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A REVIEW ON ADVANCE COMPOSITE MATERIAL FOR AUTOMOTIVE BODY APPLICATION

Dhairyashil D. Bhambure[1], Dr. Sanjay D. Yadav[2]

[1]Department of Automobile Engineering, Rajarambapu Institute of Technology Islampur, Maharashtra 415414 India.
[2]Professor, Department of Automobile Engineering, Rajarambapu Institute of Technology Islampur, Maharashtra 415414 India.

Abstract - *The importance of material in today's modern world, coming in picture from various research on materials used for different automotive components. In today's world, designer engineer are focusses more on composite materials instead of using metals and its alloys to reduce weight and improving performance. The approach is due to many advantages of composite materials over metals and its alloys. Composite of aluminum alloy with silicon carbide is one of the high strength composite. It is well known for its high strength to volume ratio, corrosion resistance, excellent machinability, wear resistance, high thermal conductivity. Thus it is used in aircraft, military, automobile industries. This review paper represents study of advance composite material for automotive body application in safety point of view for absorbing impact force during accidents and provides more safety to the passengers.*

Key Words: composite material, aluminium alloy, silicon carbide, high strength, safety.

1. INTRODUCTION

In modern world, most of research is going on composite materials because of its physical and chemical properties. They provide maximum strength to weight ratio, fatigue life, stiffness corrosion resistance, thermal insulation, wear resistance etc. Most of application of composite materials is in automotive industries, aircraft industries. Aluminum metal matrix composite are very effective due to its excellent mechanical properties, which is widely used in aerospace, automobile, marine etc. Mostly aluminum is reinforced with ceramic particles such as silicon carbide (SiC), aluminium oxide (Al_2O_3). Aluminum 7075 alloy is strong with strength comparable with many steel and has good fatigue strength and good machinability. [1].

1.1 Metal matrix composite

Most of composite research are going on metal matrix. The unique properties of metal matrix composite leads to its application at various working condition. Aluminum metal matrix composites are widely used in aircraft, automobiles, etc. The automotive components such as brake caliper, pump housing, gear, valves, pulley, drive shaft, and piston are of metal matrix composites. In aluminum metal matrix composite metal reinforced with another material. The most commonly used reinforcements are silicon carbide and aluminum oxide. [2].

The chemical composition of aluminum 7075 is given below in table 1.

Table - 1: Chemical composition of Aluminum 7075. [4].

Elements	Weight in %
Mg	2.1
Cu	1.4
Zn	5.9
Cr	0.19
Mn	0.05
Si	0.052
Ti	0.047
Fe	0.2
Other	0.025
Aluminum	Remaining

The physical properties of Silicon carbide is given below in table 2.

Table -2: Physical properties of Silicon Carbide. [4].

Material	Silicon Carbide
Density (gm/cc)	4.2
Young's modulus (GPa)	137
Thermal conductivity (W/m K)	20.5
Melting point (^{0}C)	1682
Thermal expansion (10^6 /K)	11

2. LITERATURE REVIEW

Introduction:-

The following research papers are about expt. analysis of advance composite materials. These materials shows high mechanical properties like impact strength, tensile strength, hardness, wear rate etc. Thus these materials can be used for absorbing energy during impact.

Vandana Yadav, Dr. Sudhakar Rao were develop four composite material samples having SiC constant by weight is 2% and varying Al 6061 and nickel varies from 0 to 1.5 % weight in four sample. They carry hardness test analysis, tensile strength analysis, flexural strength analysis, impact strength analysis. After all test, they got result that hardness is 165 HV in 4th sample having nickel 1.5 % weight. Tensile strength is 152.80 MPa in 3rd sample having nickel 1% weight and for other sample tensile strength is nearly same. Flexural strength is 287.475 MPa for 2nd sample having nickel 0.5% weight. Impact strength of 4th is 56 Joule having nickel 1.5 % weight. Fig 1 shows impact strength of composite.

From above research paper it is concluded that, impact strength is goes on increasing by adding nickel % by weight. [3].

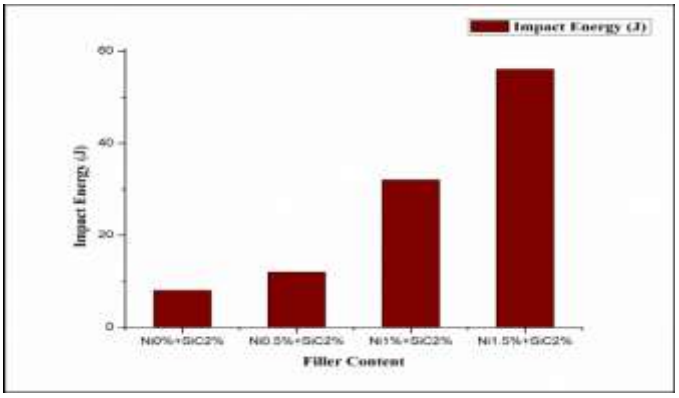

Fig- 1: Impact strength of composite. [3].

S. Suresh, G. Harinath Gowd et al. were worked on mechanical and wear behavior of Al 7075/ Al_2O_3/ SiC / Mg metal matrix Nano composite by liquid state process. They used stir casting method with 10 min stirring process. They manufacture four aluminum metal matrix composites with 1% wt. of magnesium and preheated mixture of aluminum oxide and Nano silicon carbide of 1%, 2%, 3%, and 4% and tested for tensile, compressive, micro hardness test.

From above research paper it is concluded that as compressive strength, ultimate tensile test, and hardness and wear load value increased by increasing weight percentage of Nano Al_2O_3 and Nano SiC content. [4].

M. Muttharrasan, M. Muralidharan et al. were worked on effect of processing temperature and holding time on Al/SiC composite. First they manufacture SiC plate. In furnace, this plate comes in contact with melted aluminum alloy at temperatures 700 ^{0}C, 750 ^{0}C, 800 ^{0}C, 850 ^{0}C, 900 ^{0}C and for time 10, 20, 30 min. And studied interface structure, effect of processing temperature, and effect of holding time.

From above research paper it is concluded that, fracture strength of interface increases with increase in processing temperature and increase in holding time. [5].

Philippe Bonte, Dominique Boyer et al. were invented the composite vehicle door. In their paper they reported location of composite reinforcement component between outer body panel and inner body structure of door. The composite component is made by reinforcement with continuous and chopped carbon fibers which are made by glass, carbon, cellulosic material by resin transfer molding.

From above research paper it is claimed that the weight of composite fiber door is 15% less provide more resistance and stiffness than aluminum. [6].

Laurent Rocheblave, Villeurbanne improved method for manufacturing structural component of vehicle. In this invention the composite is made by fiber with metal structural element. The fiber layers are embedded in thermosetting polymer matrix. The fibers are unidirectional arranged parallel to another and by cutting operation composite sheet is obtained. The thickness of strip of composite material is between 3 to 6 mm and between this strip and structure layer of binding material is inserted. The structure is obtained by hot stamping operation then injection molding of polymer operation is carried out. In this structure polymer covers 15 to 40% of total area of hybrid structure.

From above research paper it is concluded that this hybrid structural part having all expected mechanical and impact resisting properties. [7].

Pamarthi Harish, Veeraniki Srikanth et al. after investigating behavior of aluminum alloy 6063 based hybrid metal matrix composite containing with various properties of reinforcement at 0%, 1%, 2% and 3% are tested and microstructure of metal matrix composite. They reported that hybrid metal matrix composite containing 75% of cotton shell ash and 25% of silicon carbide.

From above research paper it is concluded that for 1 & 2 % reinforcement shows superior wear behavior and hardness improve moderately. [8].

Sedat Ozden, Recep Ekici et al. after investigation of impact behavior of aluminum based SiC particles reinforced metal matrix composite. They were made composite based on aluminum alloy 2124, 5083, 6063 .Then reported that their results that Al 6063 alloys and its composites have the highest impact toughness about 100.36 Joule for the testing temperature 100 ^{0}C. The defect in composite microstructure such as clustering of particles observed. Fig 2 shows impact energy versus test temperature for Al 6063, Al6063 [T6], Al 6063 + SiC, Al 6063 + SiC [T6].

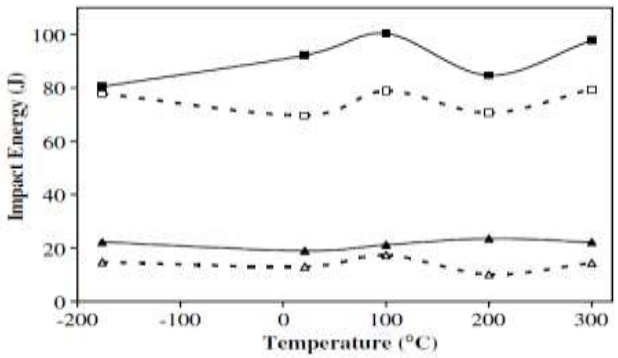

Fig - 2: Impact energy versus test temperature for: (■) Al 6063, (□) Al6063 [T6], (▲) Al 6063 + SiC, (△) Al 6063 + SiC [T6]. [9].

From above research paper it is concluded that the impact toughness of composites slightly improved with increased particle size and hot extrusion ratio. Artificial ageing decreased impact toughness of all unreinforced alloys and composites. [9].

Stanislav Dedov, Gunter Lehmann et al. were reported that they used new technology of coupled casting and forging process with heat treatment process like quenching at 520 ^{0}C for 2 hours on aluminum alloy in their institute. And this technology was successful tested on aluminum alloy with silicon percentages 1, 3, 5 and 7. Fig 3 shows yield strength of the $AlSi_3MgCu$ 0, 5 as a function of strain rate and temperature.

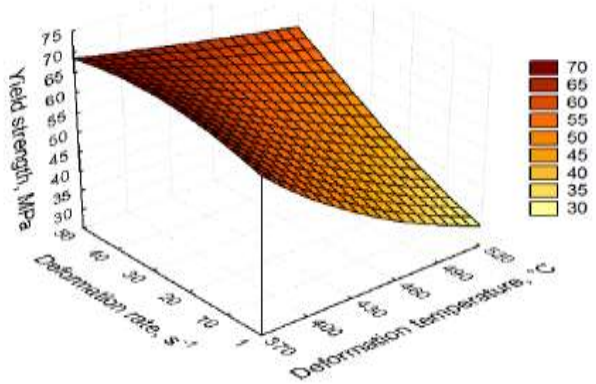

Fig - 3: Yield strength of the $AlSi_3MgCu$ 0, 5 as a function of strain rate and temperature. [10].

From above research paper it is concluded that high mechanical properties were achieved and proves flexibility of coupled technology. [10].

Gubin Sun, Fie Wu Hubei et al. Manufacture polyurethane composite and its preparation process. First they made polyurethane mold body. Then by using isocyanate group and isocyanate reactive group in presence of KOH. Then they reinforced the material. To promote the reaction they use catalyst like trim ethylamine, N-Methyl aniline, N-ethylmorphline. The catalyst has amount of 0.001% to 10% based on 100% by weight. Curing the premolded polyurethane molding body at temperature 50 ^{0}C to 300 ^{0}C and pressure from 0.1 to 50 MPa to prepare composite material.

From above research paper it is concluded that various sheets, strips, ribbon molding body is prepared and automotive parts like vehicle door, body, fender, heater cover can be manufactured by using polyurethane. [11].

Gary L. Farley experimentally shows absorption characteristics after application of static loading on aluminum and composite material tube. After application of $1.35*10^6$ N force on tube obtain load deflection curve for aluminum and composite tube. Then reported that the graphite/epoxy and Kevlar/epoxy tubes exhibits nonlinear and bilinear between energy absorption as diameter/ thickness ratio.

From above research paper it is concluded that the increase in energy absorption as diameter/thickness ratio decreases is related to reduction in interlinear cracking. [12].

J. Pawloski in his Vehicle Body Engineering book stated design of vehicle body for safety. In that book he had discussed the following formulas and theory.

The kinetic energy of vehicle destroyed during a collision is expressed by following formula.

$$E = \frac{(m - \Delta m)\, v^2}{2}$$

Where E is kinetic energy, m is total mass of vehicle, Δm is movable mass in vehicle of passenger or load and v is velocity of vehicle.
Energy absorbed by work done on material of vehicle by elastic deformation which is given by following formula.

$$\frac{(m - \Delta m)\, v^2}{2} = \int p\, ds = \frac{\sigma^2\, A\, \ell}{2\, \epsilon}$$

Where is p force generated during the collision on vehicle structure, s is the distance travelled during the collision, σ is local stress in material, ϵ is Young's modulus, A is cross sectional area of structural material and ℓ is deformation. The expression shows force generated during collision is inversely proportional to distance travelled by vehicle in coming to rest and Young's modulus of material. This would indicate that to be effective bumpers and other collision absorbing parts of vehicle should be made of such light alloys, aluminum materials. [13].

3. SUMMARY OF REVIEW PAPERS

Summary
They were prepared hybrid composite of aluminum 6061 with silicon carbide and nickel. In testing they got result as nickel % by weight increases impact strength is goes on increasing. Impact strength is 56 Joule having nickel 1.5 % weight. [3].
They manufacture composite of aluminum 7075 with 1% wt. of magnesium and preheated mixture of aluminum oxide and Nano silicon carbide. In testing they got result as weight percentage of Nano Al_2O_3 and Nano SiC content increases compressive strength, ultimate tensile test, hardness and wear load value increases. [4].
They were first manufacture SiC plate. In furnace, they kept this plate in contact with melted aluminum alloy at temperatures 700 ^{0}C, 750 ^{0}C, 800 ^{0}C, 850 ^{0}C, 900 ^{0}C and for time 10, 20, 30 min. They got result as fracture strength of interface increases with increase in processing temperature and increase in holding time. [5].
They invented the composite vehicle door made by reinforcement with continuous and chopped carbon fibers which are made by glass, carbon, cellulosic material by resin transfer molding. They got result that weight of composite fiber door is 15% less than aluminum and claimed that it can provide more resistance and stiffness than aluminum. [6].
They manufactured structural component of vehicle by composite of fiber with metal structural element embedded in thermosetting polymer matrix. And concluded that this hybrid structural part having all expected mechanical and impact resisting properties. [7].
They investigate behavior of aluminum 6063 alloy based hybrid metal matrix composite with cotton shell ash and silicon carbide reinforcement at 0%, 1%, 2% and 3% then tested and 1 & 2 % reinforcement shows superior wear behavior and hardness improve moderately. [8].
They were made composite based on aluminum alloy 2124, 5083, 6063 .Then reported that their results that Al 6063 alloys and its composites have the highest impact toughness about 100.36 Joule at 100 ^{0}C. [9].
They used new technology of coupled casting and forging process with heat treatment process like quenching at 520 ^{0}C for 2 hours on aluminum alloy with silicon percentages 1, 3, 5 and 7. Then they concluded that high mechanical properties were achieved. They proves flexibility of coupled technology. [10].
They manufactured polyurethane composite and its preparation process. By using isocyanate group and isocyanate reactive group in presence of KOH in presence of catalyst like trim ethylamine, N-Methyl aniline, N-ethylmorphline. They claim that various sheets, strips, ribbon molding body is prepared and automotive parts like vehicle door, body, fender, heater cover can be manufactured by using polyurethane. [11].
He had applied $1.35*10^6$ N force on tube aluminum and composite tube concluded that the increase in energy absorption as diameter/thickness ratio decreases is related to reduction in interlinear cracking. [12].
In his Vehicle Body Engineering book he stated design of vehicle body for safety. In that book he had discussed the formulas and theory about conversion of kinetic energy of vehicle destroyed during collision into energy which is absorbed by material during collision. [13].

The summery stated that aluminum based metal matrix composite shows variation properties by varying reinforcement materials, their weight by percentage, temperature and time. These composite materials improvement in mech. properties than aluminum alloys.

4. CONCLUSIONS

This review paper includes many investigation, mechanical characterization like tensile strength, impact strength, and hardness for various aluminum material series with different reinforcement materials like silicon carbide (SiC), aluminum oxide (Al_2O_3), Graphite and Carbon Fiber added into base metal. These type of materials can be applicable according to its requirement.

The composite material have unique physical and chemical properties which are important in aerospace, military, automobile industries etc. New metal matrix composites, fibers and new processing technique are constantly developing. The metal matrix composites are cost effective method for manufacturing of composite materials. These composites materials have light weight, High toughness, tensile strength, wear resistance, corrosion resistance. Thus they have wide range of application.

All the research papers gives motivation to do research on composite materials for getting better and better results that can be fulfilling of its requirement.

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