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MECHANICAL AND METALLURGICAL PROPERTIES OF CAST AZ91 MAGNESIUM ALLOY

[1]Mohan S R, [2]Sakthivel D, [3]Tharanikumar L, [4]Vinothkumar K K, [5]Shaik Irfan K
[1234]Assistant Professor, Mohamed Sathak AJ College of Engineering,
[5]Student, Department of Mechanical Engineering, Mohamed Sathak AJ College of Engineering.

Abstract: Magnesium alloys due to their ability to maintain high strengths at light weights has gained widespread in use of automotive for structural applications. It allows yield-cost effective solution, weight saving over another material and manufacturing methods. Here, the Metal Matrix Composites (MMC) has AZ91 magnesium alloy as a matrix metal and TiB_2 (Titanium Diboride) as a reinforcement material. This project is concerned about fabrication and determining mechanical and metallurgical properties such as tensile, compression, hardness and microstructure of TiB_2 reinforced to AZ91 Mg alloy composites by die casting process with different weight fraction.

Index Terms **- Cast magnesium, Magnesium Alloy, Cold Die Casting, Mechanical and Chemical Properties, AZ91, TiB2.**

1. INTRODUCTION

Magnesium alloys due to their ability to maintain high strengths at light weights has gained widespread in use of automotive for structural applications. It allows yield-cost effective solution, weight saving over another material and manufacturing methods [2]. Here, the Metal Matrix Composites (MMC) has AZ91 magnesium alloy as a matrix metal and TiB_2 (Titanium Diboride) as a reinforcement material. This project is concerned about fabrication and determining mechanical and metallurgical properties such as tensile, compression, hardness and microstructure of TiB_2 reinforced to AZ91 Mg alloy composites by die casting process with different weight fraction. [1]

1.1 DIE CASTING PROCESS

Die casting involves the process of compelling molten metal into a mold cavity under elevated pressure, defining it as a metal casting technique. Two robust tool steel dies, machined to the desired shape, are employed in the creation of the mold cavity. These dies function akin to an injection mold throughout the process. [4]

There are two types of die casting process. Those two were briefly explained in (Table.1)

- Hot-Chamber Die Casting
- Cold-Chamber Die Casting

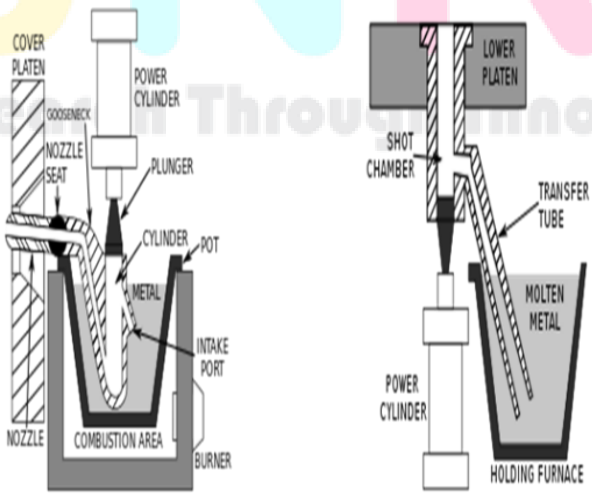


Figure 1

Hot-Chamber Die Casting	Cold-Chamber Die Casting
In this procedure, the cylinder chamber of the injection mechanism is fully submerged within the molten metal bath. A gooseneck metal feed system channels the molten metal into the die cavity. Although direct immersion in the molten bath facilitates rapid and convenient mold injection, it also enhances vulnerability to corrosion.	The cold-chamber die casting method closely resembles hot-chamber die casting. Prioritizing the reduction of machine corrosion over production speed, this process involves the automatic or manual ladling of molten metal into the injection system.
The Plunger is submerged in the molten metal which forces the metal inside the die.	The Plunger is not submerged in the molten metal.
Rate of Production is high, Suitable for low melting point nonferrous metals	Rate of production comparatively less, It is suitable for higher melting point metals .
Suitable metals for hot-chamber die casting encompass lead, magnesium, zinc, and copper.	These applications include the casting of metals with high melting temperatures, such as Aluminum alloys

Table 1

2. LITERATURE SURVEY:

[1]CUI XIAO-PENG etal(2010) "Microstructure and mechanical properties of die-cast AZ91D magnesium alloy by Pr additions" Trans. Nonferrous Met. Soc. China 20(2010) s435-s438.

In this the microstructures of Mg-9Al-xPr alloys are mainly composed of α-Mg matrix and Mg_{17} Al_{12}.

[2] E.Cerrietal (2007) "Hot compression behavior of the AZ91 magnesium alloy produced by high pressure die casting" journal of materials processing technology 189(2007) 97-106.

In this, the hot compression behavior of high pressure die casting of AZ91 magnesium alloy was investigated at 400oc for 2 hours. There was a softening effect by 30% at low temperature and at high temperature the difference is small because dynamic recovery and dynamic recrystallization cause more homogeneous straining.

[3] I. Zawadazkietal (2008) Mechanical properties of high-pressure die-casting AZ91 magnesium alloy (volume 8 , Issue 4/2008).

In this the alloy cast on a cold chamber die-casting the influence of high plunger velocity increases the properties in first stage and in second stage in low plunger velocity the properties decreases.

[4] PengYinghongetal (2005) "Numerical Study on the Low Pressure Die Casting of AZ91D Wheel Hub" School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai 200030, P. R. China ISSN: 1662-9752, Vols. 488-489.

Most magnesium alloy components available for automobile are made through die casting. With this cooling system, the hot spots at the junctions are obviously reduced and product quality is improved.

3. RESEARCH METHODOLOGY

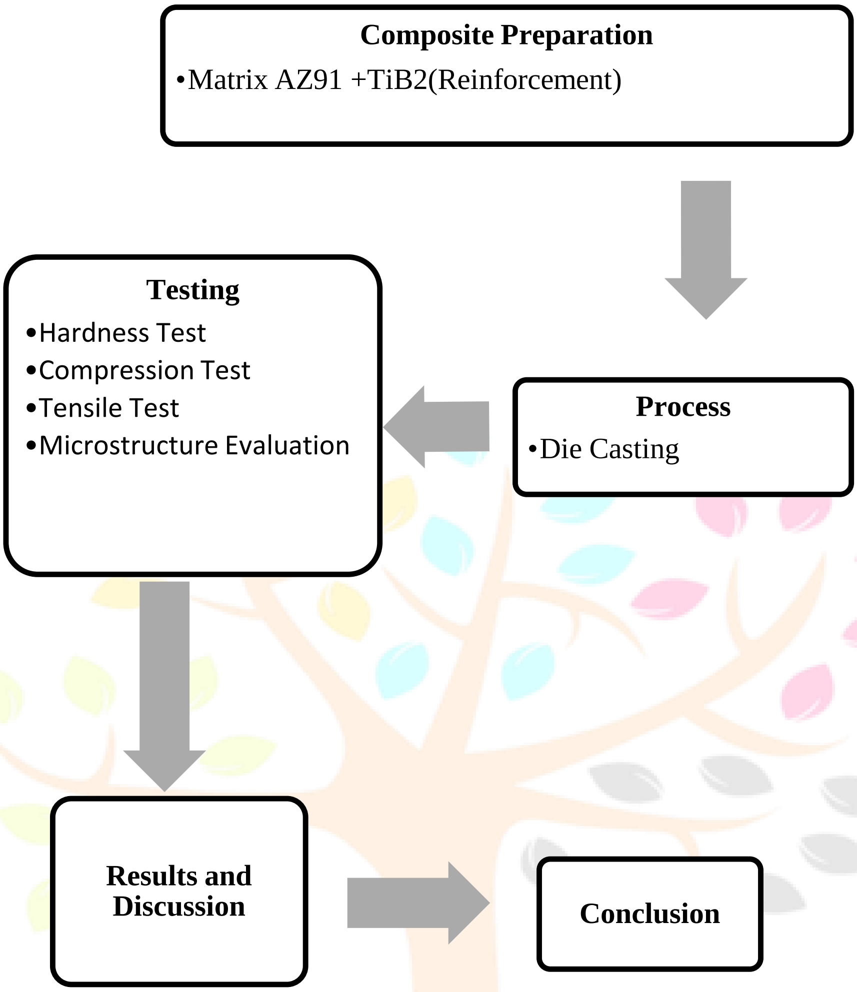


Figure 2

4. COMPOSITION OF AZ91:

ELEMENT	CONTENT (%)
Aluminum	8.3-9.7
Manganese	0.15-0.50
Zinc	0.35-1
Silicon	0.1
Copper	0.03
Iron	0.005
Nickel	0.002
Other max	0.02
Magnesium	91.3-89.8

Table 2

4.1 PHYSICAL AND MECHANICAL PROPERTIES OF TIB_2:

PROPERTY	VALUE
Density (g/cm^3)	4.52
Melting Point (^oC)	2970
Hardness (Knoop)	1800
Elastic Modulus (Gpa)	510-575
Poisson Ratio	0.1-0.15
Volume Resistivity (Ohm Cm) at 20 ^oC	15×10^6
Thermal Conductivity (W/mk)	25

Table 3

4.2 PREPARATION OF MATERIAL:

SET	AZ91 MAGNESIUM ALLOY Weight (in %)	TiB2 Weight(in %)
Set- I Magnesium Alloy (90% of AZ91) as matrix material and Titanium Diboride (10% of TiB2) as reinforcing material are used to prepare the composite material.	90	10
Set- II Magnesium Alloy (95% of AZ91) as matrix material and Titanium Diboride (5% of TiB2) as reinforcing material are used to prepare the composite material	95	5

Table 4

5. CALCULATION

i. For rod

Diameter (d) : 20 mm

Length (l) : 150 mm

ii. For Plate

Length (L) : 300 mm

Breadth (B) : 70 mm

Thickness (T) : 5 mm

iii.Density of AZ91 : 1.8 g/cm^3

iv.Density of TiB2 : 4.52 g/cm^3

- **Formula**

Density (ρ) = m/v

Mass (m) = $\rho \times v$

Density of composite 1

= $(4.52 \times 0.9) + (1.8 \times 0.1)$

= **2.012 g/cm^3**

Density of composite 2

=$(4.52 \times 0.95) + (1.8 \times 0.05)$

= **1.936 g/cm^3**

Volume of rod (v) = $\pi/4 d^2 l$

= $\pi/4 \times (2)^2 \times 15$

= **47.12 cm^3**

Volume of plate (V) = L × B × T

= 30 × **7** × 0.5

= **105 cm^3**

MASS OF THE MATERIALS SELECTED

SL. NO	SET NUMBER	ROD (in g)		PLATE (in g)	
		AZ91	TiB2	AZ91	TiB2
1	SET I	88	10	196	22
2	SET II	87	5	-	-

Table 5

6. TESTINGS OF OUR PROJECT:

The tests undergone in our project are Tensile Test(fig.5), Hardness Test(fig.6), Compression Test(fig.7) and Micro Structure Evaluation. The die(figure.3) and casted materials(Figure.4) are picturized below.

Figure 3

Figure 4

6.1 COMPOSITION AND PROPERTIES:

The chemical composition (Table.6) and properties of materials(Table.7) are listed below.

Materials	C	Mn	Si	Cr	Mo	V
Composition	0.35%	0.4%	1%	5%	1.5%	1%

Table 6

6.2 TESTING MACHINE SPECIFICATION AND SPECIMENS:

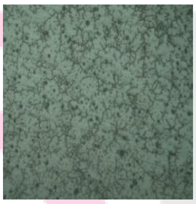
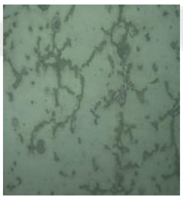
MACHINE OR EQUIPMENT	TESTS PERFORMED	SPECIFICATION	PICTURES OF SPECIMENS
Rockwell Harness Tester	Hardness Test	FIE/FRE 94/181 5mm Ball	
Universal Testing Machine	Compression Test, Tensile Test	WDW 100/TE-Jinan/Range(kN)(0-100)	 
Metallurgical Microscope	Microstructure Evaluation	Zeiss/Axiovert 40 MAT/3829000370	   

Table 7

7. ANALYSIS AND RESULTS:

Test Parameter	Observed Value	
	SET 1	SET 2
Brinell Hardness Number (5mm ball/250kg load)	61	53.5
Compressive Strength (in MPa)	134	79
Ultimate Tensile Strength (N/mm^2 or MPa)	114	110

Table 8

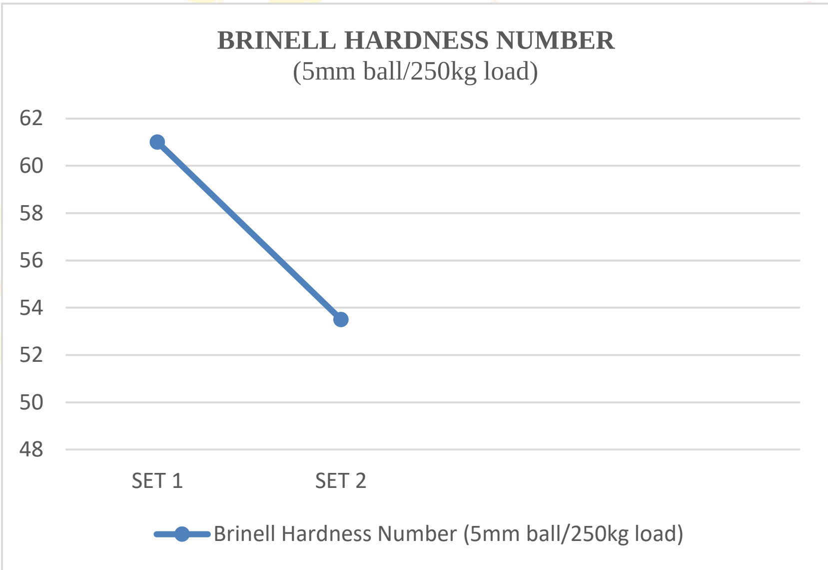


Figure 5

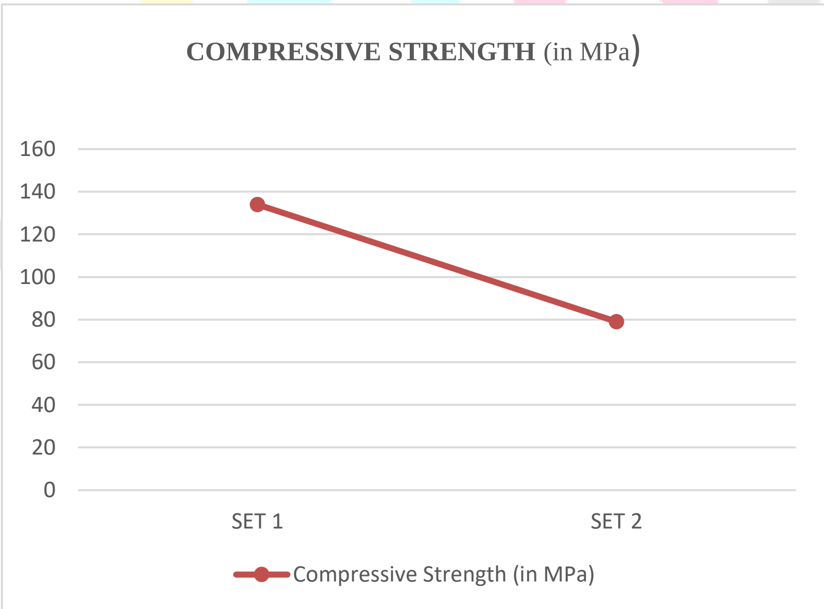


Figure 6

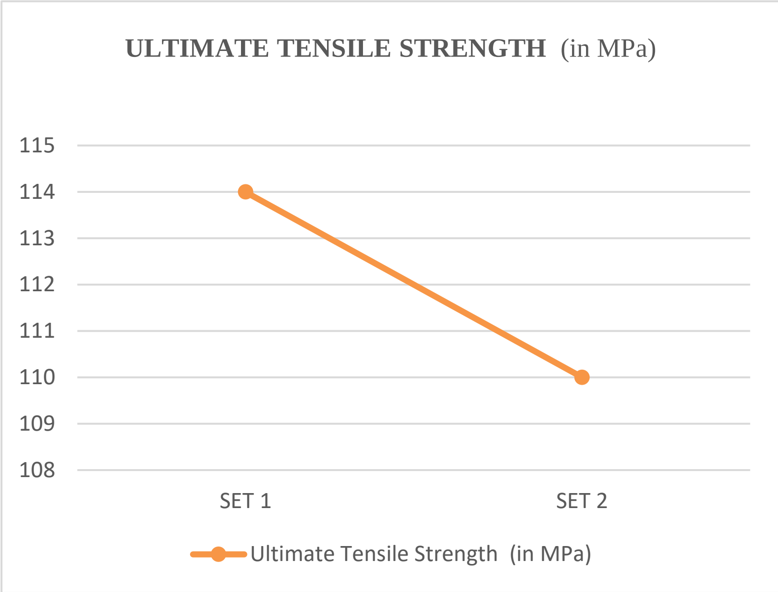


Figure 7

7.1 MICROSCOPIC EXAMINATION RESULTS:

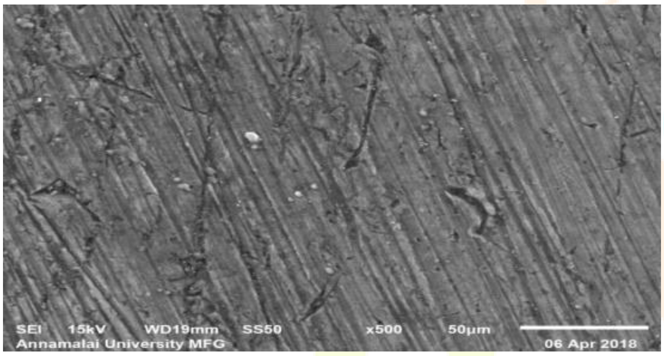


Figure 8

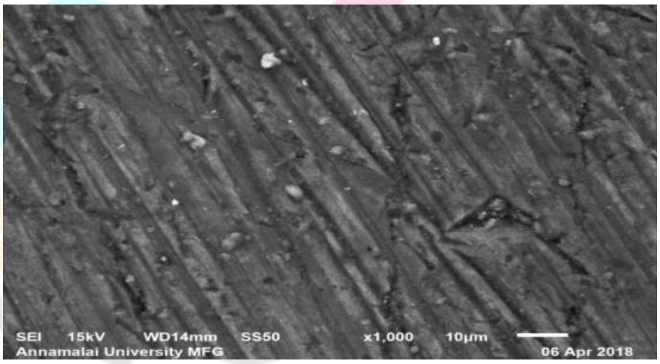


Figure 9

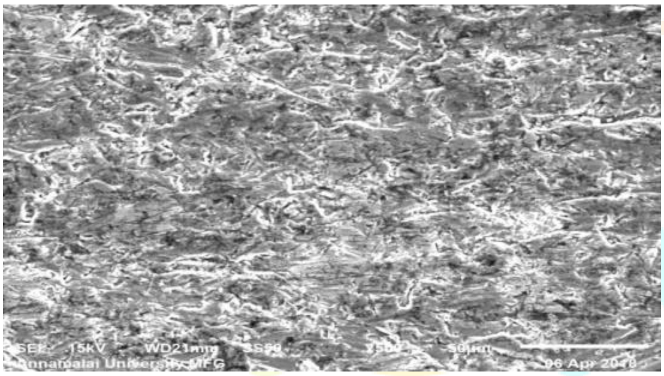


Figure 10

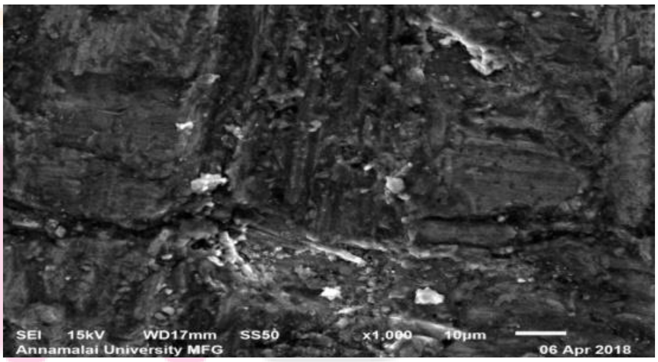


Figure 11

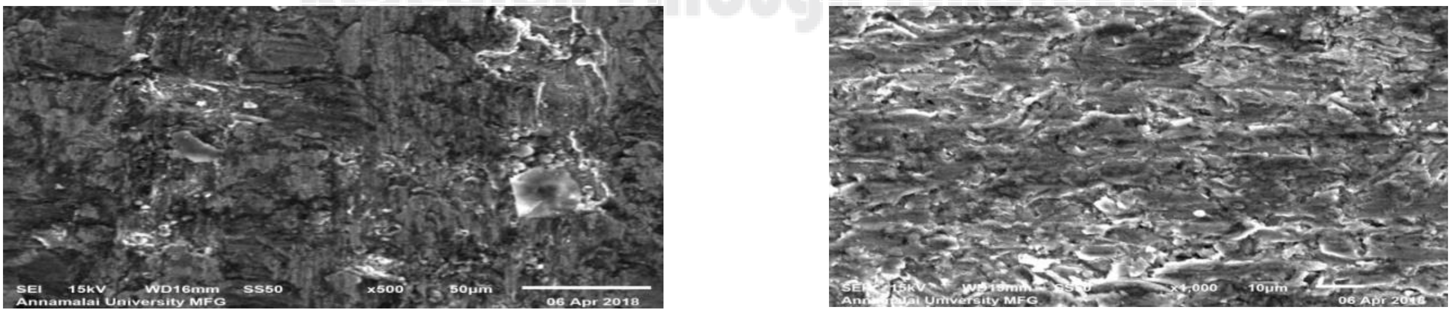


Figure 12

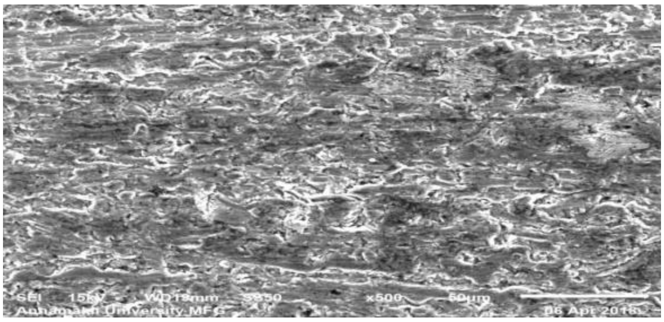


Figure 13

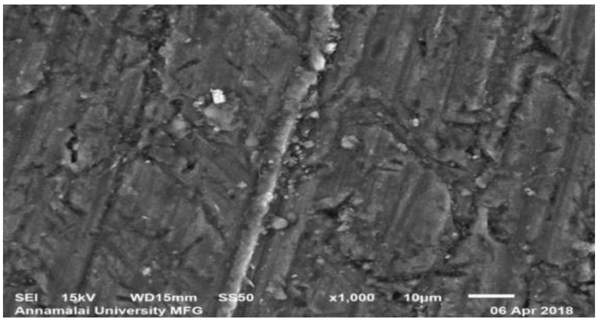


Figure 14

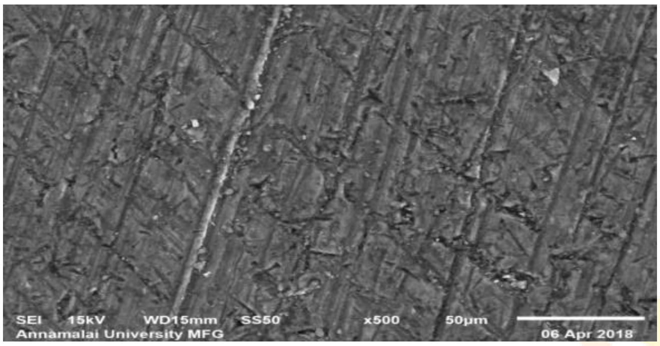


Figure 15

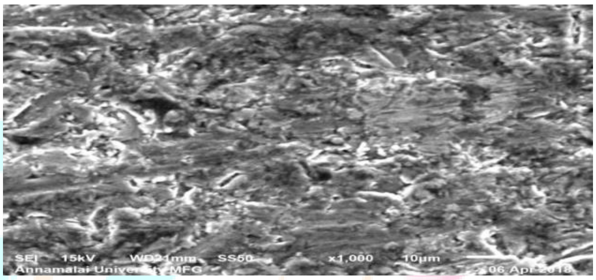


Figure 16

8. CONCLUSION

In summary Magnesium alloy AZ91 reinforced by different volume fractions of TiB2 was fabricated through die casting method. From the experimental results the following conclusion were obtained. Hardness of the composites decreases with increase in the volume fraction of the reinforced materials. As increase in the volume fraction of the reinforcement the tensile strength lowered. In tensile test Set II showed more elongation but a low tensile strength whereas Set I showed less elongation with high tensile strength. Considering the fractures taken place in the test sample, it is concluded that Set I is brittle and Set II is ductile. The compressive strength also decreases with increase in the volume fraction of the reinforcement.

9. REFERENCES

1. Cui Xiao-Peng, Liu Hai-Feng, Meng Jian, Zhang De-Ping- Microstructure and mechanical properties of die-cast AZ91 D magnesium alloy by Pr additions. - s435-s438 January 2010

2. E. Cerri, P. Leo, P. P. De Marco – Hot compression behavior of the AZ91 magnesium alloy produced by high pressure die casting. -189(2007) 97-106, January 2007

3. K.N. Braszczynska-Malik, I. Zawadzki, W. Walczak, J.Braszczynski – Mechanical properties of high-pressure die-casting AZ91 magnesium alloy. - volume 8 , Issue 4/ July 2008

4. Peng Yinghong, Li Dayong, Wang Yingchun, Yin Jilong, Zeng Xiaoq in "Numerical Study on the Low Pressure Die Casting of AZ91D Wheel Hub" School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai 200030, P. R. China ISSN: 1662-9752, Vols. 488-489. – August 2005

5. Microlab Chennai, SP 101, Second Main Road, Ambattur Industrial Estate, Ambattur, Chennai - 600 058.Tamilnadu, India.

6. Qiyao Hu, Haidong Zhao, Fangdong Li Microstructures and properties of SiC particles reinforced aluminum-matrix composites fabricated by vacuum-assisted high pressure die Casting-Materials Science &Engineering, National Engineering Research Center of Near-net-shape Forming for Metallic Materials, South China University of Technology, Guangzhou, China-October 2016.