

# International Journal of Innovative Research in Science, Engineering and Technology

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## A Review of Fabrication and Structural Analysis of Hybrid Metal Matrix Composites Using Stir Casting Process

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**ABSTRACT:** Aluminium metal matrix composites are significantly important in the various demanding fields of medicine and engineering like aerospace, defense, automobiles, dental and consumer goods. The industrial need of good materials with light weight, excellent properties and low cost demanded the scientists to research on composite materials. Among the MMCs, aluminium matrix composites (AMMCs) sought over other conventional materials because of their high strength to weight ratio, high wear resistance and low economic. In this experiment work, Al 7075 Reinforced with 2, 4 & 6 (%) weight of Silica Carbide & 2 (%) weight of Fly Ash are manufactured using stir casting technique. Sample Specimens are prepared as per the international standards for tensile, hardness, impact, wear tests are conducted. It was concluded that Fly ash and cast iron powder up to 6% can be added to Aluminum successfully by stir casting method route to fabricate a hybrid composite. The hardness and tensile strength increased with the increase in concentration of silica carbide powder. The wear and frictional force decreased with the increase in concentration of cast iron powder in the aluminum matrix. Impact strength variation is marginal with the increase in wt% of Silica Carbide

**KEYWORDS:** Metal Matrix Composite, Pure aluminum, SiCp, Fly ash, Stir Casting, Hardness Test, Tensile Test, Impact Test, Wear Test.

### I. INTRODUCTION

Metal Matrix Composites have enhanced its vitality in recent times for potential in marines, aerospace and automotive industries owing to their superior strength to weight ratio and high temperature resistance. MMCs have received substantial attention because of their improved strength, light weight, stiffness, high elastic modulus and increased wear resistance over conventional base alloys. The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and ceramics. Aluminum is the most abundant metal in the earth's crust, and the third most abundant element, after oxygen and silicon. SiCp-Fly ash reinforced aluminium matrix composite is gaining importance due to its ease of availability, easy machinability, durable, ductile and malleability. Fly ash is one of the most inexpensive discontinuous dispersoids, low-cost waste by-product and at the same time has the potential for conserving energy intensive.

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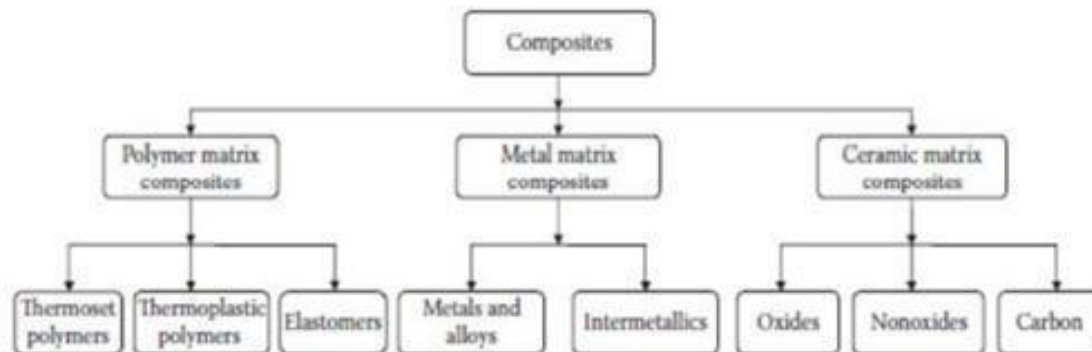
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Fiber-reinforced composite materials have gained popularity (despite their generally high cost) in high-performance products that need to be lightweight, yet strong enough to take harsh loading conditions such as aerospace components (tails, wings, fuselages, propellers), boat and scull hulls, bicycle frames and racing car bodies. Other uses include fishing rods, storage tanks, swimming pool panels, and baseball bats. The new Boeing 787 structure including the wings and fuselage is composed largely of composites. Composite materials are also becoming more common in the realm of orthopedic surgery. And it is the most common hockey stick material. Carbon composite is a key material in today's launch vehicles and heat shields for the re-entry phase of spacecraft. It is widely used in solar panel substrates, antenna reflectors and yokes of spacecraft. It is also used in payload adapters, inter-stage structures and heat shields of launch vehicles. Furthermore, disk brake systems of airplanes and racing cars are using carbon material, and the composite material with carbon fibers and silicon carbide matrix has been introduced in luxury vehicles and sports cars. Pipes and fittings for various purposes like transportation of potable water, fire-fighting, irrigation, seawater, desalinated water, chemical and industrial waste, and sewage are now manufactured in glass reinforced plastics.

## Classification of Composites based on Matrix Material



## II. METAL MATRIX COMPOSITE

The intend convoluted in designing metal matrix composite materials is to combine the desirable attributes of metals and ceramics. The addition of high strength, a high modulus refractory particle to a ductile metal matrix produces a material whose mechanical properties are midway between the matrix alloy and the ceramic reinforcement. Metals have a useful combination of properties such as high strength, ductility and high temperature resistance, but sometimes have low stiffness, whereas ceramics are stiff and strong, though brittle. Aluminum and silicon carbide, for example, have very different mechanical properties: Young's modules of 70 and 400 GPa, coefficients of thermal expansion of  $24 \times 10^{-6}$  and  $4 \times 10^{-6}/^{\circ}\text{C}$ , and yield strengths of 35 and 600 MPa, respectively. Aluminium and its alloys have continued to maintain their mark as the matrix material most in demand for the development of Metal Matrix Composites (MMCs). This is primarily due to the broad spectrum of unique properties it offers at comparatively low processing cost, and. Some of the attractive property combinations Aluminium metal matrix composites are: high specific stiffness and strength, better high temperature properties (in comparison with its monolithic alloy), thermal conductivity, and low thermal expansion

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## COMPOSITES APPLICATION

The composite materials application is increasing day to day in modern world due to the high tensile strength and with less weight. And Most widely used in Aerospace industry, defense industry, sport goods, marine application etc...

### III. LITERATURE SURVEY

#### S.Balasisivanandha Prabu et al :-

Investigated on Influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite. The AMMC (A384 as matrix alloy and SiC as reinforced material) was stirred continuously for the different combination of processing conditions by varying the stirring speed(500/600/700 rpm) and stirring time (5/10/15 min).The author observed that in some places without SiC inclusion in matrix at lower speed and lower stir time, while increasing the stirring speed and time better homogeneous distribution of SiC in the Al matrix. The author also revealed that stirring speed and stirring time effect on the hardness of the composite and obtained better hardness of the composite at higher stirring speed and stirring time.

#### V.Ramakoteswara Rao et al:-

It was produced AA7075/TiC metal matrix composite with stir casting process. They observed that hardness shows increasing trend with increasing weight percentage of TiC particulates in both cast and heat treated condition. The author also revealed that the ultimate tensile strength of the composite increased linearly with increase in weight percentage of TiC. Manoj Singla et.al. studied that with increase in composition of SiC, an increase in hardness, impact strength and normalized displacement. Mahendra Boopathi. M et.al, studied evaluation of mechanical properties of aluminum alloy 2024 reinforced with silicon carbide and fly ash hybrid metal matrix composites. Al-SiC, Al-fly ash, Al-SiC-fly ash composites were successfully prepared by two-step the initial to high volume production of goods from past decades They reported that tensile strength, yield strength and hardness of the hybrid composite increased with Increase in area fraction of reinforcement in matrix. They also concluded that the addition of SiC and fly ash with higher percentage the rate of elongation of the hybrid MMCs is decreased significantly.

#### Sumit Kumar Tiwari:-

Studied effect of heat treatment on mechanical properties of aluminum alloy-fly ash metal matrix composite. This study reveals that, there is an improvement in tensile strength, compressive strength, hardness as we increases the weight percentage of fly ash & there is an decrease in ductility with increase percentage. Also it is concluded that the tensile strength, compressive strength & hardness decreases with increase in particle size of fly ash. Heat treatment and ageing further improves these properties.

#### Vipin K. Sharma:-

In this project he investigated effect of fly ash particles on the wear of aluminum metal matrix composite. Stir casting method was used to fabricate the MMC with 2, 4 & 6% weight of fly ash contents in aluminum. The wear resistance of the fabricated composites increases with the increase in the fly ash contents. The composites with 6% fly ash contents resulted in 13.6% less wear as compared to 2% fly ash content composites. The sample with fly ash content 4% resulted in the lowest average coefficient of friction (0.12) and sample with high fly ash contents 6% shows the maximum average coefficient of friction (0.161). initial to high volume production of goods from a past decades.

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### IV. MATERIALS AND METHODOLOGY

The composites used in this study are produced by stir casting method. The matrix materials used in the present work is Al 7075 and the reinforcement materials are Silica Carbide and Fly ash particulates of grain size 200 mesh.

*The raw materials used for fabrication are*

1. Aluminum Matrix Material
2. Silicon Carbide (SiC)
3. Fly ash



S. no.	Sample nos.	Composition of reinforcement	Silicon carbide ( sic) wt%	Fly ash (wt.%)
1	Sample 1	AL7075	0	0
2	Sample 2	AL7075+2.5% sic+2.5% flyash	2.5	2.5
3	Sample 3	AL7075+5% sic+5% flyash	5	5

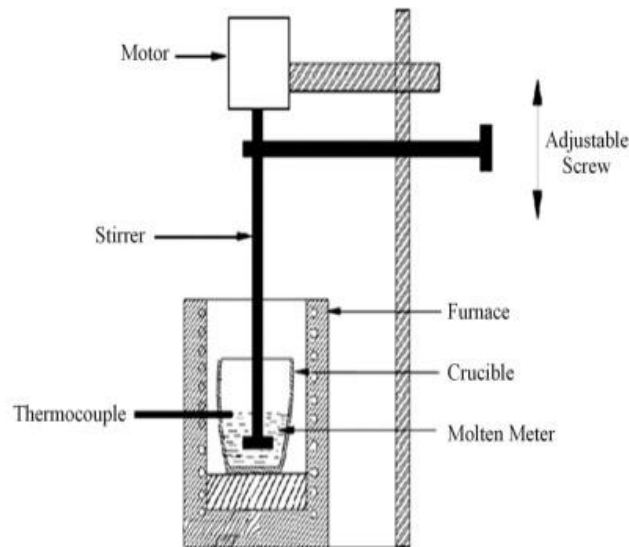
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## IV. STIR CASTING METHOD



**Stir casting process**

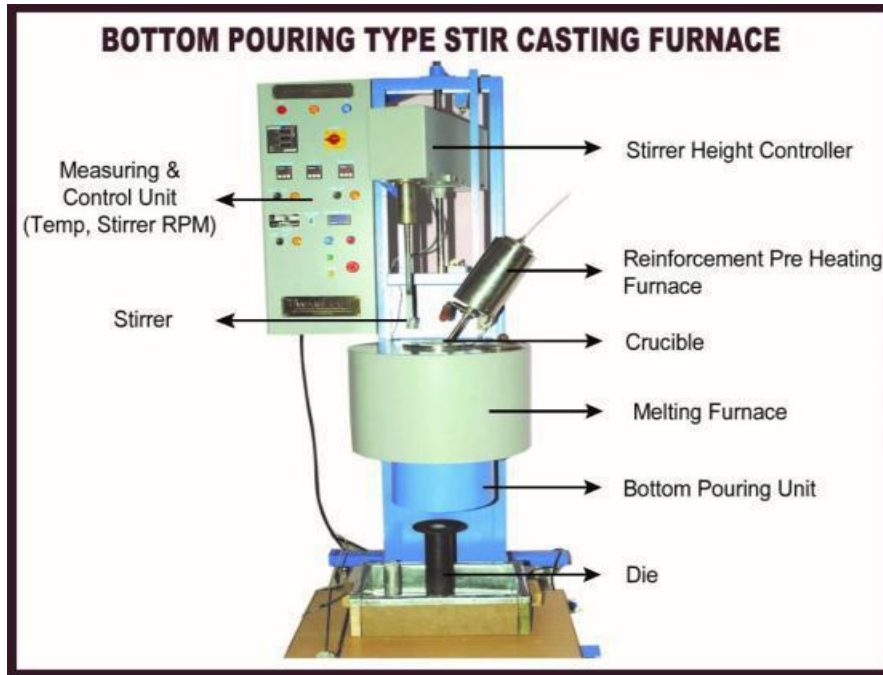
This is the initiative of stir casting of the metal matrix and it took place in 1969. Mechanical stirring is the key element of this process. Composites with up to 30% volume fractions can be suitably manufactured using this method. Sometimes the cast composites are further extruded to reduce porosity, refine the microstructure, and homogenize the distribution of the reinforcement. Segregation of reinforcing particles which is caused by the surfacing or settling of the reinforcement particles during the melting and casting processes is one of the major concerns associated with the stir casting process. The distribution of the particles in the final solid depends on strength of mixing, wetting condition of the particles with the melt, rate of solidification and relative density. The recent development in the stir casting process is the double stir casting process or two step process. In this process, initially the metal matrix composite is heated to above its liquidous temperature and then cooled then cooled down to a temperature between the liquidous and solidus points to a semi-solid state. The reinforcement material which is preheated is then added and mixed to the semi-solid state matrix material. Again the slurry is heated to a fully liquid state and mixed thoroughly. The microstructure of the composite made by double stir casting is more uniform than conventional stirring. The potency of this two-step mixing method is mainly due to its ability to break the gas layer around the particle surface which otherwise impedes wetting between the particles and molten metal. Thus the mixing of the particles in the semi-solid state helps to break the gas layer because of the abrasive action due to the high melt viscosity. Su et al. Designed a new three step stir casting method for fabrication of nano particle reinforced composite.

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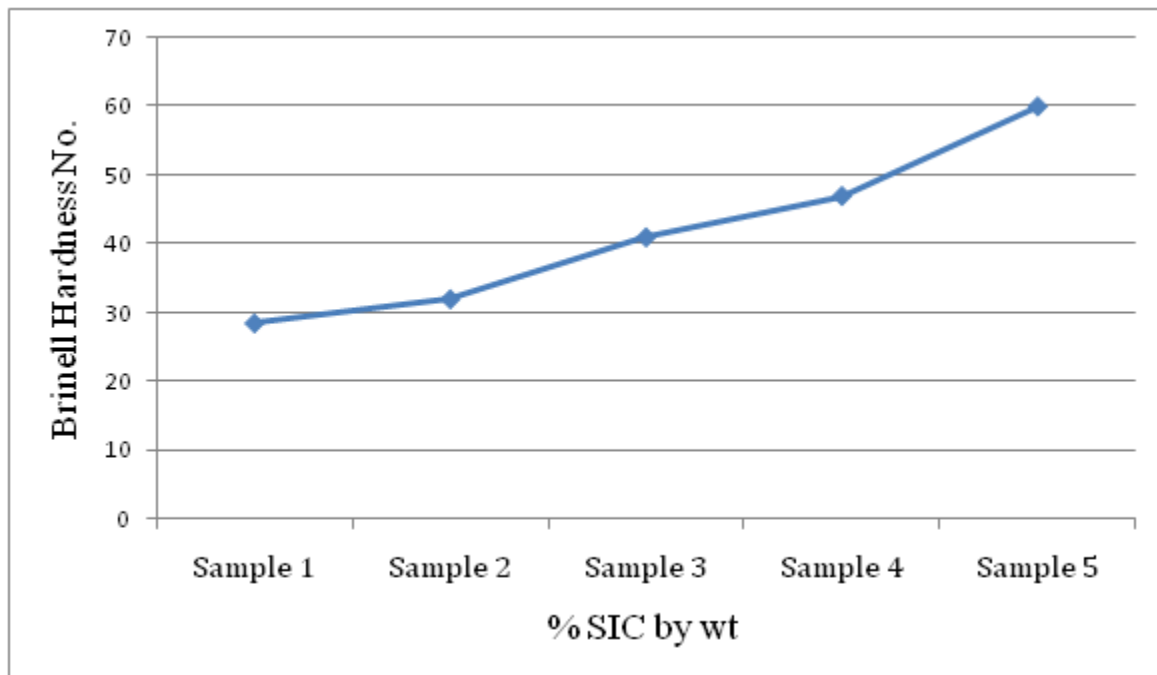
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**HARDNESSTEST:**





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Micro hardness testing is a method for measuring the hardness of the material on a microscopic scale. Microhardness was measured with the help of Brinell hardness tester. Micro hardness was calculated by using MVH-II digital micro hardness tester. A precision diamond indenter is impressed into the material at a load from few grams to kilograms. The impression length was measured microscopically, and the applied load was used to calculate the hardness value. The average micro hardness values for pure aluminum and three compositions of material are shown in figure B3. It is observed that hardness value is better in 6 wt. % of SiCp and 2 wt. % of fly ash. The hardness test on the specimens is carried out on The hardness test specimens are prepared as per the ASTM standards ( $\phi 18 \times 15$ mm). The specimens are fine turned and then polished to eradicate any burrs or irregularities on the surface. For indentation a  $136^\circ$  pyramidal diamond indenter is used.

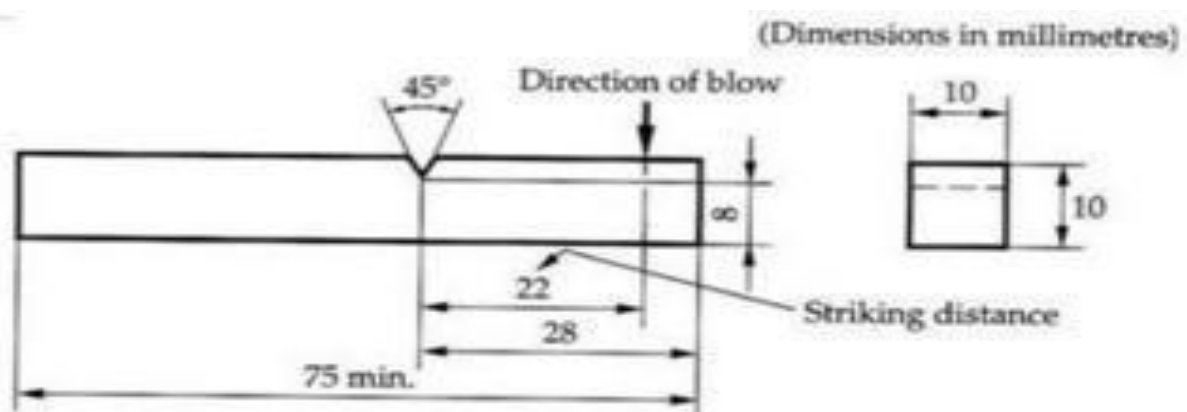
### TENSILE TEST:

The tensile tests of all were conducted by using universal testing machine. The elongation and yield stress decreases with increase The specimen shown in figure is gripped by the holding jaws. The grips are two small round shape hollow structures in which the specimen can be held in between with the help of a ring over it. There are two grips which hold the specimen from both the sides and are in turn attached to specimen holder. On fixing the specimen and ensuring that all the electrical connections are made on the tensometer, the computer that controls the system is switched on. Software controls all the operations. All the data regarding the specimen is fed in the system. After the data fed is rechecked for any errors if any, the command for "Test" is given. The readings are recorded for every displacement of 0.01mm. The tensometer stretches the specimen by incrementing the force it applies until the specimen breaks. After the specimen breaks, a message of termination of the function appears. After the readings have been saved, the specimen is removed from the tensometer and is set to be used for another specimen

### WEAR TEST:

At a constant speed of 800 rpm with normal loads of 3kg. A cylindrical pin of size around 6mm diameter and 25mm length prepared from composite casting was loaded through a vertical specimen holder against horizontal rotating disc. Before testing, the flat surface of the specimens was abraded by using grit paper. The rotating disc was made of carbon steel. Wear tests were carried out at room temperature without lubrication for 10 min. The principal objective of investigation was to study the wear rate. The wear test was conducted for all specimens by varying the load from 1kg to 1.5kg at a fixed sliding velocity of 1.5m/s at the rate of 600rpm. The pin sample was 50mm in length and 6mm in diameter as per ASTM standard E-18. The disc material used is EN19. Initially pin surface was made flat such that it will support load over its entire cross section. Run in wear was performed. This stage avoids initial turbulent period associated with friction and wear curves. Final stage is the actual testing called constant/ steady state wear. In this stage dynamic competition between material transfer processes occur. Before the test the pin and disc should be cleaned. In the present scenario the experimental parameters such as time, load, and speed is kept constant

### IMPACT TEST:



Izod impact test is performed on the specimen as shown in figure 10 as per ASTM standard. for determining the impact resistance of materials using an Izod impact testing machine. An arm held at a specific height (constant

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potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact energy is determined. A notched sample is generally used to determine impact energy and notch sensitivity.

## V. CONCLUSION

- Densities for composites were found decreased when related to the base alloy and this may be attributed due to the low-density levels of the fly ash. The theoretical densities were compared with measured ones.
- Stir casting process is well suited and economical for the preparation of AMMC's with desired properties. By increasing the wt % and decreasing the particle size of reinforced material in the aluminium composites the hardness, tensile strength and yield strength increases distance and sliding speed and the most influence parameter is sliding distance.
- The hardness of Al-SiCp-fly ash composites has increased with increase in addition of SiCp up to 6 wt. % and then decreases with constant amount of fly-ash.. The elongation and yield stress decreases with increase in addition of SiCp and fly-ash particulates reinforced in the base metal. The tensile strength is maximum at SiCp 6 wt.

## REFERENCES

- (1). Veeresh Kumar.G.B, Rao.C.S.P. and Selvaraj.N, "Mechanical and Tribological Behavior of Particulate Reinforced Aluminum Metal Matrix Composites – a review", Journal of Minerals & Materials Characterization & Engineering, USA, 10, 2011,59-91.
- (2). R. L. Deuis, C. Subramanian, J. M. Yellup, "dry sliding wear of aluminium composites-a review", Composites Science and Technology, 57, 1997, 415-435.
- (3). Bhargavi Rebba, N.Ramanaiah, "Studies on Mechanical Properties of 2024 Al – B4c Composites", Advanced Materials Manufacturing & Characterization, 4, 2014, 42-46.
- (4). P.Vivekanandan and V.P.Arunachalam, The Experimental Analysis of Stir Casting Method on Aluminium-Fly Ash Composites, International Journal of Current Engineering and Technology, Vol. 3, No. 1, 2013, pp. 215-219.
- (5). Bhaskar Chandra Kandpal, Ajay Singh, Love Kumar, Mohit Chaudhary, Om Narayan, Pallav Sharma, Piyush Singh and Som Ashutosh, Manufacturing of AMMCS using Stir Casting Process and Testing its Mechanical Properties, International Journal of Advanced Engineering Technology, Vol. 4, 2013, pp. 26-29.
- (6). Adem Onat, Mechanical and dry sliding wear properties of silicon carbide particulate reinforced aluminium copper alloy matrix composites produced by direct squeeze casting method. Sakarya University, Vocational School of Sakarya, 54100 Sakarya, Turkey, Journal of Alloys and Compounds 489 (2010)119–124.
- (7). B.G. Park, A.G. Crosky and A.K. Hellier// Composites: Part B39 (2008)1257.
- (8). S.Jeya krishnan, Sanjay S Chaudhary, "Enhanced Mechanical Properties of Metal Matrix Composites with Nanoceramics/ Nanoclay On Machinability" Technical Research Organisation India, Volume-3, Issue-5, 2016 pages 38-43.
- (9). Tamer Ozben, Erol kilickap, Orhan Cakir "Investigation of Mechanical and machinability properties of SiC particle reinforced Al-MMC" Journal of Materials Processing Technology 198 (2008), pages 220-225.
- (10). Zhang H, Z. Zhang and K. Friedrich, Effect of fiber length on the wear resistance of short carbon fiber reinforced epoxy composites, Composites Science and Technology, Vol. 67, 2007, pp 222–230.