An Estimation of Solidification Time by Varying Pouring Temperature in Investment Casting Process.

Yogesh A. joshi[1] H.D.Patel[2]
[1]Mechanical Engg. Department
[2]Professor Mechanical Engg. Department
[1,2] Government Engg. College, Dahod

Abstract--- Solidification is a very crucial factor for any casting process. Generally directional solidification will help to achieve a good quality casting product. It has been observed that casting defects like porosity, misrun, slag, etc can be minimize by providing directional solidification. Different rate of pouring temperature will also affect the solidification rate of casting and so quality of casting.

I. INTRODUCTION

It is obvious that casting has a wide range of application but here we have to consider that there is so many draw back in it like skilled labour requirement, higher material loss, higher rejection rate. Machining required for finishing, etceteras. To accommodate such draw back so many improvisation has been made in casting process and because of that die casting, shell casting, centrifugal casting, investment casting, etceteras are introduced to the world.

Foundry industry is well aware of the fact that knowing solidification sequence is very important to design risers and their connections. Furthermore, knowing the solidification sequence and contours enables the foundry engineer to improve the manufacturability by modifying the original casting designs which are created by the design engineers who are often not familiar with the solidification and how the design parameters affect the solidification patterns[4].

It is also observed that results from simulation were in excellent agreement with the result from calculations. This confirmed that casting simulation technology might substitute the casting laboratory in engineering education [3]. Among of all casting processes here we selected investment casting process to estimate the solidification time by varying level of pouring temperature. A valve body is used for this study in which WCB (wrote cast iron with grade B) material is used. 3D CAD model is generated for the experiment and it is simulated in Pro-cast at three different temperatures. First theoretical solidification time of this model is finding out by using chvorinov's rule.
STUDY:

A. *The Theoretical Aspect of the Study*

The solidification time is a function of the volume(V) of a casting and its surface area (A), which is defined by Chvorinov's rule. In simple terms the rule establishes that under otherwise identical conditions, the casting with large surface area and small volume will cool more rapidly than a casting with small surface area and a large volume. The relationship can be written as:

$$t = B\left(\frac{V}{A}\right)^n$$

Where t is the solidification time, V is the volume of the casting, A is the surface area of the casting that contacts the mold, n is a constant, and B is the mold constant. The mold constant **B** depends on the properties of the metal, such as density, heat capacity, heat of fusion and superheat, and the mold, such as initial temperature, density, thermal conductivity, heat capacity and wall thickness. The metric units of the mold constant Bare min/cm^2 According to Askeland, the constant n is usually 2, however Degarmo claims it is between 1.5 and 2. The mold constant of Chvorinov's rule, B, can be calculated using the following formula:

$$B = \left[\frac{\rho_m L}{(T_m - T_o)}\right]^2 \left[\frac{\pi}{4k\rho c}\right]\left[1 + \left(\frac{c_m \Delta T_s}{L}\right)^2\right]$$

Where

T_m = melting temperature of the liquid =1520°C
T_o = initial temperature of the mold =900°C
$\Delta T_s = T_{pour} - T_m$ = superheat=30°C
L = latent heat of fusion (in [KJ.Kg^{-1}]) =180
k = thermal conductivity of the mold (in [W.m^{-1}.K^{-1})]) =43°C
ρ = density of the mold (in [Kg.m^{-3}]) =2200
c = specific heat of the mold (in [J.Kg^{-1}.K^{-1}]) =1130
ρ_m = density of the metal (in [Kg.m^{-3}])=6970
c_m = specific heat of the metal (in [J.Kg^{-1}.K^{-1}])=450
V/A= volume to surface ratio= 2.45mm

In this work mathematical solidification time of whole assembly is 17 minutes computed.

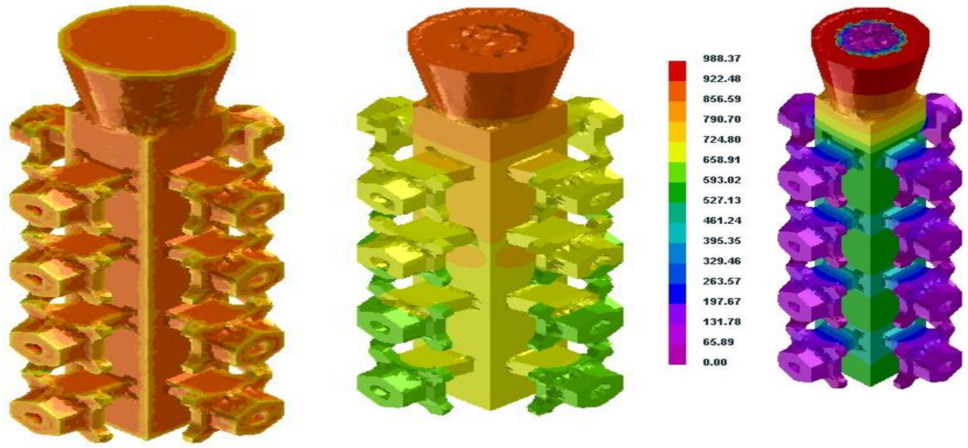
II. EXPERIMENT AND RESULT

A. *Input Data*

Metal pouring temperature	1550,1600,1650(°C)
Mould temperature	850°C
Convection metal to mould	600 W/m^{2}k
Convection mould to atmosphere	43 W/m^{2}k
Cooling type	Air cooling

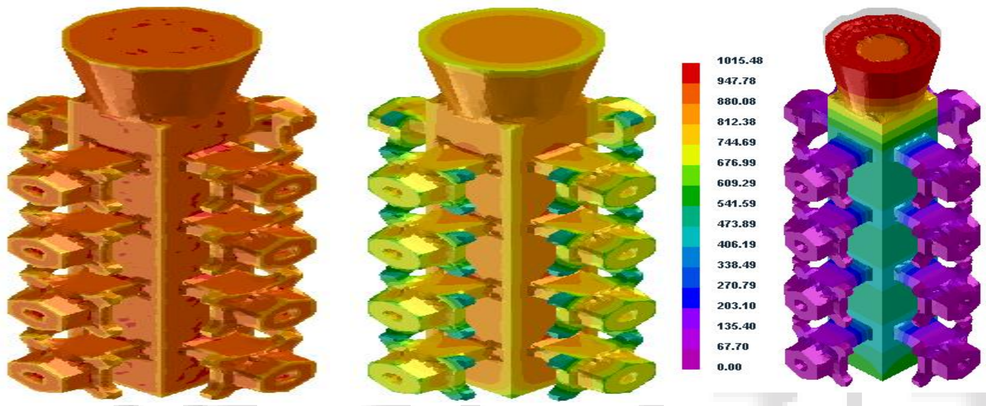
POURING TEMPRATURE	INITIAL SOLIDIFY	HALF SOLIDIFY	FULL SOLIDIFY

1550^0C



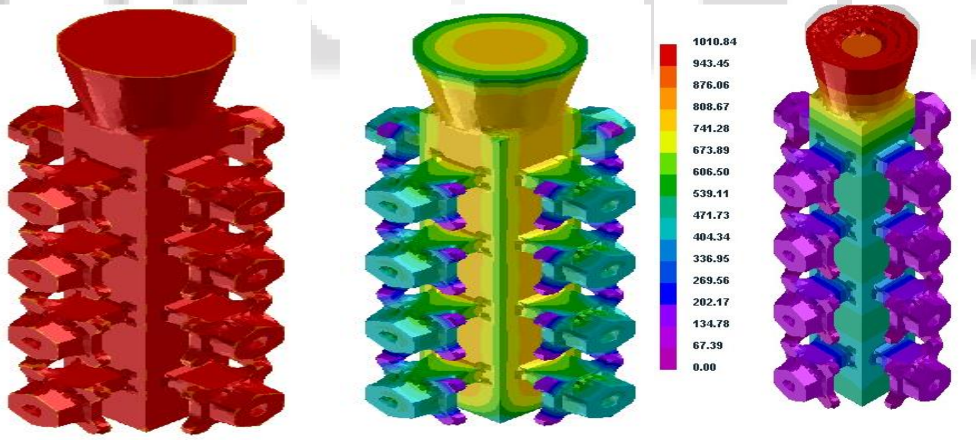
988.37 second

1600^0C



1015.48 second

1650^0C



1010.84 second

III. CONCLUSION

Here we can see that by varying the pouring temperature we get different rate of solidification time. It is also seems that by increasing pouring temperature there no significance change in solidification time. Melting temperature of WCB is 1530^0C, so when we poured metal at 1550^0C it was solidified in 988.37 second but the pattern of solidification is not satisfactory as we can see so many colours in sprue and it may be causes porosity. While we poured metal at 1600^0C and 1650^0C the results are much similar it means excessive temperature doesn't make any different in quality as we can see the very similar solidification pattern in both case and they're very negligible difference in solidification time.

REFERENCES

[1] Lewis RW, roberts PM," finite element simulation of solidification problem"appl Sci Res, 1987,44:61-92
[2] B.ravi," casting simulation and optimisation: benefits, bottlenecks and best practice", indian foundry journal,54(1),47-52,2008.
[3] Ramazan Kayıkc," Use of Computer Simulation Technology in Engineering Education", Sakarya University, turkey,2013.

[4] M. Copur et.al,"Finite volume modelling of the solidification of an axial steel cast impeller",Original ScientiĀ c Paper – Izvorni znanstveni rad,2013.
[5] Nikhil Yadav et al. "Effect of Process Parameters on the Surface Roughness of A713 Alloy Castings produced by Investment casting process", International Journal of Emerging Technology and Advanced Engineering,2013.