Experimental and Development of Polymer-Clay based Hybrid Nanocomposites

Ajish Kumar R , C P Jesuthanam, Shajin S, Pratheesh J P

Abstract*: The hybrid polymer was arranged by using of halloysite nano tubular particles in hand lay-up method. Natural polymer materials have nano-clay particles; the epoxy resin was a chemical reaction of bonding two materials. The polymer material and nano clay particles are bonding with the epoxy resin. The amount of benzyl peroxide-radical initiator was analyzed by X-Ray diffraction method. The polymer nano clay particle and glass fiber are reinforced with epoxy-resin hybrid composites. The weight fractions of nano clay particle are 1.5, 2.5, and 3.5 % (by weight.) and Halloysite Nano tubular (HNT) clay joined together with polymer clay. In this project work was carried out wear test, tensile Strength X-ray Diffraction and SEM. In this project work conducted by wear test by Varying the loads and percentage of nano clay particles can be studied

Keywords: Halloysite nano clay, polymer-clay nanocomposite, X-ray diffraction, pin-on-disk, Scanning Electron Microscope.

I. INTRODUCTION

The main application is used in circuit board, switch board, computer hardware, rockets and automobile components of the incredible between the physico-chemical, dielectric and thermoelectric aging characteristics. If hallow nano tubes hot clay has been used as reinforcement material for the number of polymers due to their Nanoscale size and interrelation between them. The HNT clay is better with cetyltrimethylammonium ions to permit its relations between polymer matrix and nanoclay to the improve organophilic.

The nano clay particle surface is ion method is prepared clay and increases between the clay surface and polymer matrix. In future, the addition of organophilic HNT clay into epoxy resin is improve the defects of the strength and thermal properties. The modified organophilic HNT clay reinforced epoxy nanocomposites show the significant developments of the thermal and mechanical properties similar to high temperature, durability, reduced flammability.

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* Correspondence Author

AjishKumar R *, Department of Mechanical Engineering, Narayanaguru College of Engineering, Manjalumoodu - 629151, Tamilnadu, India Email: ajish.mech@gmail.com

Jesuthanam C P, Principal/Professor, Department of Mechanical Engineering, Narayanaguru College of Engineering, Manjalumoodu - 629151, Tamilnadu, India. E-mail: principaldrcpj@rediffmail.com.

Shajin S, Department of Mechanical Engineering, Narayanaguru College of Engineering, Manjalumoodu - 629151, Tamilnadu, India. Email: shajinmech@gmail.com.

Pratheesh J P, Department of Mechanical Engineering, Narayanaguru College of Engineering, Manjalumoodu - 629151, Tamilnadu, India. Email: pratheshjp@gmail.com.

In recent trend of the nano clay particles is very costly than the clay particles. The characteristic of nano clay composite materials is a different size and length. Epoxy resins are the bonding the various material of the nanoclay and polymer glass fiber. This nanoclay and glass fiber combined together strong and harder material.

The polymer nano clay composite material are used in natural fiber or glass fiber. When the particles are added to polymers reacted with material bonding together and increase the strength of the material. The methodology of nanoclay composite is a different material is increasing the strength and improves the mechanical properties.

X-ray diffraction (XRD), which focusing lens (d001) spacing in the modified of clay and provides information on the degree of hybrid structure generated. Wide range of X-ray diffraction technique is used for analysis with accomplished using Rigaku D/MAX-3000 X-ray diffractometer with Cu Kα radiation (λ = 0.164nm) and a scanning rate of 1.2°/min. Bragg's law, $\lambda=2d\sin\theta$, was used to calculate the crystallographic spacing "d".

After heating to nanoclay composite at the temperature above 400°C, this typical kaolinite peak is reduced in intensity, again after heating at the temperature of 600°C only traces of it are left. Kaolinite temperature was measured by metakaolinite below at 650°C.Polymer composite is based on the nano clays is improve the physical properties than the other pure polymer or conventional composites. This can be improvements include high modulus, increased strength, toughness, heat resistance and fire flammability.

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This type of three main structures can be found when layered clay is associated with a polymer: (i) a phase-separated structure, (ii) an interrelated structure and (iii) an exfoliated or laminated structure (iv) achieves pure Nano composites. For tribological components, the coefficient of friction, the mechanical applied load carrying capacity, and the wear rate of the materials determine their acceptability for industrial uses. Polymer based composite materials are employed in tribological applications owing to their constantly increasing demand in terms of stability at higher loads, temperatures, improve the lubrication and wear properties.

The epoxy resin and glass fiber is reinforced with epoxy-clay hybrid composites are increasing the strength of mechanical properties. The clay nano composite is used in the present system were alkyl ammonium treated montmorillonite (MMT) clay based organ clay (OC) and unmodified MMT clay (UC). The addition of nano clay increases the thermal properties.

A. Natural Fiber

From natural organic material such as Plants, animals, and geological processes are prepared by natural fibers. The halloysite Nano clay particle and polymer material are joined together, having same impact strength.

In the present paper discussed with the effects of halloysite nano clay powder as fillers popular in the glass–epoxy and halloysite nano tubular particle bonding together epoxy resin and classification of tribological properties need to be measurable in the present studying. The hybrid composite and non-clay composite is using hand lay-up technique. The nano clay composites weight fraction method percentage is 1.5%, 2.5%, and 3.5%, nano clay powder elements and epoxy polymer matrix phase are measured by using x-ray diffraction technique. The crystalline grain size arranged by 1.5%, 2.5% and 3.5% nano clay improves the results of the mechanical strength of epoxy polymer in addition to glass fiber-reinforced epoxy-clay hybrid composite material. In the recent stages of the polymer clay based nano composite is used in Scherer formula.

The epoxy polymer nano clay composite particles and glass fiber are reinforced with epoxy-clay, resin material and increasing the mechanical properties of the strength and weight ratio of 1.5% 2.5% and 3.5% nano clay particles. The result of sliding speed interval to the weight load of physical properties to improve the wearer's strength of polymer nano composites. The result of pin and disc method of the sliding speed range of 645-1200 RPM, 250-850 Sec and 6-26 and are present in the wear ratio between the hardness and revolving steel disc. It is also an investigation that wears weight ratio of increasing by functional load time and sliding speeds.

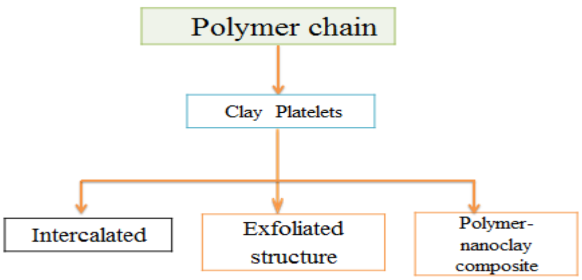

Fig -1, Illustration of the (1) intercalated, (2) Exfoliated structure and (3) polymer- nanoclay composite.

B. Materials Properties

In the present studies the tensile test will be conducted on Cu-Ep composites. The resin particulate mix was poured into the molds and cast specimens were allowed (RT cure) and an Araldite hardener HY951 (Huntsman India Ltd) are used as matrix. The halloysite nano clay clusters were found to be improving the dispersed. This also evidences that at high concentration the effect of nano clay composite and polymer

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It is organically changed by 3-aminopropyltriethoxysilane by sanction process. Woven Roving are improved of the glass fiber and increasing the strength of the material. It is mainly used for increase high potential strength of flexibility and impact load. Ideal for multi-layer hand lay-up method are used to the high compacting strength of material.

Using Woven Roving is commonly join the two materials of resins/reinforcement particle of nano clay composite and the wear ratio will be decrease above 1:2%. Woven roving fabrication is compatible with a wide range of resin systems. , weights, widths and finishes suit a wide range of applications (Saint-Gobain-Vetrotex India Ltd).

C. The Polymer /Clay-Based Nano Composites.

Polymer composites are an improvement the mechanical properties, thermal properties, optical, and physical-chemical properties compared with conventional polymers. The clay inclusion are commonly increases the heat resistance, Young’s modulus, and tensile strength, and decreases gas emissivity and absorptivity. The characterizes of stiffness matrix in the material high strength of tensile test, and the modulus in the layer direction of a clay composite is 60–450 times greater than a conventional polymer. Percentages of clay lesser than 15 weight% can significantly increase the Young’s modulus and additional mechanical properties.

D. Analysis and Synthesis of Epoxy resin and Glass Fiber-Reinforced Epoxy-HNT Clay Hybrids composite

The mixture of glass fiber and hallyosite nanoclay composites reinforced with epoxy-resin joining together with the men of hand-lay-up method. In this combined joining both material are mixed each other 60% weight of fiber and 40 % weight of epoxy resin is used for preparation of hybrid composite. The curing temperature is used to mold the material is taken for a time about 12 hrs for complete one cycle. HNT Clay Nano composites are synthetic by a mixture of hardening with cured Halloysite nano clay particles and poured into wooden box of 8 mm width and 100mm length. The wear specimens are cut as per the dimensions shown in Fig. 2.

Fig.2. Wear specimens (1.5, 2.5 and, 3.5 wt%) reinforced with Halloysite HNT nano clay composite.

II. EXPERIMENTAL SETUP

The non-destructive testing (XRD) method was Analysis the clay particles and clay particles filled epoxy to study the interlayer split-up. The process was carried out with a scanning rate of 2° per min, with CuKa radiation (λ=1.53441Å) operating at 50KV and 20 mA by the X-Ray Diffractometer (Model: 2036E201; Rigaku, Ultima IV, Japan). The wear test has found out new technology by disc on pin, using tribometer, in according with ASTM G-99 standard. It consists of a loading disc and pin and fix a point the material, load is applied and kept constant, and applied over the disc and fix the square pins. The measurement of the wear test pins is 6 mm square and 10 mm in length. The discuss of the wear pin and disc are used material is brass disc and pin is material to find the wear resistance and to find out the surface roughness of material is about 0.2132 mm. The dimensions of the wear test specimens are 10 mm width and 100mm length. The coefficient of friction rate of wear resistance for conventional composites and nano composites was observed at a constant speed of 0.15 MPa and sliding velocity of 0.3555 m/s for the sliding distance of 3600 m.

III. RESULTS AND DISCUSSION:

A. Discuss by X-Ray diffraction technique.

The Nanocomposites was observed the percentage of 1.5%, 2.5% and 3.5% nanoclay powder and epoxy polymer (matrix phase) are arranged by manual hand lay method and it's described by the X-ray diffraction method.. The different phases are detail observed in the composite material is known hybrid nano composite. The X-Ray diffraction and crystallize grain sizes are calculated by using Scherer formula. The diffraction patterns of 1.5%, 2.5% and 3.5% nanoclay composites are comparably same.

B. Crystallite size measurement for Halloysite HNT Nanoclay.

The average of crystalline grain size was observed by (FWHM) of the X-Ray diffraction highest peak Value using Scherer's formula. The crystal size is calculated peak width range is intensity of distance between points on the curve at wavelength.

C. Crystallite size measurements.

Crystallite Size = K λ / (FW (S) * Cos (θ)),
Where, 2θ is the peak position, K is the shape factor of the average crystallite.
FW (S) ^D = FWHM^D - FW (I) ^D
Clay-kaolinite ($AL_2Si_2O_5(OH)_4$)
2θ=12.379; FWHM=0.202
Crystallite Size =0.91*1.54/FW (S) COS (6.18)
FW (S) ^1.5 = 0.202^1.5-0.103^1.5
FW (S) = 0.361deg
FW (S) =0.0063rad
Crystallite Size =0.91*1.54/0.0063* COS (6.18) = 53.08 nm

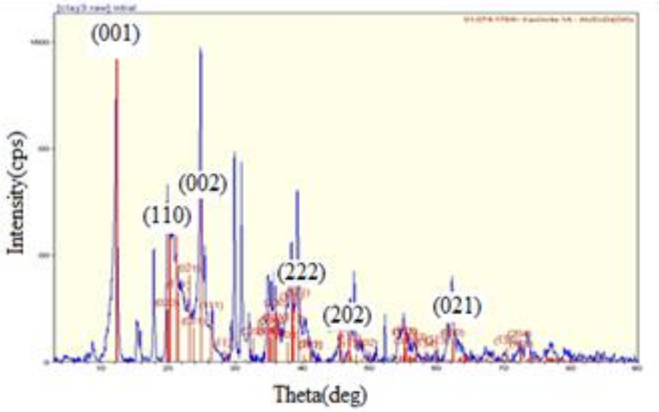

Fig.6 XRD pattern of clay nanopowder

The description of clay nano powder and composite of park value 1.5%, 2.5% and 3.5% nano clay particles and polymer fiber composite with reinforcement pattern XRD. Red coloured line indicates the clay nano powder, blue coloured line indicates the epoxy substance composite and so the selection natural phenomenon patterns are epoxy compound fiber robust composites 1.5%, 2.5% and 3.5% nano clay composite powders.

When the nano clay powder is distributed in the epoxy polymer, the composite is found with two various phases. One phase is the polymer composite and the other is polymer glass fiber or Hallyosite nano clay composite particle. The particle phase is the crystalline size in nature particles and the diffraction pattern is obtained as designated in clay nano powder. The epoxy polymers are structural design and natural material are diffraction patterns are found in XRD as pure nano clay composite at ratio was observed 1.5 %, 2.5 % and 3.5 % nano clay composite. The particle phase was observed in the polymer composite in a small peaks which are combined in together of epoxy diffraction pattern.

After completely the diffraction patterns, at θ=8.53 deg is lesser than the diffraction peak was observed. The clay nano powder is observed in the composite. In addition the pure composite and 1.5%, 2.5%and 3.5% nano clay composite diffraction patterns are same. Evaluation of section material of the XRD pattern of all above phases is shown in Fig.6, the intensity of pure nano composite diffraction peak is high and its intensity increased by 15 to 20%. The clay powder, peak intensity is lower than the other phases. These two inherent phase materials of composite material are weight fraction method was increase the strength of nano composite particle is 1.5%, 2.5%, and 3.5% nano clay is constant.

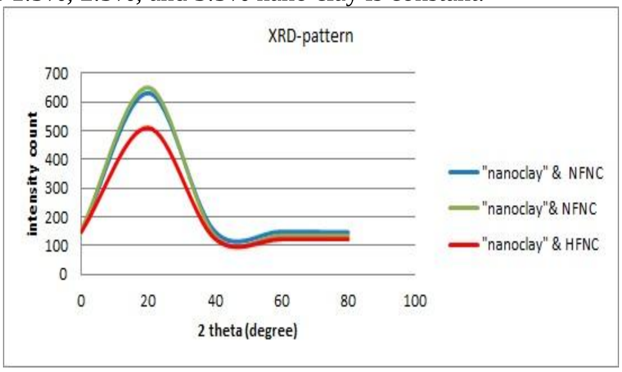

Fig.7 XRD Pattern of clay nanopowder

X-ray diffraction patterns of nonfunctional nanoclay composite and functionalize composite with the percentage of 1.5%, 2.5% and 3.5% hybrid composite. The graph Fig.7 Illustrate of the variation in the parameters of non-functionalize nano clay (NFNC) in addition, particles of nano clay composite powder is 1.5%, 2.5% and 3.5%.In this experimental work the different phase of composite material is having same in the intensity of functionalized ratio of nano clay powder (1.5%, 2.5% and 3.5%) and other non-functionalized nano clay powder. When increase of hallyosite nano clay composite powders the intensity is also increasing. It is about 10 to 12% in the nano clay powder. When the increase of nano clay powders the intensity of the material is also increased. It is about 10 to 12% in the nano clay composite is comparatively increased and nonfunctionalized nanoclay are less than other polymer clay particles to be improved. In this project work was observed value is above 40 to 45 % of 2.5% of nano clay and NFNC is increased in nonfunctional nanoclay composite.

D. Scanning Electron Microscope (SEM)

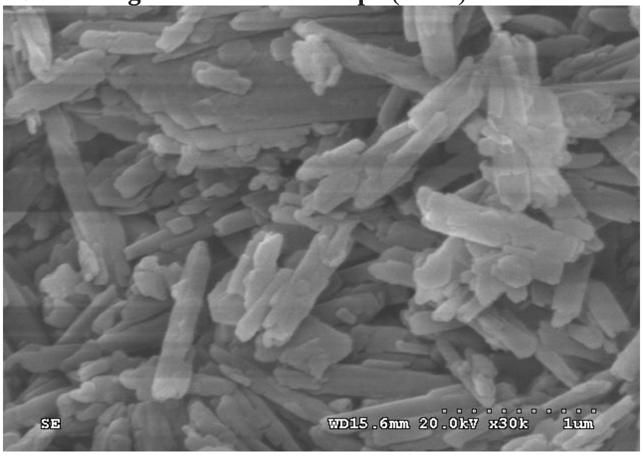

Fig-8. SEM photo of nanoclay (Hollow Nano Tubes)

The scanning Electronically Microscope was observed the nanotubular structure of nanoclay composite. The typical diameter and length/ diameter ratio of HNTs are determined by measuring 10 randomly chosen nanotubes. The characteristics of grain size of diameter ranges from 30 nm to 70 nm and the length/diameter ratio is in the range of $3\times e^{10}$.

G. Analysis of Wear rate

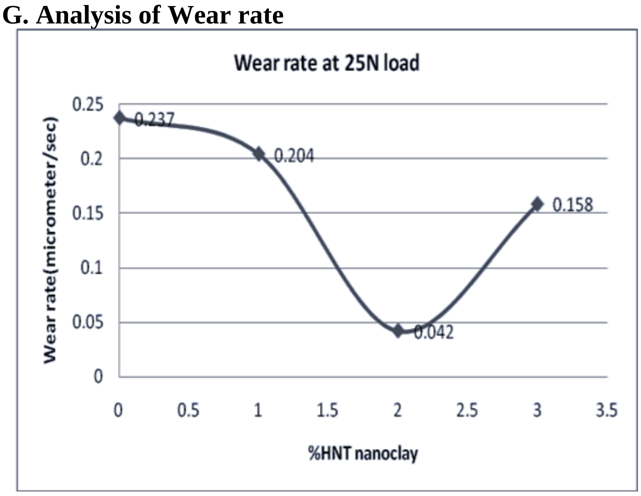

Fig-9, Wear rate by increasing the HNT Nano clay

The represents to obtained wear rate by fitting a straight line function y = mix + c where "m" is the wear rate. The wear rate of the pure samples at 25N and travel distance of 1.81km is 0.237. The wear rate of epoxy decreased from 0.239 to 0.045 nanometer/Sec at load 25N and travel at 3.84km as compared to 2.5% reinforced HNT Nano clay nanocomposites and it is increased 0.128 nanometers/Sec by reinforcing 2.5% HNT Nanoclay is shown in Fig-10. The highest wear rate is seen with pure epoxy composite and lowest wear rate is at 2.5% HNT Nano clay reinforcement. From this experiment it is concluded that, wear rate is inversely proportionally with the hardness of the Nanocomposites.

H. Microtensile test

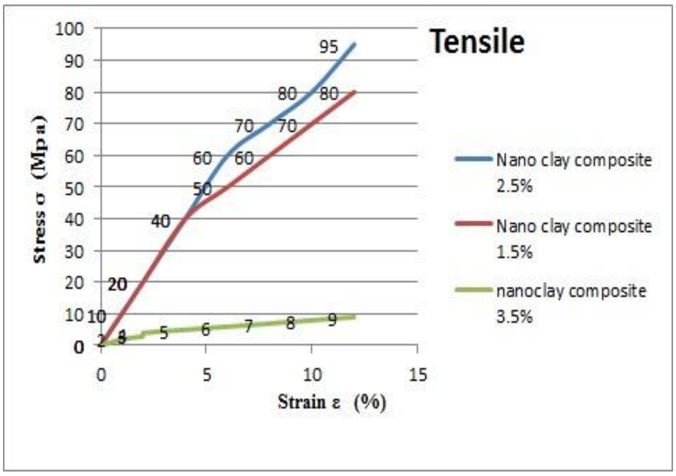

Fig-10, Microtensile test

The experimental and analysis result was observed by increase the nanoclay composite 2.5% and tensile strength is also increased above 95 N/mm^2 than the nanoclay composite of 3.5% and 1.5 %. In this project work 2.5% is good strength and harder material was observed.

I. Investigation of Wear Test

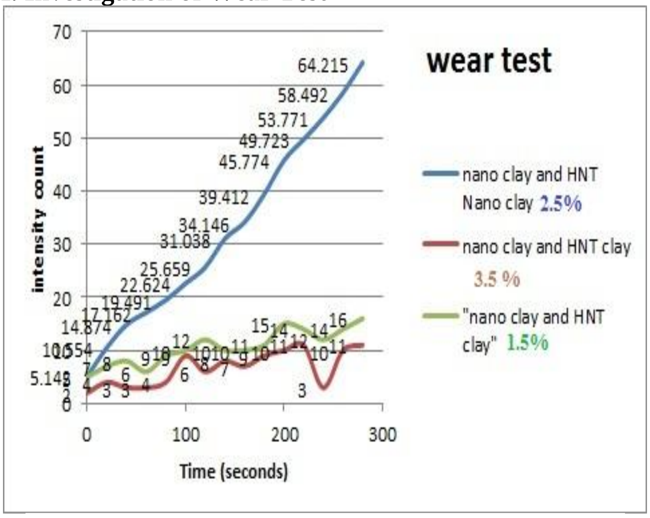

Fig. 11. Wear rate by increasing the HNT Nano clay different composition

The wear test is conducted by different loads range of 5N, 10N and 20N shows accurate response and observed that the wear rate is less than 5N. The speed of disc revolving by the addition of nanoclay particles in the order of 1.5%, 2.5% and 3. 5% and wear at a load of 5N, it is observed that the wear rate is improved (0.644) for the epoxy and its much less at 2.5 % of nanoclay particles. Analysis performed at a wear load of 15N; here the wear rate is less for 1.5% of nanoclay particle addition, 3.5% of nanoclay particle addition wear rate is high.

The wear test is conducted for a load of 25N. It is observed that 2.5% of nanoclay particles addition has much less wear rate as shown in Fig-10 .Hence by comparing the below Fig-10 the wear rate is less and comparatively varying the loads of 5N, 15N and 25N. Finally result is observed that the 2.5% wt of nanoclay particle addition is preferable.

III. CONCLUSIONS

The characterization issues of non-functionalized and functionalized type nano clay composite is studied by using X-Ray diffraction technique. Finally result was observed on the nano clay particles and nano composites are bonding joining together epoxy resin.

The non-functionalize nano clay composite particles are not correctly distributed in the matrix, but the functionalize nano clay composite having well distributed nano clay composite particles in the matrix due to chemically react. The XRD final results was found out that the intensity of non functionalize nanoclay composite is lesser than the functionalize nanoclay composite

The disc on pin test was shown on pure epoxy, 1.5%, 2.5% and 3.5% of nano clay composite with various loads and time. The results show that pure epoxy having a lesser wear rate is presently at 2.5 % other than nano clay composite is higher wear rate among them. In this project work 2.5% of nano clay composite and halloysite nano clay particle wear rate is lower due to hardness is higher than pure epoxy resin, 1.5%, 2.5% and 3.5% nano clay composites. In this experimental work wear rate is inversely proportionally with other nanoclay composites. The experimental and analysis result was observed by increase the nanoclay composite 2.5% and tensile strength is also increased above 95 N/mm^2 than the nanoclay composite of 3.5% and 1.5 %. In this project work 2.5% nano clay composite is good strength and harder material was observed.

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AUTHORS PROFILE

Ajish Kumar R working as Assistant Professor in the Department of Mechanical Engineering at Narayanaguru College of Engineering, Manjalumoodu, Tamilnadu. He has teaching experience of over 7 years. He has completed his Master of Engineering in Computer Aided design from Regional Centre of Anna University, Tirunelveli and Bachelor of Engineering in Mechanical Engineering from Sardar Raja College of Engineering, Alangulam under Anna university Chennai.

Dr. Jesuthanam C P, is serving as principal Narayanaguru College of Engineering, Manjalumoodu, Tamilnadu. His area of interest includes Manufacturing processes, Metallurgy, metrology and industrial Automation. He received his master degree in Manufacturing technology from R.E.C Trichy, and Doctoral degree from Anna University Chennai under the faculty of mechanical engineering

Mr. Shajin S, working as Assistant Professor in the Department of Mechanical Engineering at Narayanaguru College of Engineering, Manjalumoodu, Tamilnadu. He has teaching experience of over 5 years. He received his ME in Thermal Engineering from Anna University, Chennai.

Mr. Pratheesh J P, working as Assistant Professor in the Department of Mechanical Engineering at Narayanaguru College of Engineering, Manjalumoodu, Tamilnadu. He has teaching experience of over 6 years. He has completed his Master of Engineering in Thermal Engineering from Regional Centre of Anna University, Tirunelveli and Bachelor of Engineering in Mechanical Engineering from Noorul Islam college of Engineering, Kumaracoil. He is currently pursuing his Ph.D in Anna university Chennai.