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Solidification Time Analysis 0n Multi- Material Casting (Al&Pb)

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ABSTRACT

The lightweight construction philosophy is based on the principle of making the best possible use of the material. Whenever a single material does not satisfy the demands of a specific application, compound structures may generate a solution. Especially in light weight construction, a multi-material-mix can provide ideal specific properties that are suitable for the conditions to which a part is subjected. Typically such combinations of dissimilar materials provide desired properties in various areas of the single part. Multi –material casting is a process, which yields such multi-material components. The technique is not much old and a few researchers have worked on it. However, the project material casting process backgrounds and shows the great potential for further investigations and innovation in the field. The survey of existing works has revealed several gaps in the fields of substrate pretreatments, continuous flow behavior of metal during the process, correlation between mechanical and geometrical part properties, and industrial application of some advanced processes. so we take two low melting temperature material Aluminum and Lead. One has low density and another have high density both is prone to corrosion.

Keywords : Solidification Time, Multi-Material Casting , Aluminium-Lead Alloys

I. INTRODUCTION

Metal Casting process is very old manufacturing method since back 3600 B.C. in earlier day this method used for making different types of swords, arrow heads and other safety gadgets. At earlier time only casting method was there for manufacturing such things. Over the centuries from 3600 B.C. human beings are progressively developed in the field of manufacturing methods and invented many kind of casting process according to their requirements. There are prominent examples are their which shows the development of casting methods such as sand casting, injection casting, centrifugal casting, shell molding casting and investment casting. In all types sand casting is used much because it is oldest, easiest and availability. In sand casting process the process starts as same as others casting processes, process starts with making pattern (which is replica of end final product) after that sand mixture is created from different material like moisture, lime and clay etc, then pattern is dipped (dipping procedure is different for different

patterns) in the sand mixture and cavity is created then molten metal is poured and wait for solidify the molten metal, after solidify the final product is comes out with some post processing processes. In Sand casting process has many forms of casting defect and they are classified by many authors into many categories.

1.1. Need of multi-material casting

Few researcher in the field of material science & Engineering conclude the future requirement in material such as

- Light weight construction of the equipments.
- To satisfy more than single demand for any kind of application.
- To produce different mechanical properties in a single part of a machine. Reduction in dimensions of machine parts.
- To reduce the cost of manufacturing.
- To produce an efficient machine parts. And many more

For achieving all above advantages we try to develop a process, methods and conclusions in multi-material alloys. Previously/conventionally all process, methods and conclusion is available only for single materials

1.2 Division of casting process.

- **Hot forming process**: Hot forming process is a temperature and time dependent process in which the parts to be made is formed in the soft state at the elevated temperature.

  It consists following steps such as:
- The heat treatment process in the furnace.
- Transfer from furnace to different kind of tools such as press and drawing.
- Plastic hot forming.
- **Cold forming**: In cold forming process is done at room temperature which was near 27 degree Celsius and using high Pressure and high speed into steel or carbide dies metal is formed. The cold forming process increases the tensile strength, hardness, yield. The process is used to manufacture the foils, sheets, plates etc.

This process gives good dimensional accuracy, excellent surface finish, tight tolerances possible, and lubrication easier.

1.3. Sand casting process

The sand casting process involves the use of a furnace, metal, pattern, and sand mold. The metal is melted in the furnace and then labeled and poured into the cavity of the sand mould

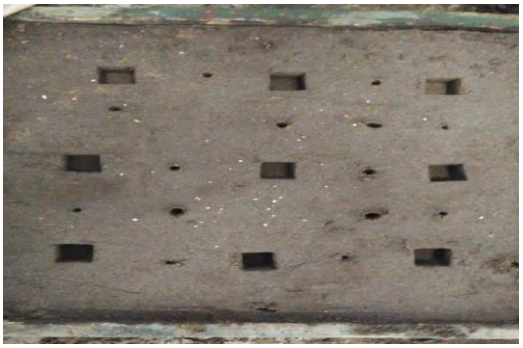


Figure 1. Sand molding cavity

Advantages of the sand casting

- Least advantages in small quantities.
- Ferrous and non-ferrous metal may cast.
- Possible to cast the very large parts.
- Low tooling expensive.

Limitations of the sand casting

- Accuracy in terms of dimensional is inferior to other processes.
- It requires larger tolerances.
- In general casting weights is always exceeding.
- Surface roughness of the ferrous metal exceeds.

Sand casting applications: Sand casting is generally used for cast iron and steel parts of small, medium

and large size where sand casting isn't only versatile in all size of its product it also create exceptionally complex or detailed casting and can be used to cast nearly any metal alloy.

II. PROBLEM IDENTIFICATION

As seen in chapter ,the literature review it is found that Al-Sn-Cu alloys have been taken for casting for getting specific properties of the materials for various specific purposes This methods has been studied by varying the composition of all the elements of the alloys. From the literature of different author it has been observed that the variation of composition by weight percentage has not been varied to the no. of alterations due to which the keen changes in the properties may not be detected. Here, in this study the numbers of alteration in composition of Al-Pb alloy is taken and worked on solidification time, mould filling time and flow ability of the molten material.

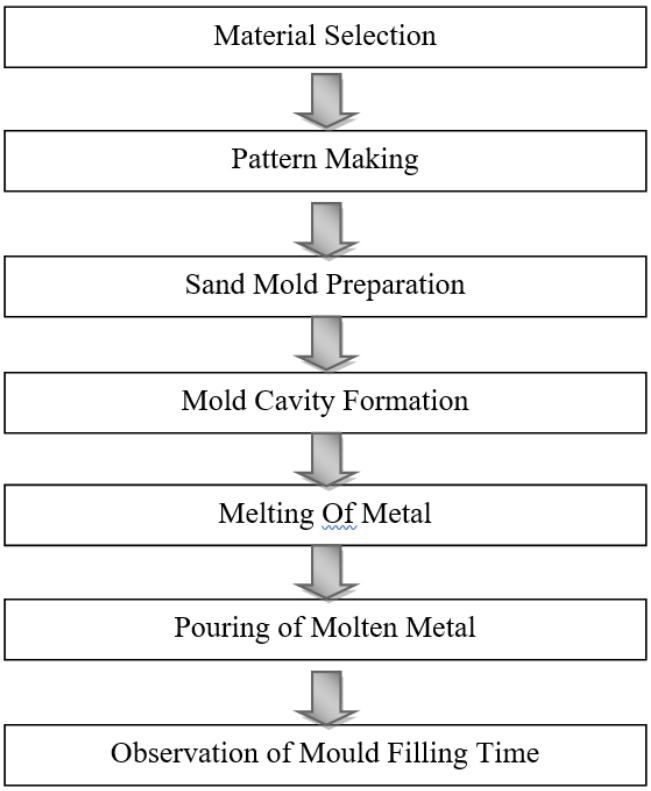
In previous studies this parameters for Al-Pb alloy with varying percentage of elements have not been discussed in detail. Particularly the multi- material casting has not been focused although a broad field area of study can be established. As there in the study it has been discussed that this process is more beneficial in light weight construction of the various mechanical equipments in very economic range. But there is no much discussion or research has been identified/available yet for variety of different materials/alloys.

The multi-material casting process has been performed in very few materials which can be further expanded to get more results in production application. The casting of mixture of aluminum and lead have not been studied so far therefore the experimental study will bring some new concept in the field area of multi-material casting.

It is already discussed in the research gap that very few work for the multi-material casting is done so far. There are some basic parameters such as mould filling time, solidification time, volume flow rate; mass flow rate etc. is studied in multi-material casting.

III.METHODOLOGY

3.1 Multi- material casting process



Material selection Material selection is a one of the challenging task in the multi-material casting process. It arises numbers of question in the actual practice because the combination any (metallic/non- metallic) of two or more material needs a deep study for its physical Knowledge of temperature and properties is very important as far as when we concerned about casting and casting properties of aluminum

Figure 2 Aluminium(Al)

Figure 3 lead (Pb)

Figure 3 shows the solid piece of Lead figure 2 shown on solid piece of aluminium

Table 1– Properties and Specificatiof Aluminium

S.No.	Properties of Material	Material Specification
1	Density	2700 kg/m^3
2	Strength	310 MPa
3	Corrosion Resistance	High Resistance
4	Thermal Conductivity	237 W/Mk
5	Melting Point	660^{0}C

Table 2. Properties and Specification of lead

Lead is a bluish -white, lustrous, diamagnetic metal. It is less dense than the iron and has a distorted form of hexagonal close packing from hexagonal crystal structur

3.2 **Preparations of the Mould**

S.No.	Properties of Material	Material Specification
1	Density	11.29 gram/cm^3
2	Strength	18 MPa
3	Corrosion Resistance	High Resistance
4	Thermal Conductivity	34.9 W/mK
5	Melting Point	328^{0}C

Firstly moulding sand was produced by adding water in appropriate proportion to foundry sand. Secondly moulding boxes was produced using wood that and that can be seen in figure 4.5. The drag was placed on a flat wooden board and then a cylindrical pattern placed on the board.

Figure 4 – Mould box

3.3 Sand Moulding

In sand moulding process sand aggregate is used to make the mould produced in large quantity and when the metal or non metal poured into sand moulds, and after solidify the product may called a sand casting.

3.4 Green-sand molding

Another name of green sand is tempered or natural sand which is prepared by mixing the green sand with 15 to 30 percent clay and content moisture from 6 to 8 percent. Clay and water furnish the bond for green sand. Properties of green sand are fine, soft and porous. It is damp when squeezed in the hand and it retains back the shape and impression to give to it under pressure as shown in figure 4.6. No backing is

required during the preparation of molds hence it is known as green sand molds. It is easily available with low cost and commonly employed for production of ferrous and non ferrous castings

3.5 Properties of moulding sand

The basic properties required in molding sand and core sand are described as under.

- Refractoriness
- Permeability
- Cohesiveness
- Green strength
- Dry strength
- Flow ability or plasticity
- Adhesiveness
- Collapsibility
- Miscellaneous properties

3.6 Limitations in the use of green sand molding are:

- Some casting designs require the use of other casting processes. Thin, long projections of green sand in a mold cavity are washed away by the molten metal or may not even be moldable. Cooling fins on air-cooled-engine cylinder blocks and head are an example. Greater strength is then required of the mold.
- Certain metals and some castings develop defects if poured into molds containing moisture.
- The dimensional accuracy and surface finish of green-sand castings may not be adequate.
- Large castings require greater mold strength and resistance to erosion than are available in green sands.

3.7 Melting of metal

Metal/non metal of different melting point is melt in the furnace, example of used furnace is shown in figure 4.8. The process includes few important steps like refining the melt, adjusting the melt chemistry and tapping into transport vessel. Refining the melt is used to remove the dangerous gases and element from the molten metal to avoid defects in casting. Adjusting the melt chemistry is done brining the material chemistry with in a specific range of specified by industry or internal standard or internal requirements, some fluxes is also used separate the metal from slag or dross and degassers. During the tap, final chemistry adjustments are made. The furnace used for melting the aluminum and lead is lift out crucible type coke fired pit furnace as shown in the Fig.5

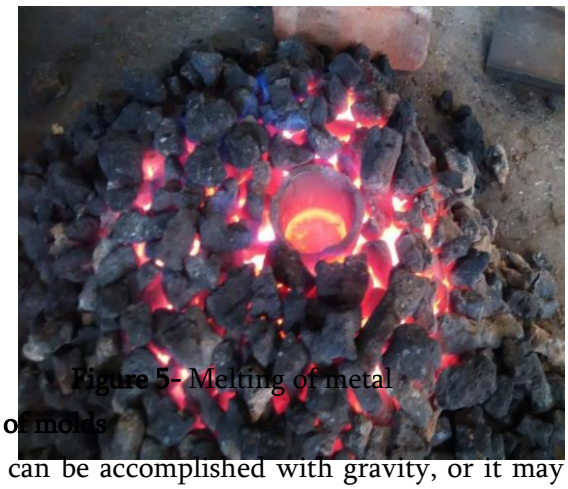


Figure 5- Melting of metal

Pouring of molds

Pouring can be accomplished with gravity, or it may be assisted with a vacuum or pressurized gas. Many modern foundries methods are available to pour material in molten state such as robots or automatic pouring machines. Conventionally, hand ladle was used to pour the moulds. Once the molten material has been poured into the mold it cools rapidly. When the temperature of the liquid metal changes below the melting point of that particular metal or alloy, the solidification process of material begins. This usually takes less than a few minutes in open space.

Figure 6 - Pouring of molten

Process of Recording solidification time

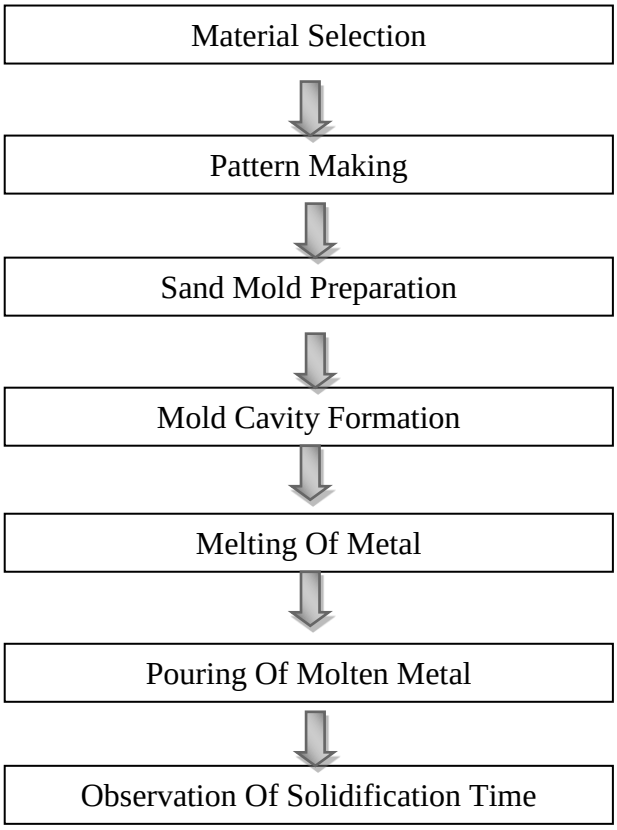


Figure 7- Solidification process

IV. RESULTS & DISCUSSION

The calculation for the desired parameters is made by using the 21 samples of different composition of aluminum and lead in their alloy. Starting from 100% Al & 0% Pb, 95%

Al & 5% Pb ……till 0% Al & 100% Pb. The various parameters such as mould filling time, solidification time, density variation rate etc

Solidification time for Al-Pb Alloy

S.No	Percentage Amount (Al+ Pb)		Solidification Time(t_{s1}) In Minutes	Solidification Time(t_{s2}) In Minutes	Solidification Time (t_{s2}) In Minutes	Average Solidification Time($t_{average}$) = In Minutes
	Al %	Pb %				
1.	100	00	2min. 36 sec	2min. 37 sec	2min. 38 sec	2min. 37 sec
2.	95	05	2min. 36 sec	2min. 39 sec	2min. 39 sec	2min. 38 sec
3.	90	10	2min. 37 sec	2min. 32 sec	2min. 39 sec	2min. 36 sec
4.	85	15	2min. 38 sec	2min. 39 sec	2min. 38 sec	2min. 38 sec
5.	80	20	2min. 40 sec	2min. 40 sec	2min. 40 sec	2min. 40 sec
6.	75	25	2min. 42 sec	2min. 44 sec	2min. 41 sec	2min. 42 sec
7.	70	30	2min. 43 sec	2min. 41 sec	2min. 42 sec	2min. 42 sec
8.	65	35	2min. 46 sec	2min. 42 sec	2min. 42 sec	2min. 43 sec
9.	60	40	2min. 46 sec	2min. 44 sec	2min. 46 sec	2min. 45 sec
10.	55	45	2min. 47 sec	2min. 45 sec	2min. 49 sec	2min. 47 sec

11.	50	50	2min. 52 sec	2min. 47 sec	2min. 51 sec	2min. 50 sec
12.	45	55	2min. 55 sec	2min. 50 sec	2min. 55 sec	2min. 53 sec
13.	40	60	2min. 52 sec	2min. 51 sec	2min. 56 sec	2min. 53 sec
14.	35	65	2min. 57 sec	2min. 58 sec	2min. 58 sec	2min. 57 sec
15.	30	70	3min. 2sec	3min. 1sec	3min. 0sec	3min. 10sec
16.	25	75	3min. 3sec	3min. 1sec	3min. 0sec	3min. 13sec
17.	20	80	3min. 4sec	3min. 2sec	3min. 1sec	3min. 23sec
18.	15	85	3min.3sec	3min.3sec	3min. 1sec	3min. 23sec
19.	10	90	3min. 5sec	3min. 5sec	3min. 2sec	3min. 40sec
20.	05	95	3min. 5sec	3min. 6sec	3min. 3sec	3min. 46sec
21.	00	100	3min. 6sec	3min. 8sec	3min.7sec	3min. 70sec

The table indicates thesolidification time of the mixture of Pb and Al by varying percentage .From the above data we observe that the average pouring time is decreasing with increase in % of Pb in Al-Pb alloy. The curve is drawn below by using the above data of pouring time.

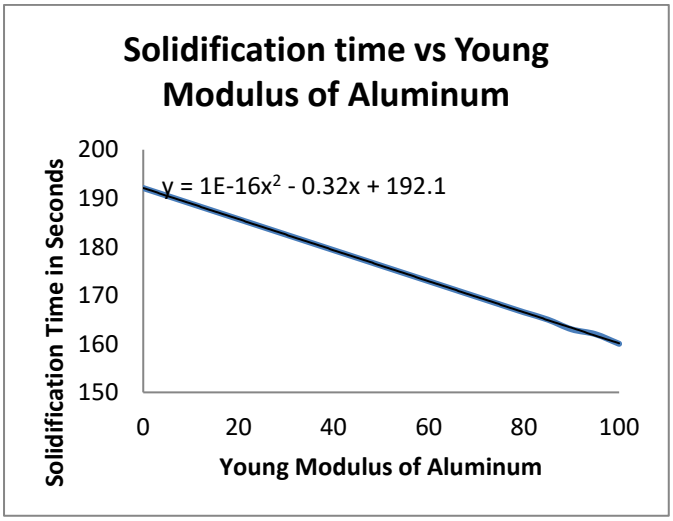


Figure 8 - Solidification time vs Young Modulus of Aluminum

The curve drawn above in figure 3.1 by using data from table 3.1, here the curve is drawn between the mould filling time denoted by (t) which is indicated in vertical axis and percentage of Pb in Al-Pb alloy

The graph obtained by using the data in table 3.2 gives the following equation-

Solidification time(y) = - 0.32x + 192.1

This is the polynomial equation of order 1 where x is the percentage of Pb in Al –Pb alloys .By using this equation the mould filling time for any percentage of Pb in Al-Pb alloy can be calculated.

V. CONCLUSION

Solidification time –It is found that when the percentage of Pb is increased in Al-Pb alloy the solidification time increases. Direct calculation of the solidification time can be obtained for all composition by the given equation below, Also we generate equation i.e.

$$y = - 0.32x + 192.1$$

VI. FUTURE SCOPE OF THE WORK

The research concept may be used to obtain the equations for other alloys that may determine the total time for casting process which will further help to get

approximate numbers of workers and it will help the organization to maintain the balanced economy.

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