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Influence of Heat Treatment on Mechanical Properties of Aluminium-7075 Reinforced With Titanium Nitride

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Abstract: Al-7075 Metal Matrix Composites (MMC) was produced using stir casting method by adding Titanium Nitride (TiN) reinforcement with varying weight percentages of 1.5, 3 and 4.5. Liquid state fabrication of metal matrix composites involves incorporation of dispersed phase into a molten matrix metal, followed by its solidification. In order to provide high level of mechanical properties of the composite, good interfacial bonding between the dispersed phase and the liquid matrix should be obtained. The produced composite was subjected to heat treatment process and mechanical tests were conducted for heat treated and untreated samples. Increase in ultimate tensile strength (201.96 MPa) and hardness (103 BHN) was observed for heat treated samples in comparison to untreated samples. Similar increased compressive strength (515.15 MPa) behavior was showed in case of heat treated samples but reduced in case of untreated samples. Overall the mechanical properties improved for the heat treated samples compared to untreated samples.

Keywords: Metal Matrix Composites, AL7075, TiN, Heat treatment. Etc.

1. INTRODUCTION

Aluminium is a silvery white and ductile member of the boron group of chemical element. Aluminum is remarkable for its ability to resist corrosion (due to phenomenon of passivation) and is low density. Structural components made from aluminum and its alloys are vital to the aerospace industries and very important in other areas of transportation and building. Its reactive nature makes it useful as a catalyst or assistive. Aluminium 7075 is used as base material Aluminium alloy with zinc has the primary alloying element. It is strong with a strength comparable to many steels and good fatigue strength and average machinability, but has less resistance to corrosion then many other aluminium alloys. Aluminium 7075 is an excellent material for use in highly stressed structural applications. Titanium nitride is used as reinforcement. Osborite is a very rare natural form of titanium nitride, found almost exclusively in meteorites. It is chemically stable at 200 C but can be slowly attacked by concentrated acid solutions with rising temperature. This composite material is of Metal matrix type composition. Metal matrix composites are composed of a metallic matrix (Aluminium, Magnesium, Iron, Cobalt, Copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase.

Stir casting method is used for casting process and the obtained castings are heated to a certain temperature and the cooled in a particular manner to alter its internal structure to obtain the desired properties. Then the composite material specimens are prepared according to ASTM standards by machining the Heat treated castings.

2. EXPERIMENTATION PROCEDURE

Aluminium alloy with zinc has the primary alloying element. It is strong with a strength comparable to many steels and good fatigue strength and average machinability, but has less resistance to corrosion than many other aluminium alloys. Titanium nitride is an extremely hard ceramic material often used as a coating on titanium alloys steel, and aluminium components to improve the substrate's surface properties.

The aluminium 7075 ingots were melted in a crucible placed inside the induction furnace at the temperature of 750^0C, and then the obtained molten metal is degassed by purging Hexa-chloroethane tablets. Hexa-chloroethane is used for smoke producing devices, in a metal and alloy production, and as an ingredient in insecticides. The Cover flux is added to the molten metal to avoid oxidation which in turn reduces casting defects, and then 1% of

magnesium is added in the form of chips to improve wettability of the matrix material, then the preheated reinforcement is added to the molten metal. Then the molten metal is poured into the Mild steel die machined with cylindrical channels of diameter 25 mm and length 130 mm was pre-heated at a temperature of 400 °C. Die was pre-heated to avoid the distortion, when the molten metal is poured into it.

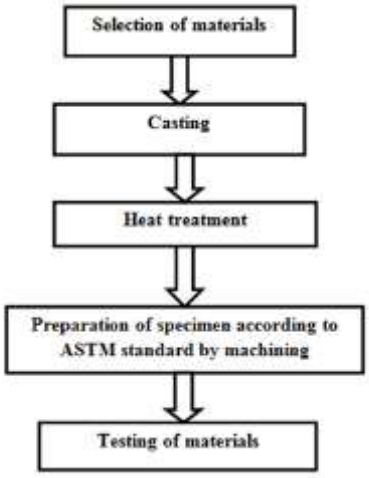

Fig-1: Flowchart of experimentation procedure

The obtained composite material was heat treated and tempered to T6 condition. i.e. the sample were heated at 530^0C for 3 hours and then immediately quenched in water at room temperature and finally were artificially aged in the furnace at 180^oC for 5 hours and then air cooled to room temperature.

The tensile and compression specimens were machined according to ASTM E8M standards with the aid of especially sharp cutting tools, to avoid any other additional deformation or over heating during machining. The cast material of different composition was turned using CNC lathe for required dimensions using high speed steel tool. The initial diameter and gauge length was measured using measuring equipment and was recorded for further calculations.

Fig-2: Tensile and Compression Test Specimen

Rockwell hardness test was performed on the Hardness test specimen. The test was carried out at different locations in order to contradict the possible effect of indenter resting on the harder particles.

3. RESULTS AND DISCUSSION

3.1Tensile test

The testing was performed on a Universal Testing Machine equipped with a computer data acquisition system, at room temperature. The test was performed on the sample with gradually increasing the load. Elongation of the material for the increasing load was recorded. The test was carried out till the material gets fractured.

Following Table 1 shows the different values of tensile strength with different Wt. % of reinforcements.

Table-1: Values of tensile strength for different compositions

SL. NO.	SAMPLE WITHOUT HT	TENSILE STRENGTH (MPa)
1	AL7075	128.11
2	AL7075+1.5%TiN	146.75
3	AL7075+3%TiN	188.98

SL. NO.	SAMPLE WITH HT	TENSILE STRENGTH (MPa)
1	AL7075	148.10
2	AL7075+1.5%TiN	166.59
3	AL7075+3%TiN	201.96

The tensile strength of the sample i.e. As cast is found to be 128.11 N/mm^2, when the sample was added with the TiN reinforcements in varying proportions i.e 1.5% and 3% the tensile properties also increased accordingly i.e. 146.75 N/mm^2 and 188.98 N/mm^2 represents the tensile strength of the samples which are subjected to the heat treatment process.

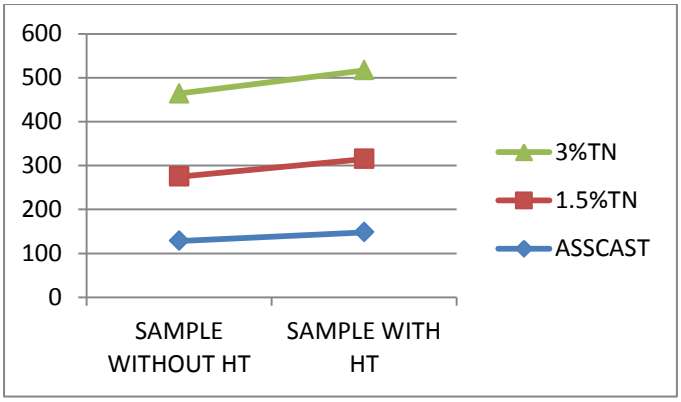

Fig-3: Variation of tensile strength with different Wt. % of reinforcement with and without HT

Here an increase can be seen in the tensile strength, as Al7075 measured 148.10 N/mm² for its tensile strength and the tensile strength of Al7075 with 1.5% TiN reinforcement and Al7075 with 3% TiN reinforcement was found to be 166.59 N/mm² and 201.96 N/mm² respectively.

So from the above results it can clearly be seen that the samples subjected to heat treatment process posses higher tensile strength than those samples which are not subjected to the heat treatment process, the reason being that the sample with heat treatment have much refined grains as well as more grain boundaries which increases the tensile strength of the samples.

3.2 Hardness test

Brinell hardness test was performed on this sample. The test was carried out at different locations in order to contradict the possible effect of indenter resting on the harder particles.

The following Table 2 shows the different hardness values for different Wt. % of reinforcements.

As cast sample has measured a hardness value of 71 BHN, when the Al7075 was added with reinforcement TiN at varying proportions i.e. 1.5% and 3% a slight increase in the hardness value was noticed i.e. Al7075 with 1.5%TiN measured 88 BHN and Al7075 with 3% TiN measured 96 BHN.

Table-2: Hardness Values for different compositions

Sl. No.	Sample without HT	BHN
1	AL7075	71
2	AL7075+1.5%TN	88
3	AL7075+3%TN	96

Sl. No.	Sample with HT	BHN
1	AL7075	83
2	AL7075+1.5%TN	95
3	AL7075+3%TN	103

As per the table as cast has hardness of 83 BHN, Al7075 with 1.5% of TiN has hardness value of 95 BHN and Al7075 with 3% TiN has hardness of 103 BHN.

By comparing the hardness results it is evident that the heat treatment process improves the hardness of the materials, reason being that microstructure of the material changes due to the grain reinforcements which makes the material hard.

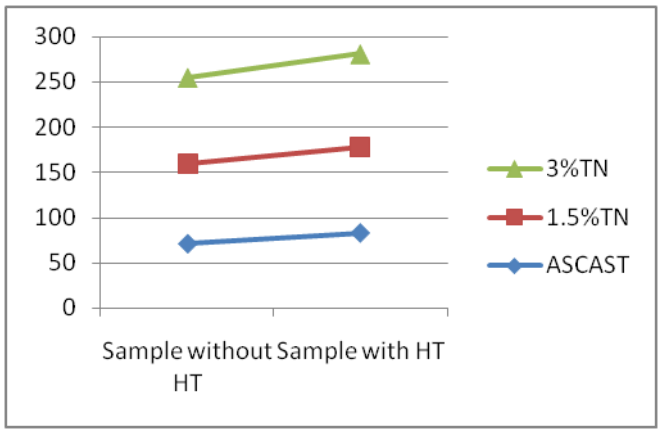

Fig-4: Variation of Hardness value with different Wt. % of reinforcement with and without HT

3.3 Compression test

The testing was performed on a Universal Testing Machine equipped with a computer data acquisition system, at room temperature. The test was performed on the sample with gradually increasing the load. Compress of the material for the increasing load was recorded. The test was carried out till the material gets fractured.

Following Table 3 shows the different values of compression strength with different Wt. % of reinforcements.

Table -3: Values of compression strength for different compositions

Sl. No.	Sample without HT	Compression Strength (MPa)
1	AL7075	327.83
2	AL7075+1.5%TiN	371.43
3	AL7075+3%TiN	481.67

SL. NO.	Sample with HT	Compression Strength (MPa)
1	AL7075	386.63
2	AL7075+1.5%TiN	426.15
3	AL7075+3%TiN	515.15

The compression strength of the sample i.e. As-cast is found to be 327.83 N/mm^2, when the sample was added with the TiN reinforcements in varying proportions i.e 1.5% and 3% the compression properties also increased accordingly i.e. 371.43 N/mm^2 and 481.67 N/mm^2. represents the compression strength of the samples which are subjected to the heat treatment process. Here an increase can be seen in the compression strength , as Aacast measured 386.63 N/mm^2 for its compression strength and the compression strength of Al7075 with 1.5% TiN reinforcement and Al7075 with 3% TiN reinforcement was found to be 426.15 N/mm^2 and 515.15 N/mm^2 respectively.

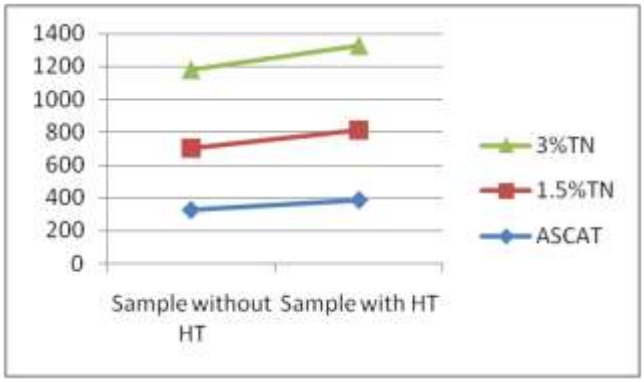

Fig-5: Variation of compression value with different Wt. % of reinforcement with and without HT

So from the above results it can clearly be seen that the samples subjected to heat treatment process posses higher compression strength than those samples which are not subjected to the heat treatment process, the reason being that the sample with heat treatment have much refined grains as well as more grain boundaries which increases the compression strength of the samples.

4. CONCLUSION

The Al7075 based composites were successfully formed by stir casting method with different weight percentage of titanium nitride reinforcement with Al7075 as matrix material. Within the study following conclusions have been drawn.

- By making use of stir casting method titanium nitride can be successfully introduced in the Al7075 matrix alloy material to fabricate composite materials.
- Tensile strength has been increased. Hardness was increased and wear compression has increased for reinforced and heat treated composites when compared to as cast composite.
- However, beyond three percentages of reinforcements, loss of reinforcement has started taking place due to floatation of the reinforcements in particular fly ash. Further, it was difficult to stir and mix them in the molten metal uniformly due to increase in volume.
- The MMC's formed are superior to AL7075 alloy and based on the experimental values, 3 hours heat treated composite has been considered as the best one among all the formed composites.
- The results confirm the viability of using the approach and showed a good accordance with experimental result obtained. These results confirmed the possibility of using the model for the prediction of mechanical properties of composites.

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