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The Effect on Mechanical Properties and Microstructure of LM6 Aluminium alloy reinforced with Tungsten Carbide (WC)

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ABSTRACT: Various experimentation and research is going on the field of Aluminium Matrix Composites (AMC) and Metal Matrix Composites (MMC). AMC and MMC have wide range of application in several fields like a automotive, marine, aerospace, defence, high elevated temperatures etc. There are several methods are used to prepare a composite material like a powder metallurgy, spray deposition, stir casting. In our project we prepare a composite material by using stir casting method because of low cost and easy availability. In our experiment LM6 Aluminium alloy is used as a base matrix material and Tungsten carbide (WC) is used as a reinforcement material. Once we make LM6 Al alloy with Tungsten carbide (WC) composite by using stir casting process then samples are prepared by vary the addition level of reinforcement material. In our experimentation there are four types of samples are prepared by adding 0% WC, 1% WC, 2% WC and 3% WC respectively by keeping basic matrix material aluminium alloy (LM6) constant. After the preparation of samples Microstructural and Mechanical properties are studied. SEM (Scanning Electron Microscope) analysis is used to check the Tungsten carbide (WC) distribution in base metal matrix. For mechanical properties conduct test like Rockwell hardness test, V-notch charpy test, Tensile test by using UTM (Universal Testing Machine). To know the hardness, impact and tensile strength through respective test. After conduction of all test we get the appropriate results. These results are analysed and compare between them.

KEYWORDS: stir casting, LM6 aluminium alloy, tungsten carbide

I. INTRODUCTION

Advanced materials play a key role in the field of engineering materials. Because of this fact advanced engineering materials necessity increased day by day in the field of engineering materials. To overcome from this problem by using MMC (Metal Matrix Composites) in place of advanced engineering materials.

Composites are nothing but combination of two or more materials to improve mechanical properties. Composite materials having a huge advantages like light in weight, easy availability, higher strength, higher stiffness, higher hardness, better properties at elevated temperatures etc. In MCC (Metal Matrix Composites) one element should be metal or alloy it occupy the maximum portion in the composite, then it is called as base metal matrix. Composite on other hand small portion of material is added to the basic metal matrix is called reinforced material.

Aluminium is the third most plentiful element after oxygen and silicon on the earth. LM6 aluminium alloy is also called Al-Si alloy because of silicon (10-13%) as a major alloying element in the LM6 aluminium alloy.

Most of the time SiC, TiC, fly ash, WC are used as a reinforced materials during preparation of the composite materials. Tungsten carbide (WC) is equal combination of both tungsten and carbon atoms. Basically tungsten carbide is chemical compound. It looks like a fine grey powder. Tungsten carbide is very hard material and its hardness value is around 1700 HV. Basically it is prepared through powder metallurgy process. In this context we use tungsten carbide as a reinforcement material in LM6 aluminium basic metal matrix material with addition of different weight percentage.

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The composite is prepared through stir casting method. We have observed that by increasing the weight percentage of Tungsten Carbide in base material matrix results in increasing its mechanical properties.

II. LITERATURE REVIEW

1. N suresh et al. (2010) most of the cases aluminium alloy is taken as a base matrix material is reinforced with ceramic materials. In this research paper they produced composite materials with cenospheres by using fly ash as a reinforced material in aluminium base matrix. They used stir casting method to prepare composite material. Addition of fly ash to base matrix material lm6 vary from 1 to 10%. After preparation of composite materials check the result they observed that its mechanical properties like hardness, ultimate tensile strength increases from approximately 35 to 45% respectively. But its density and wear loss decreases by 15% and 34% respectively. Every time addition of the fly ash into lm6 base matrix material its mechanical properties like tensile strength, impact strength, hardness are goes on increasing.

2. A R K swamy et al. (2011) in this journal paper they prepare two different composite materials. first one is al-6061 as base matrix material and tungsten carbide as a reinforcement material. second one is al-6061 as a base matrix material and graphite as reinforcement material. these two composite is prepare by new technique vortex method. the addition of the reinforcement material into the base matrix material is vary from 0 to 4% by weight percentage. the result shows that for increasing the tungsten carbide (wc) in al-6061 base matrix material. its mechanical properties like hardness, tensile strength, compressive strength is also increases. from this conclude that exactly reverse in second composite material. every time addition of the graphite into the al-6061 aluminium alloy its mechanical properties is goes on decreasing.

3. Srikanth b g (2015) this research paper illustrates, use aluminium (al 6061) as a base matrix material and tungsten carbide (wc) and fly ash as a reinforcement material. Composite is prepare through stir casting method. Tungsten carbide (wc) addition 1%, 2%, 3% and fly ash addition is 2%, 4%, 6% in base matrix material ie aluminium alloy (al-6061). After the preparation of the samples mechanical properties like hardness and tensile test carried on both unreinforced and reinforced materials. Sem analysis is carried to know distribution of tungsten carbide (wc) and fly ash in the base matrix material al-6061. Finally observed that mechanical properties like hardness, tensile strength, compressive strength increases by increase the tungsten carbide (wc) and fly ash into base matrix material al-6061. Every time addition of tungsten carbide (wc) and fly ash into base matrix material its mechanical property is improved.

III. EXPERIMENTAL DETAILS AND METHODOLOGY

3.1 Stir Casting

Stir casting apparatus consists of induction furnace and automatic stirrer arrangement. Commonly stirrer is made up of stainless steel because of its corrosive resistance and durability. Then stirrer shaft is connected to the motor around the speed of 400 rpm. In our research stir process carried by manually by using stainless steel bar. The graphite crucible around capacity of 2 kg placed inside the induction furnace. It is the basic structure of the stir casting apparatus.

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IV. RESULTS AND DISCUSSION

4.1 Rockwell Hardness Test

Table 4.1 Hardness number for different additional levels of (WC)

Sl no	Material Composition	Applied load (Kgf)	Hardness no (HRB)
1	LM6 Al + 0% WC	100	44
2	LM6 Al + 1% WC	100	54
3	LM6 Al + 2% WC	100	59
4	LM6 Al + 3% WC	100	77

From above figure it is observed that the hardness number increases with increase in the addition level of tungsten carbide. The hardness number goes on increases with the different addition levels of WC because of reformed grain size of the material that increase the strength of the material.

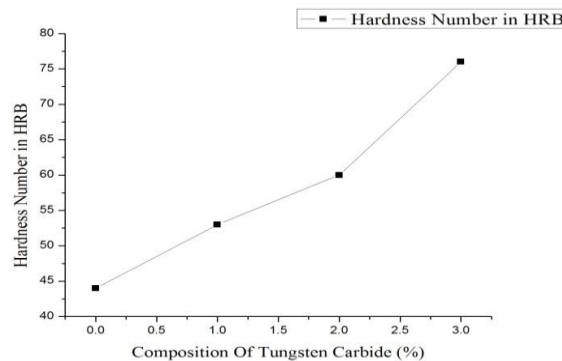


Fig 4.1: Comparison of hardness number

By observing above graph we found that without any addition of Tungsten Carbide (0% WC) the hardness number is 44 HRB. And adding 1% Tungsten Carbide (WC) the hardness number will become almost 54 HRB. Add another 1% Tungsten Carbide i.e 2% Tungsten Carbide (WC) the hardness number is become 59 HRB. Finally add 3% Tungsten Carbide (WC) into base matrix material the hardness number will becomes approximately 77 HRB.

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4.2 Charpy Impact Test

Table 4.2 Impact strength for different addition levels of (WC)

Sl no	Material Composition	Initial reading (K ₁)	Final reading (K ₂)	Energy absorbed (K ₁ -K ₂)	Impact strength (Nm/mm ²)
1	LM6+0% WC	300	298	2	0.02
2	LM6+1% WC	300	296	4	0.04
3	LM6+3% WC	300	292	8	0.08
4	LM6+4% WC	300	288	12	0.12

From above figure it is observed that the impact strength increases with increase in the addition level of tungsten carbide. The hardness number goes on increases with the different addition levels of WC because of reformed grain size of the material that increase the strength of the material.

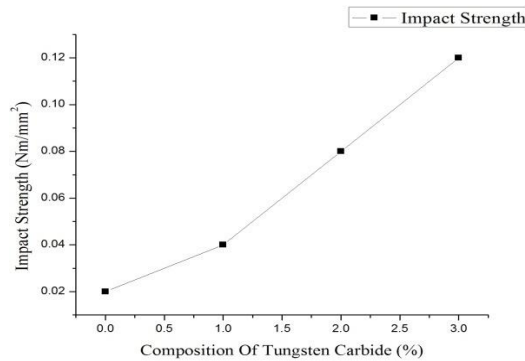


Fig 4.2: Impact strength for different addition level of WC (%)

By studying above table and graph we found that without any addition of Tungsten Carbide (0% WC) into LM6 base matrix material and impact strength will be 0.02 N-m/mm². Add 1% of Tungsten Carbide into base matrix its impact strength will becomes almost 0.04N- m/mm². Add another 1% of Tungsten Carbide i.e total 2% Tungsten Carbide (WC) its impact strength will becomes 0.08 N-m/mm². Similarly add 3% Tungsten Carbide (WC) into base matrix the impact strength will becomes 0.12 N-m/mm². Hence conclude that for every small addition of tungsten carbide in base matrix its impact strength is improving.

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4.3 Tensile Test

Table 3.3: Tensile strength for different addition levels of (WC)

Sl no	Material Composition	Ultimate load (KN)	Breaking load (KN)	Ultimate strength (N/mm ²)	Breaking strength (N/mm ²)
1	LM6 Al + 0% WC	5.1	4.7	180.35	166.20
2	LM6 Al + 1% WC	6.0	5.2	212.18	183.88
3	LM6 Al + 2% WC	6.5	5.8	229.86	205.10
4	LM6 AL + 3% WC	7.5	6.5	265.22	229.86

From above figure it is observed that the tensile strength increases with increase in the addition level of tungsten carbide. The hardness number goes on increases with the different addition levels of WC because of reformed grain size of the material that increase the strength of the material.

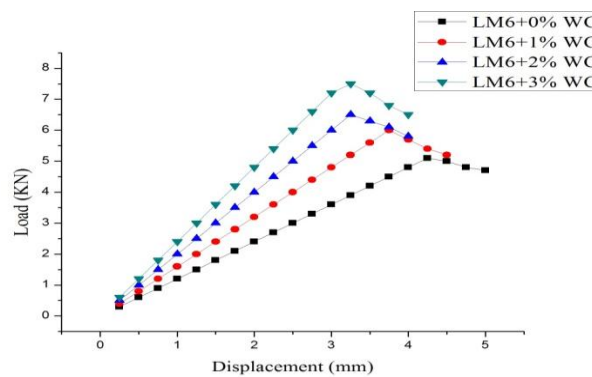


Fig 4.3: Comparison of Tensile strength for different additional level of (WC)

From above graph and table we clearly observed that the composite materials tensile strength increases with increase the addition level of tungsten carbide into base matrix material. From the above table and graph we can easily found that composites ultimate load and break load is also increases for increasing weight percentage of tungsten carbide into base matrix material. Finally it conclude that tensile strength is increases for increasing weight percentage of tungsten carbide (WC) into base matrix material.

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4.4 Microstructure Analysis

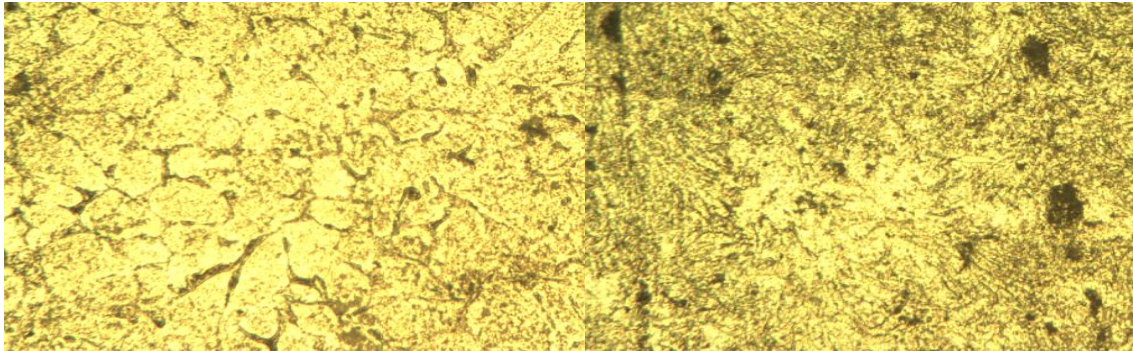


Fig 4.4: Microstructure of LM6+0% WC

Fig 4.5: microstructure of LM6+1% WC

By comparing above microscopic images we found that the grain size in LM6 Al with 0% WC will become small in LM6 Al with 1% WC. It clearly shows the strength of material is improved when 1% WC added to the LM6 Al.

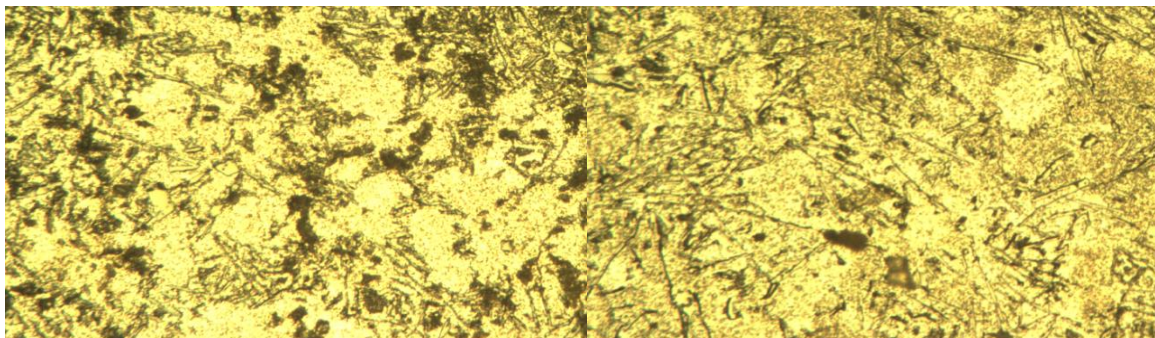


Fig 4.6:Microstructure of LM6 Al+ 2% WC

Fig 4.7: Microstructure of LM6 Al+ 3% WC

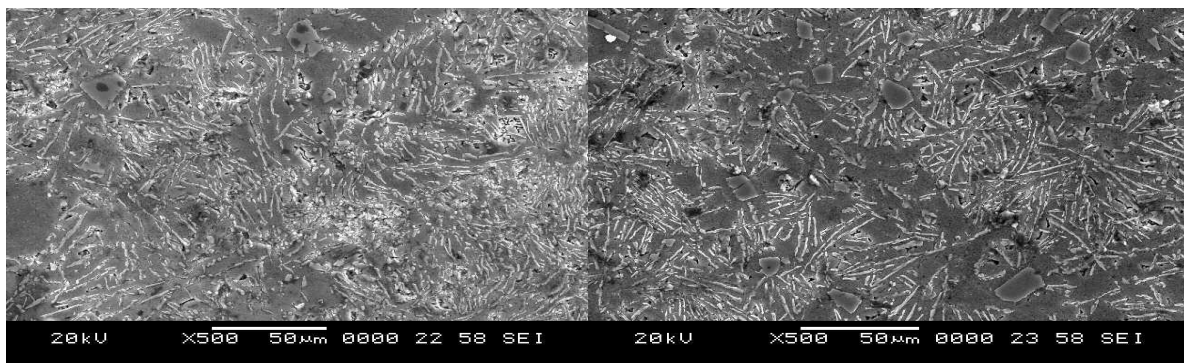


Fig 4.8:Microstructure of LM6 Al+ 2% WC

Fig 4.9: Microstructure of LM6 Al+ 3% WC

Above images are SEM (Scanning Electron Microscope) images. In SEM images we can found some white patches these are nothing but Tungsten Carbide distribution in LM6 base matrix material.

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From Microstructure and SEM (Scanning Electron Microscope) Analysis we found that increase the reinforcement material tungsten carbide in LM6 Al base matrix material the grain size will be decreased at a same time its strength will be increased. Important note is material is converted into ductile. In SEM mages the white thing is nothing but reinforcement material tungsten carbide distributed in LM6 Al base matrix material. After Microstructure analysis we can easily say that increase the weight percentage of reinforcement material in base matrix material its strength is also increases. Both are directly proportional to each other.

V. CONCLUSIONS

Commonly single alloy is poor in properties like hardness, impact strength, tensile strength etc. To overcome from this problem prepare metal matrix composite material. In our research prepare LM6-WC composite material by using stir casting method. Where LM6 Aluminium alloy as a base matrix material and different addition level of Tungsten Carbide (0%, 1%, 2% and 3%).

In this investigation the experimental data's and results clearly says as fallows

- The hardness is increased with increase the addition of WC
- The impact strength is improved with increase the addition level of WC
- The tensile strength is enhanced by adding the WC
- From microstructure analysis grain size decreases and strength is increases with adding of WC
- Uniform distribution of WC in base matrix material from microstructure analysis.

In our investigation clearly conclude that composite material having higher reinforcement material having higher mechanical properties compare to unreinforced alloy or having less weight percentage reinforcement material. The experimental results and graphs clearly shows that reinforcement plays an very important key role in metal matrix composite to improve the mechanical properties.

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