International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6S3, September 2019

Research on Mechanical Behavior of AMMC (Al-SiC) Composite in Disc Brake

Karthikeyan K, Naga Chandrika K K, Deepan Raj kumar A, Thiagarajan S, Vishnukumar V

Abstract*---*To meet the materials demand and performance of automobile components it is necessary of developing composite materials. Aluminium Metal Matrix Composite (AMMC) are utilized to meet the industrial needs. AMMC is the mixture of aluminium and silicon carbide with minimum quantity of other materials like magnesium, aluminium oxide, graphite which are mixed in precise quantity to increase the chemical, mechanical and thermal properties of material. This paper deals with the investigation of mechanical behaviour and properties of AMMC produced by stir casting technique where silicon carbide is reinforced with alloy 6061 for using in Disc Brake. The tensile, flexural, hardness and impact tests were performed and the results showed that the hybrid composites had better properties than pure aluminium and this kind of material may be subjected to use in Disc Brake. The microstructure of the hybrid composites were analyzed using Optical Microscopy.

Keywords: Aluminium Metal Matrix Composite, AMMC, Silicon Carbide, Optical Microscopy

I. INTRODUCTION

Aluminium has unique mechanical properties like good strength, high malleability, ease of machining, greater corrosion resistance and good thermal and electrical conductivity. Composites are the properties of two different materials are bind together by mechanical and metallurgical method to possess better properties and its structural characteristics. When comparing to metals, composites having unique properties and it is replace the metal. The properties of Composite materials are high stiffness, high strength and high wear resistance. The improvement of these materials in progress with the making of continuous-fiber-reinforced composites.

II. PROBLEM DEFINITION

Nowadays disc brakes are made up of cast iron, but in extreme case the disc are made in composites like reinforced carbon–carbon and ceramic matrix composites. Disk brakes are used for faster and better cooling geometry.

Manuscript published on 30 September 2019.
***** Correspondence Author (s)
Karthikeyan K, Mechanical Engineering, Easwari Engineering College, Chennai, Tamil Nadu, India. Email: karthik.arul26@gmail.com.
Naga Chandrika K K, Mechanical Engineering, Easwari Engineering College, Chennai, Tamil Nadu, India. Email: chandrikakkn@gmail.com.
Deepan Raj kumar A, Mechanical Engineering, Easwari Engineering College, Chennai, Tamil Nadu, India. Email: adrkdeeban@gmail.com
Thiagarajan S, Mechanical Engineering, Easwari Engineering College, Chennai, Tamil Nadu, India. Email: thiyagarajan56@yahoo.co.in
Vishnukumar V, Automobile Engineering, Easwari Engineering College, Chennai, Tamil Nadu, India. Email: vishaero1990@gmail.com

Gray cast iron is low tensile strength so that it is a poor shock resistor and causing residual stress. The material is liable to continuous rusting because of moisture this type of damage is unavoidable. Cast iron is heavier and it is handled

A. Objective

The objective of this investigation is to study of newly developed metal matrix composite for disc brake based upon its different mechanical properties like Hardness, Impact strength, Tensile strength, Flexural strength, and Wear resistance.

III. METHODOLOGY

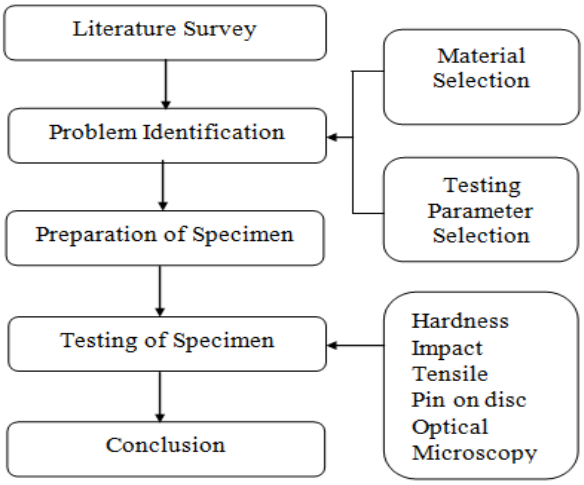

Figure - 1: Methodology

A. Material Composition

The following Material Composition are identified

- Aluminium (Al): 90%
- Silicon Carbide (SiC): 5%
- Graphite: 2.5%
- Aluminium Oxide (Al_2O_3): 1.5%
- Magnesium (Mg): 1%

B. Stir Casting Process Parameters

- **Rotational speed:** Rotational speed is significant for casting influences the structure; enhance of speed will increase the refinement and slacken of speed will leads to instability of the liquid mass.
- **Stirring speed:** Wettability is stimulated by stirring for bonding between the matrix and reinforcement. Stirring speed will control the flow pattern of molten metal. The optimum speed range is 300 to 600 rpm was suggested by Rajesh Kumar et.al, when the solidifying rate is higher there is possibility of increasing the percentage of wettability.

- **Stirring temperature:** Operating temperature at 630˚C, influenced the viscosity of Al matrix and there is change of viscosity when the particle is disturbed in the matrix. When Stirring temperature and time of stir is increased as a result of which decrease in the viscosity of liquid.
- **Reinforcement pre-heat temperature:** Preheat the reinforcement at a 500ºC for 30 minutes to remove moisture and unwanted gases within the reinforcement.
- **Stirring time**: One of the important parameter in the process of composite between matrix and reinforcement for Uniform distribution of the particles in the liquid.

C. Material Testing Parameters

According to the ASTM (American Society for Testing and Materials) standards are specified for various testing

- Tensile test - ASTM B557M
- Flexural test - ASTM D790
- Izod test - ASTM E23 TYPE A
- Micro Hardness and Microscopic test - ASTM E404
- Pin on disc test - ASTM G99

IV. EXPERIMENTAL SETUP

A. Stir Casting

Stir casting technique is used to pepare Al 6061- SiC AMMC. The matrix and reinforcement are aluminium and SiC powder respectively

B. Melting of base metal

Al 6061 rods is melt in a crucible made of graphite and placed inside the electric furnace at a melting temperature of 850º C. Graphite crucibles are having a property of high temperature resistant.


Fig. 1 - Graphite crucible


Fig. 2 - Graphite crucible


Fig. 3 - Electric Furnace


Fig. 4 - Al 6061 rods

The electric furnace is used for preheating the Al6061 rods to carry stir casting represent in fig. 5. Aluminium 6061 alloy is used as the matrix material.


Fig. 5 - Electric Furnace

C. Preheating of reinforcements in furnace

- **Aluminium Oxide:**

To increase the wear properties and compatibility add Alumina particles

- **Graphite:**

To reduce friction in composite, add of graphite particle hence it is a good dry lubricant to reduce wear and abrasion.

- **Silicon Carbide:**

Addition of Silicon carbide particle shows that greater mechanical properties and produces hard and strong material. Silicon Carbide also improves the thermal conductivity and thermal shock resistance of the material.

- **Magnesium:**

Magnesium is added to increase the wettability and reduce the porosity.

D. Preheating of Die

- Two dies of size 100*100*10 mm are preheated in a furnace at 800º C. They are preheated so that the casted material can be easily removed from the die.


Fig. 6 - Die

E. Stirring of the matrix metal with reinforcements

- A 100mm length and 25mm diameter graphite rod are used for stirring. 3 feet long internally threaded stainless-steel rod was fitted over the stirrer. The melted Al 6061 rods are taken out from the furnace


Fig. 7 - Stirrer


Fig. 8 - Adding of reinforcements

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DOI:10.35940/ijeat.F1255.0986S319
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Remove the impurities from it coverall and degasser powder are added. The reinforcements are added to the slurry when the impurities are taken out. Then the crucible is again placed inside the furnace to carry out stirring. The mixture was stirred for 10 minutes at 250 rpm before pouring into the mould.

D. Pouring of Al-SiC mixture in to mould and solidifying

- The AMMC mixture was poured into the mould and allowed to hardened. The final cast AMMC plates were taken out once they cooled.

Fig. 9 - AMMC mixture

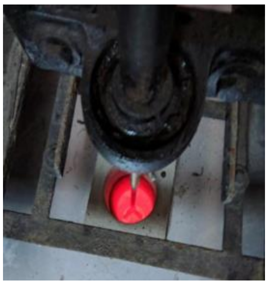


Fig. 10 - Stirring process

Fig. 10 - AMMC plates

The AMMC plates are casted by stir casting process with dimension of 100*100* 10 mm as shown in fig. 10.

V. TEST RESULTS

A. Vickers Hardness Test

Hardness Measurements:

Scale: Vicker's

Load: 0.5 Kgf

Dwell time: 10 seconds.

Unit: H.V. @ 0.5 Kg load.

Fig. 11 - Vickers Hardness Specimen

Table No - 1. Vickers Hardness Readings

Readings	Vickers hardness AMMC (HV)	Load (kgf)	Vickers hardness Cast Iron (HV)
1	61.3	0.5	52.6
2	63.9	0.5	56.9
3	65.4	0.5	59.5

B. Izod Test

Impact Test: 9.0 Joules

Fig. 11 - Before breaking

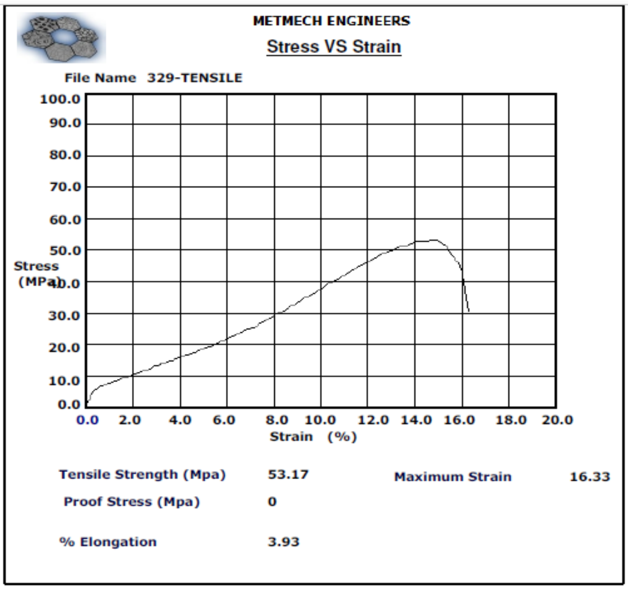
Fig. 12 - After breaking

C. Tensile Test

Fig. 13 - Before breaking

Fig. 14 - After breaking

- Figure 13 & 14 represents the relationship between stress and strain. The strain gradually increases with the varying stress.
- Here the strain in percentage is plotted in X-AXIS and stress in Y-AXIS. The maximum strain is found out to be 16.33 and the tensile strength is 53.17 MPa. The percentage of elongation is 3.93



FFig. 15 - Tensile Test Graph

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Table No. 2 - Pin on Disc test parameters

Expt. No.	1
Applied Load (N)	15
Sliding velocity (m/sec)	2.5
Sliding Distance (m)	600
Sliding dia in mm	30
RPM	600
Time in secs	636.943
Time in min:secs	10.614

Table No. 3 - Total Wear Loss

Samples	**Initial weight g**	**Final weight g**	**Wear loss in g**
1	4.864	4.855	0.185032895

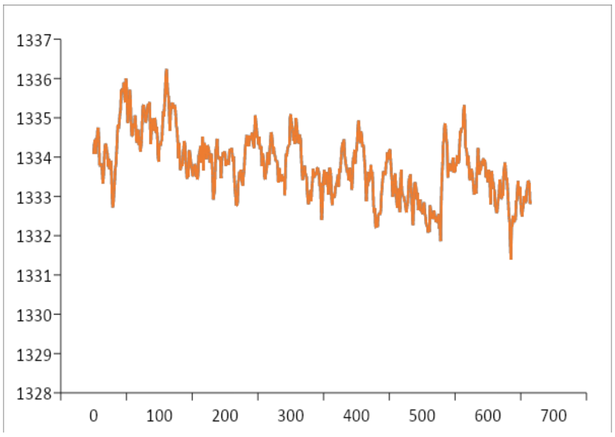

Fig. 16 Temperature vs. Time graph

Figure 16 represents the relationship between time and temperature. The temperature gets increased with a gradual decrease for a varying time. Here the time taken for the pin to slide on the disc is plotted in X axis and the temperature of the pin is plotted in Y axis. This graph shows that temperature varies with respect to time taken. Thus, this shows the varying nature of temperature of the pin with respect to the change in time taken by the pin to slide on the disc.

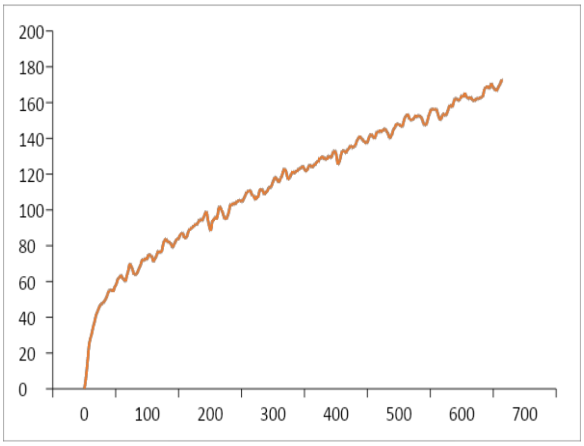

Fig 17 Time vs. Wear graph

Figure 17 represents the relationship between time and wear. The wear gets increases with an increase in time taken. Here the time taken for the pin to slide on the disc is plotted in X axis and the wear rate of the pin is plotted in Y axis. This graph shows that wear rate varies with respect to time taken. Thus, this shows the varying nature of wear of the pin with respect to the change in time taken by the pin to slide on the disc.

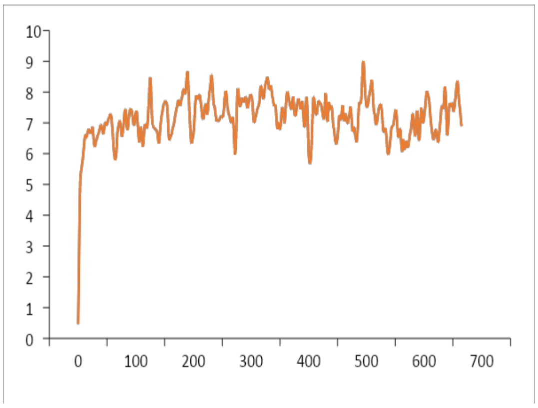

Fig 18 Frictional force vs. Time graph

Figure 18 represents the relationship between time and frictional force. The Frictional force gets increases gradually for some point and decreases suddenly repeatedly for a varying time taken by the pin to slide on the disc. Here the time taken for the pin to slide on the disc is plotted in X axis and the frictional force is plotted in Y axis. This graph shows that frictional force varies with respect to time taken. Thus this shows the varying nature of frictional force with respect to the change in time taken by the pin to slide on the disc.

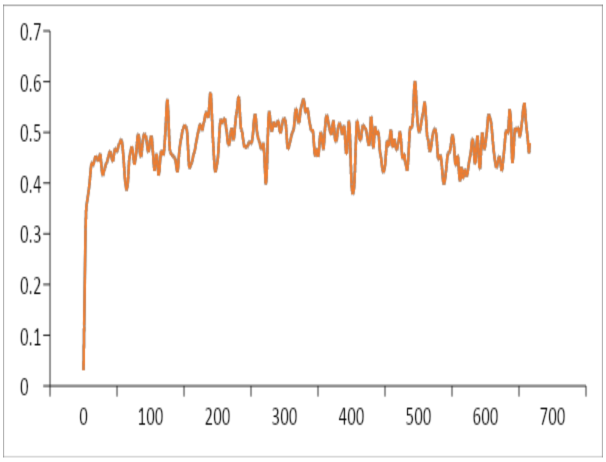

Fig 19 Coefficient of friction (COF) vs. Time graph

Figure 19 represents the relationship between time and coefficient of friction. The Coefficient of Friction increases gradually for some point and decreases suddenly and this gets repeated for a varying time taken by the pin to slide on the disc. Here the time taken for the pin to slide on the disc is plotted in X axis and the coefficient of friction is plotted in Y axis. This graph shows that coefficient of friction varies with respect to time taken. Thus this shows the varying nature of coefficient of friction with respect to the change in time taken by the pin to slide on the disc.

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Optical Microscopy Test

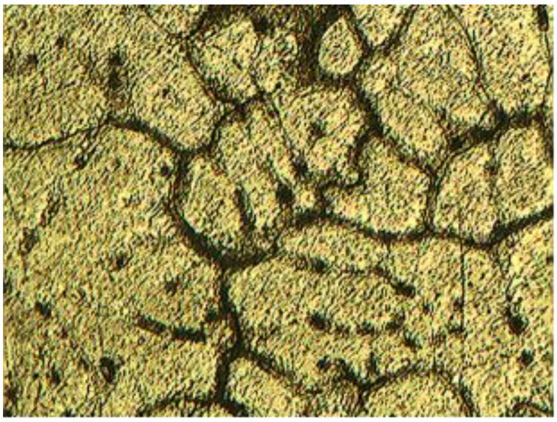

Fig 20 Optical Microscopy 100x – 1

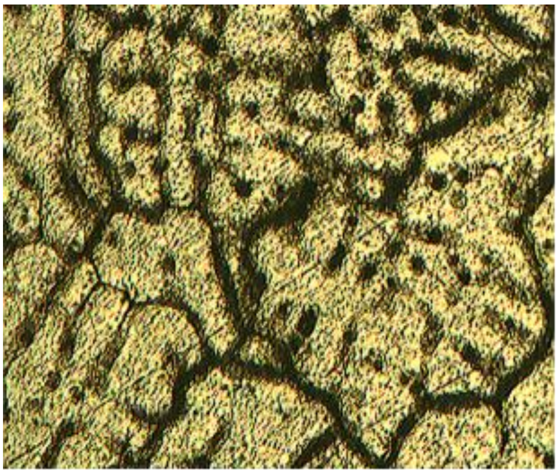

Fig 21 Optical Microscopy 100x – 2

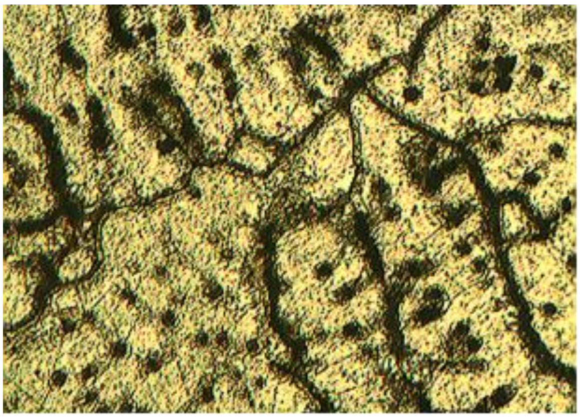

Fig 22 Optical Microscopy 100x - 3

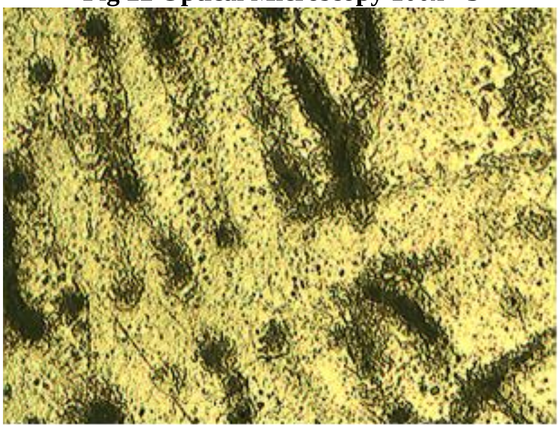

Fig 23 Optical Microscopy 200x - 1

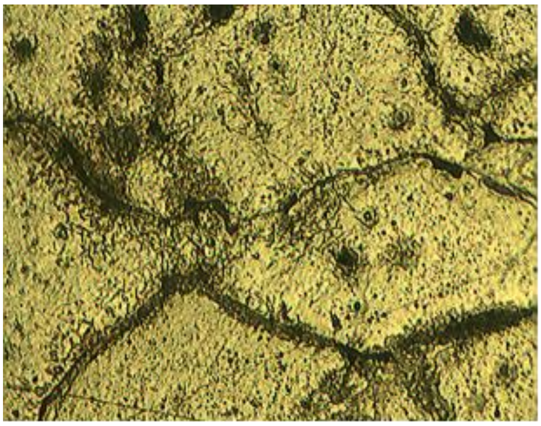

Fig 24 Optical Microscopy 200x – 2

Magnification: 100X and 200X
Etchant: Hydro fluoric acid solution

Figure 20 and 21 Show the microstructure of the metal matrix composite AA 6061 with composite particles of SiC and graphite. The microstructure shows Dendritic pattern of grains of primary Aluminium solid solution in which the composite particles are dispersed

Figure 23 & 24 Show the same sample at higher magnification of 200x. The higher magnification resolved the grain boundaries and the composite particles present at the grain boundaries.

VI. CONCLUSION

The following conclusions are made from the present work: The stir casting technique is used to synthesize Aluminium alloy matrix composites reinforced with Silicon Carbide. The mechanical properties of AMMC are investigated by conducting various mechanical tests such as tensile test, hardness test, impact test, flexural test, wear and optical microscopy test. The obtained results are resulted below:

- To increase the hardness, toughness, strength, corrosive and wear resistance of the composite add Silicon Carbide reinforcement.
- Hardness shows good when silicon carbide is employed at 4.5% weight. Hardness value increase with the increase of silicon carbide but it decrease when increase in graphite. Hence to obtain an optimum hardness of the desired number, both the reinforced material can be used in proper proportions.
- Tensile test result shows that elevation in mechanical property when they are compared with cast iron.
- Hardness test shows that improvement of hardness value up to 40% due to the good cohesion between metal matrix and reinforcement phase.
- From the impact test its clear that AMMC absorbs more energy than cast iron which absorbs up to 1.45 - 7 Joules.
- Other reinforced materials such as graphite and alumina show better results pertaining to tensile strength when compared to Silicon carbide.

- The friction coefficient of AMMC is 22-27% times than cast iron and has better wear characteristics.
- An AMMC disc could be 55% lighter than an equivalent cast iron component.

From the above results it is suggested that Aluminium Metal Matrix Composite can be used as an alternative to cast iron in automotive applications like disk brake rotor, brake pads, piston rod and aircraft materials.

REFERENCES

1. Alpas AT, Z. J. (1992). Effect of SiC particulate reinforcment on the dry sliding wear of aluinum-silicon alloys Wear, 83-104.
2. N.Chawla (2000), “Tensile and fatigue fracture of Discontinuously Reinforced Aluminium” D, Advances in Fracture Research, (2001), pp. 1-6.
3. Dmitri Kopeliovich (2010) State fabrication of metal matrix composites.
4. Gowri Shankar, M.C, Jayashree (2006): Individual and Combined Effect of Reinforcementson Stir Cast Aluminium Metal Matrix Composites. A Review, International Journal of Current Engineering and Technology, Vol.3, No.3, 2013.
5. Hashim J, Looney L, Hashmi MSJ (1999) Metal matrix composites: production by the stir casting method. Journal of Materials Processing Technology 92-93: 1-7.
6. Meena KL, Manna A, Banwait SS, Jaswanti (2003) An analysis of mechanical properties of the developed Al/SiC mmc. American journal of Mechanical engineering 1(1): 14-19.
7. Miracle DB, Donaldson SL (2001) Introduction to Composites. ASM Hand Book of Composite Materials, p. 21. 45
8. Muzakkir (1997), A. K.: An Overview on Effect of Reinforcement and Process Parameters on Properties of Aluminium Based Metal Matrix, International Journal of Research in Engineering and Science (IJRES), Volume 2 Issue 10, 2014.
9. Rajesh Kumar, Gangaram Bhandare, Parshuram M. Sonawane (2007): Preparation of Aluminium Matrix Composite by Using Stir Casting Method, International Journal of Engineering and Advanced Technology, Vol, 3, Issue 2, 2013.
10. Sarkar smarajit (2010) Some studies on aluminium matrix in-situ composites produced by chemical reaction.

AUTHORS PROFILE

K.Karthikeyan is an Assistant Professor in the Department of Mechanical Engineering at Easwari Engineering College, Chennai. He completed his Post Graduate in CAD/CAM at Bannari Amman Institute of Technology, Sathyamangalam. He is specialized in Machine Design.

Naga Chandrika K Kis an Assistant Professor in the Department of Mechanical Engineering at Easwari Engineering College, Chennai. She completed her Post Graduate in Product Design & Development at RMK Engineering College, Chennai. She is specialized in Design & Development, Rapid Prototyping.

A.Deepan Raj Kumar is an Assistant Professor in the Department of Mechanical Engineering at Easwari Engineering College, Chennai. He completed his Post Graduate in Internal Combustion Engineering at Anna University, Chennai. He is specialized in Thermal.

S.Thiagarajan is an Assistant Professor in the Department of Mechanical Engineering at Easwari Engineering College, Chennai. He completed his Post Graduate in Energy Technology at Pondicherry Engineering College, Pondicherry. He is specialized in Renewable Energy.

V.Vishnukumar is an Assistant Professor in the Department of Automobile Engineering at Easwari Engineering College, Chennai. He completed his Post Graduate in CAD/CAM at Al Ameen Engineering College, Erode. He is specialized in CAD/CAM.

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