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To cite this article: M Pasupathi and S Berlin Raj 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **507** 012023

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Microstructure Analysis and Mechanical Properties of LM25 alloy with AC4B Nano-Composite using Gravity Die Casting Method

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Abstract. Casting of Aluminium alloys with zero defects would be the ultimate aim of any manufacturer. In the present work, the Alloy LM25 which was being used for the manufacturing of intricate Automobile components is compared to Alloy AC4B Nano-composite using Gravity Die Casting method. In order to investigate the mechanical properties of the concerned materials, Tensile followed by Hardness, and Compressive tests was implemented. Microstructure investigation is examined using Scanning Electron Microscope. The outcome from micro structural study confesses the uniform distribution, grain refinement, and low porosity in Nano-composite specimen. Mechanical results affirm that addition of B4C Nano-composite leads to enhancement of yield strength, ultimate strength and hardness. The uplift in mechanical properties manifested that the type of fabrication process and particle size involved in it.

1. Introduction

In present scenario, metal matrix composites are under column consideration for outsized range of structural application. The mechanical properties and also relatively less cost create them as a gorgeous choice [David L.et.al 1,25 1985]. A laye variety of fabrication techniques that manufacture MMC materials consistent with stir casting.

Dinesh kumar et. al [1] fabricated aluminum 6063 MMC one reinforced with silicon carbide and other reinforced with boron carbide by using stir casting technique various mechanical tests like tensile, hardness test, were conducted and it concluded that there is an increased in values of tensile strength hardness value and flexural strength of composite SIC and B&C particulates. N Subramani et .al fabricated aluminum 2042 metal matrix composites reinforced with carbide sulphite by stie casting techniques and their mechanical properties are evaluated.

The stir casting process is most effective in terms of productivity and cost efficiency, which is implemented to prepare the particular MMCs. The motivation for this work was to compare and study the mechanical and micro structural properties of M25 alloy with AL4 nanocomposite at different volume fraction.





Figure 1. Micro Structural LM25 Alloy.



Figure 2. Nano Composite AL4B Materials.

2. Experimental procedure

2.1 Composition

The specific material alloy used in this study where LM25 and AC4B nanocomposite. The chemical composition of these elementary materials has been exhibited in table 1.

Table 1. Chemical composition of elementary materials.

Elements	Si	Cu	Fe	Mn	Mg	Ni	Zn	Sn	Ti	Pb	Cr
LM25	7-10	2-4	0.8	0.5	0.35	1	0.1	0.1	0.2	0.2	0.2
AC4B	6.5-7.5	0.2	0.5	0.3	0.2-0.6	0.1	0.1	0.1	0.05	0.1	

The refinement in terms of grain size is affirmed to be transverse, by Linear Intercept method.

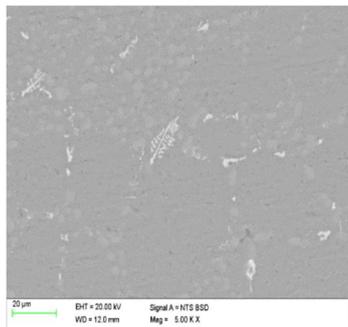


Figure 3. AC4B.

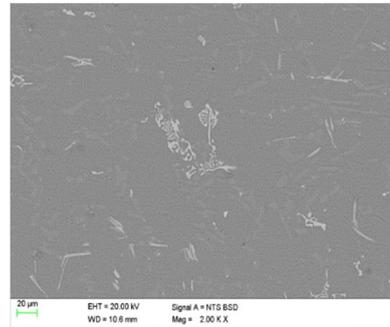


Figure 4. LM25.

2.2. Tensile strength and density

The ultimate tensile strength, yield strength, percentage elongation are shown in figure 5 and figure 6.

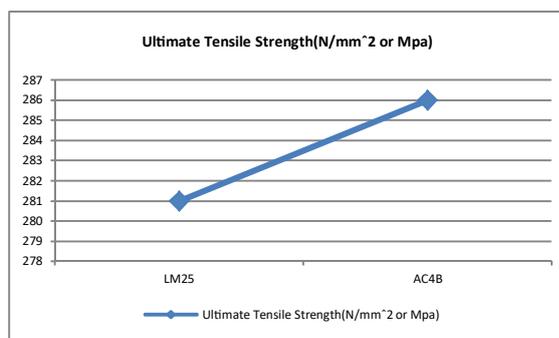


Figure 5. Percentage of tensile strength.

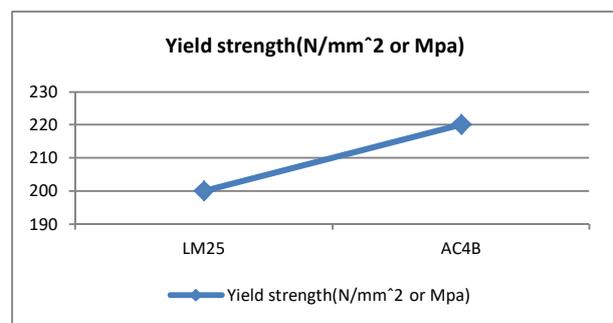


Figure 6. Percentage elongation of yield strength.

As the density level of the alloy increases, it gives the direct proportionality towards its increasing strength from the Gravity die-casting method.

3. Results and Discussion

3.1 Metallurgy Structure

Grain size plays a vital role in microstructural analysis. Figure (7) shows the microstructure of a gravity die casting sample of LM25 alloy. Figure (8) shows the microstructure of gravity die casting sample of AC4B a nanocomposite alloy. Good grain structures or size are desirable, leading to the enhancements of mechanical properties, tear resistance, pressure tightness. From above consideration the LM25 alloy, the grains are loosely packed which is verified from the Scanning Electron Microscope. Loosely packed grains leads to porosity and shrinkage defects.

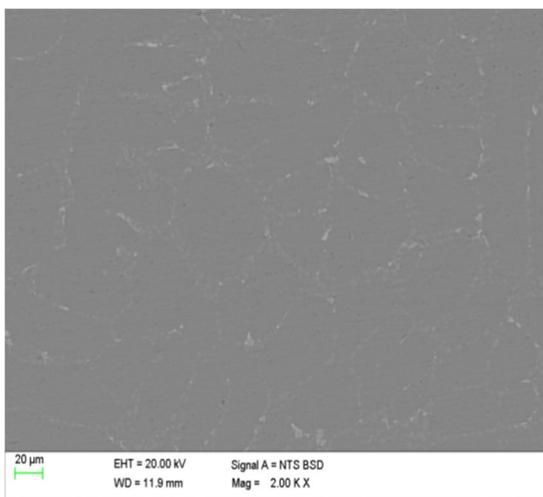


Figure 7. Ac4B.

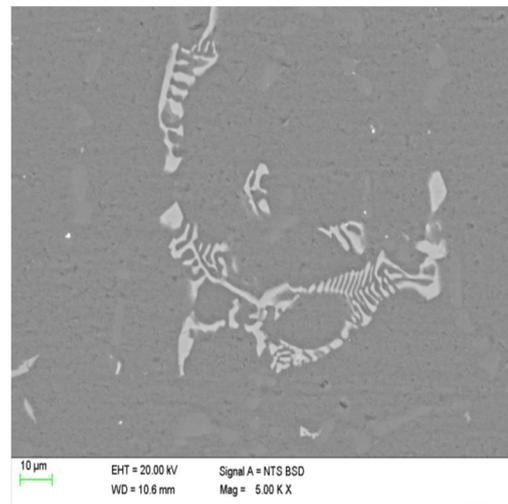
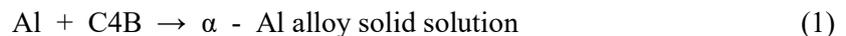


Figure 8. LM25.

In AC4B aluminium alloy, the C4B acts as grain refiners up to 3-5%, Grain refiners acts as a nuclei for grains to grow. More nucleation of likely eight sites may appear on every individual particle. In AC4B alloy, C4B make the grains to occur closely with each other as a refiner. This is formed in the form of equation.



As a result of closed packed grains and good grain structure AC4B alloy does not have any defects and the mechanical properties are comparatively good than LM25 alloy (1). In gravity die casting sample of AC4B alloy, porosity within the microstructure was not seen on the surface or located in very small amount. AC4B shows good enhancement in mechanical properties which are resulted below.

3.2. Tensile Strength

The values of the ultimate tensile strength, yield strength, and percentage elongation are shown in table 2. In addition of a nanocomposite material, the yield strength of the material increases which had been examined by the Scanning Electron Microscope. Followed, the ultimate strength also increases by adding C4B a nanocomposite material was resulted through microstructure analysis. The testing machine and specimen is shown in figure 9 and figure 10.



Figure 9. C4B a nanocomposite material.

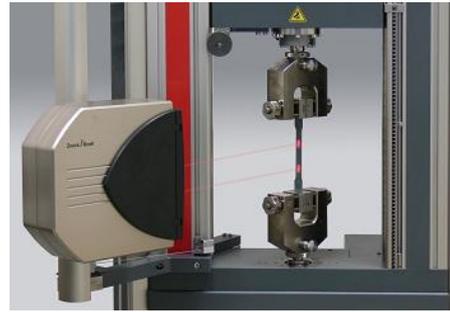


Figure 10. Testing machine and specimen.

Table 2. Tensile strength, Yield strength, and percentage elongation.

Test Parameters	LM25	AC4B
Yield strength Mpa	220	222
Ultimate strength Mpa	281	286
% Elongation in 4D GL	6	2.5

3.3. Hardness Test

The Brinell hardness test is furnished in Table 4. Brinell hardness test specimen is shown in figure 2.

Figure 10 shows the hardness value of three samples. It can be noted that sample 2 has the maximum hardness followed by sample 1 in all the trials.

Generally increasing the trend of hardness with C4B, 5% volume composite content of C4B performs minor hardness than sample of 2% volume. This may be emerged from existence of more porosity with greater content of C4B.

Table 3. Brinell hardness test.

Test parameters	LM25	AC4B
BHN (5mm ball/250 kg load)	93.9,92.8,92.3	89.7,90.2,89.2

3.4. Elongation

Percentage Elongation quantifies the ability of an element or compound to stretch up to its breaking point. In this research, the elongation of LM25 is comparatively low in ductile property and grain refinement. Nanocomposite C4B was tested and the test affirms the addition of nanocomposite C4B with LM25 improves the elongation property. The % Elongation is plotted in a form of chart.

LM25 alloy, the bonding between the elements breaks up in the process called stir casting. In addition of C4B the electromagnetic bonding showed a rise in its elongation properties where C4B acts as an elastic component with Aluminium clearly manifestations the elongation properties.



Figure 11. LM25 is low in ductile property.

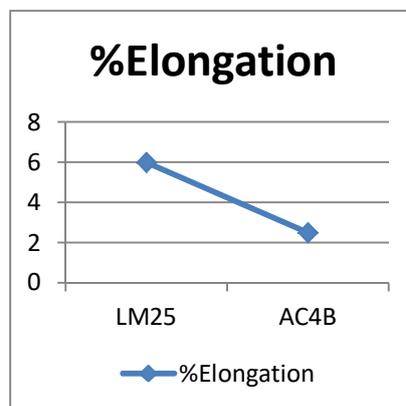


Figure 12. Elongation is plotted.

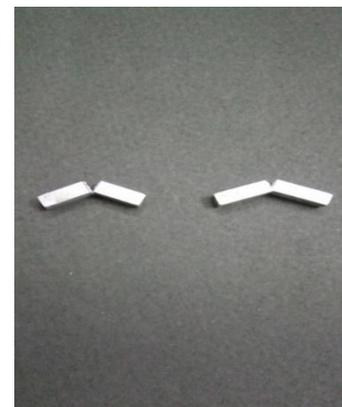


Figure 13. Stir casting.

3.5 Flexural test

Three point flexural testing machine is used for flexural test and as per ASTM: E290 Standard the specimen was cut. Test specimen is shown in figure 11-13 and flexural properties are shown in table 3.

4. Conclusion

The Aluminium alloy LM25 reinforced with AC4B nanocomposite is fabricated via AC4B using Gravity Die Casting method. The reinforced nanocomposite particles have shown significant results in terms of mechanical properties. However, the changes in the alloy is visualised and changes in tensile, hardness and yield strength tests are revealed. The other tests includes charpy impact test and brinell hardness test which proves that nanocomposite material shows good enhancement over mechanical properties of the materials.

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