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Experimental Studies of Establishment of IHTC Value for Pure Aluminum and LM 13 Material in Sand Casting Process by Using Procast

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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 Aluminum & LM-13 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. Thermocouple at two boundary points for generation of solidification curve has considered. The thermal history obtained from the experiment has used to solve IHTC Acquired IHTC values have presented as a function of time and casting surface temperature at the interface. The same has applied to the specific case of numerical study of solid cylinder. Finite element method is used for numerical simulation problem. The time taken for completion of solidification with respect to the process parameters is discussed. Pro-Cast software package is used for numerical simulation. Autonix Temperature indicator and K-type thermocouple is used for temperature measurement.

Keywords: Finite element method, IHTC Pure Aluminium, LM 13materail K-Type Thermocouple, Thermal Indicator.

I. INTRODUCTION

Casting is one of the oldest manufacturing processes. It begins with creating a mold, which is reverse shape of part to be made. These molds 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.

Sand casting uses synthetic or natural sand which usually a refractory material called silica .The sand grains should be small enough so that they can be packed densely and also they should have large enough to allow passage gasses formed during the metal pouring to escape by the pores. Large size molds use green sand .Sand can be reused and excess poured metal is cut off and reused also.

II. EXPERIMENTAL PROCEDURE

In this study we have take two material for establishing IHTC value; two materials name are:-LM-13 and Pure Aluminium. solid cylinder is a basic parts manufacturing sector its shape is also used in automobile such as :-piston-cylinder assembly. So for analysis purpose solid cylinder taken as a part of our experiment. Sand casting is a very cheap and basic casting process. In sand casting generally for mould cavity generation two types of pattern material are used which are:-Wood And metal. wood type pattern is used for small scale production. But metal type pattern is used for large scale production. Wood pattern is easily manufacture at very cheap cost. in our experiments wood type split pattern is used. Spilt pattern is a type of where pattern is divided into two parts:-namely called cope type and drag type. In split type pattern Sprue and feeder is generally kept in cope part whereas runner gating system base well is kept in drag part. Orientation is also affect casting quality. Researchers classified casting according to its orientation :-horizontal type and vertical type. For reducing mould height and minimising possibilities of defects in casting horizontal type is used. Figure 3.1 shows wood type cylinder pattern. whereas figure 3.2 &3. 3 shows Sprue and feeder which is used in experiment. rectangular type runner system was used for flowing molten metal between Sprue and mould cavity.

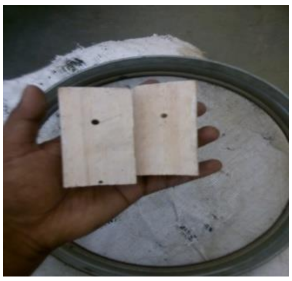

Table: 1: *Dimensions of gating system & feeder*

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S.no	Part	Dimension Description (All dimension in c.m.)
1	Diameter of Sprue (Top)	6
2	Length of Sprue	3.5
3	Length of runner	7.0
4	Base well height	2.0
5	Feeder diameter	3.0
6	Feeder length	3..5

Figure shows cope layout and figure3. 6 shows drag layout.

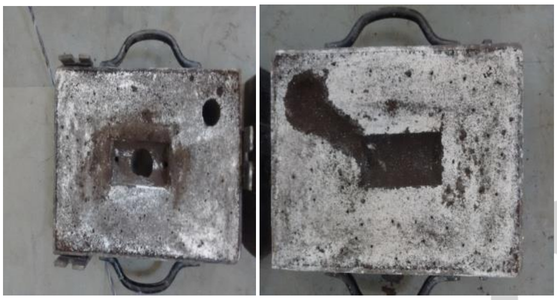

Fig: Cope layout   Drag layout

after complete cope and drag part proper venting is done. 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. The mould hardness of a green sand mould is increased, permeability decreases, and gas pressure increases. When gases cannot escape easily, the metal flow is inhibited venting directly into thin section cavities will benefit fluidity. Although, various researchers have suggested that venting is beneficial to the filling of moulds. Clamp is used to minimise possibility of flash defects in casting. after clamp K -type thermocouple is used for temperature measurement. Type K is the most common general purpose thermocouple with a sensitivity of approximately 41 µV/°C. It is inexpensive, and a wide variety of probes are available in its −200 °C to +1350 °C range (−330 °F to +2460 °F). Autonix K type of temperature indicator is used.

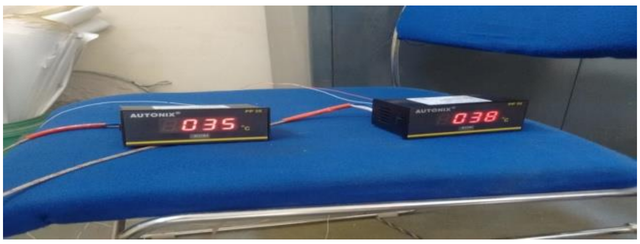

Fig: Autonix K-Type Indicator

After data observation we plot a curve between time and temperature. These curve shows solidification behaviour of respective materials either it is pure Aluminium or LM-13. all other parameters are constant for both materials and check solidification behaviour. Results are also compare with simulation results.

III. SIMULATION STEPS

In simulation steps all design parameters are same. Figure 10 &11 shows FE model of solid cylinder and node location in part. CREO 2.0 is used for design of part and mould cavity generation.

Fig: FE model of Solid cylinder

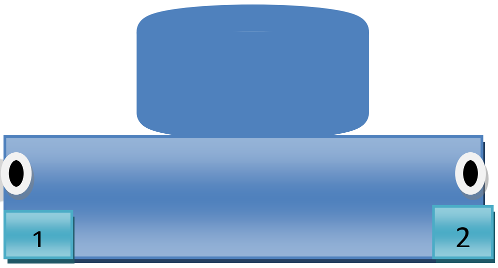

Fig: Location of nodes

But we need some data which are related to boundary condition, step size. In a pro cast module first we open window; in this window there are six module which names are :- (i)Mesh cast (ii) Pre CAST (iii) Data cast (iv)pro cast (v) View-cast (vi) status

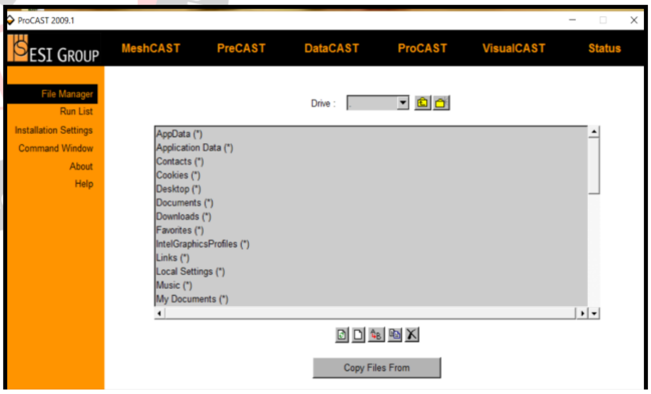

Figure shows Pro cast environment

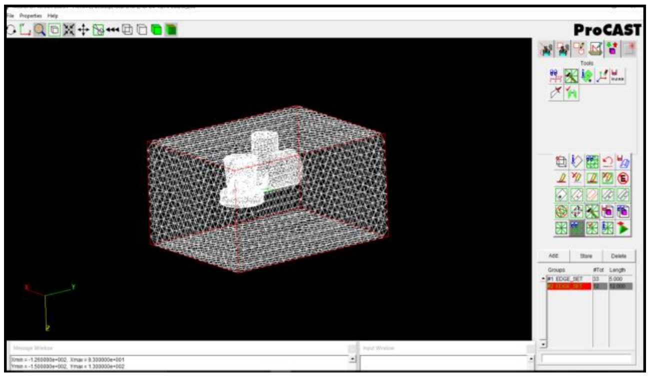

Fig : Mesh cast environment with unit cell size

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Fig: Tetrahedral environment

shows part in a tetrahedral format. In this step various information are displayed like dimension of cell, bad angle criteria tolerance angle total number of elements, nodes and surface area. After completion of tetrahedral cell generation windows shows number of materials used in a casting, total volume of meshing. in this window if we press smooth meshing bad sector is minimised or removed in part and meshing part is ready to precast environment. In Pre cast module we apply a boundary condition on designed part. Figure 3.18 shows Pre cast window. in a pre cast window various information's are available for mathematically models like number of materials ,total number of nodes, total number of elements etc.

the definition of the phase change. Instead of defining the specific heat, and the latent heat, one can define the corresponding enthalpy curve.

The enthalpy as a function of temperature, H(T), is defined as follows :

$$H(T) = \int_0^T C_P(T)dt + L(1 - f_s)............(3.1)$$

where cp(T) is the specific heat as a function of temperature, L is the latent heat and fs is the fraction of solid.

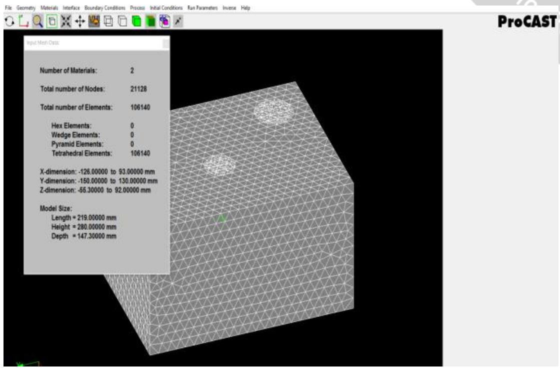

Fig: Pre cast window

pre cast>interface>assign material> type of entry> Coinc> Choose DB value> assume 500 w/m^2/k.

if we apply interface ,next part is called Boundary condition where we assign heat transfer mode and its heat transfer value and inlet condition for sand casting process. other conditions are also avail like pressure,vent, temperature, wall, inject, displacement ,velocity and heat. these B.C. are used to determined through type of process and material thermo physical properties .Table 3.3 (a) & .3 (b) Pure Al and LM13 properties where as table 3.4 shows green sand properties. Figure 3.19 shows Boundary condition environment. Table 3.4 shows green sand properties. Fig 3.21 shows Boundary condition environment. for flow calculation Navier stokes equation are used. N-S equation is also called a momentum conservation law. These equations are determining velocity of fluid in simulation: equations are given below:

$$\rho\left(\frac{du}{dt} + u\frac{du}{dx} + v\frac{du}{dy} + w\frac{dw}{dz}\right) = -\frac{dp}{dx} + \rho g_x + \mu\nabla^2 u$$
....

$$\rho\left(\frac{dv}{dt} + u\frac{dv}{dx} + v\frac{dv}{dy} + w\frac{dv}{dz}\right) = -\frac{dp}{dy} + \rho g_y + \mu\nabla^2 v$$
....

$$\rho\left(\frac{dw}{dt} + u\frac{dw}{dx} + v\frac{dw}{dy} + w\frac{dw}{dz}\right) = -\frac{dw}{dz} + \rho g_z + \mu\nabla^2 z$$
....

Where p is the pressure of unit density, Pa; μ is the dynamic viscosity P as; g is the acceleration due to gravity m/sec2 is laplacian operator; ρ is the density of fluid kg/m3; t is the filling time sec. When Navier stokes equation is sum up with incompressible continuity equation, we easily determine flow characteristics.

Table:Pure Al properties

Type	Physical properties
Heat of fusion	10.71 Kj/mol
Heat of vaporisation	284.4Kj/mol
Molar heat capacity	24.2 J/mol-K
Liquidus temperature	560
Solidus temperature	550

Table:3.3 LM 13 properties

Type	Physical properties
Density (Kg/m^3)	2758
Conductivity(W/m/k)	71
Specific heat (Kj/kg/k)	1.591
Latent heat (Kj/kg)	459.4
Liquidus temperature (^{0}c)	627.3
Solidus temperature (^{0}c)	520.0

Table: Green Sand properties

Properties	mould (Green sand)
Density (Kg/m^3)	1370
Conductivity(W/m/k)	0.87
Specific heat (kj/kg/k)	1.236

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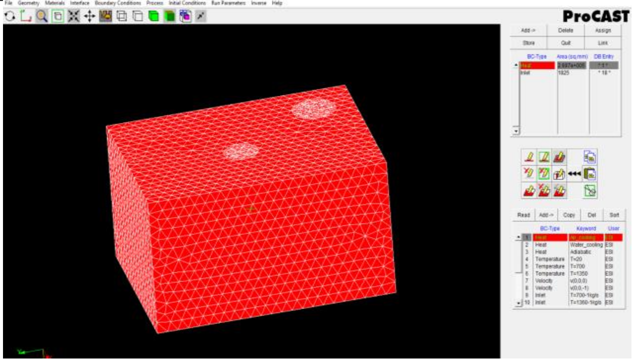

Fig: Boundary condition air cooling

So completion of precast module now we move to data cast and procast.this module is used for generate .unf files for calculation data like velocity, fluid flow ,heat transfer phenomena. after run both module we can see and casting. we can also analyse process at different parameters. Figure 3.24 shows view cast environment during process.

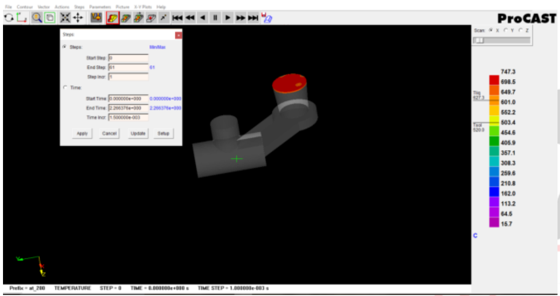

Fig: View-cast environment

IV. RESULTS AND CONCLUSION

LM-13 EXPERIMENTAL RESULTS

LM 13 is melt and solidify according to Time - Temperature graph. In our experimental study two K-type Thermocouple is inserts corner at the casting mould interface which is same distance from the mould wall. Time Temperature graph is first obtained by at left hand side. Temperature at node 1 & Temperature at node 2 shows practical data. Temp. XXXX shows simulation at different Intermediate Heat Transfer Coefficient (IHTC).

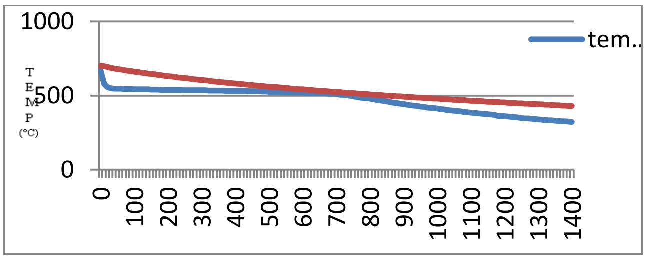

Fig: Experimental results with simulation results at node_1

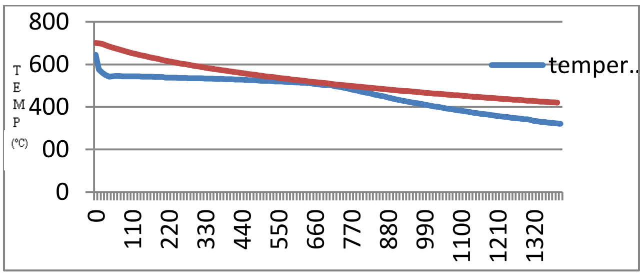

Fig: Experimental results with simulation results at node_2

Figur shows compare experimental results with simulation. In both figures shows IHTC minimum value is 30 w/m^2/k. whereas figure 4.3 & 4.4 shows maximum value of IHTC is 5000 w/m^2/k. In between these curves IHTC value vary according to its time. temp_5000 indicate simulation value at 5000 w/m^2/k. If we compare both results and put on same graph maximum and minimum value of IHTC are 30 and 5000 w/m^2/k value. Figure shows validation of statements.

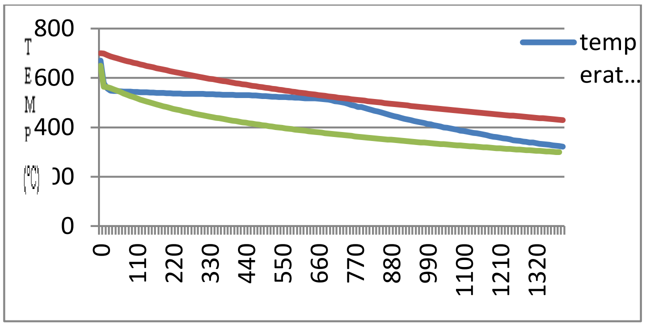

Fig: Experimental results with simulation results at node_1

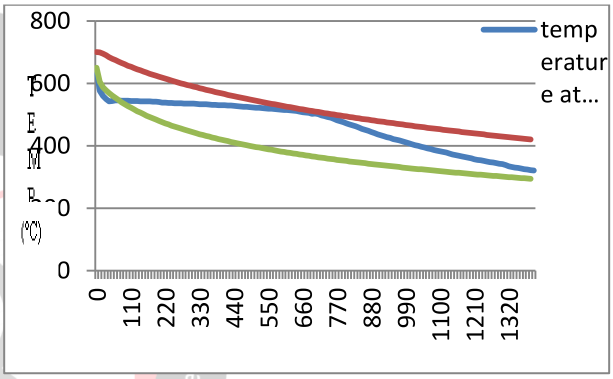

Fig: Experimental results with simulation results at node_2

PURE ALUMINIUM EXPERIMENTAL RESULTS

In second case Pure Al is melt and solidify according to Time -Temperature graph. In our experimental study two K-type Thermocouple is inserts corner at the casting mould interface which is same distance from the mould wall. Time Temperature graph is first obtained by at left hand side. Temperature at node 1 & Temperature at node 2 shows practical data. Temp. XXXX shows simulation at different Intermediate Heat Transfer Coefficient (IHTC) value.

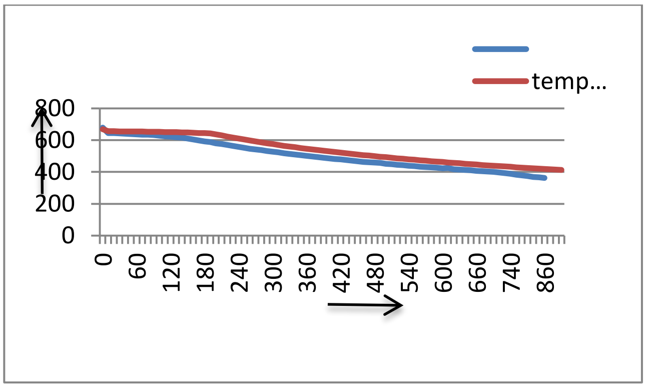

Fig: Experimental results with simulation results at node_1

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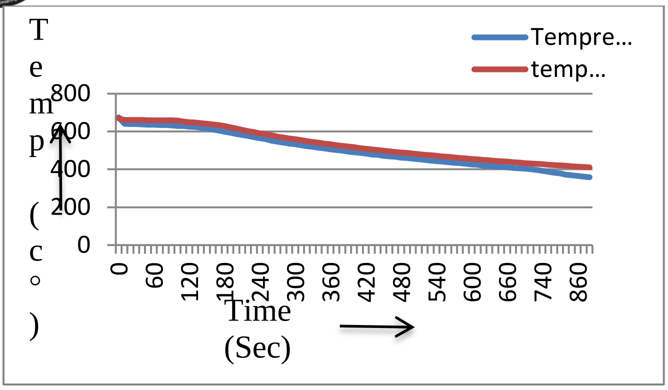

Fig: Experimental results with simulation results at node_2

If we compare both results and put on same graph maximum and minimum value of IHTC is 5000 $w/m^2/k$ value . Figure 4.7 & 4.8 shows validation of statements.

V. CONCLUSION

- Finite element method is used to establish IHTC value for Pure Al and LM13 material.
- For Pure Al IHTC value is 6000$w/m^2/k$. But in case of LM 13 value of IHTC in range which are between 50 and 6000w/m2/k.
- curves also shows solidification behavior of pure Al and LM13 material.
- FE model is very good tool for establishing IHTC value.

REFERENCES

[1] Degarmo E.P., Black J.T, Kohser R.A, Materials and Processes in Manufacturing, 9th Edition, Wiley Inc, USA, 2003.

[2] Field A.L., Solidification of steel in ingot mold Trans. Amer. Soc. Steel Treat. 11, 1927 p.264.

[3] Chvorinov N, Giesserei, Control of the solidification of casting by calculation. 27, 1940. p.177, 201, 222.

[4] C.M. Choudhary, Narkhede B. E., Mahajan S.K., Modelling and Simulation with Experimental Validation of Temperature Distribution during Solidification Process in Sand Casting. International Journal of Computer Applications. 2013, 78, p.23-29.

[5] C .M. Choudhari, K. J. Padalkar, K. K. Dhumal, B. E. Narkhede, S. K. Mahajan, Defect free casting by using simulation software, Applied Mechanics and Materials, 2013, 313-314, 1130-1134.

[6] T.R. Vijayaram, S. Sulaiman, A.M.S. Hamouda, M.H.M. Ahmad, Numerical Simulation of Casting Solidification in Permanent Metallic Molds, Journal of Materials Processing Technology 178 (2006) 29–33

[7] Hassan Jafari, Mohd Hasbullah Idris , Ali Ourdjini, Saeed Farahany, In situ melting and solidification assessment of AZ91D granules by computer-aided thermal analysis during investment casting Process, Materials and Design 50 (2013) 181–190

[8] Denis O' Mahoney, David J. Browne, Use of experiment and an inverse method to study interface heat transfer during solidification in the investment casting process, Experimental Thermal and Fluid Science 22 (2000) 111 - 122.

[9] A. Venkatesan, V.M. Gopinath, A. Rajadurai, Simulation of casting solidification and its grain structure prediction using FEM, Journal of Materials Processing Technology 168 (2005) 10–15

[10] M. Ruhul Amina, Anurag Mahajan, Modeling of turbulent heat transfer during the solidification process of continuous castings, Journal of Materials Processing Technology 174 (2006) 155–166.

[11] Lei Zhang, Yi-Ming Rong, Hou-Fa Shen, Tian-You Huang, Solidification modelling in continuous casting by finite point method, Journal of Materials Processing Technology 192–193 (2007) 511–517.

[12] W.Kurz, D.J. Fisher, Fundamentals of Solidification, Trans Tech Publications, Aedermannsdorf, Switzerland, 1989.

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