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Fabrication and Characterization of Silicon Carbide and Epoxy Matrix Radiator: A Study Approaches the Experimental Setup

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Abstract : The recent advancement in engineering has invented the forced engine cooling system to develop new strategies to improve its performance of engine efficiency and also reduces the specific fuel consumption along with controlling of engine emission abiding environmental pollution control norms. This paper involves on the parameters which influence efficient heat transfer in radiators by modifying Universal Aluminum Radiator in to Silicon Carbide and Epoxy Matrix Radiator. As silicon carbide has higher thermal conductivity and lower thermal expansion than Aluminum. A high thermal conductive Epoxy resin is mixed at the ratio of 20wt% of epoxy resin 80% of Silicon Carbide.
Keywords : Silicon Carbide, Epoxy resin, Epoxy matrix, Radiator and Heat Transfer.

Introduction

Radiators are heat exchangers used for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, railway locomotives, motorcycles, stationary generating plant or any similar use of such an engine. Internal combustion engines are often cooled by circulating a liquid called engine coolant through the engine block, where it is heated, then through a radiator where it loses heat to the atmosphere, and then returned to the engine. Engine coolant is usually water-based, but may also be oil. It is common to employ a water pump to force the engine coolant to circulate, and also for an axial fan to force air through the radiator.

First Generation (1900s - 1970s) Copper/Brass 100% from the birth of the earliest automobiles to the early 1970s, radiators made from copper and brass were in 100% of cars and trucks. There was no good reason to use anything else because nothing else could compete with the metal's many advantages.

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Second Generation (1970 - 1990s) Aluminum Gains, Copper/Brass Still Leads Market in the 1970s, the radiator environment changed. Early in the decade, Volkswagen decided to go from an air-cooled engine to a water-cooled engine. A few years later, in the wake of the world oil crisis and urgent calls for ways to reduce fuel consumption, major automobile manufacturers in Europe and the U.S. began making cars and trucks with lighter materials. For radiators, this translated to aluminum, which is one third the density of copper/brass and can handle heat fairly well despite its many shortcomings. These qualities - along with dire, albeit unrealized, predictions of commodity analysts that copper/brass would be in short supply in the 1980s - created a wave of enthusiasm for something new.

Third Generation (1990s - 2000s) Technology Takes Copper/Brass Further While aluminum was growing in use in new cars and trucks, the copper/brass industry began looking at ways to improve the traditional copper/brass radiator with the goal of competing aggressively against aluminum which began to manifest several disadvantages as a metal for radiators. Using these technologies, the copper/brass industry, in cooperation with major automobile and radiator manufacturers in the U.S., Europe and Japan, has designed an advanced radiator that is lighter, more compact and more durable than anything currently in use worldwide. Now in the first stages of field testing, it could be available in cars as early as 1995.

Silicon carbide

Silicon carbide can prepare as a structural member and characteristic are low thermal expansion, high thermal conductivity, hardness, resistance to abrasive and corrosion and most important to withstand of elastic resistance at the temperature maintained up to 1650°C have led to the suitable applications. Silicon carbide is composed of tetrahedral of carbon and silicon atoms with strong bonds in the crystal lattice. The electrical conduction of the material has led to its use in resistance heating elements for electric furnaces, and as a key component in thermistors (temperature variable resistors) and in varistors (voltage variable resistors).

Formations of Silicon Carbide and Technology

There are some classified structures availed to prepare the structural silicon carbide member:

a) Sintered
b) Bonded
c) Liquid Phase
d) Sintered solid state

Mostly SiC bonded by the reaction of compound arrange as a continue matrix of SiC having 5% to 20%. As know that the powder coal containing and added or decomposes of resin maintained imitate temperature 1500°C.When the process of sintered structure can arrange the continue matrix formation where the silicon reacted to perform a structure of bridge and remaining silica has residual pore give complete dense in uncovered area or non-reacted silicon area. The structural integrated on that point noted temperature 1370°C and melted 1410°C. The literature and characteristic can able to identify the group of composite materials are silicon carbide make perfect suit of ceramics and its applications.

But the strong character of the silicon carbide are elastic modulus, thermal expansion like conductivity and diffusivity of material. Best suit for rapid changes in temperature can preference identifiable materials are $Si3N_4$ over SiC. To avoid furnace resistance and over lead the suitable application and uses are in combustion engine such as turbine rotor.

Application are:

a) Sand blasting injector
b) Automotive water pump seals
c) Bearings
d) Pump components
e) Extrusion die

Epoxy Resin

In the realm of fiber reinforced polymers (plastics), epoxy have used as the resin matrix to efficiently hold the fiber was place. It has more compatible with all common reinforcing fibres including fiberglass, carbon fibres, and basalt. In our project we have used epoxy resin as a binding agent for Sic.

Literature Survey

Reinforced Polymer Composites

S. Rajesh, B. VijayaRamnath, The main objective of the paper involved fabrication of epoxy and polyester resin composite by using materials aluminium oxide and silicon carbide with different proportion of Al_2O_3-SiC reinforced. The proportional made with GFRP contain extremely five fibers of glass. The epoxy resin given binding properties of fibres layers and hardener executed to improve adhesion and strength of the composite ratio 10:1 and in term as Hy 951 obtained as matrix composition.

They were done experimental work as per the standard setup and processes handled to preparing the hardening in the formations of solid matrix like liquid monomer polymerizes into the polymer.

Compositions were executed ranges in four different samples:

Sic (3%) + Al_2O_3 (3%) + Epoxy
Sic (2%) + Al_2O_3 (2%) + Epoxy
Sic (3%) + Al_2O_3 (3%) + Polyester
Sic (2%) + Al_2O_3 (2%) + Polyester

With this test sample experimented the mechanical characteristics like Tensile Strength, Shear Strength, Impact Test, Hardness Test and Biaxial Strength completed successfully by this article.Maximum tensile strength reached 36.53 MPa, Shear Strength 6.45 kN, Biaxial Stress 40.7 MPa, Good Stiffness and Shrinkage reduced.[1]

Heat Transfer Process of Internal and External Flow in Radiators

Mathew Carl, Dana Guy, Brett Leyendecker, Austin Miller and Xuejun Fan, illustrated the heat transfer process involved in the operation of an automotive radiator. The analysis of a radiator encompasses nearly all of the fundamentals discussed in a heat transfer, including the internal and external fluid flow through the heat exchanger. The theoretical heat exchanger investigation begins with analyzing the internal fluid flow through the radiator’s non circular tubes, yielding the convective heat transfer coefficient of water. The external fluid flowing across the radiator tubes and the fins is then analyzed to find the convective heat transfer coefficient of the air. There were numerous assumptions that were made. Although these assumptions changed the final values for the theoretical outlet temperatures and heat transfer rate.[2]

Modern and Conventional Radiators

Pawan S. Amrutkar, Sangram R. Patil, have studied different factor the influence the performance of the radiator along with reviews of conventional and modern enhancement in improving the performance of the radiator. And the factors that affected by the engine cooling system such fuel consumption and thermal efficiency.[3]

Change in Heat Exchanger Material

W Lin, B Sunden, explained in the paper that the graphite foam is a potential candidate material for heat exchangers in vehicles. In order to evaluate the performance of graphite foam heat exchangers, a corrugated graphite foam is compared with a convectional aluminum louver fin. The major results are as follows: The value of PD and CF are much higher in the corrugated graphite foam than in the aluminum louver fin. Thus, the graphite foam can reduce the weight and size of heat exchangers significantly, which would lead to a light or compact cooling system in vehicles. The aluminum louver fin has a higher COP value than the corrugated graphite foams. By increasing the velocity, the difference in COP between the corrugated foam and aluminum louver fin heat exchangers becomes smaller. Because the graphite foam is not a mature thermal material, there are still several problems (high pressure drop, low COP value, weak mechanical properties, and so on) blocking the development of graphite foam heat exchangers. Thus, much work has to be done before the graphite foam heat exchangers appear in vehicle cooling systems.[4]

Materials and Methodology

Software used for Designing

The design was done by using AUTOCAD software. The design was done in 2D. The radiator is drawn in first angle projection and the tube is drawn in isometric view.

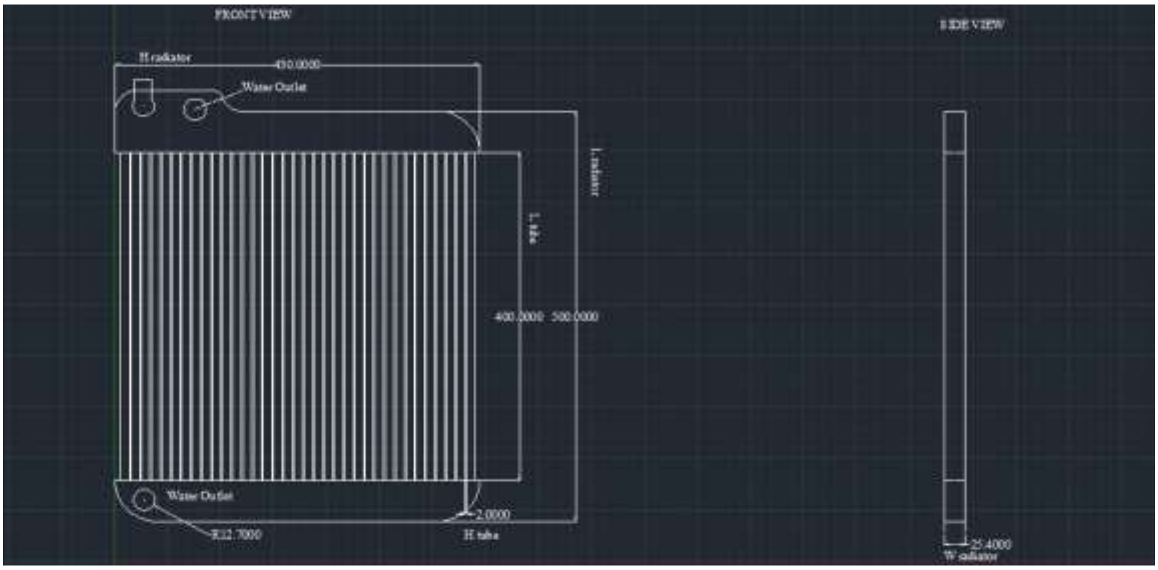

Fig: 1 Radiator design in AUTOCAD Software

Fig:2 Silicon Carbide

Silicon Carbide

Silicon carbide of 50µm about 500gm was bought from Vazirbun Trading, Broadway, Chennai.

Radiator

The radiator used in this project is a Universal Aluminum Radiator. Model belong to Hyundai Santro along with the fan was purchased in Raja Car Parts at Pudupet.

Epoxy Resin

An epoxy resin Araldite AW106 Resin and HV 953 U Hardener of 500ml each is purchased at Universal Machine Tools, Broadway, Chennai. The resin is diglycidyl ether of bisphenol-A and hardener is 2-ethyl-4-Methylimidazole.

Table 1: Material Properties

Properties	Resin	Hardener
Colour / Appearance	Colourless Liquid	Amber Liquid
Specific Gravity	1.17	0.92
Viscosity	50000	35000
Thermal Conductivity	0.39 W/m2K	

Fig: 3 Hardener and Resin

Fabrication Technology

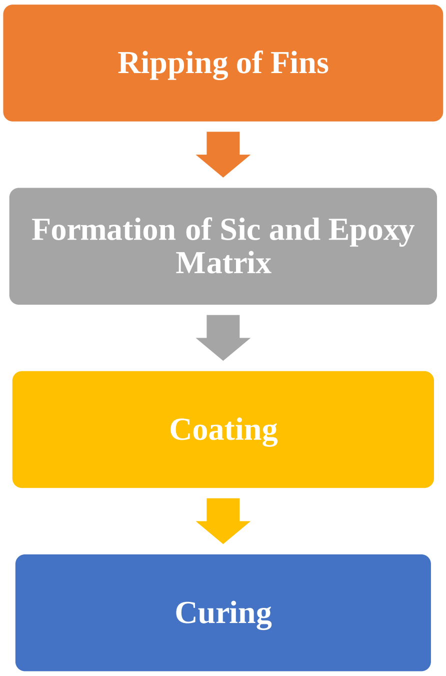

Fig: 4 Layout diagram for fabrication methodology

Ripping of fins

The fins of the radiator are attached by soldering where molten lead is poured over the heater core. First fins in the radiator where ripped from the radiator manually by using a flat file 6" the extended surface has torn off and the edge of the fins was removed by us DE soldering technique. Where a soldering iron and fume extraction equipment was used.

Formation of Sic and Epoxy matrix

The epoxy resin is provide with two part a Resin and a Hardener. Resin and the hardener are mixed in the ratio 1:1 volumes till pale color liquid is obtained. Then Sic is added 80% of weight. It is added little by little and constantly stirred. Finally a slurry is formed from Sic and Epoxy.

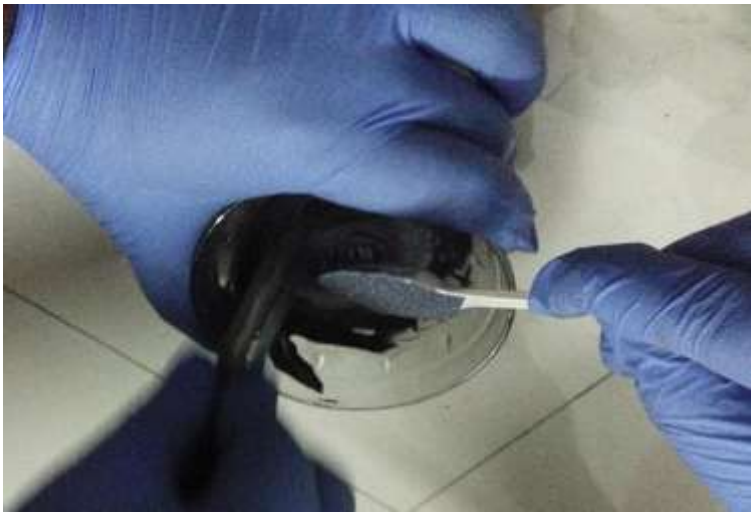

Fig: 5 Formation of Epoxy Matrix

Coating

Fig: 6 Coating

Coating is a covering that is applied to the surface of an object, usually referred to as substrate. The method employed here is film coating. Film coating is a thin polymer based coat applied to a solid. Then the formed slurry of SiC and Epoxy was coated over the entire surface of the tube by means of a small shovel and thickness was measured and then lapsing part was once again coated. Excess was scraped off.

Curing

Curing is the process were the viscosity of the resin drops initially upon the application of heat, passes through a region of maximum flow and begins to increase as the chemical reaction increase the average length and the degree of cross linking in terms of process ability of the resin this marks an important watershed. Before gelation the system is relatively mobile after it the mobility is very limited, the micro-structure of the resin and composite material is fixed and severe diffusion limitations to further cure are created. Therefore the SiC and epoxy is cured at room temperature of 303K for one hour. Hence the composite matrix is formed over the tube.

Conclusion

The project concluded the method of experiment and technology with the brief discussion in the references [1, 2, 3 and 4] given the identification of problems, tools, techniques and necessity of expected new design and dimension drawn in CAD Modellingsoftware's.The above statement given the clear knowledge to the fabrication in silicon carbide epoxy matrix radiator. The fabrication work has done as per the methodology layout fig 4.

With the clear conclusion of literature survey, design and fabrication of silicon carbide epoxy matrix radiator work has to get success or failure of the project to know by the evaluationof the experimental setup and it will be going to run in future.

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