ppm, only about 3% of light transmitted in whole wavelength range. Excellent radio property of Ni/C Ionanofluid qualifies it for promising heat absorbing material for medium to high temperature DASCs.

**Table:1 Research perspective of use of Nanofluids as heat transporting and absorbing medium in DASCs for improvement in thermal efficiency**

| S. No | References | Types of nanoparicles | Size (nm) | Base fluid | Applications | Findings |
|---|---|---|---|---|---|---|
| 1 | Tyagi et.al [9] | Al | 10 -20 | Water | Direct absorption solar collector | 10% higher absolute efficiency for 0.8% volume fraction than conventional flat plate collector |
| 2 | Lenert et al.[31] | Co | 28 | VP-1 Therminol | Volumetric receiver(DASC) | With increase in nanofluid height and solar insolence efficiency of receiver increases. Optimum increase in system efficiency achieved is 35% for H>5cm and c-100 |
| 3 | Otanicar et al.[15] | CNT,Graphite and Silver | Graphite 30,CNT(6 | $H_2O$ | Direct absorption solar | Increase in efficiency of solar collector recorded is 5% |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | -20),Silver (20-40) | | collector | |
| 4 | Taylor et al.[15] | Any nanoparticle | Nano range | Common base fluid i.e. water, molten salt, oil | Modeling and experimental study for commercial application of nanofluids(10-100MWe) | 10% increase in efficiency of high flux solar collector is achievable at very small concentration of nano-particles in base fluid without any adverse change in capital cost |
| 5 | Lazdevardi et al. [19] | graphite | 50-300 | Pure water | Volumetric receiver(direct absorbing) collector | For 0.000025% volume concentration, increase in solar radiation absorbance from 27% to 50% |
| 6 | Parvin et al.[20] | Cu | Not given | Water | Direct absorber collector | Simulation study, collector efficiency increases about two fold with increase of Reynolds no from 200 to 1000 at volume fraction 0.03 |
| 7 | Filho et al.[26] | Ag | 10-80 nm | $H_2O$ | DASC | SAR achieved 0.6kw/g for 6.5ppm and decreases to 0.01kw/g at 650ppm, probably due to enhanced particle to particle interaction |
| 8 | Zhang et al.[30] | Carbon coated Ni nanoparticle | 40 mean dia | Ionic liquid(HMIM) | Direct absorption solar collector to study radiation absorption ability | Volume fraction varied from 10ppm to 40ppm, radiation absorption reaches up to 100% for 1cm deep penetration of solar radiation. Recommended as absorber especially in medium-high-temperature DACs. |
| 9 | Qinbo et al. [24] | Cu | $H_2O$ | 30 mean dia | Transmittance analyses of nanofluid | Experimental results shows that transmittance of Cu-$H_2O$ nanofluid is much less than that of demonized water and also decreases with increasing particle size, mass fraction and depth of penetration. highly suitable for DASCs |

## V CONCLUDING REMARKS

Review based on previous works establishes that by applications of nanofluids in solar energy systems, thermal conductivity, heat transfer rate, and optical absorption characteristics can be enhanced. Large number of experimental and mathematical model based studies has been performed. It is unanimously accepted that nanofluids have ability to enhance overall thermal efficiency of solar and thermal energy systems.

It is desirable to do further research work to find nanomaterials to increase surface absorption capability of absorbing plate of flat plate collector in order to further increase thermal efficiency of collector.

Lot of mathematical model studies has been performed in application of nanofluids for volumetric receivers working as DASCs. More experimental work still required along with focus on optical property of nanofluids. Nanofluids having higher extinction coefficient are preferable for DASCs.

More focused research work is needed in field of Brownian motion of particles, dynamic properties of nanofluids, mechanism of agglomeration and methods to increase stability.

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# DSP-BASED CURRENT SHARING OF AVERAGE CURRENT CONTROLLED TWO-CELL INTERLEAVED BOOST POWER FACTOR CORRECTION CONVERTER

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## ABSTRACT

*With rapid development in power semiconductor devices, the usage of power electronic systems has expanded to new and wide application range that include residential, commercial, aerospace, traction system and SMPS. The current drawn by power electronic system from the line is distorted resulting in a high Total Harmonic Distortion(THD) and low Power Factor (PF). Hence, there is a continuous need for power factor improvement and reduction of line current harmonics. This project on developing a circuit for power factor correction (PFC) using active filtering approach by implementing interleaved boost converters working in parallel. It is based on an optimized power sharing strategy to improve the current quality and at the same time to reduce the switching losses. Power factor correction (PFC) pre-regulators are used between the ac line and non linear load to improve the line current in terms of power factor and total harmonic distortion (THD). In medium and high-power applications, the interleaved boost PFC converter is the proper solution for this purpose to obtain a pre-regulator with lower size. The operation of the interleaved boost PFC converter provides a reduction of the inductor and electromagnetic interference filter volumes compared with those of the conventional single switch boost PFC converter. However, proper current sharing and current ripple minimization must been assured to achieve these benefits. The current sharing problem between the two-cell interleaved boost PFC converter is analyzed and discussed in this report and the resolved with usage of a digital signal processing (DSP)-based solution*

***Keywords: Boost PFC Converter, AC to DC Power Converter, DSP***

## I INTRODUCTION

Power factor is the ratio between the KW (Kilo-Watts) and the KVA (Kilo-Volt Amperes)drawn by an electrical load where the KW is the actual load power and the KVA is the apparent load power. It is a measure of how effectively the current is being converted into useful work output and more particularly is a good indicator of the effect of the load current on the efficiency of the supply system. All current flow will causes losses in the supply and

distribution system. A load with a power factor of 1.0 results in the most efficient loading of the supply and a load with a power factor of 0.5 will result in much higher losses in the supply system[1].

### 1.1 Linear System

In a linear system, the load draws purely sinusoidal current hence the power factor is determined only by the phase difference between voltage and current. A linear load does not change the shape of the waveform of the current, but may change the relative timing(phase) between voltage and current. Thus,

Power Factor

$PF = \cos\varphi$

Active Power

$P = V I\cos\varphi$

Reactive Power

$Q = V I\sin\varphi$

### 1.2 Non Linear System

A non-linear load on a power system is typically a rectifier (such as used in a power supply), or some kind of arc discharge device such as a fluorescent lamp, electric welding machine, or arc furnace. Because current in these systems is interrupted by a switching action, the current contains frequency components that are multiples of the power system frequency [1].

### 1.3 Power Factor

Power factor is defined as the cosine of the angle between voltage and current in an ac circuit. There is generally a phase difference between voltage and current in an ac circuit. If the circuit is inductive, the current lags behind the voltage and power factor is referred to as lagging. However, in a capacitive circuit, current leads the voltage and the power factor is said to be leading. In a circuit, for an input voltage V and a line current I,

$$S^2 = P^2 + Q^2$$

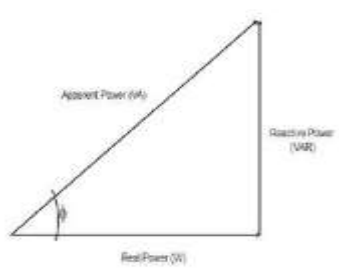


**Fig. 1.The Basic Power Triangle**

### 1.4 Significance of Power Factor

To better understand Power Factor (PF), it is important to know that power has two components:

• Real Power

• Reactive Power

Real Power is the power that is actually consumed and registered on the electric meter at the consumers' location. It performs the actual work, such as creating heat, light and motion. Real Power is expressed in kW and is registered as kWH on an electric meter. Reactive Power is required to maintain and sustain the Electromagnetic Field (EMF) associated with the industrial inductive loads. Reactive Power is measured in kVAR. The total required power capacity including the real and the reactive components is known as Apparent Power ,expressed in kilovolt ampere (kVA).

### 1.5 Distortion Power Factor

The distortion power factor describes how the harmonic distortion of a load current decreases the average power transferred to the load is the total harmonic distortion of the load current. This definition assumes that the voltage stays undistorted(sinusoidal, without harmonics). This simplification is often a good approximation in practice. $I1rms$is the fundamental component of the current and $I2rms$ is the total current - both are root mean square-values. The result when multiplied with the displacement power factor (DPF) is the overall, true power factor or just power factor (PF):

$$Pf = \cos\varphi = \frac{1}{\sqrt{1+THD2}}$$

## II.BASIC CIRCUIT TOPOLOGIES OF ACTIVE POWER FACTOR CORRECTION

Many circuits and control methods using switched-mode topologies have been developed with standard. The active PFC's can be implemented using several converter topology some of them are as below.

1. Buck Converter
2. Boost Converter
3. Buck-Boost converter
4. Cuk converter

We go for boost converter is most proper topology for PFC system.

### Boost Converter

A boost converter (step-up converter) is a power converter with an output DC voltage greater than its input DC voltage. It is a class of switching-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element .Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple

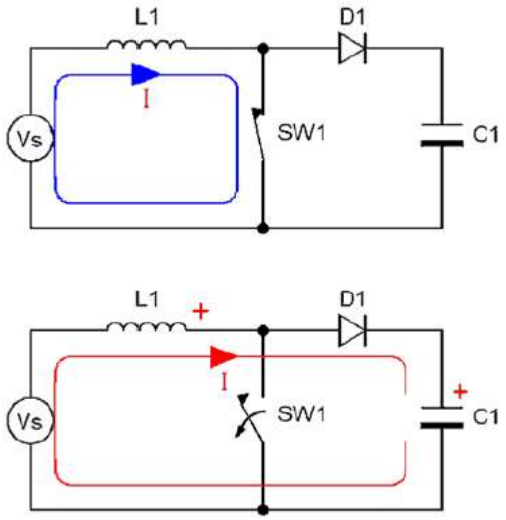


**Fig. 2.Boost Converter operating circuit[3]**

-in the On-state, the switch S is closed, resulting in an increase in the inductor current as shown in fig

-in the Off-state, the switch is open and the only path offered to inductor current is through the free wheeling diode *D*, the capacitor *C* and the load R .as shown in "fig".

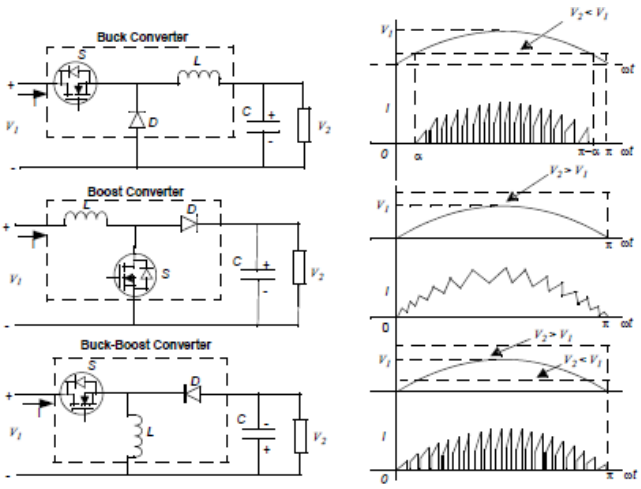


**Fig. 2.Power conversion Topology**

| Type of | Output | Cross | Line Current |
|---|---|---|---|
| Buck | Positive | Yes | Always |
| Boost | Positive | No | Continuous |
| Buck- | Negative | No | Always |

**Table-1.Comparison of Different PFC Topologies**

### 2.1 Boost Power Factor Correction Circuit

For the development of applications with sinusoidal current consumption more design work will be required than ever before. An active PFC also generates additional advantages, which does not generally lead to additional costs. Precondition is a system design that uses the advantages of an active PFC as smaller DC-link capacitor, loss reduction in the application connected to the output achieved by the increased and constant output voltage. Conventionally, boost converters are used as active Power factor correctors. Active Power Factor Correction (Active PFC)since it provides more efficient power frequency. Because Active PFC uses a circuit to correct power factor, Active PFC is able to generate a theoretical power factor of nearly unity. Active Power Factor Correction also markedly diminishes total harmonics ,automatically corrects for AC input voltage, and is capable of a full range of input voltage. Since Active PFC is the more complex method of Power Factor Correction, it is more expensive to produce an Active PFC power supply. Circuit diagrams for boost types of PFCs are as given below:

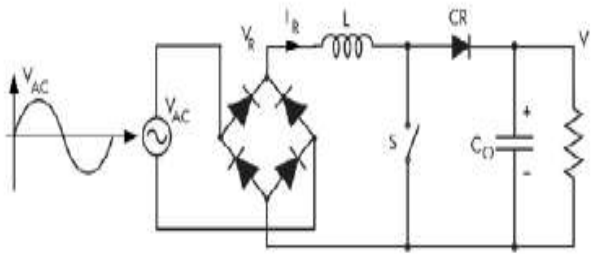


**Fig. 3.Classical Power Factor Circuit**

### Advantages

1. Overall high efficiency.
2. Reduction of the development cost due to the modular design.
3. High reliability.
4. Reduction in the current ripple.
5. Reduction of conduction losses.
6. Size reduction of active and passive components as boost choke.

### 2.2 Types of Power Factor Correctors

### Passive PFC

Harmonic current can be controlled in the simplest way by using a filter that passes current only at line frequency(50 or 60 Hz). Harmonic currents are suppressed and the non-linear device looks like a linear load. Power factor can be improved by using capacitors and inductors i.e. passive devices.

**Active PFC**

Here, we place a boost converter between the bridge rectifier and the main input capacitors. The converter tries to maintain a constant DC output bus voltage and draws a current that is in phase with and at the same frequency as the line voltage.

## III. INTERLEAVED BOOST CONVERTERS

The concept of interleaving or more generally that of increasing the effective pulse frequency of any periodic power source by synchronizing several smaller sources and operating them with relative phase shifts. Interleaving technique actually exists in different areas of modern technologies in different forms The difference between an Interleaved PFC and a single stage PFC is that two or more boost converter are used for to supply the load. In high power applications, the voltage and current stress can easily go beyond the range that one power device can handle. Multiple power devices connected in parallel and/or series could be one solution. However, voltage sharing and/or current sharing are still the concerns. Instead of paralleling power devices, paralleling power converters is another solution which could be more beneficial. Furthermore, with the power converter paralleling architecture, interleaving technique comes naturally. Benefits like harmonic cancelation, better efficiency, better thermal performance, and high power density can be obtained. In earlier days, for high power applications, in order to meet certain system requirement, interleaving multi-channel converter was a superior solution especially considering the available power devices with limited performance at that time.

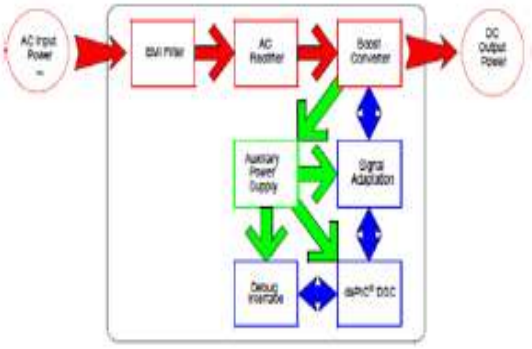


**Fig. 4 : Block Diagram Of Interleaved Boost PF [3]**

**Advantages:**

1. Interleaved PFC allows a more efficient power factor correction deign.
2. Interleaved PFC also reduces output current ripple.
3. Increased capacity to serve power requirements.
4. Better voltage regulation.
5. Lower energy and distribution costs.

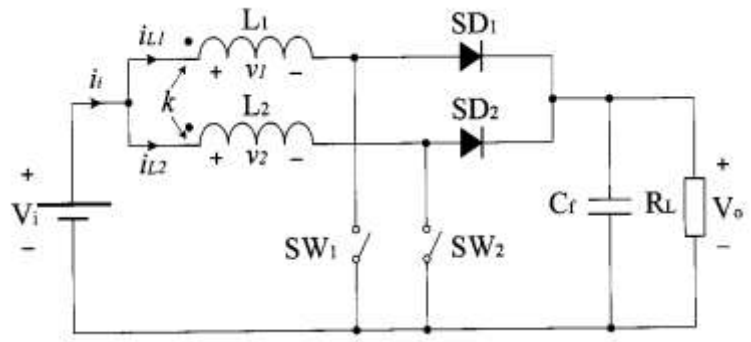


**Fig. 5 .Interleaved Boost PFC**

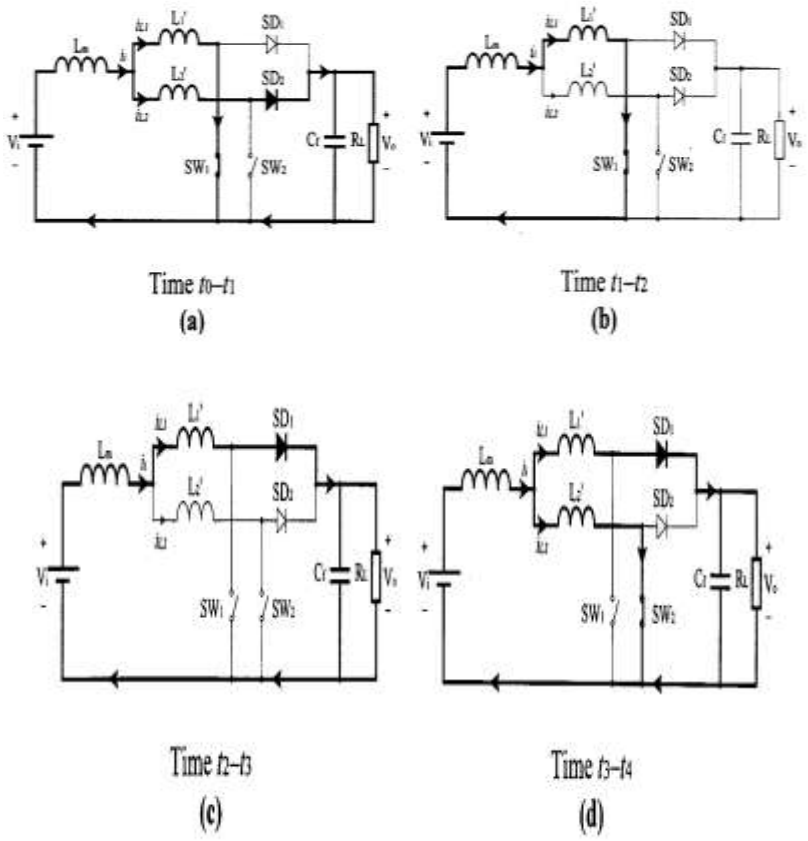


**Fig. 6.Operation Of Interleaved PFC**

**State a**- At time , SW is closed. The current in the inductor L1 starts to rise while L2continues to discharge. (The current inL2 was acquired in the last switching cycle.)

**State b -** At time , L1falls to zero L2continues to rise

**State c -** At time t2, SW is opened. The energy stored in the Inductor L1 is transferred to the load via the boost rectifier SD .

**State d -** The switch SW is closed at time t3. The current inL2 inductor starts to rise. L1 continues to discharge.

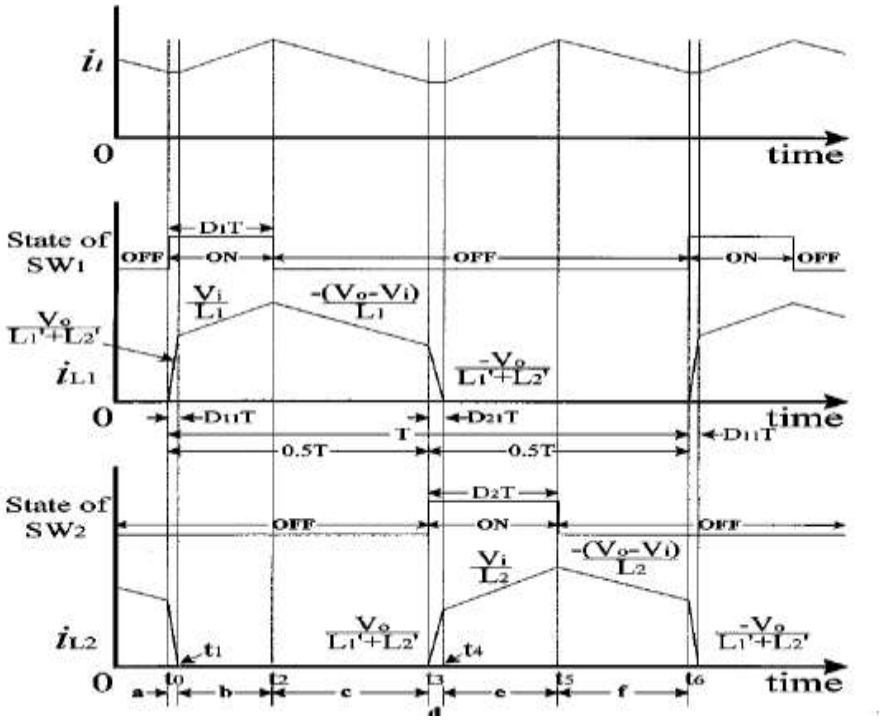


**Fig.7 .Current Waveform Of Converter**

## IV.CONTROL TECHNIQUE

The main reason for the poor current sharing is that the slopes of the phase shifted ramps are unequal due to differences in the values of the timing capacitors and the charging currents. Power factor correction interleaved boost converters provide a reduction of the inductor volume and weight when compared with the conventional PFC boost converter. However ,to achieve this benefits proper current sharing and current ripple minimization must been sure[3].Conventional off-line switch-mode AC-to-DC converters draw pulsating ac line current from the utility grid, therefore, they produce a reactive fundamental component and high order harmonic components to the utility line. These result in

• Electromagnetic interference (EMI) and line distortion,

• Increase of rms current in the transmission line, and, thus, additional losses.

With increasing demand for more power capability and better power quality from the utility line, power factor correction techniques have attracted much more attention. Numerous methods have been proposed in recent years

[2,6] to achieve unity power factor for the switch-mode power supply. Among them, the boost converter in the continuous conduction mode (CCM) with constant switching frequency is the most popularly used topology. The advantages are:

1. The input current is a smooth waveform, resulting in much less electromagnetic interference and therefore reduced input filtering requirements;

2. Current stress in the power switches is lower.

### 4.1 Requirement for PFC

1. Voltage Mode Control

2. Current Mode Control

### 1.Voltage Mode Control

The first approach developed to control SMPS applications is called Voltage Mode. Voltage mode is intuitive, the actual output voltage is compared to the desired output voltage and the difference (error) is used to adjust the pwm duty cycle to control the voltage across the inductor.

### 2.Current Mode Control

Current-Mode control was developed to correct some issues known with voltage mode. Current-mode uses the error between the desired and actual output voltages to control the peak current through the inductor. Current mode control provides inherent current limiting on a cycle by cycle basis.

### 3. Average Current Mode Control

The IPFC system uses the average current mode control method to meet the system requirements. The IPFC system uses the average current mode control method to meet the system requirements. For PFC, this control method is used to regulate DC output voltage while keeping the input current shape sinusoidal and in phase with the input voltage. The control method operates in Continuous Conduction mode in most parts of the operating regions of the converter. The operation is primarily based on the value of the load current at any point and the selection of the inductor.

## V. CONCLUSION

In this paper, the problem of current sharing between the inductors of the interleaved boost PFC converter is pointed out and a DSP-based simple practical solution is use. In the proposed technique, the equal current sharing between two cells of an interleaved boost PFC is achieved by using predictive control strategy in which the active filtering approach can be utilized so as to further reduce the current ripples and switching losses. The switches can be made to be work under soft-switching condition. This whole entire system is controlled by using DSP Programmed.

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# SYNTHESIS OF TITANIA-BEZYLIDENOIMINO HYBRID QUANTUM WELL SOLAR CELL

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## ABSTRACT

*Solar energy is the biggest advantage over the conventional power generation systems that the sunlight can be directly converted into electricity without any emission of greenhouse gases. In last few years photovoltaic industries have emerged with an annual growth of 40%. Solar cells are renewable pollution free source of electrical energy which can easily replace traditional fossil fuels. Solar power, potentially the most fruitful source of renewable energy. Priorily silicon based solar cell were widely used but according to demand of the community and industries various photovoltaic cells based on inorganic, organic material, multi junctions, hybrid heterojunction combination with quantum wells are widely used now a days.*

***Keywords: Hybrid Solar Cells, Titania, 2-Bezylidenoimino-6-Substituted Benzothiazoles***

## I INTRODUCTION

Solar energy is the most promising source of renewable energy. It has the fascinating advantage over the conventional power generation systems that the sunlight can be directly converted into power with the help of solar cells. This type of electrical energy production methods is cost effective, no toxic by products generation, in other words strategy follows sustainable environment.

Priorily the large work has been done on silicon based solar cells, but due to high cost and limitations of conversion efficiencies now a days different type of solar cells like multi junction solar cells, inorganic-organic hybrid cells are widely used for improved efficiency[(1-14)]. Organic quantum well solar cells (OQWSC's) are kind of green energy source show great potential application due to low production costs, mechanical flexibility devices by using simple techniques with low environmental impact. Rapid development of this technology has led to growing interest in OSCs in academic and industrial laboratories. The combination of organic skeleton into inorganic base enomoursly increase the efficiency of photovoltaic cell[(15-21)].

Looking the need of photovoltiac cells and benefits of hybrid quantum well (Inoraganic/Organic) solar cells here we present an UV responsive inorganic-organic hybrid solar cell based on Titania/2-benzylidenoimino-6-substituted benzothiazole ($TiO_2$/2-BNZA) heterojunction. In this solar cell, $TiO_2$ is an ultraviolet light absorber and electronic conductor, 2- benzylidenoimino -6-substitued benzothiazole is a hole conductor, the light-to-electrical conversion is realized by the cooperation for these two components.

## II EXPERIMENTAL

Reagent-grade chemicals were used without further purification. The substrates and solvents were used as received. All the melting points are taken in open capillary and uncorrected. The purity of synthesized compounds was checked by Thin Layer Chromatography studies. I.R. spectra were measured on FT-IR Perkin-Elmer (spectrum RX1) spectrophotometer ($\vec{v}$ in $cm^{-1}$) using KBr disc. $^1$HNMR were recorded in $CDCl_3$ and DMSO with Tetramethylsilane (T.M.S.) as the internal standard at 300 MHz on a Bruker DRX-300 spectrophotometer. The chemical shifts are reported as parts per million (ppm). The organic solar cells presented here were prepared by thin-film based technologies. The films in this work have been prepared mainly by spin-coating. The spin-coating method is probably the easiest and fastest for thin film preparation [22-24] This procedure is typically used to apply thin films on flat substrates. A typical process involves depositing a small puddle of a solution of the desired compound or a mixture of compounds onto the center of a substrate and then spinning the substrate at high speed, generally under controlled atmosphere. Centripetal acceleration will cause the solution to spread to, and eventually off the edge of the substrate, leaving a thin film of the desired compound or mixture on the surface. One of the most important factors in spin-coating is its repeatability.

In the present study, $TiO_2$ layer and 2- benzylidenoimino - 6-substituted benzothiazoles bulk have been deposited by spin-coating, when used as the main photoactive layer in photovoltaic devices.

### 2.1 Synthesis of 2 –benzylidenoimino- 6-substituted benzothiazoles

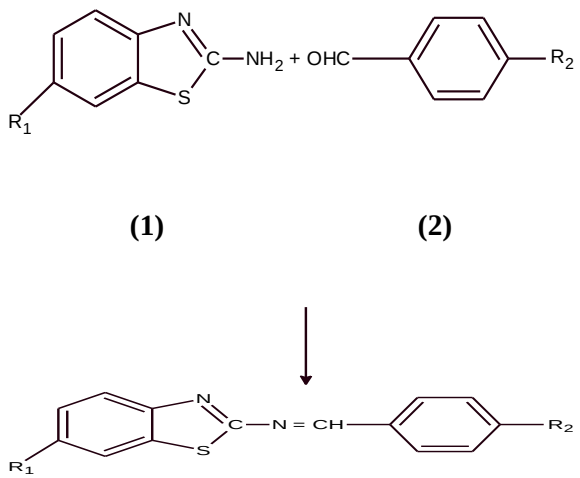


**Figure 1**

In the present investigation substituted 2- amino benzothiazoles were synthesised by thiocyanogenation of substituted anilines [25]. To a solution of 2-amino-6-substituted benzothiazole (0.01 mol) (2) in 25 ml of freshly distilled ethanol, 0.01 mol of aromatic aldehyde (3) was added at room temperature, and the reaction mixture was thoroughly mixed to confirm

homogeneity of reaction mixture. The reaction mixture was refluxed on a heating mental for 4 hours. After cooling residual solvent was evaporated under reduced pressure, during evaporation a solid mass 2- benzylidenoimino- 6-substituted benzothiazole derivatives (3) were obtained. Products were recrystallized from ethanol/hexane mixture to give pure (3). (Figure 1)

$$\mathbf{R_1 = Cl, Br, NO_2, OC_2H_5;\ R_2 = H}$$

In the present investigation synthesized 2- benzylidenoimino - 6-substituted benzothiazoles were:

3a. 2-(benzylidenoimino)-6-chlorobenzothiazole

3b. 2-(benzylidenoimino)-6-bromobenzothiazole

3c. 2-(benzylidenoimino)-6-nitrobenzothiazole

3d. 2-(benzylidenoimino)-6-ethoxybenzothiazole

## 2.2 Structure elucidation

The structure of synthesized compounds were confirmed by their analytical data, Infrared spectral data and $H^1$NMR data.

**3a** $R_1 = Cl$, $R_2 = H$, M.F. $C_{14}H_9N_2SCl$, M.P. 161 $^oC$, Elemental Analysis C=61.05%, H=0.03%, N=10.27%, IR (KBr) $v_{max}$ in $cm^{-1}$859(C–Cl), 1349(C–S), 1597(C=N), 1447, 1535 (ArC=C), $^1$HNMR (300MHz, $CDCl_3$): δ (4.02(s, 1H,=CHPh, 7.10- 7.632 (m, 8H,ArH),

**3b** $R_1 = Br$, $R_2 = H$, M.F. $C_{14}H_9N_2SBr$, M.P. 190 $^oC$, Elemental Analysis C=52.99%, H=0.02%, N=8.83%, IR(KBr) $v_{max}$ in $cm^{-1}$ 809 (C–Br), 1376 (C–S), 1598 (C=N), 1460, 1531 (ArC=C), $^1$HNMR (300MHz, $CDCl_3$): δ 4.0 (s, 1H, =CHPh),7.02-7.52 (m, 8H, ArH),

**3c** $R_1 = NO_2$, $R_2 = H$, M.F. $C_{14}H_9N_3SO_2$, M.P. 262 $^oC$, Elemental Analysis C=59.36%, H=0.03%, N=14.84%, IR (KBr) $v_{max}$ in $cm^{-1}$ 1380, 1510 $(-NO_2)$, 1597 (C=N), 1346 (C–S), 1436, 1490, 1539 (ArC=C), $^1$HNMR (300MHz, $CDCl_3$ ): δ 5.6 (s,1H, = CHPh), 7.02–7.90 (m,8H, ArH),

**3d** $R_1 = OC_2H_5$, $R_2 = H$, M.F. $C_{16}H_{14}N_2SO$, M.P. 120 $^oC$, Elemental Analysis C=68.08%, H=0.04%, N=9.92%, IR(KBr) $v_{max}$ in $cm^{-1}$ 1058 (C–O–Csym.) 1209 (C–O–Casym.), 1457, 1545 (ArC=C), 1596 (C=N), 2974 (C–Hstr.), $^1$HNMR (300MHz, $CDCl_3$ ): δ 1.45 (t, 3H, $CH_3$ ), 4.0 (q.2H, $OCH_2$), 5.4 (s, 1H,=CHPh),7.25–7.55(ArH)

### 2.3 Photocurrent measurement

After the photovoltaic samples were prepared, their current-voltage (*J-V*) characteristics were measured under dark and white-light illumination. By recording the *J-V* curves of illuminated solar cell, it is possible to determine the maximum power output, and thus the power conversion efficiency. Most of the photovoltaic parameters can be directly derived from the J-*V* characteristics, like short circuit current $(J_{sc})$, open circuit voltage $(J_{oc})$,calculated fill factor (FF), and power conversion efficiency. $J_{sc}$ is the current, which flows with zero internal resistance (at $V$ = 0, when no bias voltage is applied). $U_{oc}$ is the voltage in the open-circuit conditions, i.e. when no current flows through the cell. The power

conversion efficiency of the device (η) can be calculated from the defined parameters. is the ratio of the generated power to the incident optical power $(P_0)$. In the end, (η) is the most important parameter of any given solar cell. Hence, (η) can be expressed as following expression [22-24]:

$$\eta = \frac{P_{\max}}{P_0} = \frac{FF \cdot J_{sc}, U_{oc}}{P_0}$$

FF is the maximumpower that can be withdrawn from the device $(P_{\max})$ and theoretical power:

$$FF = \frac{P_{\max}}{J_{sc} \cdot U_{osc}} = \frac{J_{\max} \cdot U_{\max}}{J_{sc} \cdot U_{oc}}$$

FF is directly related to the series and shunt resistance of the solar cell. Higher P1' is desirable and corresponds to a more "square-like" shape of the *J-V* curve. Following Figure shows the schematic diagram of *J-V* curves of an ideal photovoltaic device both in the dark and in a white-light illumination. In the dark, the solar cell photocurrent passing through the cell until the voltage is high enough or in other words the cell behaves like a diode. When the solar cell is illuminated, the *J-V* curve shifts downwards by the amount of photocurrent generated. The power (*P*) produced by the cell can be calculated along the *J-V* sweep by theequation *P* = *JU*. The power is zero at the $J_{sc}$ and *Uoc* points, and the maximum power $(P_{\max})$ between the two points (shaded square in Figure 2).

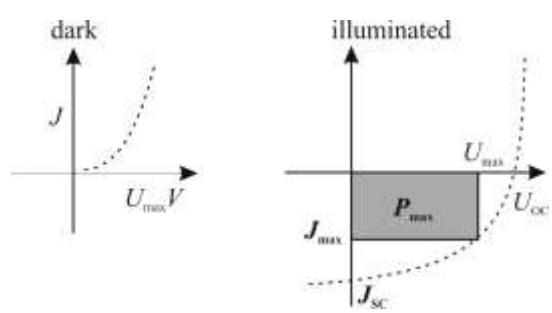


**Fig. 2 Current-voltage (*J-V*) characteristics of an ideal solar cell both in the dark (left) and under illumination (right).**

In this work, the *J-V* curves were recorded in the dark and under AN/I 1.5 sunlight illumination. All the measurements were carried out in an open air at room temperature.

## III RESULTS AND DISCUSSION

The synthesis of heterocyclic compounds and fabricating on inorganic base Titania open the new pathway for enhanced efficiency of photovoltaic cells. Doping quantum wells of other inorganic materials in hybrid solar cell may enhance the photovoltaic performance of the cell.

## IV ACKNOWLEDGEMENT

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# FRAMING CONTROLLERS APPLYING PADÉ APPROXIMATION TECHNIQUE

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**ABSTRACT-***This brief presents a method to commence a reduced order system for a given SISO (stable) linear continuous time system. This approach is about to retain the stability while converting the higher order system into its lower order approximant using Padé approximant and then a controller is put together in the reduced order system attaining stability and necessary parameters of the system. A numerical example is also presented to illustrate the behavior of the original system with its reduced order approximation and then attaching a controller and check the stability of the reduced order system with controller.*

***Keywords*: *Controller Designing, Model Truncation, Padé Approximation Technique, SISO Linear Continuous Time System*.**

## I INTRODUCTION

In many cases, it is quite essential to illustrate a high order system by a lower order system. System reductions of continuous and discrete systems have been broadly examined. There are several techniques which are Aggregation method [14], Moment matching technique [15], Padé approximation [16], Routh approximation [17], $L^{\infty}$ optimization technique [18]. Padé approximation provides computational modesty and fitting of time moments.

But in many cases it provides instability in the reduced order model while the early system is stable. To get a truncated order system; Shamash [19] has already provided a technique of merging the Routh approximation and time moment matching. Just have a glimpse [20] of the technique in which denominator of the system is taken by keeping the dominant poles of the system and the numerator is achieved by comparing the time moments. These techniques provide certainty in obtaining a truncated order system and these are often called Partial Padé approximation in the frequency domain. A time domain version of these Padé approximation techniques have been described by Bandyopadhyay and Lamba [21].A consolidation of frequency and time domain Padé approximation is also illustrated in [22].

Reduced order control modeling techniques, Anderson and Liu [23] are characterized in two types, direct and indirect techniques. In Direct techniques controller order is confined firstly and then find gain by extension, while indirect technique truncate the size of high order controller. Optimal projection theory, Gangsaas ***et al.***[24]and Bernstein and Hyland are the direct techniques and the parameter optimization approach.

## II. PADÉ APPROXIMATION TECHNIQUE

Let us assume the transfer function illustrate a stable single input single output (SISO) system which is given below:

$$G(s)=\frac{\Omega_1 s^{n-1}+\Omega_2 s^{n-2}+\ldots\Omega_n}{S^n+\Gamma_1 S^{n-1}+\ldots\Gamma_n} \quad (1)$$

$$=t_1+t_2S+\text{---------}+t_nS^{n-1}+\text{----------} \quad (2)$$

(Expansion around s=0)

$$=M_1S^{-1}+M_2S^{-2}+\text{------}+M_nS^{-n}+\text{---------} \quad (3)$$

(Expansion around s=∞)

To drive its poise compressed order (rth. order) approximant, the transfer function will be:

$$G_{comp}(S)=\frac{\nu_1 S^{r-1}+\nu_2 S^{r-2}+\ldots+\nu_r}{S^r+X_1 S^{r-1}+\ldots+X_r} \quad (4)$$

$$=\Delta_1+\Delta_2\ S+\ldots+\Delta_n S^{n-1}+\ldots \quad (5)$$

$$=N_1 S^{-1}+N_2\ S^{-2}+\ldots+N_n S^{-n}+\ldots \quad (6)$$

To acquire the Pade approximant, comparing the first 2r items of equation (2) to the 2r items of equation (5) respectively. Sometimes Padé approximant gives ambiguity in the response of the system. By introducing many stable reduction methods planted on the retention of r items this issue can be overthrown; have a look, for illustration [1]-[12].Many a times, it is not plenty enough to compare r items for a satisfactory total time response approximation[5];both time moments and Markov parameters must be taken. To maintain stability, a number of methods are in existence that helps in fully retaining r-items. Here according to the previous results Vimal Singh[13 ] by using Routh-Padé approximants it is viewed that, the denominator of the system must be taken, So as to reduce error between the (r+1)th and the consecutive time period. To retain stabilized system; Markov parameters are introduced where the numerator can be obtained in such a way, by fully restraining the first r-time moments /markov parameters of the system

## III. PRIMARY RESULTS

Considering the outcomes [13], we can have an idea that with the help of Padé approximation technique a higher order system can be reformed into lower order system retaining its stability. Here the closed loop transfer function of a system is given below:

$$G(s)=\frac{8s^2+6s+2}{s^3+4s^2+5s+2} \tag{7}$$

Equation (8) is attained by Routh-Padé approximation techniques; planted on the contemplation of time moments and it nearly preserves r+2 time moments. So equation (8) is the reduced order approximant which is given in equation (7).

$$G_{comp(s)}=\frac{8.0s+8.129004}{s^2+4.307413s+8.129004} \tag{8}$$

## IV. CONTROLLER ARCHITECTURE

For a given control system; fig (1) Gpri(s) and H(s) are already provided. Our main goal is to acquire the transfer function of the controller Cp(s) and with the help of Cp(s) desired response of the closed loop system is obtained. For modeling of controller Cp(s) an indirect technique is used here. To model and acquire the closed loop transfer function of the controller; assumptions for model specification of the compressed order model has been taken.

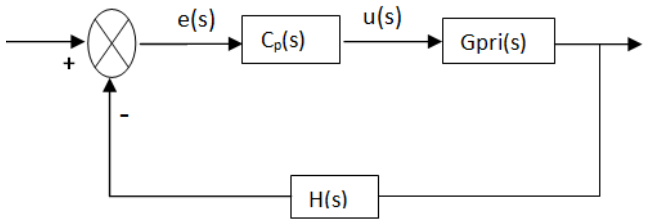


**Fig. (1) Control Structure**

$$G_{fpp}=\frac{Cp_{(s)}Gpri_{(s)}}{1+Cp_{(s)}Gpri_{(s)}H_{(s)}} \tag{9}$$

So, $$Gcomp_{(s)}=\frac{Cp_{(s)}Gpri_{(s)}}{1+Cp_{(s)}Gpri_{(s)}H_{(s)}} \tag{10}$$

After modification for controller, the transfer function will be:

$$Cp_{(s)}=\frac{Gcomp_{(s)}}{Gcomp_{(s)}\left[1-Greq_{(s)}\right]} \tag{11}$$

With the help of Padé approximation technique $G_{pri}(s)$ can be easily estimated by a reduced order transfer function $G_{comp}(s)$ shown in fig. (2)

$$Gfcc_{(s)} = \frac{Cpcomp_{(s)} Gcomp_{(s)}}{1 + Cpcomp_{(s)} Gcomp_{(s)} H_{(s)}} \quad (12)$$

$$Gfcp_{(s)} = \frac{Cpcomp_{(s)} Gpri_{(s)}}{1 + Cpcomp_{(s)} Gpri_{(s)} H_{(s)}} \quad (13)$$

To get a reduced order controller, $C_{pcomp}(s)$; the method has been explained.

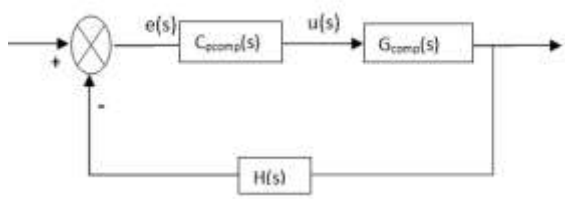


**Fig.(2) Closed Loop control with $C_{pcomp}(s)$ and $G_{comp}(s)$**

## V. NUMERICAL EXAMPLE

The transfer function of the primary system is [13]

$$Gpri_{(s)} = \frac{8s^2 + 6s + 2}{s^3 + 4s^2 + 5s + 2} \quad (14)$$

Let us consider a reference model. In this example, a standard second-order transfer function is taken with damping ratio $\epsilon$ =0.7 and natural frequency $w_n$=1.5 rad/sec. Therefore

$$Gref_{(s)} = \frac{\omega_n^2}{s^2 + 2\omega_n \varepsilon s + \omega_n^2} \quad (15)$$

$$Gref_{(s)} = \frac{2.25}{s^2 + 2.1s + 2.25} \quad (16)$$

A second order model given in the equation (17) is obtained by Padé approximation technique.

$$G_{comp(s)} = \frac{8.0s + 8.129004}{s^2 + 4.307413s + 8.129004} \quad (17)$$

Now let us calculate the transfer function of the controller with the primary system which is given in equation (19)

$$Cp_{(s)} = \frac{Gref_{(s)}}{Gpri_{(s)}\left[1+Gref_{(s)}\right]} \qquad (18)$$

$$Cp_{(s)} = \frac{2.25s^5 + 13.725s^4 + 35.21255s^3 + 48.375s^2 + 34.7625s + 10.125}{8s^6 + 39.6s^5 + 116.48s^4 + 188.76s^3 + 188.37s^2 + 89.1s + 20.25} \qquad (19)$$

Now let us calculate the transfer function of the controller with the reduced order system which is given in equation (21)

$$Cc_{(s)} = \frac{Gref_{(s)}}{Gcomp_{(s)}\left[1+Gref_{(s)}\right]} \qquad (20)$$

$$Cc_{(s)} = \frac{2.25s^4 + 14.416s^3 + 43.704s^2 + 60.218s + 41.153}{8s^5 + 41.729s^4 + 123.422s^3 + 204.12s^2 + 196.23s + 82.307} \qquad (21)$$

The closed loop transfer function when the controller is attached to the primary system; is given below:

$$P(s) = \frac{Cp_{(s)}Gpri_{(s)}}{\left[1+Cp_{(s)}Gpri_{(s)}\right]} \qquad (22)$$

$$P(s) = \frac{18s^7 + 123.3s^6 + 368.544s^5 + 625.728s^4 + 638.78s^3 + 386.328s^2 + 130.276s + 20.25}{8s^9 + 71.6s^8 + 332.88s^7 + 991.98s^6 + 1973.564s^5 + 2645.068s^4 + 2334.8s^3 + 1289.568s^2 + 409.726s + 60.75} \qquad (23)$$

The closed loop transfer function when the reduced order controller is attached to the primary system; is given below:

$$Q(s) = \frac{Cc_{(s)}Gpri_{(s)}}{\left[1+Cc_{(s)}Gpri_{(s)}\right]} \qquad (24)$$

$$Q(s) = \frac{18s^6 + 128.828s^5 + 440.628s^4 + 772.8s^3 + 774.94s^2 + 367.354s + 82.306}{8s^8 + 73.729s^7 + 348.338s^6 + 1051.281s^5 + 2153.906s^4 + 2907.471s^3 + 2496.558s^2 + 1171.349s + 246.92} \qquad (25)$$

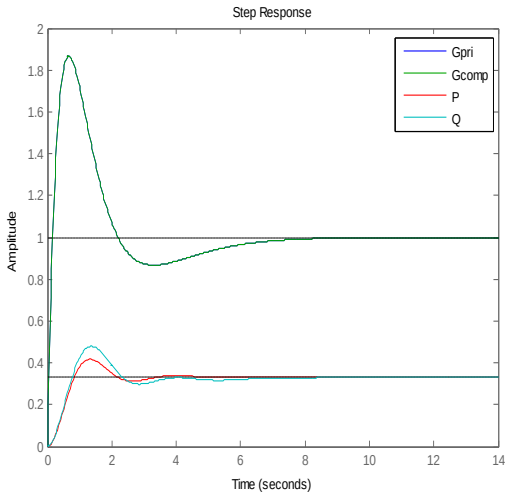


**Fig.(3)-1.Step responses of Gpri(s) and Gcomp(s), 2. Step responses of P(s) and Q(s)**

## VI. CONCLUSION

In the present work a controller is designed using the classical approach. The system is first approximated by a low order model using Pade approximation technique and a controller is designed for this low order model. For the design of the controller, a reference model $G_{ref}(s)$ with has been chosen. Then this reduced order controller is attached to the original higher order system and it was found that the step response of the primary system with reduced order controller is a good approximant to the step response of primary system with higher order controller. The present technique has been applied to the continuous systems further it would be interesting to implement the same idea to the discrete systems as well.

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# NEED FOR COMPETENCY MAPPING OF PROJECT MANAGERS IN INDIAN CONSTRUCTION SECTOR

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**ABSTRACT**

*The current globalization and complexity of construction work, forces construction industry professionals to evaluate and adopt. The purpose of this study is to determine the skill requirements and competencies expected of project managers. This paper discusses the importance of finding out competencies of project managers in Indian construction sector and importance of mapping those competencies based on a desired level of performance. This paper defines different methods of mapping the competencies and also suggests the required skill set to perform project managers' job and competencies associated with it. The skills and competencies recommended are useful to any organization for providing trainings to existing project managers so as to improve their performance in their weak areas. Gap closure, thus achieved is useful for a person in not only improving his performance but further making him capable so as to accept higher responsibilities in the organization and contribute towards the attainment of the company's strategic objectives.*

***Keywords*: *Competency mapping, Project Manager, Skill set.***

## I INTRODUCTION

India is the second largest growing economy/ developing country in the world. As per the GDP of last few years, construction sector is playing vital role in Indian economy. Construction sector has been contributing to around 8% of India's GDP. There are almost 250 ancillary industries which depend upon construction sector, therefore minor increase in investments in this sector leads to multiplier effect in generating income up to five times more than earlier. It is the second largest employer in India next to agriculture.

Secondly due to diversity in India, construction sector also faces changes in work to some extent like type of houses, roads, dams, etc according to the requirements of people, type of land, locally available materials and most importantly environmental condition.

Large amount of work, huge investments in construction sector by government as well as private companies and diversity in work environment, all together emphasize great responsibilities to the person working at the higher level of management in construction industry.

Amongst the top management the project managers have responsibility of actual execution of project. They are involved in construction from pre design phase of work till completion of project. This initial involvement increases responsibilities on project managers. Now days, complexity of work and huge cost involvement increases the requirement of good management skills and technical knowledge of those who are involved in every phase of construction work. Traditionally the project managers are those who have experience of minimum 10-15 yrs of work in similar projects irrespective of technical educational background. But as per the current scenario and project complexity the person without technical background and experience of managing projects would not manage the project effectively. Due to the complexity of construction projects it is required to improve the knowledge and skill levels of existing project managers.

Growth of any construction company mainly depends on performance of project managers who manage the projects for the company. Hence it is required to find out the skill and competencies required for the project managers as per their job roles and responsibilities, which can further be useful to find out the gaps in required competencies based on the actual level of competencies. On bridging the gaps by appropriate training programs, the quality of work performance will be improved. Hence skills and competencies are useful to select appropriate persons for the post.

## II LITERATURE REVIEW

David Arditi[1] states that, women are as competent as men for holding project management positions in construction companies. The result of study suggested that, women scored significantly higher in three competencies: sensitivity, costumer focus, authority and presence. In order to increase the number of women in the industry, one should improve the industry image, its working conditions, and working hours, rather than women's managerial abilities.

Ahadzie [2] suggested that, the best predictors of the Project Managers' performances are: job knowledge in site layout techniques, dedication, job knowledge in technology, time management, and ability to solve conflicts, and approachability and voluntary acumen. The various statistical tests employed confirm the goodness of fit and validity of the model. The significance of the findings viz. Project Managers performance improvement in the management of the company has also been highlighted. The model has considerable potential for immediate implementation within the housing industry

Dr. Wira[3]. Concluded that, to meet today's professional demand and to ensure their continued relevance in the industry, project managers must continually improve themselves, in both construction specific and non-construction competencies demanded of them in order to fulfill the requirements for the project.

Anderson [4] proposes a process to address the impact of changing owner-contractor work relationships on capital projects. The process seeks to fulfill owners' need for a decision process to determine the most appropriate use, strategically, of their resources in work relationships with contractors to successfully develop and execute capital projects. As the work process was developed and implemented in a practical situation, a clear set of benefits become apparent.

Yepes [5] proposes a tool for analyzing and comparing graduate programs related to management and administration in the construction sector. Further research is recommended to enhance the proposed methodology and seek the best way to cover current needs of professionals and employers in the construction industry

Alroomi[6] has addressed a growing concern about the loss of knowledge, skills, and experience of cost estimators. The study has found that most critical competencies are soft skills or knowledge, which is difficult to transfer.

## III NEED FOR DEFINING AND MAPPING COMPETENCIES OF PROJECT MANAGERS IN INDIAN CONSTRUCTION SECTOR- FEW OTHER POINTS

- Diversity in Indian environment leads to change in requirements and types of construction work significantly. For example construction method applied in North region of India may not be applicable in south region.
- There is no such a standards defined for the performance evaluation of project managers though they play a very important role in execution and managing the projects.
- Globalization and complexity of construction projects requires improving the knowledge and skill levels of existing project managers.
- Selecting of new project managers should be as per the current requirements based on some defined scientific method which further can be helpful to access actual performance.
- Competency mapping contributes in enhancing the existing level of competencies which further leads to overall growth of company.
- Performance of project manager is directly proportional to the success or failure of project. As he is managing the project on behalf of company a little ignorance towards his work may lead the company the great loss in terms of money and reputation.
- A competent project manager can lead his team players towards vision and mission of company

## IV COMPETENCY AND COMPETENCY MAPPING

Competency has been defined in number of ways by different researchers. There are various definitions with little difference in them. Competencies can be defined as areas of knowledge, skills and attributes, personal behavior of an individual that distinguish him from ordinary performer to excellent performers. [7] The common elements most

frequently mentioned are knowledge, skills, abilities, aptitudes, personal suitability, behavior, experience and impact on performance at work.

There are five types of competency characteristics.

- Knowledge- Information a person has in specific areas.
- Skill- The ability to perform physical or mental task
- Motives- The things a person consistently thinks about or wants and which causes action. Motives 'drive, direct or select' behavior towards certain actions or goals and away from others.
- Traits- Physical characteristics and consistent responses to situations or information.
- Self-concept -A person's attitudes, values and self-image

Competency mapping is a very important tool which helps organization to identify and analyze competencies that are needed to perform job effectively. Every organization which would like to increase of productivity, quality, growth, stability, performance and finally the profit margin should pay attention to enhance competencies of employees by using competency mapping technique.

## V VARIOUS METHODS OF MAPPING COMPETENCIES

1. Job Competence Assessment Method- This is developed using interviews and observations of outstanding and average performers to determine the competencies that differentiate between them in critical incidents.
2. Modified Job Competence Assessment Method- This also identifies such behavioral differences, but to reduce costs, interviewees provide a written account of critical incidents.
3. Generic Model Overlay Method- Organizations purchase an off-the-shelf generic competency model for a specific role or function.
4. Customized Generic Model Method- Organizations use a tentative list of competencies that are identified internally to aid in their selection of generic competencies.
5. Flexible Job Competency Model Method- This seeks to identify the competencies that will be required to perform effectively under different conditions in the future.
6. Systems Method- This demands reflecting on not only what exemplary performers do now, or what they do overall, but also behaviors that may be important in the future.
7. Accelerated Competency Systems Method- This places the focus on the competencies that specifically support the production of output, such as an organization's products, services or information.[7]

To perform the job effectively and efficiently by fulfilling all the expectations and responsibilities of company, a project manager requires various skills and competencies. Skill is the ability to do something excellent arising from

talent, practice and training while competency is the capability to apply a set of related knowledge, skills, and abilities required to successfully perform tasks in a defined work practices.

A table below describes the skills and corresponding competencies to perform the project manager's job effectively. The required skills have been found out from the roles and responsibilities of project manager and the major competencies referred here are taken from Lominger's competency framework [8] (67 defined competencies).

**Table 1- Required skills and competencies associated**

| Sr. No. | Required skills | Suggested Competencies |
|---|---|---|
| 1 | Written communication | Written Communications, Informing |
| 2 | Oral communication | Command Skills, Informing |
| 3 | Presentation | Presentation Skills |
| 4 | Listening | Listening |
| 5 | Flexibility | Dealing With Ambiguity, Approachability |
| 6 | Leadership | Directing Others |
| 7 | Motivation | Motivating Others, Directing Others, |
| 8 | Team Player | Directing Others, Interpersonal Savvy, Motivating Others, Building Effective Teams, Command Skills |
| 9 | Negotiation | Negotiating, Conflict Management |
| 10 | Mediator | Boss Relationships, Managing Diversity |
| 11 | Stress management | Composure , Patience |
| 12 | Time management | Time Management |
| 13 | Decision making | Timely Decision Making |
| 14 | Understanding others | Peer Relationships, Understanding Others |
| 15 | Influencing others | Motivating Others |
| 16 | Creativity | Creativity |
| 17 | Adoptability | Learning on the Fly , Self-Development |
| 18 | Integrity | Ethics and Values, Integrity and Trust, Managing Vision and Purpose |
| 19 | Planning | Planning, Managing and Measuring Work |
| 20 | Analytical thinking | Decision Quality |
| 21 | Sensitivity | Approachability, Compassion |
| 22 | Goal setting | Perseverance, Drive For Results |
| 23 | Application of knowledge | Functional/Technical Skills |
| 24 | Understanding of work | Functional/Technical Skills |
| 25 | Risk analysis | Problem Solving, Perspective |

| | | |
|---|---|---|
| 26 | Delegation of Authority | Delegation, Hiring and Staffing |
| 27 | Persistence | Ethics and Values |
| 28 | Judgment | Decision Quality |
| 29 | Cultural perception | Ethics and Values |
| 30 | Follow up | Managing and Measuring Work |
| 31 | Initiative | Action Oriented, Innovation Management |
| 32 | Flexibility | Dealing With Paradox |
| 33 | Quick Learner | Learning on the Fly |
| 34 | Courage | Managerial Courage |

## VI COMPETENCY MAPPING AS HUMAN RESOURCE TOOL- A CASE STUDY

The construction company represents a reputed, major contracting firm operating in not only Indian domestic market but also has a significant global presence.

Business area include

- Real Estate
- Infrastructure
- Complex industrial projects

As company policy all the senior staffs as well as the project managers are evaluated for their performance based on a 360 degree feedback mechanism every year. Each individual is thoroughly assessed for the generic (5 nos) as well as the functional competencies (15 nos) needed (Strategic competencies are evaluated only for selected percentage amongst the top level managerial staff).

40 mangers and senior level staff as mentioned below were evaluated for their competencies (Experience of minimum 10 years to more than 25 years)

| Sr. No. | Designation of employee | Number of employees participated |
|---|---|---|
| 01 | Manager (Projects) | 04 |
| 02 | Project managers | 04 |
| 03 | Deputy Project managers | 08 |
| 04 | Senior Engineers | 04 |
| 05 | Junior engineers | 20 |
| Total Number of employees participated | | 40 |

Except for Manager (projects) and the project managers, all the other human resources as mentioned above were categorized in two separate roles i.e. planning and execution

Generic competencies assessed include -

1. Presentation skills
2. Oral and Written communication skills
3. Understanding and implementing effectively from drawings
4. Management of time
5. E-awareness

Functional competencies were categorized in-

a. Behavioral subheads
b. Project management subheads

Behavioral subheads include following competencies-

1. Managerial skills
2. Leadership
3. Customer focus
4. Negotiation skills
5. Influencing skills

Project management subhead include-

1. Structural knowledge background
2. Estimation and quantity surveying
3. Contracts management
4. ISO standards management
5. Safety management
6. Cost management
7. Managerial skills
   a. Assertive communication
   b. Teamwork
8. Application of project management software
9. Application of design and estimation software
10. Application of ERP software

Each competency is benchmarked by the company on a 5 point scale based on 3 levels of attainment

1. Excellent – scale in 5 to 4.1
2. Good - scale in 4 to 3.1

3. Average – scale in 3 to 2.5

A score less than 2.5 are considered to be an indication of non existence of any required competency. For every competency the benchmarked meaning, at each level of expected performance is drafted and re-drafted based on conducting competency assessment workshop on a regular basis, directed by Human resource manager. These results are available as a confidential document but to be used within the company for their employees. Re-drafting is necessary to take care of dynamic fluctuating business environment scenario

Before evaluating the human resource for his performance the required level of competency for a particular role is informed. For example, project manager must get score of min 3.5 with respect to assertive communication and must get score of 4.5 with respect to influencing skills. Senior site engineer must get score of 3.5 for structural knowledge background and must get score of 4.5 for safety management, so on so forth. Actual level of performance is measured, based on average score through a 360 degree feedback mechanism including the following

1. Rating from the different superiors
2. Rating from the different peers
3. Rating from the different sub ordinates
4. Rating from other stakeholders involved

Based on this; the gaps in each competency are determined

Competency Gap = Expected Level – Actual level

Though the above criterion gives an objective assessment, subjectivity never the less exists and hence a gap of 0.5 on a scale of 5 is generally neglected. A gap higher then this value is required to be closed by the human resource. A time frame varying from minimum six months, to maximum two years is considered reasonable for the gap closure, under normal circumstances. In case of accelerated level of performance which is sometimes demanded, particularly for the projects being executed on a fast track, the time frame given is reduced.

The gaps are closed by the company policy based on adopting permutation combination of the following methods-

1. Self initiative and self learning drive,
2. Deputation for executive development programs (EDP) organized at National and International levels,
3. Competency training during in house programs organized by company itself,
4. On job/ on site trainings.

During the 360 degree appraisal conducted consequently, following considerations are made by the company officials-

A. For those persons who do not show significant improvements even after the Human Resource Developmental Program, a role change exercise is attempted based on the individuals other strengths.
B. For those persons who shows significant improvements, as well as for those who exhibit negative gaps, their potential for higher posts is further considered. In such cases, for the higher posts, the benchmark performance expected for particular competencies may increase, that is gap may reopen subsequently.

Out of the 40 human resources mapped for their actual competencies it was found that, 30 managerial staff had competency gaps ranging in between 0.5 to 2, during initial assessment. Project executed by these competent people demonstrated an average time growth (25%), cost growth (10%) and significant construction disputes. (The time-cost effect, of which is not considered in the above study, since it is beyond the present scope)

## VII CONCLUSION

The findings presented highlight the importance of conducting competency assessment in a scientific manner, through the experienced and expert staff may exist with the organizations.

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# ANALYSIS OF PEAK TEMPERATURE AND FLOW STRESS IN FRICTION-STIR WELDING THROUGH SIMULATION

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## ABSTRACT

*Amongst the emerging new welding technologies, friction stir welding (FSW), invented and established by The Welding Institute (TWI) in 1991, is used frequently for the welding of high strength materials such as aluminum alloy, steel alloy, titanium alloy etc. which are difficult to weld by conventional fusion welding techniques. The FSW process parameters such as tool rotational speed, welding speed, axial force, and tool pin profile, etc... Play an important role in deciding the weld joint quality. In this research work, the simulation study has been carried out to observe the effects of rotational speed and traverse speed on output variables like peak temperature and flow stress for aluminum alloy 6061. Both the output variables affect the microstructure and weld quality. Hence, both the output variables need to be analyzed. For this purpose, five levels for each parameter (Rotational speed, Traverse speed) have been selected. Non linear thermal simulations have been carried out using FEA software called Hyperworks.*

***Keywords*: *FSW, Peak Temperature, Flow Stress, Simulation, Hyperworks***

## I INTRODUCTION

Friction stir welding (FSW) is a solid-state joining technique which was invented at The Welding Institute (TWI), UK, in 1991. The FSW has been found to be effective for joining hard-to-weld metals and for joining plates with different thickness or different materials. In the FSW process a non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of work pieces to be joined and traversed along the line of the joint as shown in fig. 1. As the tool travels, heat is generated by the contact friction between the shoulder and the work piece, and by the plastic deformation of the materials in the stir zone. The high strain and heat energies experienced by the base metal during stirring causes dynamic recrystallization, which is the formation of new grains in the weld zone. FSW is often a preferred joining technique not only for aluminum alloys but also for other difficult-to-weld metals such as magnesium alloys, titanium alloys and

metal-matrix composites, etc. The technique is now widely used in many industrial sectors such as marine, aerospace, railway, land transportation, etc. The behavior of the FSW joints is not only influenced by the geometry of the tools and the joints but also by different process parameters. Numerical analysis has found widespread applications in FSW [1]. Significant progress has been made in the fundamental understanding of both the FSW process and the properties of the resulting welded joints. The heat generated during the process raises the temperature initially at the contact of the tool and work-piece to an extent capable of lowering the material flow stresses which in turn improve plastic flow of work-piece material along the interface. The temperature rise and its distribution in the weld zones become responsible for evolution of the microstructure within the weld that includes grain size, grain boundary character, coarsening and dissolution of precipitates and resulting mechanical properties of the welds when the FSW produces tremendous plastic deformation around the tool and friction between tool and work piece[2]. It, therefore, becomes necessary to obtain information regarding temperature distribution and flow behavior during FSW.

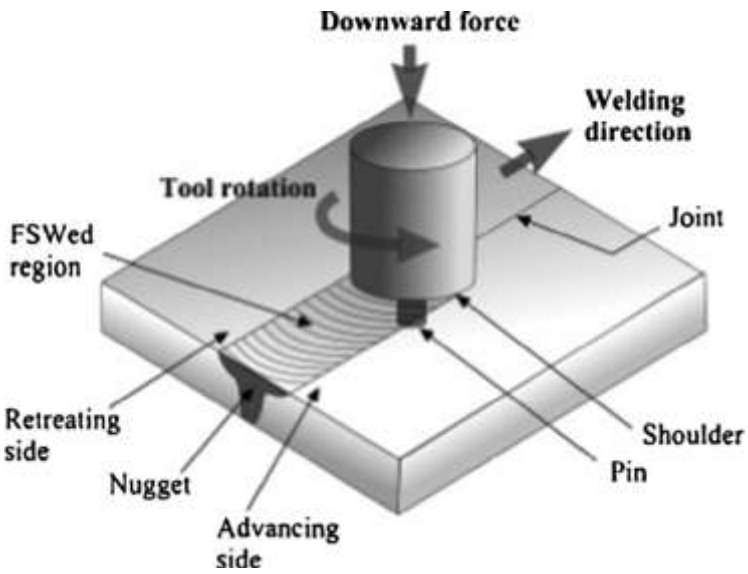


**Fig. 1 Principle of the friction stir welding process**

## II KEY BENEFITS OF FSW

The FSW process (as all friction welding of metals) is the solid state welding process as the metal does not reach to its melting temperature. So there are fewer defects caused due to the melting and solidification of the metal. Other advantages are as follows:

- Low distortion of work pieces.
- Good dimensional stability and repeatability.
- No shielding gas is required.
- No surface cleaning is required.
- No loss of alloying elements.
- Fine microstructure.

- Can be operated in all positions as there is no weld pool.
- Energy efficient.

There are many disadvantages in the welding techniques where the metal is heated to its melting temperatures and let it solidify to form the joint. The melting and solidification causes the mechanical properties of the weld in some cases to deteriorate such as low tensile strength, fatigue strength and ductility. The disadvantages also include porosity, oxidation, micro segregation, hot cracking and other micro structural defects in the joint. The process also limits the combination of the metals that can be joined because of the different thermal coefficients of expansion. As the metal in solid state welding does not reach to its melting temperatures, there are fewer defects caused due to the melting and solidification of the metal. In solid state welding the metals being joined retain their original properties as melting does not occur in the joint and the heat affected zone (HAZ) is also very small compared to fusion welding techniques where most of the deterioration of the strength and ductility begins. Dissimilar metals can be joined with ease compared to fusion welding [3].

## III EXPERIMENTAL WORK

### 3.1. Material selection for tool & work piece

Tool steel is the most common tool material used in friction stirring. This is because a majority of the published FSW literature is on aluminum alloys, which are easily friction stirred with tool steels. The advantages to using tool steel as friction stir tooling material include easy availability and machinability, low cost, and established material characteristics. AISI H13 is a chromium-molybdenum hot-worked air hardening steel and is known for good elevated-temperature strength, thermal fatigue resistance, and wear resistance. In addition to friction stir welding aluminum alloys, H13 tools have been used to friction stir weld both oxygen-free copper (Cu-OF) and phosphorus-deoxidized copper with high residual phosphorus (Cu-DHP) [4]. Due to the foresaid reasons, H-13 has been selected as the tool material. Aluminum alloys (6XXX) are widely used in friction stir welding as a base material because they are heat treatable; they have high corrosion resistance, excellent extrudibility, moderate strength and are available at low cost. And they are most commonly used in building & construction, highway, automotive and marine applications [5].

Aluminum alloy AA6061-T6 plates of size 381 mm x 127 mm x 4 mm with the properties as shown in Table I were selected for the simulations & FSW tool of chromium-molybdenum hot-worked air hardening steel (H-13) with the properties shown in Table II was used to perform virtual FSW using HyperWorks9.0. The tool geometry was selected with cylindrical pin having a shoulder diameter (D), shoulder length (L), pin diameter (d) and pin length (l) of 18mm, 50mm, 6mm and 3.5mm respectively.

| Property | Value |
|---|---|
| Density (kg/m$^3$) | 2700 |
| Specific heat (J/kg-K) | 896 |
| Conductivity (W/m-K) | 180 |
| Melting temperature (°C) | 652 |
| Young modulus (Pa) | 4.00E+10 |
| Poisson ratio | 0.35 |

**Table – I Physical & thermal properties of AA 6061-T6**

| Property | Value |
|---|---|
| Density (kg/m$^3$) | 7870 |
| Specific heat (J/kg-K) | 460 |
| X-Conductivity (W/m-K) | 24.3 |
| Y-Conductivity (W/m-K) | 24.3 |
| Z-Conductivity (W/m-K) | 24.3 |
| Young modulus (Pa) | 2.10E+11 |
| Poisson ratio | 0.35 |

**Table – II Physical & thermal properties of H – 13**

### 3.2. Selection of process parameters

In this research work, Five levels of rotational speed (600, 800,1000,1200,1400 rpm) and traverse speed (60, 80,100,120,140 mm/min) have been selected to study their effects on output variables like peak temperature and flow stress with the help of simulations.

| Variables | Levels | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Rotational speed (RPM) | 600 | 800 | 1000 | 1200 | 1400 |
| Traverse speed (mm/min) | 60 | 80 | 100 | 120 | 140 |

**Table – III Input parameters and their levels for simulation**

## IV RESULTS & DISCUSSION

From this research work, it can be found that both the input parameters have significant effects on output variables. It can also be found that as the rotational speed increases and traverse speed decreases, the value of peak temperature increases as shown in fig. 4 and hence the value of flow stress decreases as shown in fig. 5, as the material will flow in a better way at higher temperature. The maximum peak temperature (648°C) and minimum flow stress (48 MPa) is obtained at 1200 rpm and 60 mm/min as shown in table IV. For the rotational speed of 1400 rpm, the software didn't give the converged solution. So the results from Sr. no. 21-25 can't be considered in the analysis. Fig. 2 shows the result of peak temperature generated in hyperworks 11.0 for 1200 rpm of rotational speed and 60 mm/min of traverse speed. The result shows that the maximum peak temperature is generated around the pin i.e. 611 to 685°C. So, the average value of peak temperature has been considered here i.e. 648°C. And the region for the maximum peak temperature and minimum flow stress is same. So the flow stress has also been observed in similar way as shown in fig. 3.

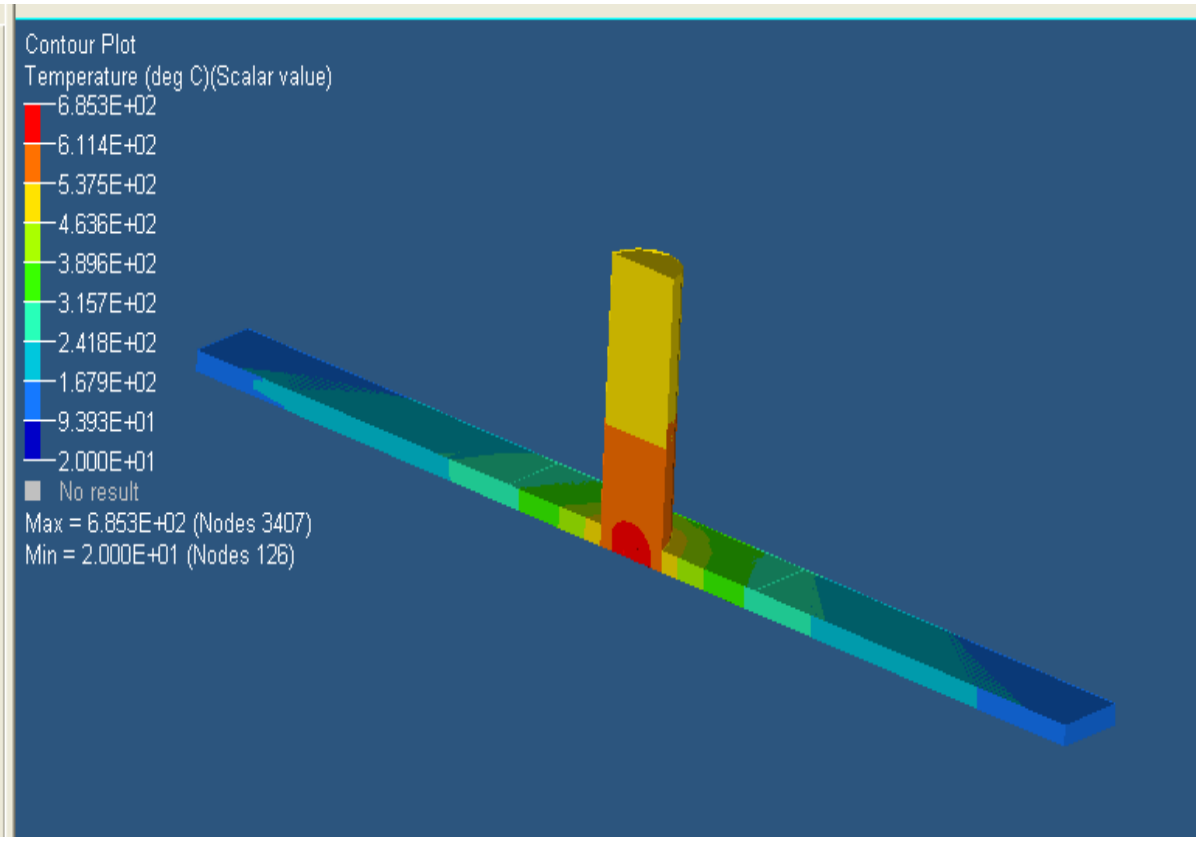


**Fig. 2 Result of peak temperature generated in Hyperworks 11.0**

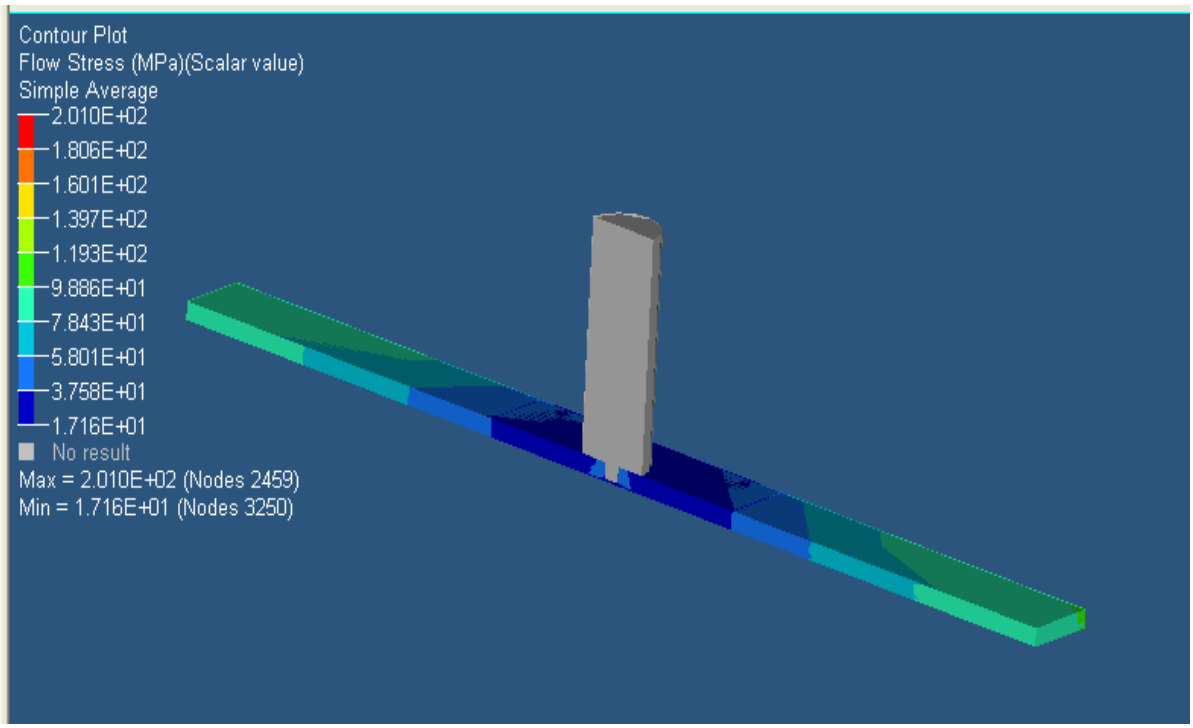


**Fig. 3 Result of flow stress generated in Hyperworks 11.0**

| Sr. no. | RS (RPM) | TS (mm/min) | Peak temp. (˚C) | Flow stress (Mpa) |
|---|---|---|---|---|
| 1 | 600 | 60 | 489.5 | 63.5 |
| 2 | | 80 | 479 | 65.5 |
| 3 | | 100 | 470.5 | 67 |
| 4 | | 120 | 464 | 68.5 |
| 5 | | 140 | 458 | 69.5 |
| 6 | 800 | 60 | 551 | 56.5 |
| 7 | | 80 | 541 | 58.5 |
| 8 | | 100 | 532.5 | 60 |
| 9 | | 120 | 525 | 61 |
| 10 | | 140 | 519 | 62 |
| 11 | 1000 | 60 | 602 | 52 |
| 12 | | 80 | 592.5 | 54 |
| 13 | | 100 | 583 | 55.5 |
| 14 | | 120 | 576 | 56.5 |
| 15 | | 140 | 569.5 | 57 |
| 16 | 1200 | 60 | 648 | 48 |
| 17 | | 80 | 632 | 50.5 |
| 18 | | 100 | 623.5 | 52.5 |
| 19 | | 120 | 615.5 | 53.5 |
| 20 | | 140 | 609.5 | 54 |
| 21 | 1400 | 60 | 596.5 | 52 |
| 22 | | 80 | 636 | 49.5 |
| 23 | | 100 | 648 | 50 |
| 24 | | 120 | 644 | 51.5 |
| 25 | | 140 | 638 | 52 |

**Table – IV Input parameters and output variables**

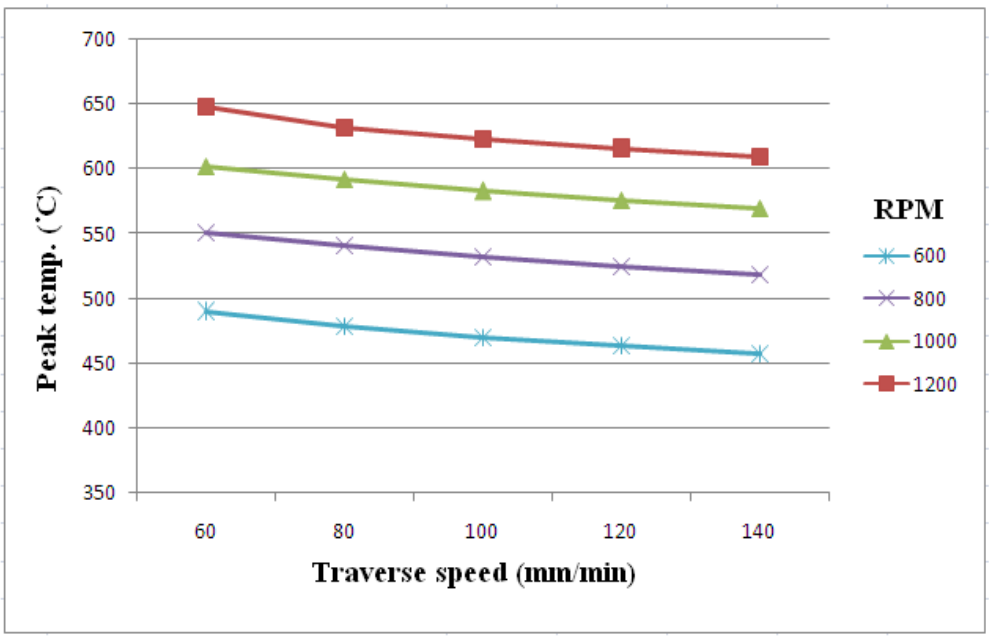


**Fig. 4 Graph of peak temperature versus traverse speed**

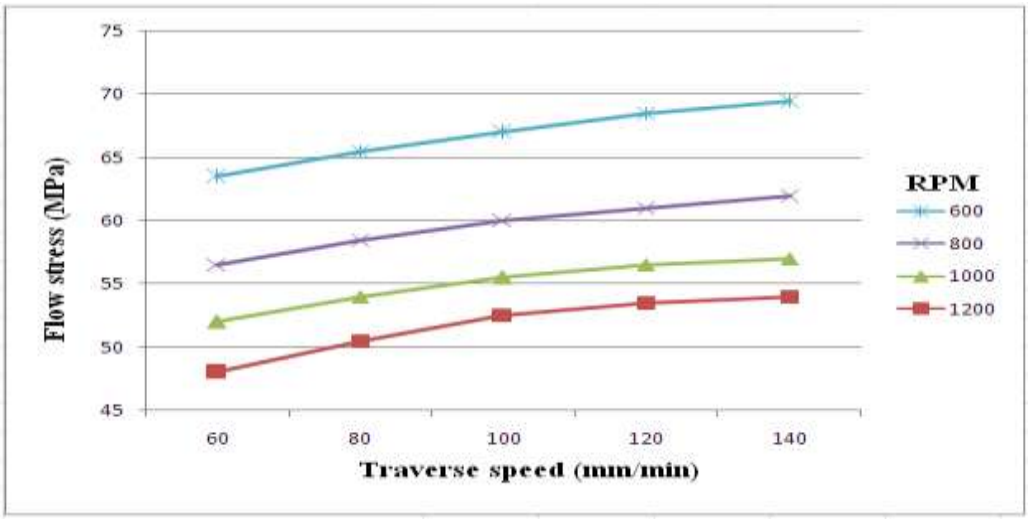


**Fig. 5 Graph of flow stress versus traverse speed**

## V CONCLUSION

From the above results, it can be said that the process parameters such as tool rotational speed and tool traverse speed play an important role in obtaining a specific temperature distribution and subsequent flow stresses within the material being welded, the former controlling the micro structure and in turn, mechanical properties and later, the flow of material which depends up on the peak temperatures obtained during FSW. It can also be said that, the max. Peak temperature and min. flow stress are observed at high rotational speed and low traverse speed. As the peak temperature generated is associated with the microstructure and mechanical properties (Lower temperature can cause the defects like porosity, cracks etc… and if the temperature generated is higher than the melting temperature then it may be the chances of splashing out of the material) and flow stress is associated with the energy consumption (The lower is the flow stress, the lesser is the energy required to carry out the weld) both the output variables need to be analyzed.

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# OVERVIEW OF PALMPRINT IDENTIFICATION TECHNIQUE

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## ABSTRACT

*Biometrics refers to automatic recognition of people based on their anatomical and behavioural characteristics. Biometrics is the effective method of person identification of with high accuracy. In this paper, we are studying two different wavelet based palmprint identification techniques. These techniques are basically based on discrete wavelet transform and contourlet transform. The comparison of these two palmprint identification techniques is shown by using different palmprint images and also quantitative results showing the superiority between these two palmprint identification techniques.*

***Keywords: Biometrics, Palmprint, Anatomical, Behavioural***

## I INTRODUCTION

Person identification is an important part of the infrastructure. Palmprint is widely used in personal identification for an accurate recognition. There are many features like principle lines, ridges, wrinkles, minutias, singular points and texture present in palmprint image which can be used for person identification.

Palmprint identification using transform domain is a new topic and on this domain there are many algorithms present. Wavelet transform is an essential tool in the palmprint recognition. Here, two transform base palmprint identification techniques are shown. The first technique is based on discrete wavelet transform and the second technique is based on contourlet transform. Both these techniques are compared using different palmprint images.

### 1.1 Discrete Wavelet Transform

Wavelets are mathematical functions that satisfy certain properties and can be used to transform one function representation into another. Any decomposition of an image into wavelets involves a pair of waveforms: one represents the high frequency and one represents the low frequency.DWT is more efficient technique and has the benefit of extracting non-overlapping information about the signal.2-D transform can be obtained by performing two 1-D transform.

Figure 1 represent that how Discrete Wavelet Transform works.

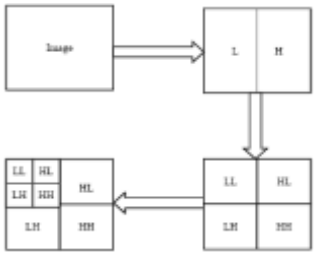



**Figure 1.Discrete Wavelet Transform**

### 1.2 Discrete Cosine Transform

Discrete cosine transform (DCT) is the basis of many image compression methods.DCT constitutes a powerful tool in signal processing. It transforms a signal from a spatial domain into a frequency representation. The main advantage of DCT is its high energy compactness. It is widely used as feature extraction.

### 1.3 Contourlet Transform

Contour refers to an outline. Mathematically it is a curve along which the function has constant value.Contourlet transform is filter bank structure that can deal efficiently with piecewise smooth images with smooth contours. The resulting image is the directional multiresolution analysis framework composed of contour segment. Hence it is named as contourlet.Contourlet transform overcomes the dis-advantages of wavelet transform. It is a double filter bank structure. It provides the representation for two-dimensional piecewise smooth signals that resemble images.

## II LITURATURE SURVEY

In 2004, the authors [5] showed that the biometrics has the potential to become an irreplaceable part of many identification systems. Consequently, person identification is an integral part of the infrastructure such as finance, health care, transportation, entertainment, law enforcement, security, access control, border control, government and communication.

First online multi-spectral palmprint recognition system which is never designed before introduced in [3].It uses multispectral capture device to sense images under different illumination. Authors use competitive coding scheme as matching algorithm, which performs well in online palmprint recognition.Wavelet-based image fusion is used as data level fusion scheme.

In [6], authors develop a three-dimensional (3D) palmprint identification system.Two-dimansional (2D) has dis-advantage of noise effect like scrabbling and dirt in palm. To overcome these dis-advantages, 3D system is used. The Palmprint Identification Using Transform Domain and Spatial Domain Technique (PITS) is introduced in [12].To enhance the contrast of an image, histogram equalization is used.Then on histogram equalized image, DWT is applied to separate low frequency and high frequency components.Then on low frequency components, DCT is applied. Finally the Euclidean Distance (ED) is used to compare database and test image. In [13], contourlet transform is used for palmprint recognition. In this, authors use Gray-Level Contourlet Matrix (GLCM) to extract feature vector. Then Linear Discriminant Analysis (LDA) is used to reduce the

dimensionality of feature vector. In this system also, the Euclidean Distance (ED) is used to test the results of database and test images.

## III PROBLEM DEFINITION

Here, we defined the fundamental problems in palmprint recognition (i) accuracy, (ii) scale, (iii) security and (iv) privacy.Biometric systems have to establish fault tolerance limits.In the field like banking, security of the individual has high importance. Traditional methods such as names and passwords are not reliable because they can be stolen or forgotten. Also to increase correct recognition rate is the main objective of palmprint identification.

Feature extraction from palm area is the major issue. It is somewhat a difficult process. It can determine how complex and efficient is the identification system. Hence, extraction of region of interest is also the important issue. Also large-scale identification applications require a large sustainable output with as little human power.

## IV PALMPRINT IDENTIFICATION TECHNIQUES

### 4.1 Palmprint Identification using Transform and Spatial Domain (PITS)

PITS stands for 'Palmprint Identification using Transform Domain and Spatial Domain'.Palmprint is the physiological biometric trait of person. The features from palmprint can be extracted by transform domain and spatial domain. Here, the transform domain technique used is Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT).

Again the spatial domain technique used is Principal Component Analysis (PCA).Palmprint has the characteristics of uniqueness, reliability and security.Palmprint recognition procedure has three steps namely (i) pre-processing, (ii) feature extraction and (iii) matching. Person can be identified using PITS technique as shown in the figure 2.The Poly-U multispectral database is used to analyse the PITS algorithm. There are forty-six palm images. Out of them, twenty-eight images are used to create database. The remaining are used as test images.

Both the images in database and test are first histogram equalized. Histogram equalization varies the contrast of an image. Hence, it increases the clarity of image.Then the two-dimensional Discrete Wavelet Transform (2D-DWT) is applied on images. Now, we obtain four different bands of low frequency and high frequency. They are namely approximation band, horizontal band, vertical band and diagonal band. Large content of information about image is present in approximation band.

A Discrete Cosine Transform (DCT) has a feature of strong energy compaction. Hence it is used in signal processing and image processing. The low frequency components are converted into DCT components.DCT gives in general good features for object description. More precisely, DCT transforms a signal from the spatial domain to the frequency space, with minimum information redundancy. Like other transforms, the Discrete Cosine Transform (DCT) attempts to decorrelate the image data. After decorrelation each transform coefficient can be encoded independently without losing compression efficiency. Principal Component Analysis (PCA) is used to obtain the palmprint features eigen values and eigen vectors are obtained with the help of PCA.

The objectives of PITS algorithm are:

(i)To increase correct recognition ratio (CRR)

(ii)To decrease false acceptance rate (FAR)

(iii)To reduce false rejection rate (FRR)

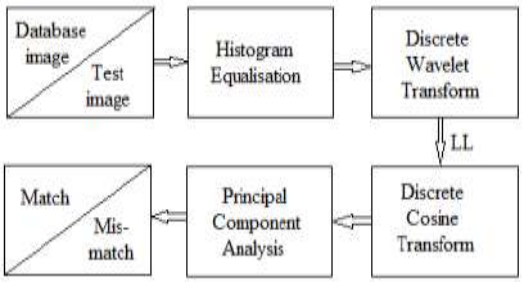


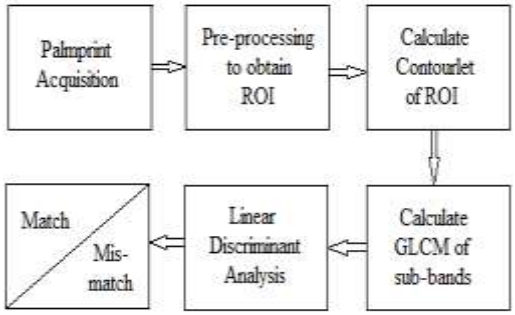

**Figure 2 Block diagram of PITS algorithm based palmprint identification system**

### 4.2 Palmprint Identification using GLCM of contourlet transform

Feature extraction is the important step in palmprint identification. Texture-based technique is more efficient to extract features from image. Gabor filter can be efficiently applied to the palm region to extract texture features of the palm. Texture features are used in this system. Figure 3 shows the block diagram of GLCM-based palmprint identification system.

In this scheme, palmprint images are obtained from Poly-U database is used. The background of all images has low intensity. Hence, all the palmprint images are not suitable for identification. Most useful part of palmprint is in center of palmprint.Only one threshold can extract the required area from palmprint image. Closing operation is performed due to lighting conditions.

To find ROI, centroid of the image is calculated.Contourlet transform is the extension of wavelet transform. It is two-dimensional transform. It overcomes the limitations of wavelet transform. After decomposition eight sub-bands can be obtained. They are represented in figure 4.



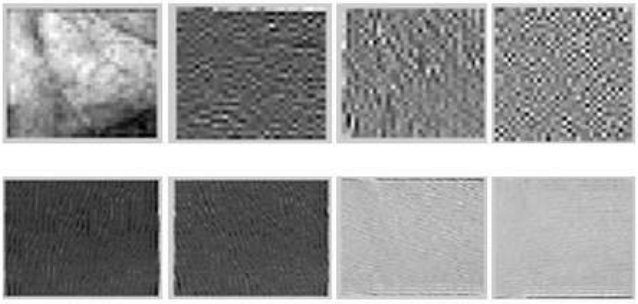



**Figure 3** **Figure 4**

**Figure 4 Block diagram of GLCM-based palmprint identification system**

**Figure 4 Different sub-bands calculated by contourlet transform**

Then for extracting features, Gray-level Contourlet Matrix of each sub-band is calculated. Then with the help of Linear Discriminant Analysis (LDA) low dimensional feature vectors are obtained.

### 4.3 Euclidean Distance(ED)

We can express the Euclidean distance between two i-dimensional vectors x and y as,

$$d_{x,y} = \sqrt{\sum_{i=1}^{i} (x_i - y_i)^2} \qquad 1$$

This is called as Euclidean distance. Euclidean distance is used to compare test features with database features for matching. For analysis, Euclidean distance of both database image and test image is calculated. Both are compared. If both are matching then the person is authorized. Otherwise he/she is un-authorized person.

## V RESULTS

Palmprint Identification Technique have been tested on several palmprint images to show the superiority of these techniques. The experimental results show that the Gray-Level Contourlet Matrix (GLCM) based palmprint identification system performs better than the PITS algorithm-based system. Our experiments are evaluated on the palmprint image database. After pre-processing, palmprint database derived from the original database.

Table 1 shows the comparison of accuracy of both the techniques.

Also some of the objectives of both the algorithms are namely (i) to increase Correct Recognition Rate (CRR), (ii) to decrease False Acceptance Rate (FAR) and (iii) to reduce False Rejection Rate (FRR).We have also compared both the algorithms based on these objectives.They are listed in table 2.

In order to evaluate the performance of both the algorithms we have used standard multispectral Poly-U palmprint database. This database contain all the gray scale images. There are in all forty-six palm images. Twenty-eight out of images of palm are used to create the database. The remaining are used for testing perpose only. Then database images and test images are histogram equalized to make the image illumination invariant. It varies the contrast of the image.

Our main objective is to find that which technique has better accuracy than the other. Contourlet transform is new, advanced and superior technique than wavelet transform. It is the two dimensional extension of wavelet transform.

**TABLE I**

**ACCURACY RESULTS FOR PITS ALGORITHM AND CONTOURLET TRANSFORM**

| System | Accuracy |
|---|---|
| Palmprint Identification using Texture and Spatial Features | 91.4% |
| Palmprint Identification using Contourlet Transform | 93.6% |

**TABLE II**

**COMPARISION OF BOTH THE PALMPRINT IDENTIFICATION TECHNIQUES ON THE BASIS OF DIFFERENT RECOGNITION RATES**

| Rate | Palmprint Identification using Texture and Spatial Features | Palmprint Identification using Contourlet Transform |
|---|---|---|
| CRR | 0.80 | 1 |
| FAR | 0.89 | 0.83 |
| FRR | 0 | 0 |

Both the proposed algorithms mainly focused on the objective of improving accuracy. Gray-Level Contourlet Matrix of contourlet transform technique is much better than Palmprint Identification using Texture features and Spatial features together.Contourlet transform provides improved results in terms of accuracy, correct recognition rate, false acceptance rate and false rejection rate.

In table 1 we can see that the accuracy obtained from wavelet transform or PITS algorithm is 91.6% and the contourlet transform provides 93.6%.Correct recognition rate from PITS algorithm is 80% and that of GLCM technique is 100%.CRR should be as high as possible. False acceptance rate from PITS is 89% and from GLCM is 83%.Also false rejection rate from PITS algorithm as well as GLCM technique is 0%.FRR should be as low as possible. All the results are displayed in the tabular form in table 1 and table 2.

Again the steps in pre-processing are more in number for GLCM technique than for PITS technique. Different sub-bands of palmprint image are obtained before matching in GLCM.So that there is large content of useful information in this method. This is not possible in wavelet transform. Automatically the accuracy output from GLCM is better than PITS algorithm.

Hence, Contourlet transform based technique gives more accuracy than wavelet transform. The relation between accuracy of both the techniques is graphically shown by figure 5.

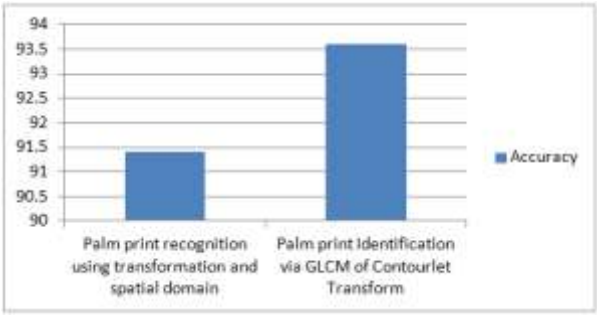



**Figure 5 Graphical Representation of accuracy of both Palmprint Recognition Algorithms**

## VI CONCLUSION

In this paper, comparison of two palmprint identification techniques are shown to improve the accuracy of biometric based person recognition system. Hence, we got a highly enhanced and sharper accuracy using both these identification techniques.

From all the visual and quantitative results, it is cleared that the output obtained from Gray-Level Contourlet Matrix of contourlet transform having high accuracy than output obtain from palmprint identification using texture features and spatial features.

## ACKNOWLEDGMENT

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# COMPARISON OF FEEDING TECHNIQUES FOR THE DESIGN OF MICROSTRIP RECTANGULAR PATCH ANTENNA FOR X-BAND APPLICATIONS

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## ABSTRACT

*A microstrip patch antenna is presented for wireless communication system. In this paper two different feeding techniques of microstrip rectangular patch antenna like direct line feed and proximity coupled feed is designed for the same dimensions of patch, feed and substrate. The designed antennas are resonating at the frequency of 7.5 GHz which is desired frequency for X-band applications. The frequency range for X-band application is 7 to 8 GHz. The Ansoft/Ansys HFSS V13 software is used to analyze the different results and some of them like return loss, bandwidth and gain is compared and discussed in this paper*.

***Keywords: Bandwidth, Gain, HFSS, Microstrip Patch Antenna, Return Loss.***

## I INTRODUCTION

Microstrip antennas have many attractive features that are draws the attention of researchers over the past work [1-2]. Microstrip antennas are used in number of applications like biomedical diagnosis and wireless communication [3]. With the rapid growth of the wireless communication system the future technologies need very small, compact and multiband antennas. Nowadays, people demand multiband wireless phone supporting more than one network, having different frequencies and simultaneous transmission of video, audio and data. These services are possible with the help of microstrip patch antenna having multiband characteristics. Modern wireless communication system also requires low profile, light weight, high gain, ease of installation, high efficiency, simple in structure to assure reliability and mobility characteristics. Microstrip antennas satisfy such requirements. Research on microstrip antenna in 21$^{st}$ century aims at size reduction, increasing gain, wide bandwidth, multiple functionality and system level integration. Significant research work has been reported on increasing gain and bandwidth of microstrip antennas. Many techniques have been suggested for achieving wide bandwidth [4-5]. Main advantage of microstrip antenna includes low profile easy to fabricate (use etching and photolithography), easy to feed (proximity coupled, microstrip line, etc.) and easy to use in array of incorporate with other microstrip circuit elements [6].

In this paper two feeding techniques microstrip line feed and proximity coupled feed are compared.

The remaining paper is organized as follows section 2 gives information about types of feeding techniques. Section 3 shows the design of microstrip rectangular patch antenna using two different feeding techniques. Section 4 gives the comparative analysis of microstrip line feed and proximity coupled feed antennas with its results. Section 5 and 6 gives conclusions and references respectively.

## II FEEDING TECHNIQUES

There are many techniques are used to feed or transmit electromagnetic energy to a microstrip patch antenna. The feeding is very important for the efficient operation of antenna to improve the antenna input impedance matching. The two feeding techniques used in this paper are microstrip line feeding and proximity coupled feeding.

### 2.1 Microstrip Line Feeding

Microstrip line feeding is a technique in which a conducting strip is connected directly to the edge of the microstrip patch as shown in figure 1. The width of conducting strip is smaller as compared to the patch. This type of feeding arrangement has the advantage that the feed and patch can be etched on the same substrate to provide a planar structure. The inset cut is introduced in the patch to match the impedance of the feed line to the patch; by using inset cut in the patch additional impedance matching element is not required. This can be achieved by controlling the inset position properly. Hence this feeding scheme is easy as compared to others, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used increases, which also increases surface waves and spurious feed radiation, and hampers the bandwidth of the antenna [7].

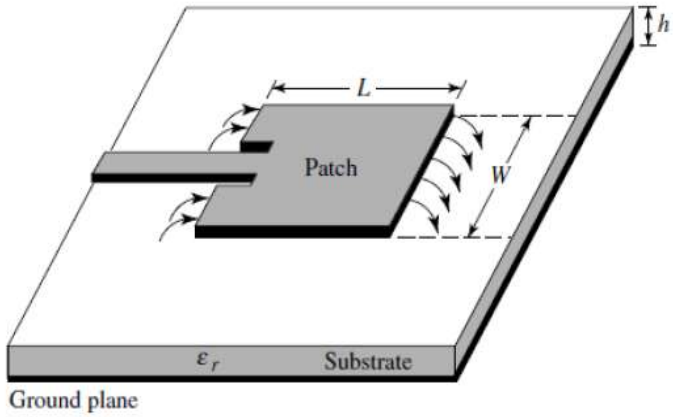



**Fig. 1: Rectangular microstrip patch antenna with inset line feeding [7-8]**

### 2.2 Proximity Coupled Feeding

This method uses electromagnetic coupling between the feed line and the radiating patches, printed on separate substrates [7]. Two dielectric substrates are used such that the radiating patch is on top of the upper substrate and feed line is between the two substrates. The advantage of this coupling is that it yields the largest bandwidth compared to other coupling methods, it is somewhat easy to model and has low spurious radiation. This feeding method also provides choices between two different dielectric media, one for the feed line and one for the patch to optimize the individual performances. Matching can be achieved by controlling the width-to-line ratio of the patch and length of the feed line. The major disadvantage of this feeding scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment. Also, the overall thickness of the antenna also increases [7].

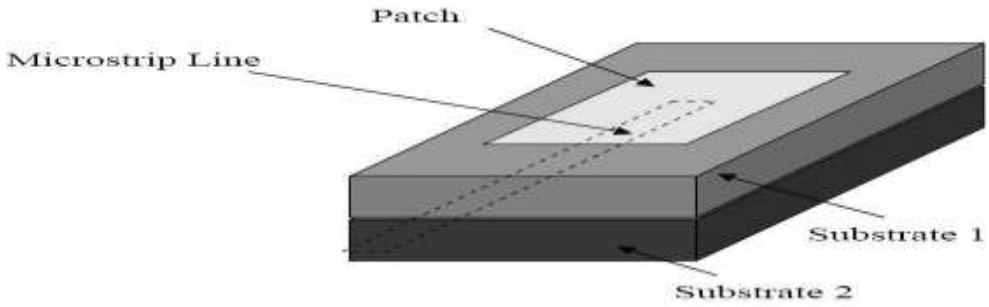



**Fig. 2: Proximity coupled feeding for patch antenna [7]**

## III DESIGN OF RECTANGULAR MICROSTRIP PATCH ANTENNA USING DIFFERENT FEEDING TECHNIQUES

In this the microstrip rectangular patch antenna using two types of feeding techniques is designed using HFSS V13 software. The dimensions of patch and the feed are same in all the feeding techniques. The patch and feed is fabricated on the same substrate (Rogers RT/duroid 5880) whose relative permittivity is 2.2. The dimensions of the patch and feed of feeding techniques are shown in Table 1.

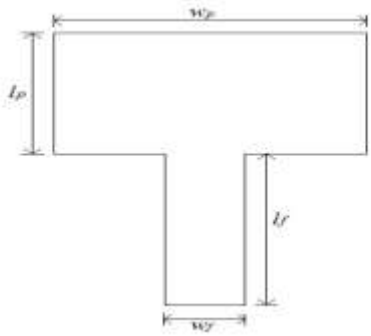


**Fig. 3: Geometry of rectangular microstrip patch antenna**

**Table 1: Dimensions for the rectangular microstrip patch antenna for different feeding techniques**

| Feeding Techniques | Patch width (*wp*) | Patch length (*lp*) | Feed line width (*wf*) | Feed line length (*lf* ) |
|---|---|---|---|---|
| Microstrip Line | 16 mm | 12.45 mm | 3.9575 mm | 15.5 mm |
| Proximity Coupled | 16 mm | 12.45 mm | 3.9575 mm | 15.5 mm |

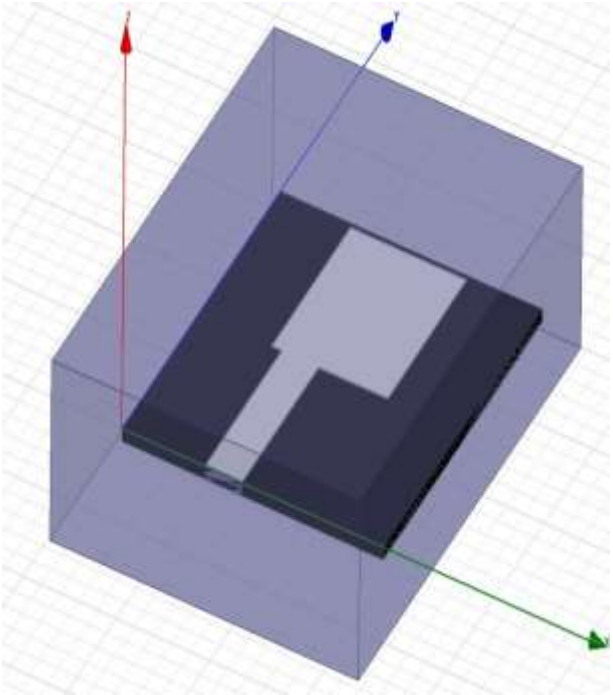


**Fig. 4: Design of rectangular microstrip patch antenna using line feed**

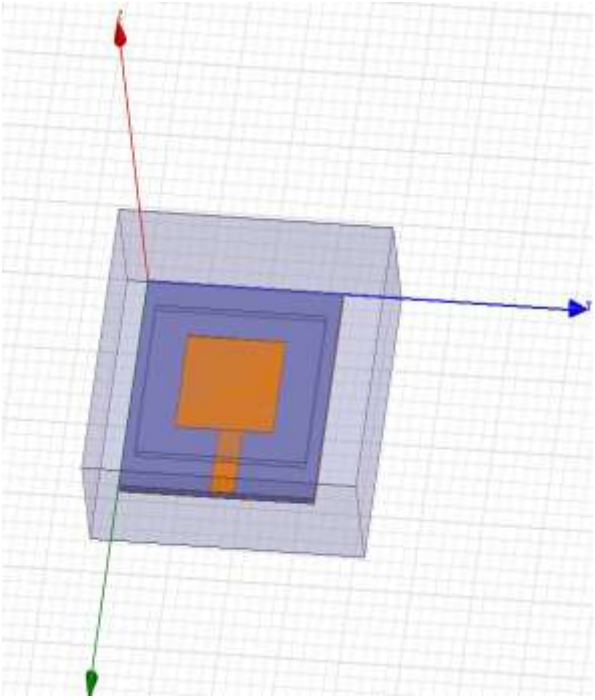


**Fig. 5: Design of rectangular microstrip patch antenna using proximity coupled feed**

## IV RESULTS

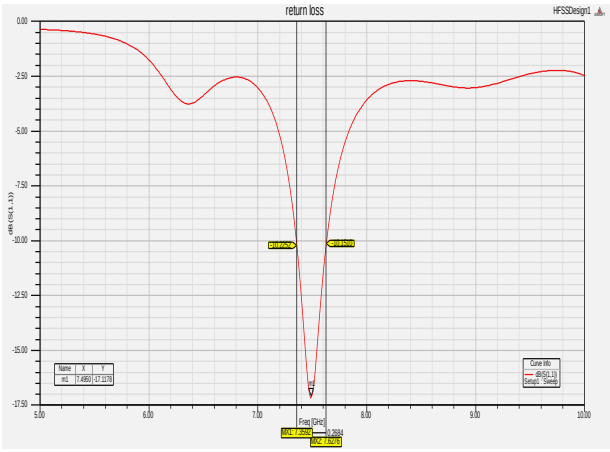
### 4.1 Return Loss and Bandwidth

Return loss is the difference between forward and reflected power in dB, generally measured at the input to the feed connected to the antenna [9]. If the power transmitted from the source is $P_T$ and the power reflected back to the source is $P_R$, then the return loss is given by $P_R/P_T$. For maximum power transfer, the return loss should be as small as possible. This means that the ratio should be as small as possible.

*Bandwidth Calculation= f2-f1*

Where *f1* and *f2* are lower and upper frequencies.

These upper and lower frequencies are calculated from the Return Loss curve of the feeding techniques discussed in figure 6 and 7. The corresponding bandwidth is shown in Table 2.



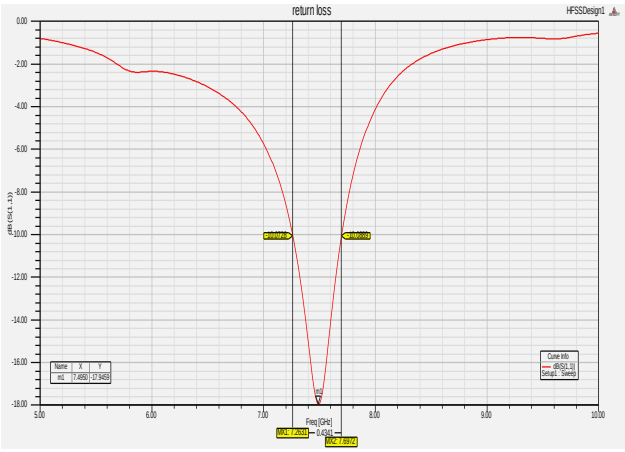



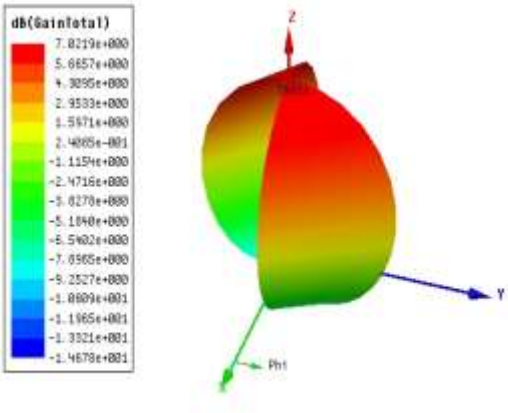

**Fig. 6: Return loss (in dB) of microstrip line feed** **Fig. 7: Return loss (in dB) of proximity coupled feed**

**Table 2: Comparison of Return Loss and Bandwidth of different Feeding Techniques**

| Feeding Techniques | Resonate Frequency of Antenna | Return Loss | Bandwidth | Gain |
|---|---|---|---|---|
| Line Feed | 7.4950 GHz | -17.11 dB | 0.2684 GHz | 7.02 dB |
| Proximity Coupled Feed | 7.4950 GHz | -17.94 dB | 0.4341 GHz | 7.17 dB |

## 4.2 Gain

Gain describes the efficiency and directional capabilities of the antenna [7]. Three dimensional radiation pattern of rectangular microstrip patch antenna with Line feed and Proximity coupled feed are shown in figure 8 and 9 respectively and calculated gain is shown in Table 2.



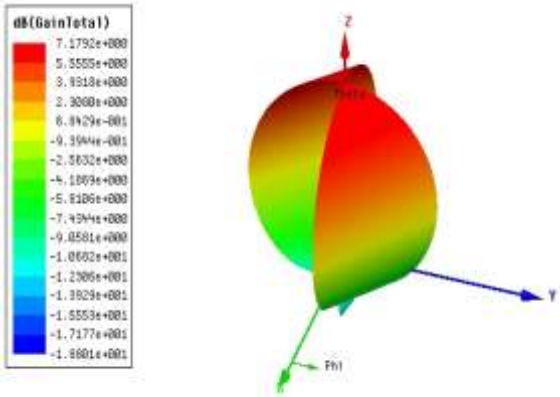




**Fig. 8: Gain of microstrip line feed** **Fig. 9: Gain of proximity coupled feed**

## V CONCLUSIONS

The rectangular microstrip patch antenna of same dimensions using two different feeds has been designed and simulated using HFSS V13 software. The Gain, Bandwidth and return loss of different feeding antennas has been calculated. From the Table 2 it is clear that the Proximity Coupled feed has better gain, return loss and bandwidth then Line feed. Thus the Proximity Coupled feed is more useful for the X-Band applications.

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# RIDE COMFORT ANALYSIS OF QUARTER CAR MODEL ACTIVE SUSPENSION SYSTEM SUBJECTED TO DIFFERENT ROAD EXCITATIONS WITH NONLINEAR PARAMETERS

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**ABSTRACT**

*Ride comfort is a key issue in design and manufacture of modern automobiles. It is necessary to design finer suspension system in order to improve the quality of vehicles. Most real-world phenomena exhibit nonlinear behavior.This paper addresses the ride comfort analysis of quarter car model active suspension system. The analyses uses different standard road inputs with and without consideration of nonlinear behaviour of suspension spring. In this study the equations of motion are derived for quarter car model active suspension system. Theactive suspension system is proposed based on the Proportional Integral Derivative (PID) control technique for the enhancement of its ride comfort. The ride comfort analysis of the system has been determined by computer simulation using MATLAB/Simulink.*

***Keywords : Active Suspension,MATLAB/Simulink, Nonlinear, PID, Ride Comfort.***

## I INTRODUCTION

A car suspension system is the mechanism that physically separates the car body from the wheels of the car. Suspension system is one of the important part of the vehicle. Therefore, it is quite necessary to design finer suspension system in order to improve the quality of vehicles. Since the disturbances from the road may include uncomfortable shake and noise in the vehicle body, it is important to study the vibrations of the vehicle.

Suspension consists of the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. The main function of vehicle suspension system is to minimize the vertical acceleration transmitted to the passenger which directly provides road comfort. Traditionally automotive suspension designs have been compromise between the three conflicting criteria's namely road handling, load carrying, and passenger comfort. There are mainly three types of suspension system; passive, semi-active and active suspension system.

Traditional suspension consists springs and dampers are referred to as passive suspension, then if the suspension is externally controlled it is known as a semi active or active suspension [1].

Most real-world phenomena exhibit nonlinear behavior. There are many situations in which assuming linear behavior for physical system might provide satisfactory results. On other hand, there are circumstances or phenomena that require a nonlinear solution. A nonlinear structural behavior may arise because of geometric and material nonlinearities, as well as change in the boundary conditions and structural integrity. A nonlinear spring has a nonlinear relationship between displacement and force. A graph of force vs. displacement for a nonlinear spring will be more complicated than a straight line, with a changing slope. As nonlinear springs have different load-deflection characteristics than the linear spring, there will be difference in the amplitude of main mass obtained by theoretical and experimental methods [2].

Ride comfort is a key issue in design and manufacture of modern automobiles. Design of advanced suspension systems is one of the requirements, which provide a comfortable ride by absorbing the road disturbances as well as maintain the vehicle stability. A good amount of research activities has been directed to improve the ride comfort especially over the last decade[3].

The objective of this study is to determine ride comfort of quarter car model active suspension system for different road excitation by using MATLAB/Simulink with nonlinear parameters.

## II MODELING OF ACTIVE SUSPENSION SYSTEM

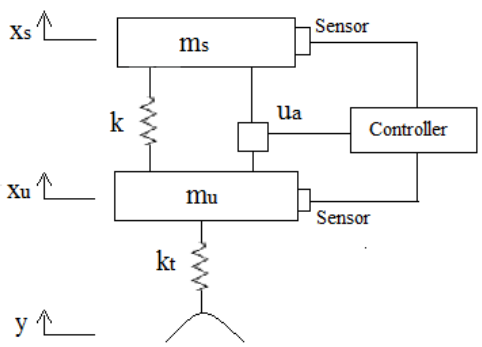


**Fig.1. Quarter Car Model Active Suspension System**

Quarter car model is used for suspension system analysis and design for its simplicity and yet ability to capture many important parameters. In Fig. 1, quarter car model active suspension system is shown. The sprung mass is denoted by '$m_s$'and unsprung mass is by '$m_u$'. Instead of damper, the force actuator is used in active suspension system. The tire is assumed to have only the spring feature and is in contact with the road terrain at the other end.

For this analysis the Hyundai Elantra Model is selected. The Suspension Parameters for Hyundai Elantra Model are, [4]

Sprung Mass: $m_s$: 236.12 kg

Unsprung Mass: $m_u$: 23.61 kg

Suspension Stiffness: k: 12394 N/m

Tyre Stiffness: $k_t$: 181818.88 N/m

Now, by applying Newton's Second Law of Motion for given system,

The equations of motion for the linear active suspension system are,

$$m_s\ddot{x}_s = -k(x_s - x_u) + u_a \quad (1)$$

$$m_u\ddot{x}_u = k(x_s - x_u) - k_t(x_u - y) - u_a \quad (2)$$

Where, y – Road displacement

$x_s$ – Sprung mass displacement

$x_u$ - Un-sprung mass displacement

$u_a$ – Actuator force

The non-linear effects included in the spring force $f_s$are due to two parts. One is bump stop which restricts the wheel travel within the given range and prevents the tire from contacting the vehicle body. And the other is strut bushing which connects the strut with the body structure and reduces the harshness from the road input. This non-linear effect can be included in spring force $f_s$with non-linear characteristic versus suspension rattle space ($x_s$- $x_u$) from the measured data on SPMD (Suspension Parameter Measurement Device) is as shown in Fig.2.

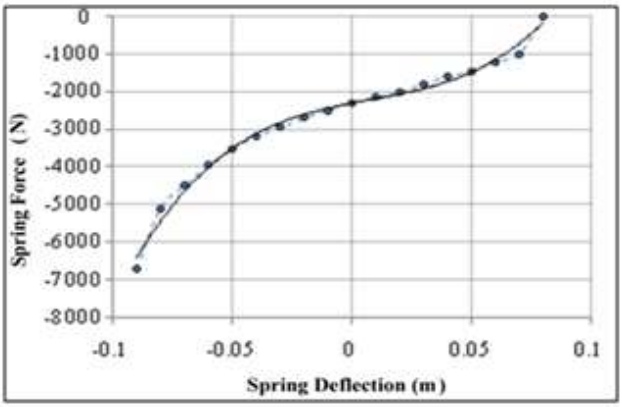


**Fig.2. Non-linear Spring Force Property of Hyundai Elantra Model Suspension Spring**

The spring force $f_s$is modelled as third order polynomial function

$$f_s = k_0 + k_1\Delta x + k_2\Delta x^2 + k_3\Delta x^3$$

Where the co-efficient are obtained from fitting the experimental data, which resulted in,

$k_3$ = 3170400 N/m$^3$, $k_2$= -73696N/m$^2$, $k_1$= 12394 N/m, $k_0$= -2316.4 N

(The SPMD data from the model Hyundai Elantra front suspension were used) [4]

Now, the equations of motion for active suspension system with nonlinear parameters are,

$$m_s\ddot{x}_s = [-\ k_0 - k_1(x_s - x_u) - k_2(x_s - x_u)^2 - k_3(x_s - x_u)^3] + u_a \quad (3)$$

$$m_u\ddot{x}_u = [k_0 + k_1(x_s - x_u) + k_2(x_s - x_u)^2 + k_3(x_s - x_u)^3] - k_t(x_u - y) - u_a \quad (4)$$

## III ROAD EXCITATION

Vehicle is assumed to be travelling over a road with velocity of 50 km/hr, during this travel the excitation frequency is calculated as,

$$\omega = \frac{2\,\pi\,V}{\lambda}$$

$$\omega = \frac{2\,\pi \times 50\ \times 1000}{6 \times 3600} = 14.55\ \frac{rad}{sec} = 2.31\ \text{Hz}$$

For the ride comfort analysis of quarter car model active suspension system, three different road excitations are considered.

### 3.1 Bump Excitation

A single bump road input, y as described by (Jung-Shan Lin 1997), is used to simulate the road to verify the developed control system. The road input described by Eq. (5) is shown in Fig.3.

$$a\,(1 - \cos\omega t\,) \qquad 0.4 < t < 0.9 \qquad (5)$$

In Eq. (5) of road disturbance, 'a' is set to 0.02 m to achieve a bump height of 4 cm.

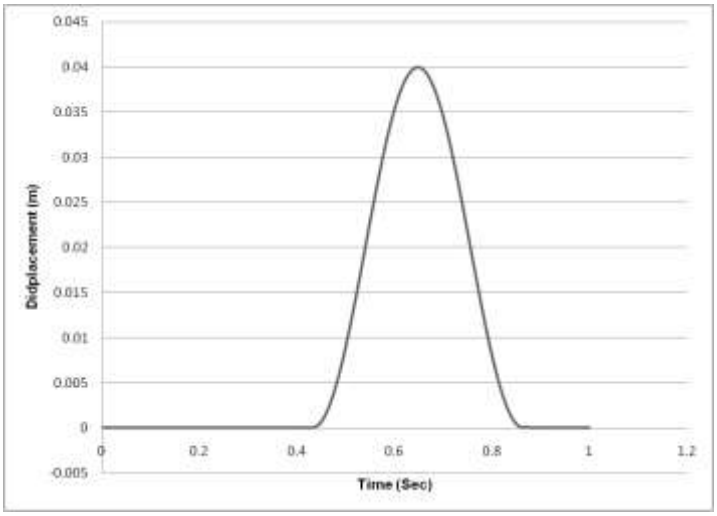


**Fig.3. Road Profile for Bump Excitation**

### 3.2 Step In Excitation

The Step InExcitation is represented by the Eq. (6),

$$y = \begin{cases} 0.00 & t < 0.43 \\ -0.04 & t \geq 0.43 \end{cases} \qquad (6)$$

Here the height of the road disturbance is maintained at 4 cm. The road input described by Eq. (6) is shown in Fig. 4

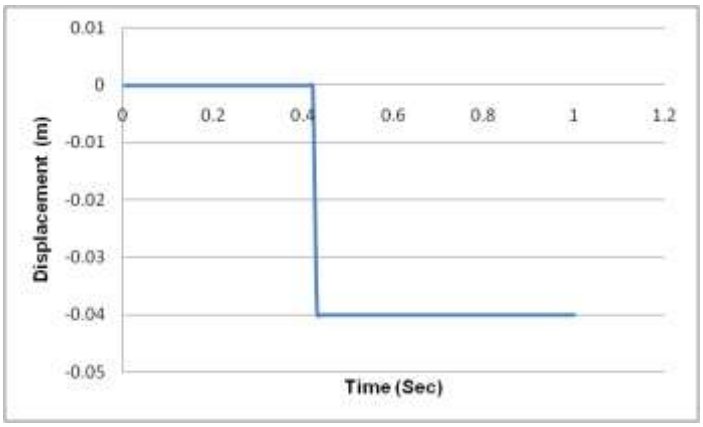


**Fig.4. Road Profile for Step In Excitation**

### 3.3 Rectangular Pulse Excitation

The Rectangular PulseExcitation is represented by the Eq. (7),

$$y = \begin{cases} 0.00 \rightarrow 0.43>t>0.86 \\ 0.04 \rightarrow 0.43 \leq t \leq 0.86 \end{cases} \quad (7)$$

Here also the height of the road disturbance is maintained at 4 cm. The road input described by Eq. (7) is shown in Fig. 5.

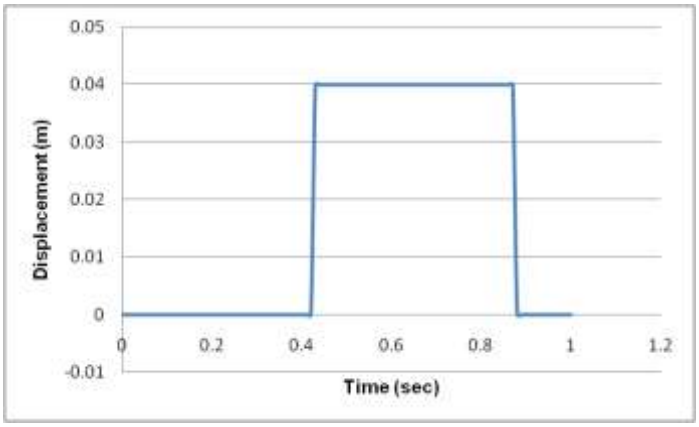


**Fig.5. Road Profile for Rectangular Pulse Excitatio**

## IV SIMULATION AND RESULTS

Mathematical modeling is transformed to computersimulation model and MATLAB/Simulink is usedfor the simulation. PID controller is used for controlling the force. For every system, PID controller should be set itsvalue with respect to the system. For this reason,PID controller had to be tuned with system. In thisresearch, Ziegler-Nicols Method is used to tune PID controller. According to the continuouscycle method (Ziegler-

Nichols Method) first thePID block was attached to the system by setting$K_P$=1, $K_I$=0, $K_D$=0.And then PID is tuned so that the response forthe disturbance is good [5].We tuned the PID controlleruntil the desired response was achieved.

Ride comfort analysis of quarter car model active suspension system for linear and nonlinear model is carried out in MATLAB/Simulink. For simulation the model variable-stepcontinuous solver ODE45 (Dormand-Prince) isused.

### 4.1 For Bump Excitation

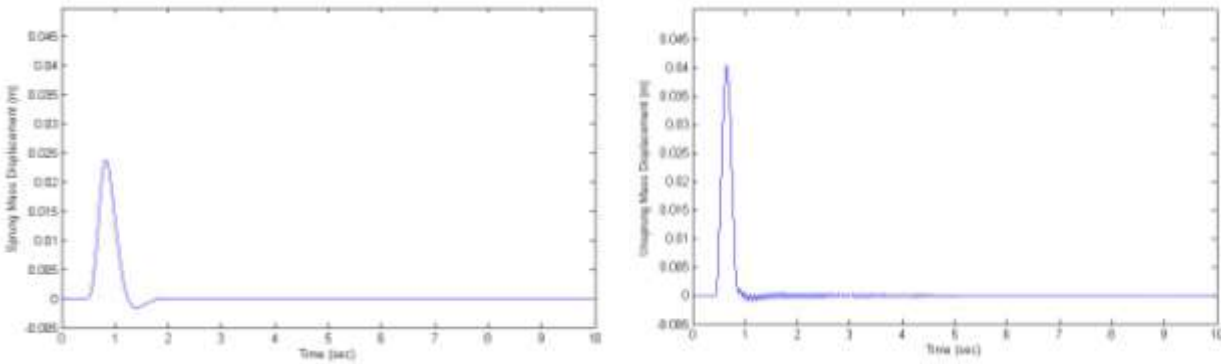

**Fig.6. Sprung and Unsprung Mass Displacement of Linear Active Suspension System**

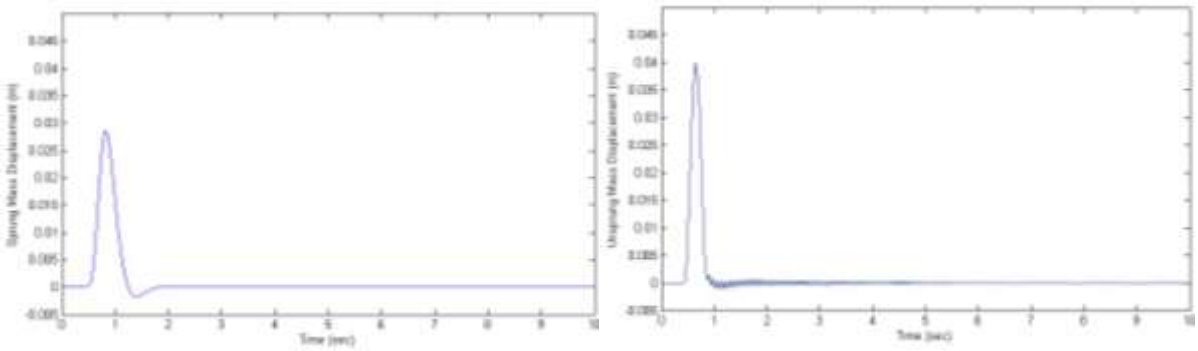

**Fig.7. Sprung and Unsprung Mass Displacement of Nonlinear Active suspension System**

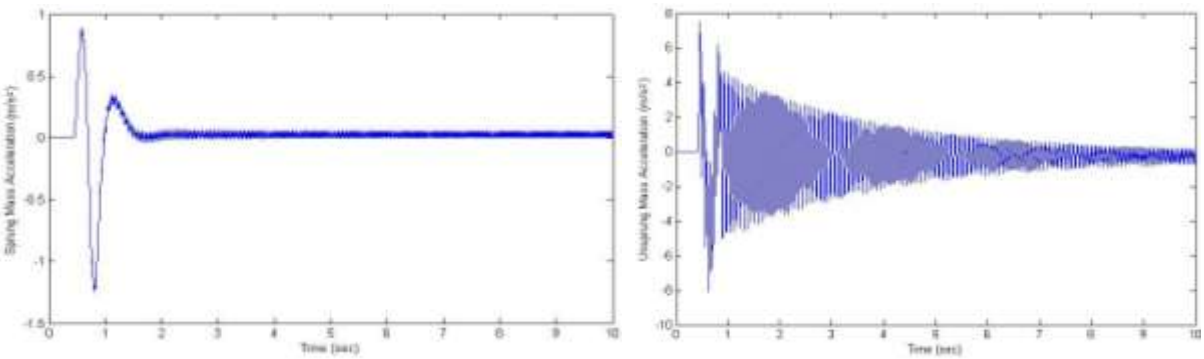

**Fig.8. Sprung and UnsprungMass Acceleration of Linear Active Suspension System**

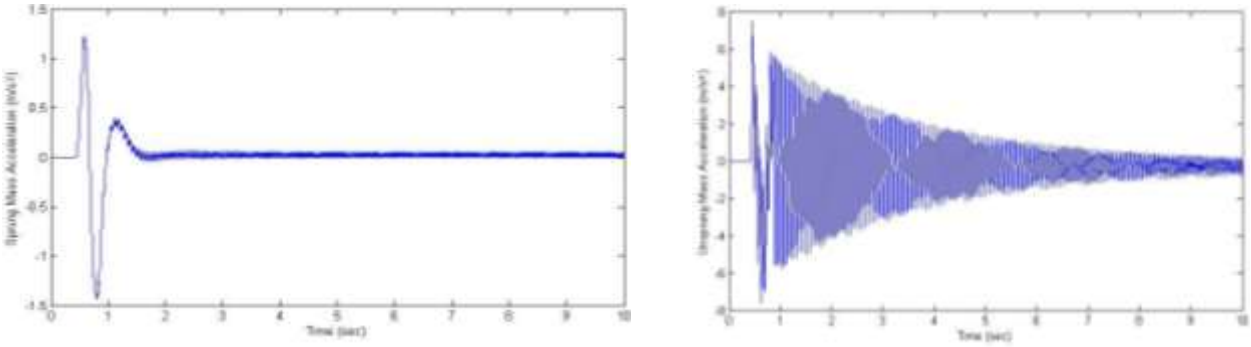

**Fig.9. Sprung and Unsprung Mass Acceleration of Nonlinear Active Suspension System**

**4.2 For Step In Excitation**

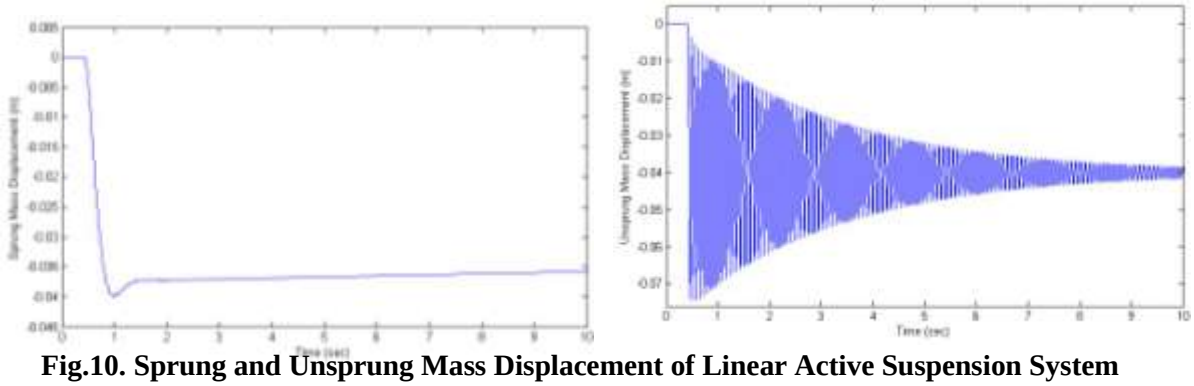

**Fig.10. Sprung and Unsprung Mass Displacement of Linear Active Suspension System**

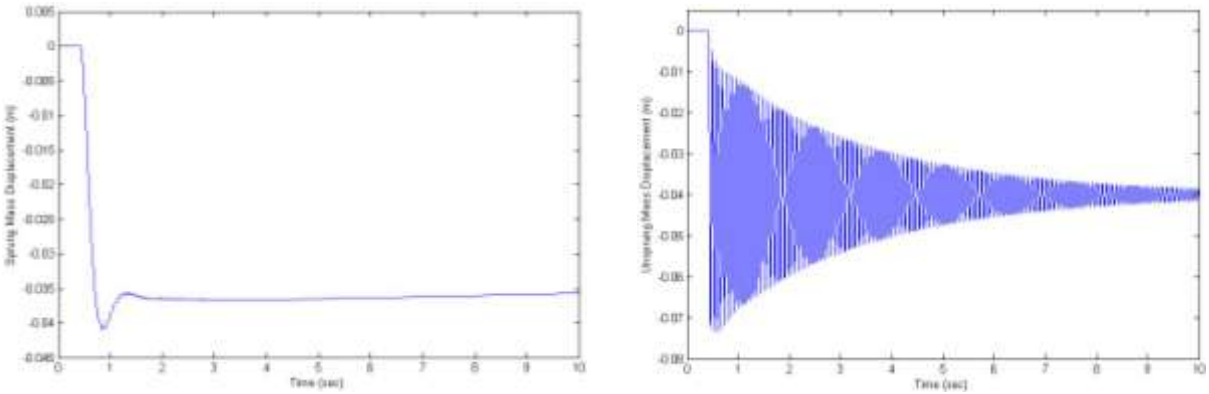

**Fig.11. Sprung and Unsprung Mass Displacement of Nonlinear Active suspension System**

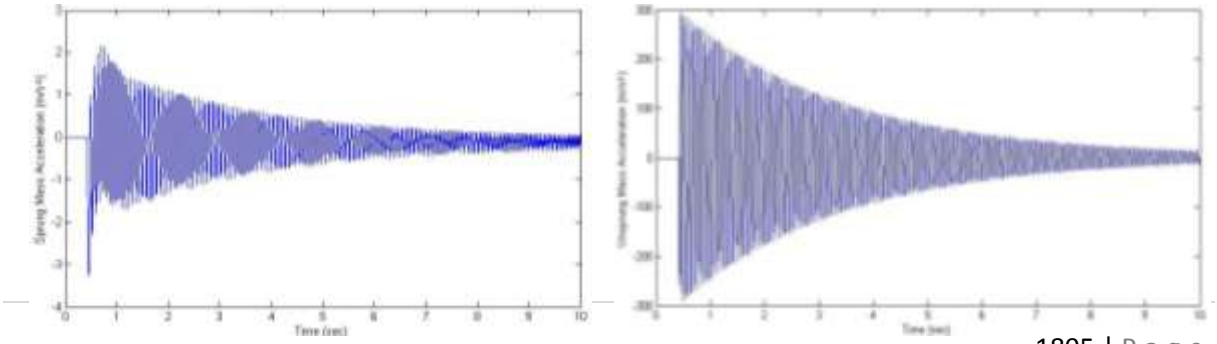

**Fig.12. Sprung and Unsprung Mass Acceleration of Linear Active Suspension System**

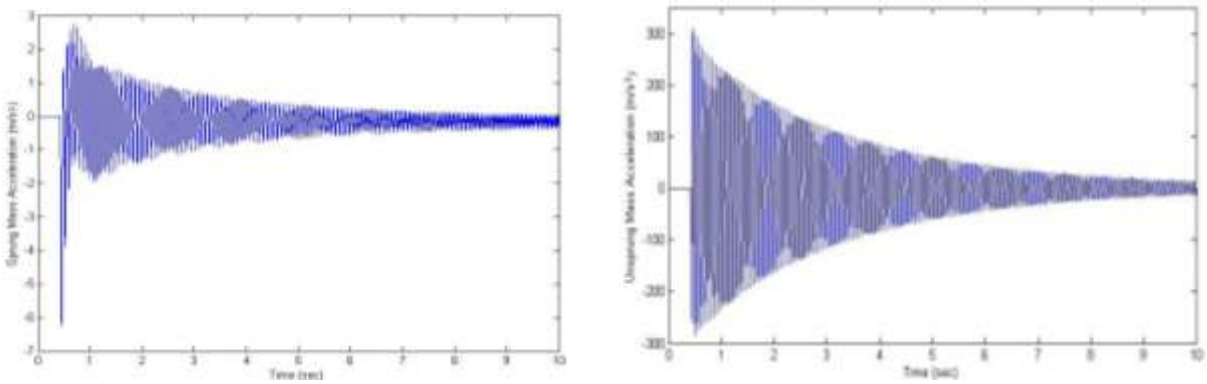

**Fig.13. Sprung and Unsprung Mass Acceleration of Nonlinear Active Suspension System**

**4.3 For Rectangular Pulse Excitation**

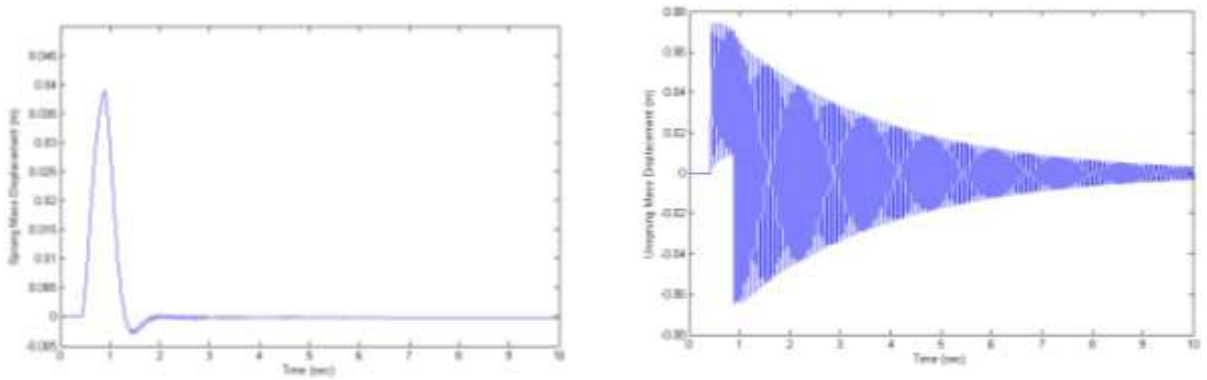

**Fig.14. Sprung and Unsprung Mass Displacement of Linear Active Suspension System**

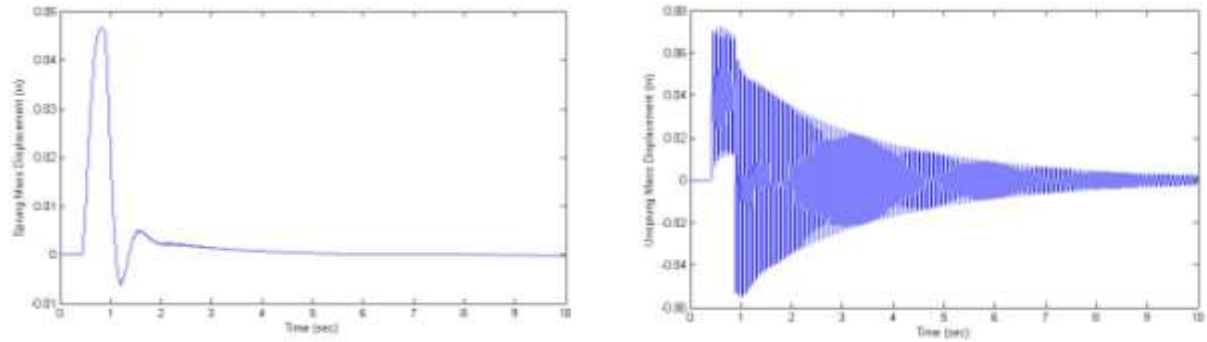

**Fig.15. Sprung and Unsprung Mass Displacement of Nonlinear Active suspension System**

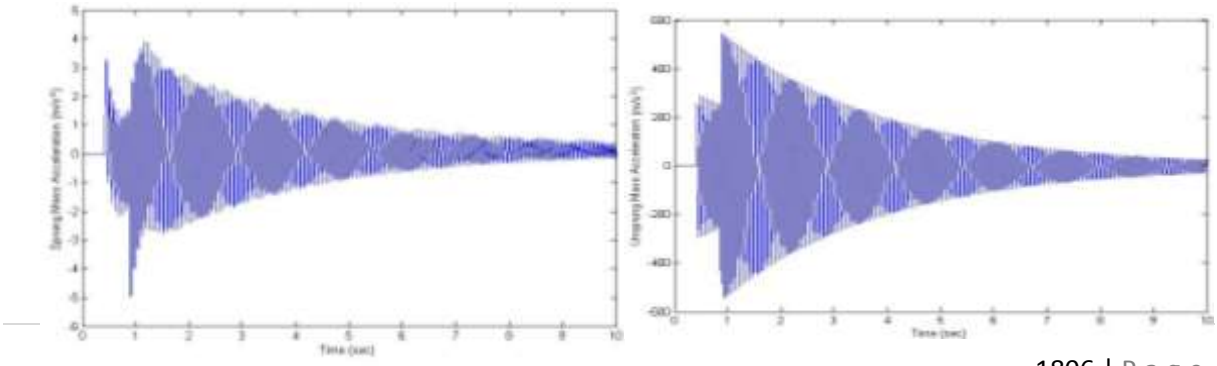

**Fig.16. Sprung and Unsprung Mass Acceleration of Linear Active Suspension System**

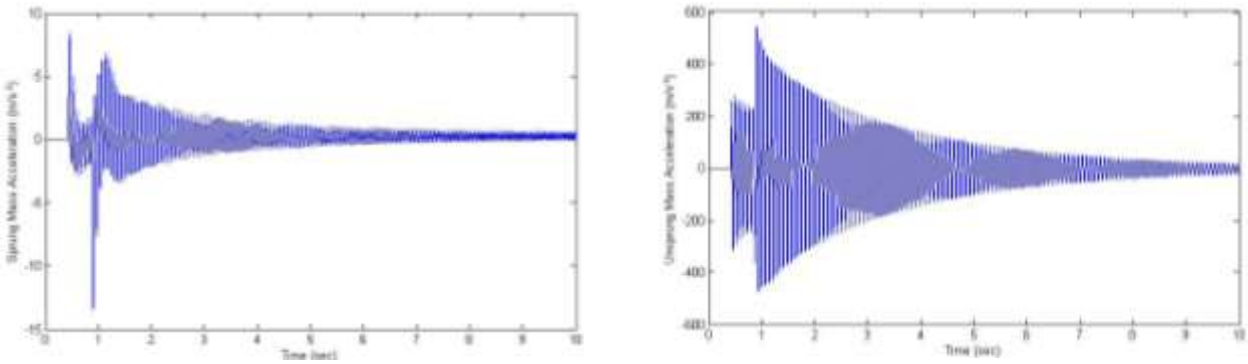

**Fig.17. Sprung and Unsprung Mass Acceleration of Nonlinear Active Suspension System**

## V CONCLUSION

From the results obtained from simulation, it is seen that importance of consideration of nonlinear parameter. When graph of nonlinear active suspension system is compared to linear suspension system for different road excitations, it is clearly seen that the behaviour of nonlinear active suspension system tends to more actual behaviour of the system. Therefore nonlinear parameters are required to be considered in the analysis, in order to achieve the real time result.

From simulation results it is seen that active suspension system reduces the disturbance coming from road and reduces the acceleration of sprung mass and provide good ride comfort.

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# ANALYSIS OF ANTI-ROLL BAR OF PASSENGER CAR USING ALTERNATIVE MATERIAL

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## ABSTRACT

*Now a day's customer demands comfortable car. This is accomplished by influencing the motions affected by road irregularities to the wheels and axles while minimizing their effect on the vehicle body and frame. Anti-Roll Bar is used in suspension system to limit the body roll angle. They are useful to improve the handling characteristics of the vehicle. In this paper the Anti-Roll Bar is designed. The Nylon is considered as alternative material for Anti-Roll Bar. It is also compared with Mild steel properties. Reducing un-sprung weight has an effect on the fuel consumption. Hence alternative material for analysis of anti-roll bar is selected and justified. The modeling and analysis is done using CATIA and ANSYS.*

***Keyword*: -Anti-Roll Bar, ANSYS, Nylon, Torsional Stiffness, Suspension System.**

## I INTRODUCTION

All suspension systems have a common goal, which is to improve the ride in terms of comfort, handling and safety. This is accomplished by influencing the motions effected by road irregularities to the wheels and axles while minimizing their affect on the vehicle body and frame. A successful design would therefore incorporate (a) A High sprung-to-unsprung-mass-ratio, (b) A Mass-Spring-Damper system between the vehicle body and the wheels, and (c) An Anti-Roll Bar. Consequently, the wheels and axles endure the most of the motions caused by road irregularities while their effect is minimized on the vehicle body as desired. The main goal of using anti-roll bar in suspension system to limit the body roll angle. They are useful to improve the handling characteristics of the vehicle. The ends of the anti-roll bar are connected to the suspension links while the center of the bar is connected to the frame of the car such that it is free to rotate. The ends of the arms are attached to the suspension as close to the wheels as possible. If the both ends of the bar move equally, the bar rotates in its bushing and provides no torsional resistance. But it resists relative movement between the bar ends, the bar's torsional stiffness-or resistance to twist-determines its ability to reduce such relative movement. The effective spring rate of the bar is determined by its length, cross section, shape, material and manufacturing process. In doing so, the anti-roll bar provides a level of resistance to the forces generated by the movement of the vehicle. This resistance is the key principal behind an anti-roll bar. In this paper torsional stiffness of anti-roll bar is improved using alternative material [1][2].

## II ALTERNATIVE MATERIAL

Fiberglass is a type of fiber reinforced plastic where the reinforcement fiber is specifically glass fiber. The glass fiber may be randomly arranged but is commonly woven into a mat. The plastic matrix may be a thermosetting plastic-most often epoxy, polyester resin- or vinylester, or a thermoplastic.An individual structural glass fiber is both stiff and strong in tension and compression-that is, along its axis. Although it might be assumed that the fiber is weak in compression, it is actually only the long aspect ratio of the fiber which makes it seem so; i.e., because a typical fiber is long and narrow, it buckles easily. On the other hand, the glass fiber is weak in shear-that is, across its axis. Therefore, if a collection of fibers can be arranged permanently in a preferred direction within a material, and if they can be prevented from buckling in compression, the material will be preferentially strong in that direction. Furthermore, by laying multiple layers of fiber on top of one another, with each layer oriented in various preferred directions, the material's overall stiffness and strength can be efficiently controlled. In fiberglass, it is the plastic matrix which permanently constrains the structural glass fibers to directions chosen by the designer. With chopped strand mat, this directionality is essentially an entire two dimensional plane; with woven fabrics or unidirectional layers, directionality of stiffness and strength can be more precisely controlled within the plane[3].

Nylon is very much suitable for hosiery and the knitted fabrics because of its smoothness, light weight and high strength. Nylon is lustrous fiber. The luster of the fiber can be modified by adding the de blustering agent at the molten stage. The nylons are polyamides with recurring amide groups. They contain carbon, oxygen, nitrogen and hydrogen elements. Nylon has good tenacity and the strength is not lost with age. Nylon has a high strength to weight ratio. It is one of the lightest textile fibers is at the same time also one of the strongest. It is one of the fibers which are added at the points of wear such as knees, toes and heels of socks. The strength of the nylon fabric is lost when wet. Nylon has excellent abrasion resistance. Nylon has good elasticity which makes it much suitable for the apparel purposes. The excellent elasticity would mean that the nylon materials return to their original length and shreds the wrinkles or creases. Nylon like other fibers has its own limit of elasticity. Nylon recovers to its original shape. If stretched too much, it will not completely recover its shape. The high elongation and excellent elastic recovery of nylon contributes to the outstanding performance. Nylon fabrics have excellent resilience. The heat conductivity of the nylon fabrics vary depending upon the fabric construction, the type of nylon (staple/filament) used in the construction. Good machinability and less cost easy to replace are some of the advantages of nylon.

## III ANTI-ROLL BAR ANALYSIS

This topic focuses the work did in the software’s for the analysis of the antiroll bar used in the vehicle. A Maruti Alto K10 model was used as the test vehicle to verify the results of the simulations. Nylon is used as alternative material for anti-roll bar with, anti-roll bar of nylon material has diameter 1.5 times diameter of anti-roll bar of mild steel material. The 3D model of the anti-roll bar is developed in the CATIA V5 R20 as depicted in fig.1. The model is developed after measuring the dimensions of the anti-roll bar in the 3D modeling environment. The boundary conditions and the constraints are applied on the model to simulate actual condition [4].

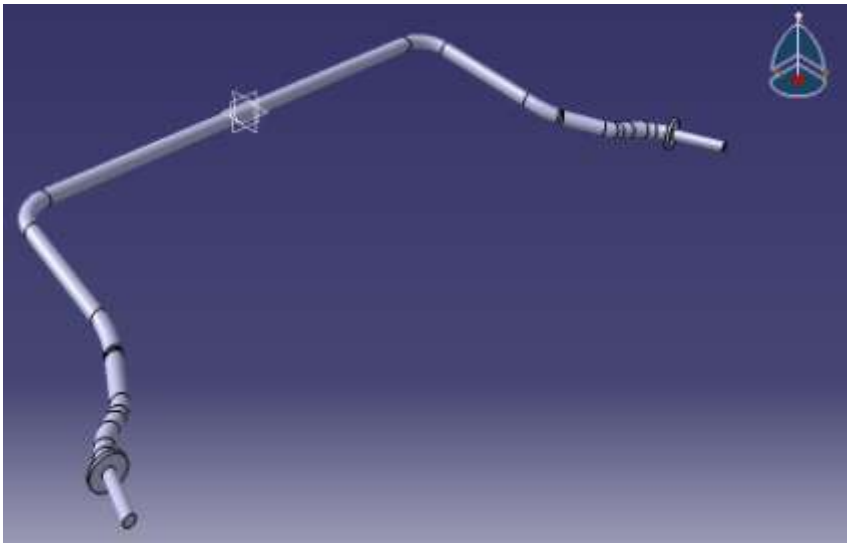

Fig.1- 3D Modeling of Anti-Roll Bar

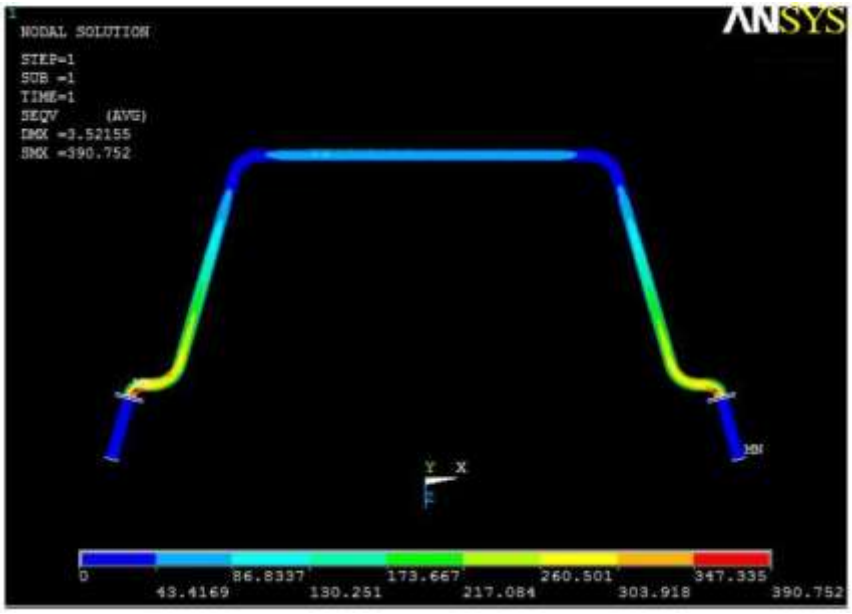


Fig.2- Analysis of Anti-Roll Bar in ANSYS

Fig. 2 depicts the finite element modal of the antiroll bar in ANSYS. For meshing 10 circumferential and 3 radial subsections are used for solid circular cross-section and extruded throughout axis of anti-roll bar. The bar will be meshed with BEAM189 elements. Anti-roll bar only is free to rotate in bushing. Therefore loads are applied at free ends of anti-roll bar to its relative moment.

## IV RESULTS

Fig. 3 and 4 shows torsion (N.mm) Vs. angular displacement (rad) graph of both anti-roll bar. Torque in both graph taken same and effect on angular moment are placed. The ANSYS analysis on anti-roll bar of mild steel

of diameter of 22 mm. and effective length of 670 mm. is considered for the analysis. Quarter weight of car is used for applying load on one end of anti-roll bar i.e. 1766 N is applied. The maximum angular displacement on rod is 0.175 rad and the results are shown on the Fig.3. The Fig.4 shows the ANSYS results for anti-roll bar of nylon of diameter 33 mm. Same load is applied on one end so maximum angular displacement on rod is 0.0875 rad. Hence it is justified that the Nylon can be used as anti-roll bar.

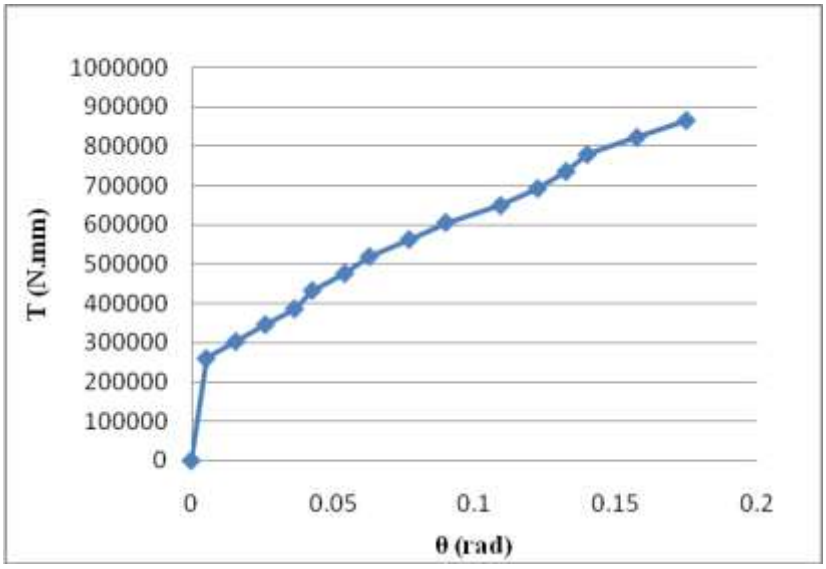


Fig.3- Analysis on Mild Steel Anti-Roll Bar

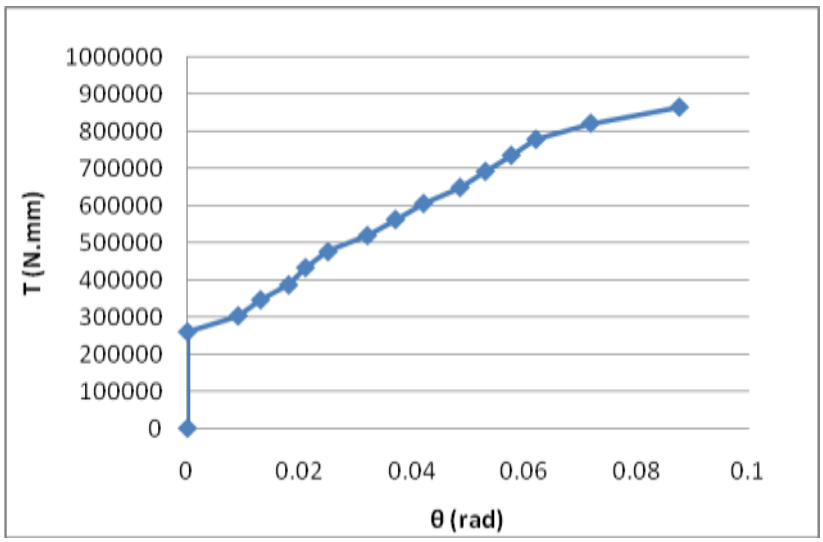


Fig.4- Analysis on Nylon Anti-Rol

## V CONCLUSION

The ANSYS results of the anti-roll bar shows favorable results to select Nylon as alternative material for anti-roll bar. However in practice the anti-roll bar will not be rotated in rotation, it's only produce twisting effect. From ANSYS result it shows torsional stiffness of nylon anti-roll bar is higher than for M. S. , but M. S. is used

due to cost and easy machinability. From analysis it is seen that though the diameter of nylon anti-roll bar is increased, the angular deflection and weight decreases compare to M.S. anti-roll bar. This reduction in weight of the un-sprung mass of the vehicle also helps to reduces fuel consumption.

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