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Effect of Silicon and Lead Contents on the Mechanical Properties of Aluminum Alloy

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Abstract

Aluminium alloys are broadly utilized in many industries due to their lightweight, better machinability, better corrosion resistance properties, better thermal properties and many more. One of the best examples is the automotive industries due to the genuine need to weigh putting something aside for more decrease of fuel utilization. The majority of alloying components are copper, magnesium, manganese, silicon, lead and zinc. In this research work, we examine the mechanical properties of aluminium alloy by differing the percentage level of silicon and lead element. This aluminium alloy further cast through ferrous and sand casting and finally compared their mechanical properties. The outcomes showed that with the increase of silicon content up to 12%, the mechanical properties are better in ferrous casting ascomparewithsandcastingandalittlebitdependentonthepercentageoflead.

Keywords: - Aluminium, Silicon, Lead, Ferrous and Sand casting, Mechanical Properties

I.INTRODUCTION

Aluminium alloys are acquiring immense industrial significance because of their exceptional properties of mechanical, physical and tri-bological over the base amalgams. These properties incorporate high strength to weight ratio, high wear resistance, corrosion resistance, stiffness and strength to resist the temperature and improved damping limit. A powerful strategy for the vehicle weight decrease, with the goal that the substitution materials of steel have been generally evolved. Among these light materials, Aluminium-based alloys are the most demanded light metals, are normally utilized in the automotive industry because of their superior properties like high strength, high corrosion resistance, recycling ability and many more. Pure aluminium is not directly used for any structural stability, structural fabrication or even not directly used for manufacturing of any automotive components, it is mandatory to add some other elements to aluminium to increase their strength and stability also reduced the weightratio.

1.1 Effect of Silicon Material onAluminium

Silicon is the principle-alloying component, it grants high smoothness, fluidity and low shrinkage, which bring about great cast capacity and weldability. The low coefficient of thermal expansion is abused for pistons, the high hardness of the silicon particles for improving the wear properties. The most extreme measure of silicon in cast composites isof the request for 22-24% of silicon material, however, amalgams made by powder metallurgy may go as high as 40-50% of silicon. Castings are the fundamental utilization of aluminium-silicon alloys, albeit some sheet or wire is made for welding and brazing, and a portion of the piston compounds are developed and extruded for forgingstock.

1.2 Effect of Lead Material onAluminium

Lead material presents just as a minor component in commercial-purity aluminium. Its maximum solubility in aluminium is 10.3 to 12.3 %, however, the lead content in present wrought composites doesn't surpass 9%. The option of lead material added at about 0.8% level with the aluminium to improvethe machinability and also reduces the friction.

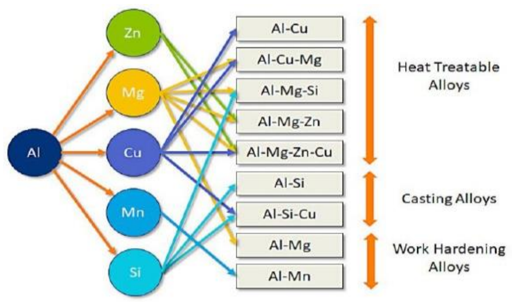

Figure 1: Classification-of-cast-aluminum-alloys

2. EXPERIMENTALPROCEDURE:

The experimental and alloy preparation procedures and their strategy for manufacturing of various specimens and their testing like the mechanical characterization of materials using hardness test, tensile test, impact test and non-destructive testing has been carried out. In this process, the fine powders of aluminium, silicon and lead metals are used. The metal powder which has the highest melting temperature that is silicon is first heated in the crucible and allow to melt on the furnace then the aluminium metal powder is allowed to melt with silicon and lastly lead powder is allowed to melt in the crucible. After proper mixing and melted the molten metal into the crucible it is poured into the predefined mould cavity and allow to solidified and cast through sand and ferrouscasting.

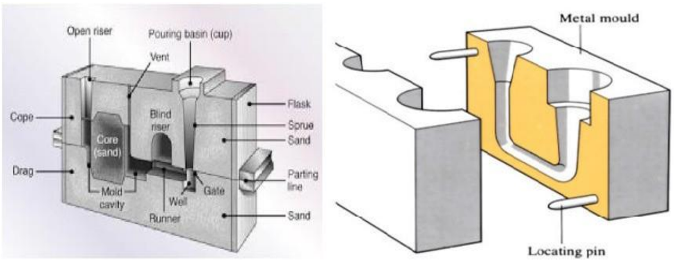

Figure 2: Cross Section of Sand and Ferrous Casting Mould System

2.1 AlloyPreparation

For the experimental set up of Al-Si-Pb percentages are maintain with weight as per the given set and alloys are prepare on the basis of weight ratio

(a) Al-92%, Si-6%,Pb-2%

(b) Al-88%, Si-8%,Pb-4%

(c) Al-80%, Si-12 %, Pb-8%

All the above-said composition of the mixture were used for the process and all individual process are identified by special notation.

Table 2.1 Percentages of Al- Si-Pb mixture and Casting Code

Sl.No	Percentage of Al-Si-Pb alloys	Types of Mould	Casting Code
1	Al-92%,Si-6%,Pb-2%	Sand	A1
2	Al-92%,Si-6%,Pb-2%	Ferrous	A2
3	Al-88%,Si-8%,Pb-4%	Sand	B1
4	Al-88%,Si-8%,Pb-4%	Ferrous	B2
5	Al-80%,Si-12%,Pb-8%	Sand	C1
6	Al-80%,Si-12%,Pb-8%	Ferrous	C2

After 20 to 24 hours of proper solidification of the mixture, each set of casting was removed from the mould.

RESULT ANDDISCUSSIONS:

2.2 Hardness of theSpecimens

All the specimens are to be prepared as per the standard IS 1586, Part I: 2018. After prepared the specimen as per standard hardness test is performed on the Rockwell hardness machine and recorded all the values in HRB scale as shown in Table 3.1. It was found that the hardness value is increase when the % of Silicon and % of lead is increases. It was also observed from the graph and recorded data that the hardness value was better in ferrous casting as compared with sandcasting.

Table No 3.1 Hardness Testing

Sample no	Silicon%	Lead %	Casting type	Rockwell hardness No.(HRB)
A1	6	2	Sand	44
A2	6	2	Ferrous	45
B1	8	4	Sand	47
B2	8	4	Ferrous	48
C1	12	8	Sand	53
C2	12	8	Ferrous	54

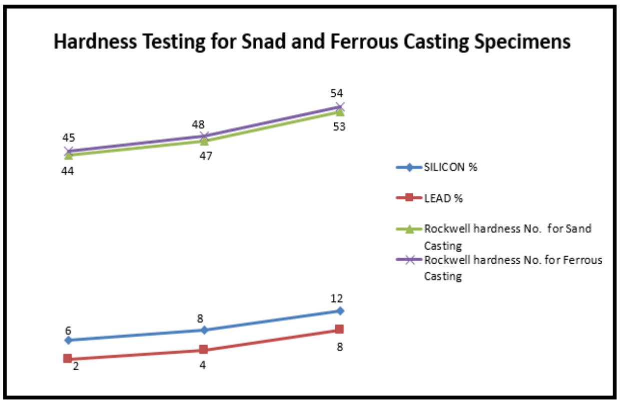

Figure 3.1: Hardness Value for Sand and Ferrous Casting Specimens

2.3 Variation of Yield Load & Yield Strength with % Si & %Pb

All the specimens are to be prepared as per the standard IS: 1608, Part I: 2018. After prepared the specimen as per standard, gauge length is 50 mm and gauge diameter is 10 mm a tensile test is performed on the universal testing machine and recorded all the values in the kN scale as shown in Table 3.2. From the tensile test experiment, it was found that the yield value and yield strength are increase when the % of Silicon and % of lead is increases. It was also observed from the graph and recorded data that the Yield load and Yield Strength value was better in ferrous casting as compared with sand casting.

Table 3.2 Variation of Yield Load and Yield Strength

Sample no	Silicon%	Lead %	Casting type	Yield Load (kN)	Yield Strength (Mpa)
A1	6	2	Sand	10.25	130.57
A2	6	2	Ferrous	10.75	136.94
B1	8	4	Sand	11.25	143.31
B2	8	4	Ferrous	11.75	149.68
C1	12	8	Sand	14.25	181.53
C2	12	8	Ferrous	14.5	184.71

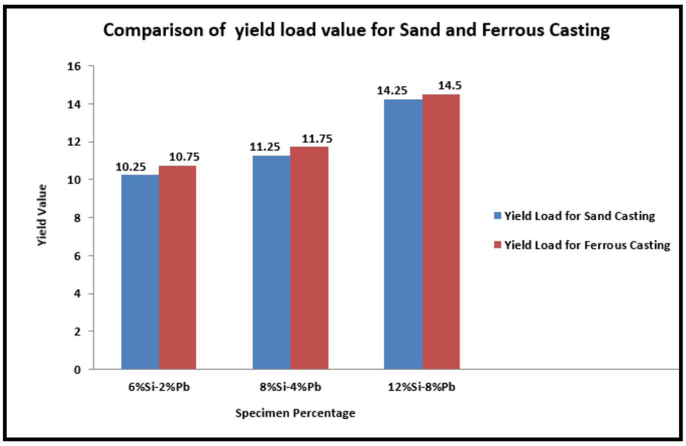

Figure 3.2(a): Yield Load Variation

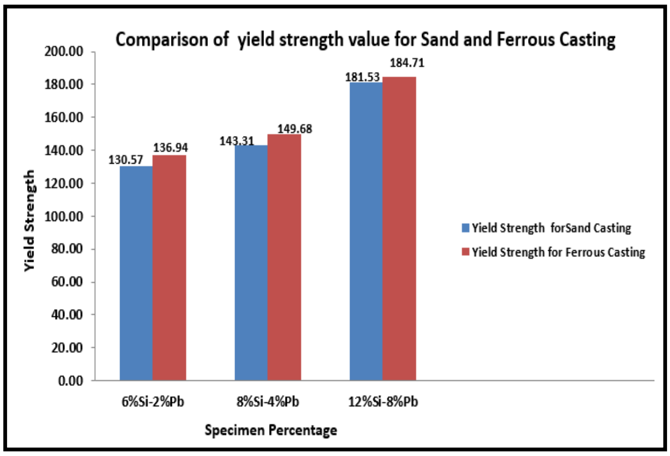

Figure 3.2(b): Variation of yield strength

2.4 Variation of Ultimate Load & Ultimate Strength with % Si & %Pb

All the specimens are to be prepared as per the standard IS:1608, Part I:2018. All the values in the kN scale as shown in Table 3.3. From the tensile test experiment, it was foundthattheultimatevalueandultimatestrengthareincreasewhen the%ofSiliconand% of lead is increases. It was also observed from the graph and recorded data that the Ultimate Load and Ultimate Strength value was better in ferrous casting as compared with sandcasting.

Table 3.3 Variation of Ultimate Load and Ultimate Strength.

Sample no	Silicon %	Lead %	Casting type	Ultimate Load (kN)	Yield Strength (Mpa)
A1	6	2	Sand	16.5	210.19
A2	6	2	Ferrous	16.75	213.38
B1	8	4	Sand	17.50	222.93
B2	8	4	Ferrous	17.75	226.11
C1	12	8	Sand	20.25	257.96
C2	12	8	Ferrous	20.75	264.33

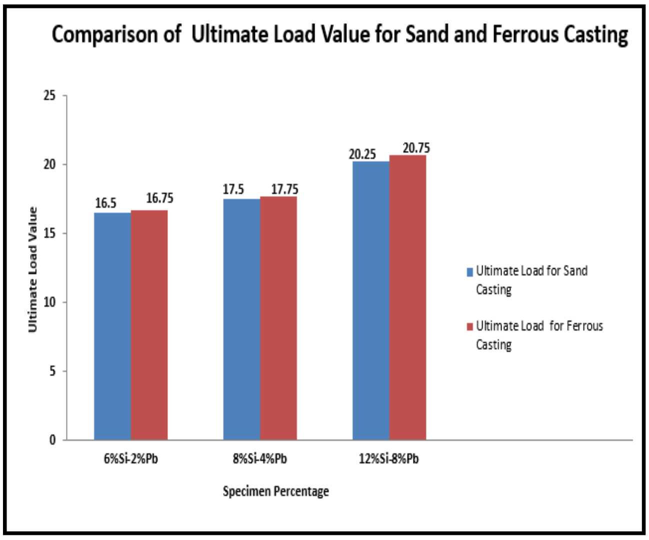

Figure 3.3: Ultimate load variation

2.5 Variation of % Elongation with % Si & %Pb

It was found that the % elongated length value is increase when the % of silicon and % of lead is increasing. All the specimens are tested and recorded their % elongated length value in table 3.4. It was also observed from the graph and recorded data that the percentage of elongated length value was better in ferrous casting as compared with sand casting.

Table 3.4 Variation of % Elongation.

Sample no	**Silicon %**	**Lead %**	**Casting type**	**% Elongation.**
A1	6	2	Sand	0.4
A2	6	2	Ferrous	0.4
B1	8	4	Sand	0.6
B2	8	4	Ferrous	0.8
C1	12	8	Sand	2.2
C2	12	8	Ferrous	2.6

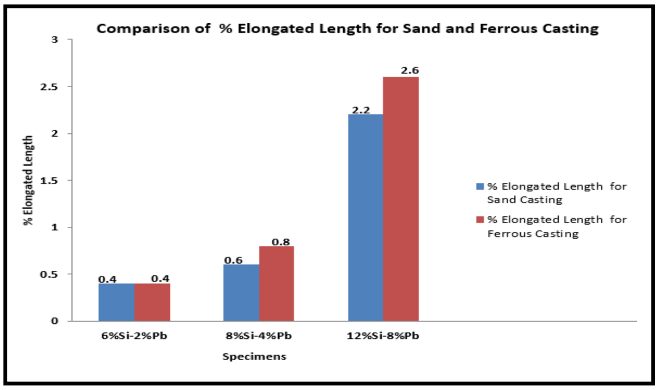

Figure 3.4: Percentage Elongated Length

CONCLUSION:

The mechanical properties of aluminium alloy were analysed with the variation of silicon and lead content and after studies, the following conclusions are as listed below.

- The melting point of aluminium alloy is decreases as increase the silicon whereas fluidity will increase due to the increase of leadcontent.
- The tensile strength properties will increases when increasing the silicon and lead content.
- The maximum yield strength was 184.71 MPa in 12% of silicon and 8 % of lead contents in aluminiumalloy.
- The Maximum ultimate strength was 264.33 MPa in 12% of silicon and 8 % of lead contents in aluminiumalloy.
- Thehardnessvalueoftheferrousspecimensisbetterascompa redwithsandspecimens.
- The tensile properties are better in ferrous specimens as comparewith sand specimens.
- The elongated length is maximum in ferrous specimens as compared with sand specimens.

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