

Development of WC-Feal Composite by Stir Casting Method

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ABSTRACT

In this paper author make an effort to develop a new material for fulfill the need of present requirement. This material is developed by the using of stir casting method. A AMMC's composite are developed to fulfill the need of present requirements. This composite material is prepared by the use of 3 metals. These metals are iron (Fe), aluminum (Al) and tungsten carbide (WC). Thus this composite come under metal matrix composite. This composite is WC – FeAl composite. This is prepared by the use of stir casting method. The base metals are iron and aluminum. These are having equal quantity by weight. In this the sample is prepared by the change the of percentage reinforcement. This is varying from 0 to 3%. A test is conduct to check their tensile strength as well as compressive strength. By these test it is confirm that with the increase the percentage of reinforcement in the composite their tensile strength is decrease but their compressive strength is increase.

Keywords-- Iron, Aluminum, Tungsten Carbide, Stir Casting method, Mechanical Property

Composite material has high strength to weight ratio. By selecting a suitable combination of matrix and reinforcement material, a new material can be made that actually meets the requirements of a particular application. Composite designs also provide flexibility because many of them can be molded into complex shapes. Negative side is often cost. Although the resulting product is more efficient, raw materials are often expensive.(1)

The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

For example, reinforced concrete (made of concrete and steel) has resistance to pressure and to bending forces. Bullet-proof glass (made of glass and plastic) is more resistant to impact. Concrete itself is a composite material, one of the oldest man-made composites, used more than any other man-made material in the world. Wood is a natural composite of cellulose fibers in a matrix of lignin. The earliest man-made composite materials were straw and mud combined form bricks for building construction. polymerase in wide use today, as is glass-reinforced plastic. The ordinary word 'composite' gives a slight indication of the vast range of personal combinations involved in this class of material.

I. INTRODUCTION

A composite material is made up of two or more materials which are combining in same or different percentage by weight or by mass. These materials have different mechanical as well as chemical property. The composite material fulfills the need of present requirements.

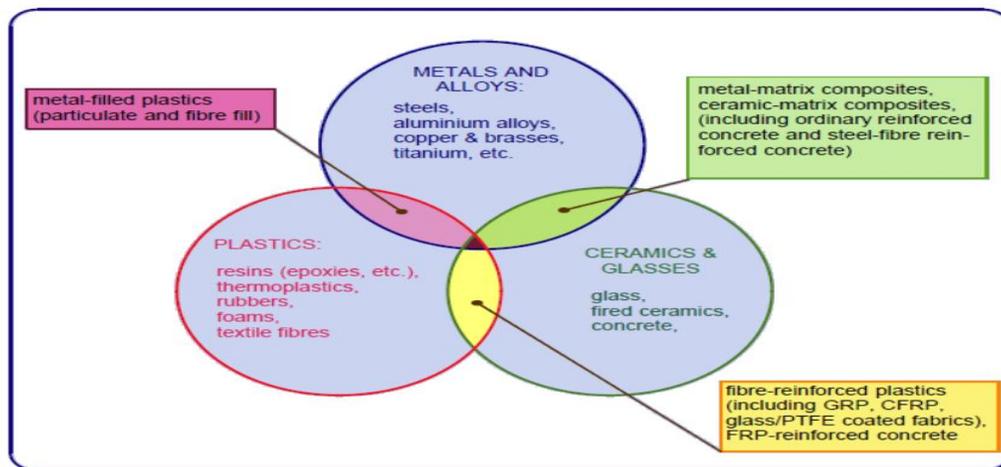


Figure 1 Relationships between classes of engineering materials

We have mentioned some more familiar one, but figure 1.1 has given a simple idea for simplicity which is available to the content scientist and his client, design engineer. First of all, each group of materials - metal, ceramic and polymer – is already some familiar materials that can be described as composites. (2)

AMMC's one of the most suitable composite material that fulfills the need of present requirement. Aluminum has low density. Due to this the AMMC's composite also have low density.

In the present research an iron aluminide composite are prepared with the use of WC as reinforcement in this composite. WC has high strength, greater hardness value, and high melting point. In this composite aluminum provide low density and tungsten carbide provides high strength and hardness. Iron also use in this composite. This composite is prepared by the use of stir casting method.

II. LITERATURE REVIEW

Gomez deals with analysis of boron carbide aluminium matrix composites Boron carbide (B₄C) is obtained by solid-state processes (powder metallization and extrusions) as the reinforcement of aluminum matrix composites (AMCs). Two different reinforcements were considered: B₄C for the purpose of this study and for direct comparison of results, SiC The aluminum alloy AA6061 was used as the matrix in all cases. Comparative analysis between both SiC and B₄C composites was focused on mechanical and tribological properties and correlated to microstructural features It concludes that with the volume fraction of reinforcement, the hardness and strength for composites increased, its maximum value reached 10% B₄C. Regarding tribology, composites showed increased dynamic friction coefficient, but lower wear rate than unrelated aluminum alloy. Applications for the automotive industry as a brake disk are predictive. [4]

Ravi Kant deals with the analysis aluminium matrix composites. In this four Alloy are prepared by the mixing of different reinforcement in the Iron aluminide(FeAl). Sliding wear behavior of the Alloy is tested. During the testing they find that Alloy-1 have low strength and hardness because of the graphite present in the Alloy-1. Alloy-2 and Alloy-3 exhibit comparable values of strength and hardness but higher than those of Alloy-1 due to the presence of hard ZrC and TiC carbides, respectively. Lower volume fraction of carbides results in lower strength and hardness in Alloy-2 compared with Alloy-3. Alloy-4, which has the highest carbon (and carbide) content, exhibited the highest values of hardness and strength. Thus strength of these Alloys is determined by the volume fraction and hardness of carbides present. [5]

Ryoichi Furushima and Kiyotaka Katou has studies on the wear behavior of FeAl composite which is

sintered by PCS technique (pulse current sintering) and vacuum sintering technique. The use of pulse current sintering techniques enables to densify the WC-FeAl composite at a temperature lower than that of FeAl liquid phase formation. That difference of sintering temperature results in crucial difference of the microstructure of the composites. Whereas some WC grain growth and huge FeAl phases are observed from the sample of vacuum sintering technique. As a result, superior mechanical properties such as Vickers hardness and bending strength are obtained from the samples of the pulse current sintering technique in the WC-FeAl system. [6]

M Adrewry make a wind turbine by using the composite material. They were always attended, sometimes inhabited and, largely, manually controlled. They were integrated within the community, designed for frequent replacement of certain components and efficiency was of little importance. In this they used NDT testing methods to examine rotor blades. The analysis of damage in most towers shows that it occurs under a wind of medium intensity, and the reason is fatigue failures. In this study, a wireless system using a tiny oscillation circuit for detecting delamination of carbon/epoxy composites is proposed. [7]

III. EXPERIMENTAL PROCEDURE

For the preparation of composite use aluminum plate, iron powder and tungsten carbide. The plate of aluminum plate (Aluminum 6063- T6) obtained from "vijayprakashgupta and sons New Delhi", iron powder obtained from Gangotri Inorganic Pvt. Ltd Ahmedabad Gujarat India and WC particles from UNITED WOLFRAM Surat Gujarat India.

Firstly the aluminum plate is cut into small size to be easily placed in crucible for melting. The crucible was placed in the electric furnace for melting the aluminum. So after two hours the temperature inside the furnace reached 750°C, which was shown on the control panel display and measured by thermocouple. At this 750°C temperature, the matrix material was melted.

After the melting of aluminum in the furnace mix iron powder equal to the weight of aluminum and then heated. After 2 hours its temperature are reaches upto 1550°C which was shown on control panel display.

When the iron and aluminum is melt and mixed. Then poured tungsten carbide (5µm) as reinforcement in the crucible. A mechanical stirrer is use to mixed this material properly. In the mixing process, the first stimulant was molten and the motor was turned on. After this, the reinforcement was sprinkled in the molten matrix. The mixture of matrix and reinforcements were stirred by mechanical stirrer at 1550°C temperature, at 400 rpm, for 10 minutes.



Fig 2 Complete stir casting setup

After then minute the molten metal ate poured into the sand mold which are already prepared. The casting of these metals is showed in to the size of specimen for the testing of strength in tensile and makes another sample for the testing of compressive strength.

Similar process is repeated with change the percentage of reinforcement. And make other sample for testing. The percentage of reinforcement is varying from 0%, 1%, 2%, and 3%.

IV. RESULT AND DISCUSSION

Tensile Testing: - Tensile testing is done on the on UTM. Tensile testing is used to provide information that will be used in design calculations or to demonstrate that the material complies with the requirements of appropriate specifications - so it can be either quantitative or qualitative test. Tensile strength of the specimen is measured by tensile

testing. In this research tensile testing is carried out on universal testing machine.

The test is done by applying the continuous growing uni-axial load by holding the ends of the standardized test piece, properly prepared in a tensile test machine and then on failure. As per ASTM standard the size of test piece is based on the following relation:-

$$L_0 = k\sqrt{A}$$

Where

L_0 = Original gauge length, the portion of sample with minimum diameter (m)

k = constant (value of k varies from 5 to 6, we take it 5.65)

A_0 = Original area of cross-section at gauge length (m^2)

In present experiment the tensile test are conducted on aluminium MMCs. Following formulas are used.

$$\sigma = P/A_0$$

$$e = (L_f - L_0)/L_0 = (A_0 - A_f)/A_0$$

σ_u = maximum load /cross-sectional area

Table 1 Tensile strength of specimen at different % of Reinforcement

S No.	Specimen composition (% weight)			Tensile strength (MPa)			
	Al	Fe	WC	Test 1	Test 2	Test 3	Average
1.	50	50	0	315	317	320	317
2.	49.5	49.5	1	302	307	311	307
3.	49	49	2	295	298	301	298
4.	48.5	48.5	3	285	289	293	289

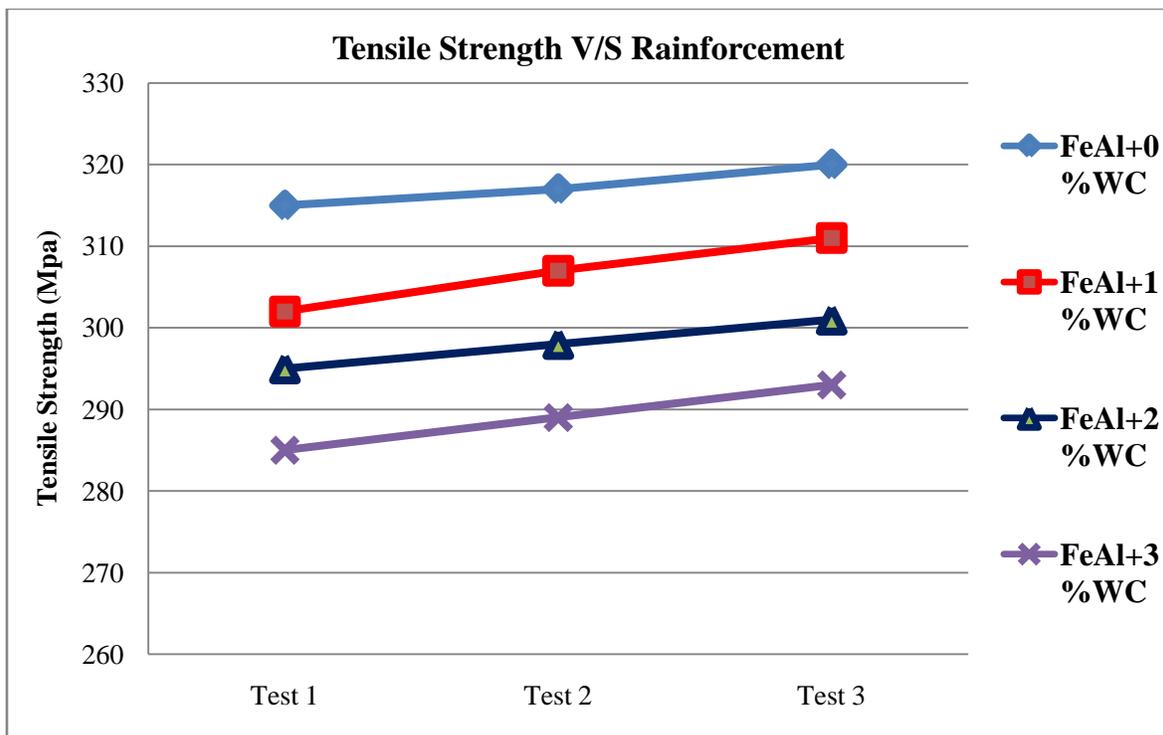


Fig.5.2 Tensile strength of specimen at different % of Reinforcement

Compressive Testing: - Compressive strength of the specimen is measured by Compressive testing. Compressive strength test, mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The test piece, usually in the form of a cube, prism, or cylinder, is compressed between the platens of a compression-testing machine by a gradually applied

load. In this research Compressive testing is carried out on universal testing machine.

In present study the compressive test are conducted on aluminium MMCs. Following formulas are used.

$$\sigma = P/A_0$$

$$e = (L_f - L_0)/L_0 = (A_0 - A_f)/A_0$$

$$\sigma_u = \text{maximum load} / \text{cross-sectional area}$$

Table 2 Compressive strength of specimen at different % of Reinforcement

S No.	Specimen composition (% weight)			Compressive Strength (MPa)			
	Al	Fe	WC	Test 1	Test 2	Test 3	Average
1.	50	50	0	180	190	197	189
2.	49.5	49.5	1	220	229	238	229
3.	49	49	2	290	303	317	303
4.	48.5	48.5	3	400	409	417	409

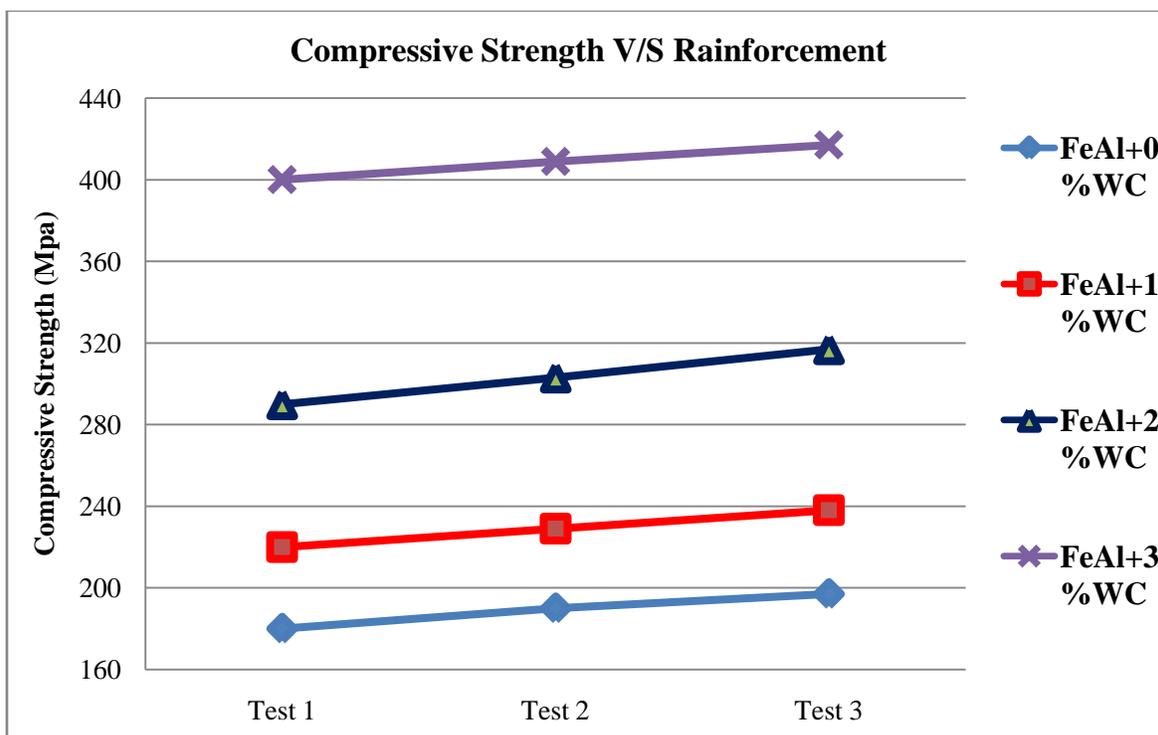


Fig.5.3 Compressive strength of specimen at different % of Reinforcement

In alloy 1 when no reinforcement added in base material (FeAl) their tensile strength is 317 Mpa but in alloy 2 when the percentage of reinforcement reaches 1% their tensile strength decrease reaches at 307 MPa. In alloy 3 percentage of reinforcement is 2 % their tensile strength decrease at 298 mpa. And in alloy 4 at 3% of reinforcement added in base metal their tensile strength reaches at 289 mpa.

In alloy 1 when no reinforcement added in base material (FeAl) their compressive strength is 189 Mpa but in alloy 2 when the percentage of reinforcement reaches 1% their compressive strength increase, reaches at 229 MPa. In alloy 3 percentage of reinforcement is 2 % their tensile strength decrease at 303 mpa. And in alloy 4 at 3% of reinforcement added in base metal their compressive strength reaches at 409 mpa.

V. CONCLUSION

From all this result it is clearly specify that at the increase of reinforcement in the base material its tensile strength decrease slowly but compressive strength increase rapidly.

- WC- FeAl composite was successfully developed by stir casting method.
- On the basis of above result it is clearly specify that at 3 % of reinforcement compressive strength

reaches at 409 mpa. But on other hand at 3 % of reinforcement tensile strength reaches at 289 mpa.

- Due to high compressive strength it is suitable to use for the manufacturing of machine base and can be replaced cast iron.
- It is a ductile material due to presence of iron and steel and its tensile strength in not very less so it is useful as a shock absorbing material.
- AMMC’s has low density and tungsten carbide has high strength and melting point. Due to this such material has combine property of both materials.

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