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Preliminary studies on melting of lm25 grade aluminium alloy for industrial applications

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Abstract : Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Far from being rare, Aluminium is in fact the third most common element in the Earth's crust, and it is the most common metallic element on Earth. Aluminium cannot be produced by an aqueous electrolytic process because hydrogen is electrochemically much nobler than aluminium. About 75percentage of this total volume is extracted directly from the ore and the remaining will be derived from recycling of Aluminium scrap. About 55percentage of the scraps are normally being converted into usable Aluminium and remaining will be lost as metal oxides and impurities in the form of a slag. Conventional recycling techniques generate dangerous residues that require elimination usually at high cost. This traditional recovery procedure is inefficient and leads to at least 50percentage loss.This paper discussed about melting characteristics of LM25 and their mechanical, X-ray and porosity results have been discussed. This research has been done for both pure ingots as well as return melts of LM25 seperately.
Keywords : AluminiumLM25,pure ingots, returnmelts, recycling, gravity die casting.

Introduction to aluminium

Aluminium is the second most used metal after steel, largely because of its versatility. It is used in a great number of household items as well as in industrial equipment. Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Far from being rare, Aluminium is in fact the third most common element in the Earth's crust, and it is the most common metallic element on Earth. In the pure form, Aluminium is silvery white and extremely lightweight. Because of its light weight and relatively strong structure it can be made into very thin wires which can then be re-enforced by steel and iron made into power lines.

Aluminium production

Aluminium is formed at about 900°C, but once formed has a melting point of only 660°C. In some smelters this spare heat is used to melt recycled metal, which is then blended with the new metal. Recycled metal requires only 5 percent of the energy required to make new metal. Blending recycled metal with new metal allows considerable energy savings, as well as the efficient use of the extra heat available. When it comes to quality, there is no difference between primary metal and recycled metal. The smelting process required to produce aluminium fromthe alumina is continuous, the potline is usually kept in production for 24 hours a day year around. A smelter cannot be easily stopped and restarted. If production is interrupted by a power supply failure of more than four hours, the metal in the pots will solidify, often requiring an expensive rebuilding process.

Properties of aluminium

PROPERTIES OF ALUMINIUM	
Periodic table block	P-block
Atomic number	13
Tempertature in solid nature	20°C
Electronic configuration	$[Ne]3s^23p^1$
Melting point	660.323C
Density	2.70 g/cm3
Relative atomic mass	26.982
Specific heat capacity	897 $JKg^{-1}k^{-1}$
Young's modulus	70.3 Gpa
Bulk modulus	75.5 Gpa
Shear modulus	26.1 Gpa

LM24 (EN 1706 AC-46500) - Aluminium Casting Alloy(Al-Si8Cu3.5)Colour Code - RED/BLACK. This alloy conforms to BS 1490:1988 LM16. Castings are standardized in the solution treated and naturally aged (TB) condition and in the fully heat treated (TF) condition. Material supplied as standard 7kg aluminiumingo.

Chemical Composition

	%	EN 1706 AC-46500
Copper	3.0-4.0	2.0 - 4.0
Magnesium	3.0 max	0.05 - 0.55 (0.15-0.55)
Silicon	7.5-9.5	8.0 - 11.0
Iron	1.3 max	1.3 (0.6 - 1.2)
Manganese	0.5 max	0.55
Nickel	0.5 max	0.55
Zinc	3.0 max	3.0
Lead	0.3 max	0.35
Tin	0.2 max	0.25
Titanium	0.2 max	0.25(0.20)
Chronium	-	0.15
Aluminium	Remainder	-
Others: each	-	0.05
Others: total	0.5 max	0.25

Strength at Elevated Temperatures: Room temperature tensile strength is largely retained up to temperatures in the order of 150°C, and approximately halved at 250°C.It should be noted that other factors may restrict the use of die castings at elevated temperatures.

Physical Properties

Coefficient of Thermal Expansion (per°C at 20-100°C)	0.000021
Thermal Conductivity (cal/cm 2 /cm/°C at 25°C)	0.23
Electrical Conductivity (% copper standard at 20°C)	24
Density (g/cm 3)	2.79
Freezing Range (°C) approx	580-520

Machinability: Machining practice is similar to that for other Aluminium casting alloys containing Silicon. Whilst there is not the tendency to drag associated with high silicon alloys such as LM6, tool wear is more rapid than in the case of alloys containing relatively small amounts of Silicon. The use of carbide-tipped tools is recommended but a good finish can be obtained with high speed steels. Lower alloy steel tools may be used, provided they are frequently reground to maintain a sharp cutting edge. A cutting lubricant and coolant should be employed.

Corrosion Resistance: Resistance to attack under normal atmospheric conditions is similar to that of alloy LM4, i.e. fairly good. In marine atmospheres, or under other severe conditions, castings of this alloy should be protected by painting.

Anodizing: Anodizing treatment by either the chromic or sulphuric acid process produces an anodic film of a grey colour. The surfaces of die castings are not generally suitable for decorative anodizing. Anodizing would be necessary if this alloy is for use in a corrosive environment.

Casting Characteristics

- FLUIDITY - Good, this alloy is used successfully for thin sections.
- PRESSURE TIGHTNESS - Excellent, suitable for leak tight castings.
- HOT-TEARING - Excellent, castings can be produced without hot tears.
- TYPICAL POURING TEMPERATURE - 700°C
- PATTERNMAKERS' SHRINKAGE - 1.3% or 1/75.

Applications:

LM24 is essentially a pressure die casting alloy, for which it has excellent casting characteristics and is generally a little simpler to die cast than the higher Silicon containing alloys. Die castings in LM24 are suitable for most engineering applications and have an advantage over an alloy such as LM6 when maximum mechanical properties are required. In practice LM6 is preferred to LM24 only for die castings in which a high resistance to corrosion is the primary requirement. An alloy of composition similar to LM24 is by far the most widely used die casting alloy in the United States of America , and a similar alloy has recently been adopted by the European Die Casting Committee. It is used for vacuum cleaners, floor polishers, motor frames and housings.

LM24 has poor weld ability and braze ability. For the vast majority of die castings, the alloys LM2 and LM24 are equally suitable. The values shown are typical ranges for Chill and Die cast test bars produced to the requirement of B.S. 1490. Die cast test bars were 6mm diameter. Those in heavier type are minimum specification values.

2. Methodology

The methodology we used in this research work is Gravity die casting. And the experiments were carried out in a reputed industry.

Gravity die casting

This molding technique is widely used for the manufacture of castings parts made of non-ferrous alloys such as aluminum, magnesium, copper or zinc. This is mainly due to the low melting temperatures not exceeding 1000°C. For this type of casting, metal is poured at atmospheric pressure in a “permanent mold, made from two machined steel blocks. Cavi-ty, which will form the final part, is machined from solid block. Each block represents an half of the fi-nalworkpiece: the upper mold and the lower mold connected by a parting line determined during the design phase. The parting line position is essential to remove the part without damaging the mold or the piece after the solidification phase.The gravity casting can produce complex parts, so-metimes with cavity or pin hole thanks to sand cores or metal pins.

Pouring temperature

Pouring temperature generally varies from 650 to 800 degree Celsius. When we pour aluminium alloy then its fluidity is completely dependent upon pouring temperature. Generally, a better fluidity in higher temperature is connected with the decreasing viscosity and surface tension of molten metal with the increasing of pouring temperature, which leads to the increasing filling speed. At the same time, the heat capacity of molten alloy rises with increasing temperature of the pouring, what results in the increase of filling time.

Fig 2.1 Pouring temperature

On the other hand, the oxidation liability of magnesium alloy increases with the pouring temperature rise, what increases the viscosity and decreases the filling speed. Therefore, growth rate of fluidity above 735 °C is lower than between 695 °C and 735 °C. The pouring temperature also affects the microstructure formation at a greater extent and which in turn affects the final structure and toughness of casting product.

Preheat temperature

Preheating in the gravity die casting is done to remove the possibility of formation of temperature gradients. If we increase the preheat temperature from a particular range then it may affect the die coating and also it may create defects like rough surface finish and also if the temperature is removed considerably then this may cause a particular chilling effect which in turn leads to less solidification of core and due to this difference in solidification rate defects like Solidification shrinkage may occur. A significant precondition for the production of high quality castings is keeping an optimum temperature (200-250)^{o}c for 30minutes .

3.Experimentation

Experimentation for 100%pure ingots

Melting furnace capacity	: 500 kgs
Melting furnace type	: Gas furnace
Alloy used	: LM 25
Ingot poured	: 450.39 kgs
Holding furnace	: Silicon carbide

Melting furnace energy meter readings

Initial reading	: 39273.082 m^3
Final reading	: 39302.960 m^3
Fuel used	: 29.878 m^3

Holding furnace energy meter readings

Initial reading	: 175.136 w hr
Final reading	: 175.204 w hr
Energy consumed	: 0.068 w hr

Melting loss calculation :

Initial weight	:450.39kgs
Production(components) weight	: 309.5 kgs
Dross weight (melting&holding)	: 4.29 kgs
Bale out weight(melting&holding)	: 131.46 kgs

Melting loss formula = Initial wgt–(Component wgt+Drosswgt+ Baleoutwgt)= 450.39 –(309.5+4.29+135.46)= 1.14 kgs.

4.Testing and validation

The test specimen have been undergone some testing process : Tensile test , Hardness test ,Porosity test, Chemical composition testing & X-Ray test.

Tensile test results

These tests are carried out in the reputed lab inCoimbatore. There are 3 samples undergone this process. And the results are as follows :

Sample 1 : 310.25 Mpa
Sample 2 : 300.38 Mpa
Sample 3 : 302.56 Mpa.

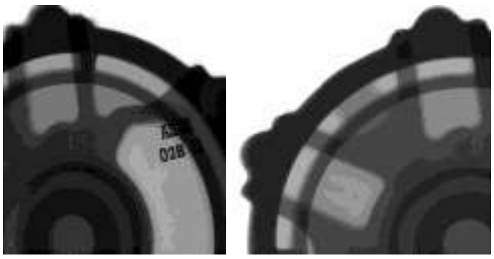
Hardness test results

Hardness test is carried out in Brinell testing method.10 mm ball is used in this process and the applied load is 500kgf . And the results are

Sample 1 : 101.60 BHN
Sample 2 : 100.66 BHN
Sample 3 : 102.33 BHN

X-Ray results

We have captured the images of the X ray results as follows :



4.1X-RAY image of 100% pure ingots

There are no defects found in X ray results

Porosity test results

The method we used in this test is mushroom cup system. Certain amount of melt is being placed on the porosity tester for 15mins. Then the mushroom shaped melt is being cut into two pieces and the porosity is checked by visual method. There is no porosity found in this 100%pure melt.

Experimentation for 100% return melts

Melting furnace capacity : 500 kgs
Melting furnace type : Gas furnace

Alloy used : LM 25
Ingot poured : 431.560 kgs
Holding furnace : Silicon carbide

Melting furnace energy meter readings :

Initial reading : 39345.603 m^3
Final reading : 39372.065 m^3
Fuel used : 26.462 m^3

Holding furnace energy meter readings :

Initial reading : 240.331 w hr
Final reading : 240.436 w hr
Energy consumed : 0.105 w hr

Melting loss calculation

Initial weight :438.506kgs
Production(components) weight : 328.63 kgs
Dross weight (melting&holding) : 19.64 kgs
Bale out weight(melting&holding) : 85.15 kgs

Melting loss formula=Initial wgt–(Component wgt+Drosswgt+ Baleoutwgt)= 438.506–(328.63+19.64+85.15) = 5.086 kgs.

Tensile test results:

These tests are carried out in the reputed lab inCoimbatore. There are 3 samples undergone this process. And the results are as follows :

Sample 1 : 295.97 Mpa
Sample 2 : 253.58 Mpa
Sample 3 : 298.89 Mpa.

Hardness test results

Hardness test is carried out in Brinell testing method.10 mm ball is used in this process and the applied load is 500kgf . And the results are

Sample 1 : 98.56 BHN
Sample 2 : 96.80 BHN
Sample 3 : 100.33 BHN

X-ray test results:

Fig 4.1 X ray result for 100% return melt

There are no defects found in X-ray image.

Porosity test results:

There were no porosity found in the 100% returnmelts. The procedure taken for the test same as the technique used in the 100%pure melt experimentation.

Conclusion

Pure Aluminium ingots and return melts were melted by the GDC. Proper X ray and porosity tests were conducted on the samples and the results were plotted.The present work proposes the study about the pure aluminium casting and return melts and their melting loss and costs. There are no major variations between 100%pure and 100% returnmelts.we got good mechanical results as well. The motives of this project include recycling the aluminium scraps in different grades by taking into consideration the equipment's and applications foreseen. The quality of aluminium made is assessed and compared only with that aluminium product which shares similar quality and features, thus comparing the processes, energy and financial investment of both the methods. Then, the optimal process will be suggested.

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