Solidification Curve Generation of Pure Aluminium in Sand Casting Process

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Abstract— Experimental study of solidification phenomenon by plotting time temperature curve has been studied in the present work. Solid cylinder as a casting part has been considered. Pure aluminium as molten metal and green sand as mould cavity material have been adopted. Wood as pattern material has considered. K-type thermocouple has been utilized to measure and collect the temperatures data. Sand casting is one of oldest and ancient manufacturing process. In casting process molten metal is poured in previously prepared mould cavity. Casting solidification process is divide into three steps: (i) Liquefaction (ii) During solidification (iii) After solidification. Thermocouple at two boundary points for generation of solidification curve have considered. Results indicate that aluminium melts around 660-650˚C.K-type thermocouple found to be good for recording the temperature data.

Key words: Pure Aluminium, Sand Casting, K-Type Thermocouple, Thermal Indicator, Wood Pattern of Solid Cylinder

I. Introduction

Casting is one of the oldest manufacturing processes. It begins with creating a mould, which is reverse shape of part to be made. These moulds are made from refractory material like sand. The metal is heated until it melts, and this molten metal is poured into the mould cavity. Metal in form of liquid takes the shape of cavity, which is desired shape of part. Then it is allowed to cool until it solidifies. And then the solid metal part is removed from the mould. From pouring to sodify, one single term used for define is" solidification process". in a solidification process metal is solidify into three category:- (i)Liquefaction(ii) Before solidification (iii)After Solidification. During second & third steps extra metal is supply by feeder/riser. These all three steps are understood by solidification curve. Solidification curve is plot between Time and Temperature. and these curve is plot at two node location which is boundary between mould cavity and mould wall.

II. Literature review

The solidification rate of steel in an ingot mould was first studied by Field [1]. The reasoning is difficult to follow, but Field is also arrived at a parabolic relationship between thickness solidification and time. Although much simpler, analytically, the heat flow problem in the sand casting have only been considered separately by Chvorinov [2]. Chvorinov simplifies the problem by neglecting any temperature gradients in the casting and concludes that time for complete freezing should be proportional to, volume and surface area Chvorinov partially verifies his conclusion with the temperature measurements in the steel casting sand moulds. Choudhari et.al, [3] conducted Modelling and Simulation with Experimental Validation of Temperature Distribution during Solidification Process in Sand Casting. They studied heat flow within the casting, as well as from the casting to the mould, and finally obtains the temperature history of all points inside the casting. They found that that most important instant of time is when the hottest region inside the casting is solidifying. They performed Transient thermal analysis using ANSYS software to obtain the temperature distribution in the casting process. They obtained results by simulation software and compared that with the experimental reading of temperature. They also studied the significance of filling pattern and appropriate orientation of gating system. In the end they concluded that the simulation of casting process helps in finding temperature distribution of different parts of the mould. They also concluded that simulation helps in reducing the cost of development and material utilization (yield). Choudhari et. al, [4] studied Optimum Design and Analysis of Riser for Sand Casting using ANSYS. They find that simulation of the solidification process allows visualization of solidification inside a casting and helps in finding last freezing regions or hot spots. They noticed that simulation also helps in optimizing the placement and design of feeders and feeding aid. They concluded that solidification defect can be minimized after finding optimum location of riser. They determined that simulation can help in optimizing dimensions of riser and casting feeding efficiency. They also validated their results of optimized riser dimensions based on simulation by carrying out actual trials in a foundry. In the end they concluded that utilizing sleeve as a feed aid helps in reducing riser dimensions from 60 mm to 50mm which helps in increasing the casting yield.

III. Data collection & results

A. Mould Box Configuration

In present study solid cylinder taken as a part for analysis. Dimension of the cylinder is:-50×100 mm.Other information's are provided in given table:

S.no	Part	Dimension Description (All dimension in c.m.)
1	Mould box size (Cope)	30×20×7.5
2	Mould box size (Drag)	30×20×7.5
3	Diameter of Sprue (Top)	5
4	Length of Sprue	30
5	Length of runner	7.5
6	Base well height	1.5

Table 1: Mould box configuration

Fig. 1: Cope Layout

Fig. 2: Drag Layout

Fig. 3: Mould cavity layout

Fig. 4: Mould cavity with thermocouple

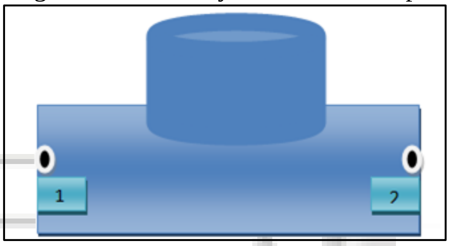

Fig. 5: Locations of nodes

Figure 1 to 5 shows the experimental arrangement of solid cylinder casting. figure 1 shows cope layout with Sprue and feeder cavity. Figure 2 show drag layout with runner cavity. horizontal type of cylinder in mould cavity. Figure 3 & 4 show the mould cavity with thermocouple. K-type thermocouples have used for data measurement. Autonix K-type temperature indicator is used for collecting data.

Venting is primarily used to reduce the build-up of gasses that work against the filling of the mould cavity. Venting can help shorten pouring time and reduce misrun, gas pockets, poor surface finish, and dimensional control problems.

B. Molten metal& Sand properties

Table 2 & 3 shows pure Al and sand properties shown in below:

Type	Physical properties
Phase	Solid
Boling point	2743K
Density	2700 Kg//m^3
Heat of fusion	10.71 Kj/mol
Heat of vaporisation	284.4Kj/mol
Molar heat capacity	24.2 J/mol-K

Table 3: Pure Aluminium properties

Type	Wt%
Silica sand	96%(up to)
Clay	2 to 5%
Water	2 to 8%
Binder	<0.002
Parting sand	<0.001

Table 4: Sand compositions

C. Data Collection

Pure aluminium is used for melting purpose. When it is melt, pouring from ladle to cavity Autonix temperature indicator reads data accordingly.

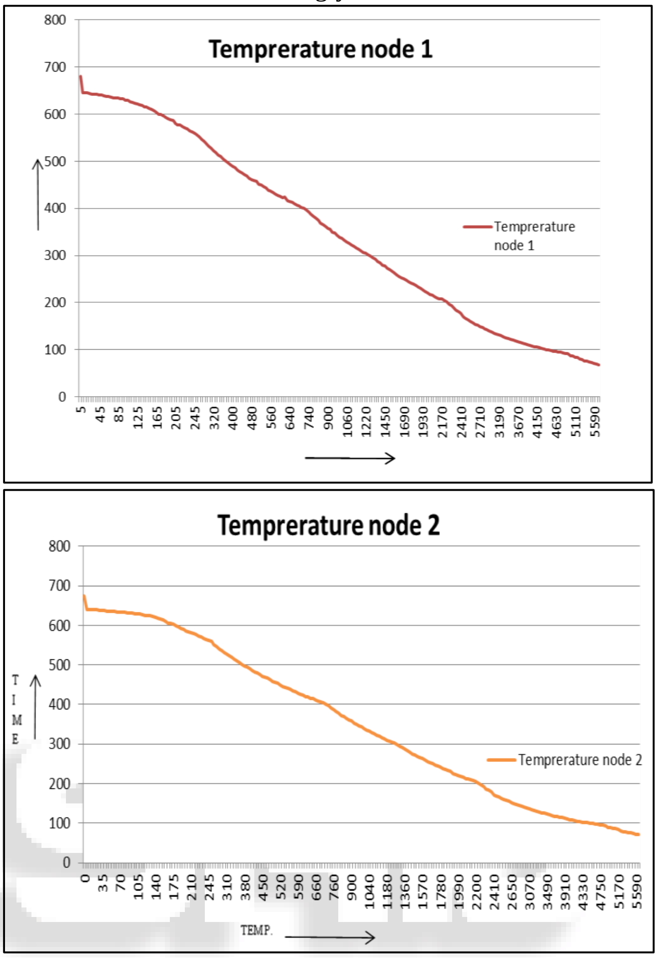

Fig. 6: Graph

IV. Conclusion

1) Solidification curve better explain heat transfer phenomena inside casting.
2) Thermocouple serves very good as an indicator for temperature-time profile.
3) Curves show both phenomena, before solidification and after solidification, which validate the work.
4) Pure aluminium melts between 660˚C -650˚C.

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