TEST Engineering & Management

January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209

Transient Thermal Observation for Casting of Assembly of Aluminum Alloy with Sand Mold & Mullite Mold

1-Rahul Shukla 2-Dr. AmitMedhavi 3- Dr.(Prof.) Raghuvir Kumar 4-Abhishek Kumar Pandey
1-RESEARCH SCHOLAR 2-ASST. PROF. 3-DIRECTOR GENERAL 4- RESEARCH SCHOLAR
1,2 Department of Mechanical Engineering, K.N.I.T.Sultanpur U.P.
3 B.N.C.E.T. Lucknow U.P. ,4 Department of Mechanical Engineering, I.E.T. Lucknow
E-mail 1-rahul.shukla@knit.ac.in ,2-amitmedhavi@gmail.com,
3-directorgeneral.bncet46@gmail.com, 4-er.abhishekpd@gmail.com

Article Info
Volume 82
Page Number: 4201 - 4209
Publication Issue:
January-February 2020

Abstract
In this analysis simulation in two dimension for solidification of aluminum alloy with greensand AI50/60 (AFS) & with mullite mold by finite element method and ANSYS software has been donefor it thermophysical properties of sand and mullite taken dependent on temperature but aluminum alloy properties are constant along convection heat transfer taken in consideration on mold external surface due to dependency of properties of mold on temperature. For this the problem modelling have non-linear equation. Effect of heat transfer shown in two-dimension with thermal gradient, effect of thermal flux and convergence curves that control the feasibility of Newton-Rapson algorithm process.

Due to complex physics concept in applied in whole process of casting there are various parameter to control the perfection of casting. Mold design also matter which to be optimize. A methodology developed on optimization technique of cavity wall & cavity-cavity gap for casting to find a proper layout and the number of cavity in a mold .We done observation on heat transfer process in the casting .Resistant within casting due to solidified metal , metal mold interface and the mold have major part in thermal resistant & the liquid & surrounding of the mold have vey low participation which can be neglect. Resistant due to air gap in between solidify metal & mold also having major impact on casting microstructure &quality of casting it is a great resistant for heat transfer . In this paper we understand phenomena involved solidification of casting , to find the several parameters which affect solidification of casting & interrelation between these parameter . a mathematical model also developed to get correct understanding of the heat dissipation in the casting finally applied the ANSYS to get correct understanding. The effect of different-different mold on the heat distribution is main work done here to get a good casting for a specific purpose. Here temperature variation in the aluminum casting & mold during solidification process studied.

Article History
Article Received: *18 May 2019*
Revised: *14 July 2019*
Accepted: *22 December 2019*
Publication: *21 January 2020*

Keywords: *Casting Process, Heat Transfer, mullite mold,sand mold, Aluminium Alloy*

TEST Engineering & Management

January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209

INTRODUCTION:

Metal Casting : To get a sound quality in a casting we should know about

- How to Prepare a mold and pattern,
- Method to pour liquefied metal
- Process involve in Solidification thenreachedat thetemperature of room
- method of checkingforperfection level.

MoldSelection

Generally permanent metal mold or expandableandrefractory mold used
Dies which is generally metal moldsto prepareproduct in die casting has various constraints

Mold design: Use to reduces number of moldingoperations along withreduction of sand consumption. All above mentioned objectivescan be findwith usenumbers moldswith two or large number of patterns should becoupledto feed it by same sprue andsame feedprocess: doing this we find
(i) Good utilization of mold
(ii) Better yield ratio
(iii) Less production time for a casting

Casting solidification: ProcessofSolidification for castings startsby the formation of crystal onwalls of mold justfrom liquid metal poured, due to it formation of thin solid metal layer stared , increase in thickness in this layer proceeds solidification.

Heat transfermechanisms: Mechanics of heat transfer taken place by conduction,convection, radiation, boiling and condensation in this conduction, convection and radiation having major part
(i) Conduction: In metal casting,
conduction heattransferred taken place in the metal which is solidifyand the castingmold. This heat transfer occur in two state one is steady and other is transient. Here conduction through transient has major domination
conduction heat generally get

$Q = KA(\Delta T)/t$ ……(1)

(ii) Radiation: besides conduction a form of energy transfer occur in a casting,thiscan be also transferred by a vacuum. In this mechanism transfer taken placeby electromagnetic radiation, that is known thermal radiation. This takes place
Atmold's external layer and in interface of mold and casting
Transfer of energy in this is

$Q = \varepsilon_1 A_1 \sigma(T_s^4 - T_\infty^4)$ ……(2)

Where
ε_1= Emissivity of the surface
σ = Stefan-Boltzmann constant =$5.67\times10^8 W/m^2K^4$
T_s = Mold Surface Temperature
T_∞=Ambient Temperature
(iii) Convection*:* Convection heat transfer taken place in casting at
1. within liquid metal heat transfer
2. Heat lost at moldouter surface
3.At interface of mold and metal
A assumptionthattransfer of heat byfrom external area of moldtaken place through natural convection as well as
radiation. The heat transfer :

$Q = hA(T_s - T_\infty)$ ……..(3)

Where
Q = Heat flow through convection
h = Convective Heat Transfer Coefficient
A = Surface Area through which heat is flowing
T_s= Mold Surface Temperature
T_∞= Ambient Temperature

LITERATURE REVIEW:

Qiao et al.observed that corrosion as well as breakdown may be also taken placebecause of high speed , high temperature in the moltenmetal. For prevention of it analysis of

January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209

flow and heattransfer should be done during the packing stage of thecast. There isshortersolidification time for thin component ascompare tothick component. physical and mechanicalproperties of finished componentsforanalysis aspectsinclude nucleation density, grain size, the more adequatefor filling the nucleation density larger but grain sizesmaller, directly determines it.

Pariona et al. Sand system cooling process was slower as compare of mullite system. It meangradient of temperature in mullite is small as compare to sand .it happen in lowest temperature region of the casting at which solidification begin

Mechanical properties of casting also affected by energy degradation by mold to environment. In the process of convergence mold made of mullite requireda no ofiteration,reason behind it that itachieved lower temperaturesas compare to sand system, within the equal solidification time. From cooling curves, atvarious pointsin mold made of sand it is find that it presented phase changes, but at same it didn't happened in the mullite system.**Prabhu et al.**They find that the peak mold temperature increased with casting thickness because of its higher heat

content. Stable solid shell formed and this formation resultant, heat flux transients showing a peakthat have higher thermal

conductivitylarger than the liquid metal beforegeting of the peakcontactwith the mold wall. obtained very high with in case of thin moldsvalues of heat flux transients having large value cause mold distortion because of thermal stresses.

Seetharamul et al. From this research we find that A single cooling environment over solidification period exists for a static castingbut there isdifferentenvironmentmold,sprays, pinch rolls contact, radiation in continuous cast section encountersprior completion of solidification. Due to regular change of zone in continuous casting it has good thermal stresses as compare to ingot casting.

Continuouscast section, also stressed due to pinch rolls,bending and straightening operations during solidificationmold oscillation. At wide faces of large slabsferrostatic pressureproduce huge stress cause bulging.

Cervera et al.they observedconditions of mold and casting with aspects of thermo-mechanical,here assumption taken that normalpressure along with mechanical gapsaffects heat flux anddivision of governingequations used to get solutionwith a fraction step method.

Vijayaram et al. They did Solidification simulation of castingsthat give information about temperature contours,time-temperature data, locations of hotspot, latent heat of fusionand solidification timedegree of recalescence.

Canales et al. The temperature,not affected eitherby siliconor iron at which formation of complex Al-Si-Cu-Mg eutectic is taken place is unaffected by either siliconor iron. Because of presence of modifying effect of manganese in theexperimental heat the iron rich intermetallic were of the α- type.

Kang et al. They find advantage ofcomputersimulation of die design andcompared it with the traditional process which performed by designer's experience and trial and error. From traditional die design they made casting of semisolids. They find defects shapes at surface of the semi-solid cylinder block.By computer simulationdie gate system evaluated to get parts which don't have anydefects was realise.Heat transfer is taken majorly in thermal system, neglecting effect of naturalconvection. In this research study effect on solidification rateby natural convection of liquid water is done.

TEST Engineering & Management

January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209

Simulation of the latent heat release is done through apparent capacity method.

Prashant et al. They find that effective modulus of neck is always more than calculated modulus. There is strong possibility that neckmodulus may be more thanreversefeeding and feeder modulus from casting to feeder thatresults shrinkage of porosity in the casting.

Sergey et al. numerical results Comparison done here to getexperiment resultwhich show that the formulated model gives a solution which is acceptable accurate despite some uncertaintyin material properties along with boundary and initial conditions.

Das et al. they find that in mullitemoldthere is less thermal stress as compare to sand mold. If we take composite of sand-mullite the observation shown thatleastshrinkagein it and shrinkage for casting also less. But stress due to temperaturein this is higheras compare of mullitemold. Soa future work to optimize can be done asto getgood combination of moldmaterials .

Objectives:

Detail observation of the physics of the solidification process ofcasting, parameters influence solidification process of& Study the inter-relationship of these parameters and their collective influence on the solidification process of castings.

Methodology:

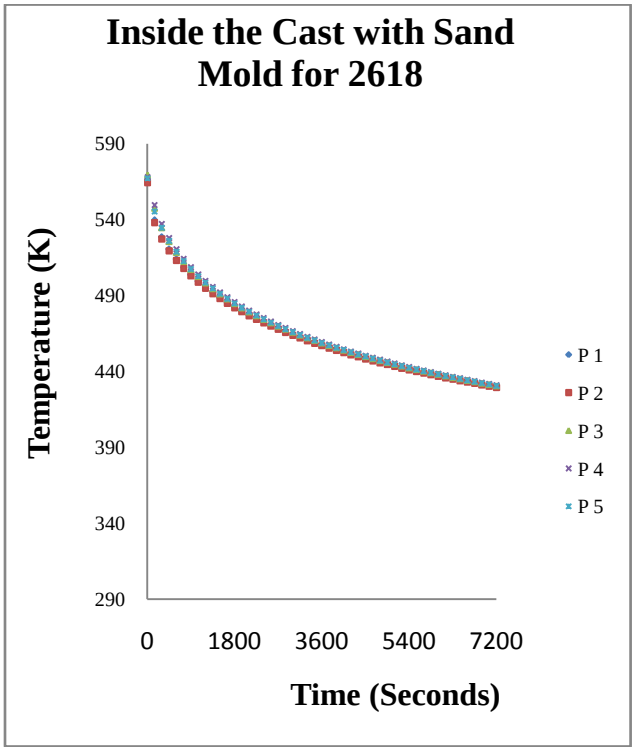
casting object as well asmolding design in this paper istaken by M. M. Pariona and A. C. Mossi's paper [3]. In this research paper A. C. Mossi and M. M. Pariona chosecast object of channelshaped which was made by casting process of pure iron.

Calculation of solidification time of a casting is done with the help of temperature profile of mold.We taken the properties of aluminium which is variable with temperature.With the help of thermal conductivity and enthalpy which are Temperature dependentproperties of material heat transfer during phase change is determined.

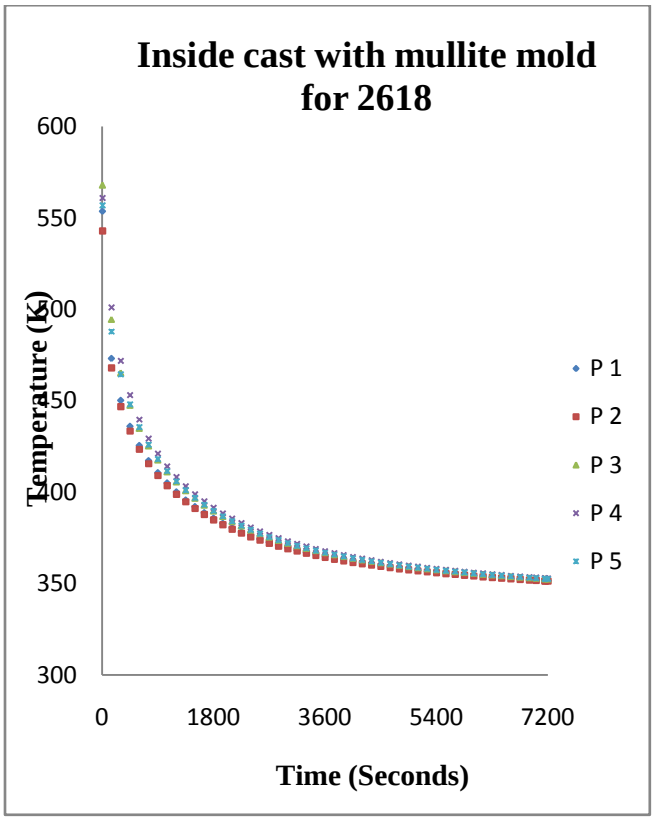
RESULTS AND DISCUSSION:

In this observation we took a fix timing for study of solidification behavior of sand and mullite mold for 7200 sec to get complete understanding of dispersal of temperature, thermal gradient, heat flux, cooling curvesfor casting as well as behavioral changes at the time of cooling and heating within mold for casting aluminum alloy.

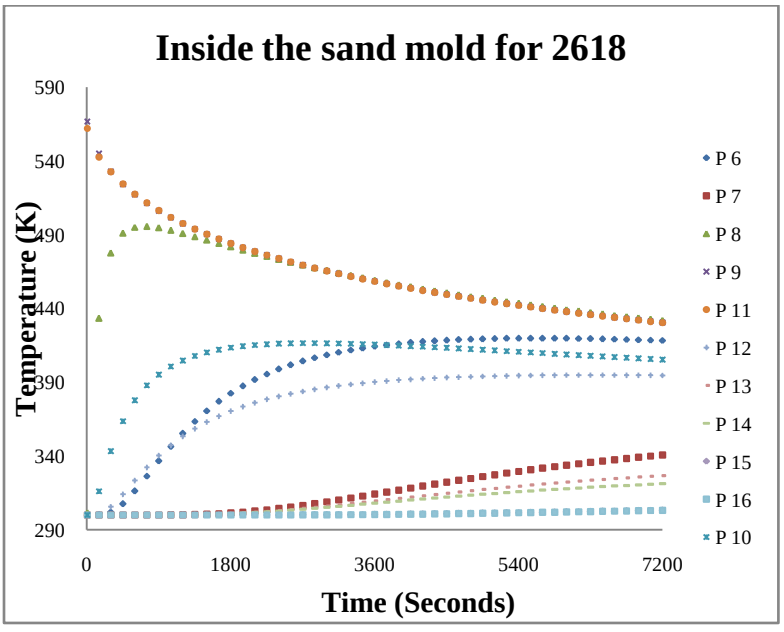
In this study theconvection process that taken place through themoldin environment was also include. Temperature variation in sand mold is between303K and 431K which is343K and 378K, for mullite, for the sand moldwide temperature variationoccure.thermal flow having highest value for the point where temperature dispersal is minimum, because this is the point wheresolidification begins.



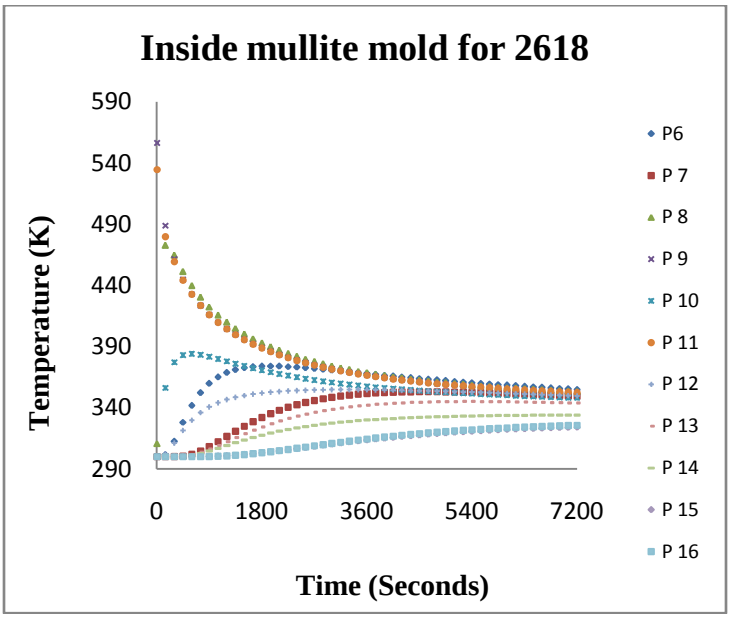
January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209



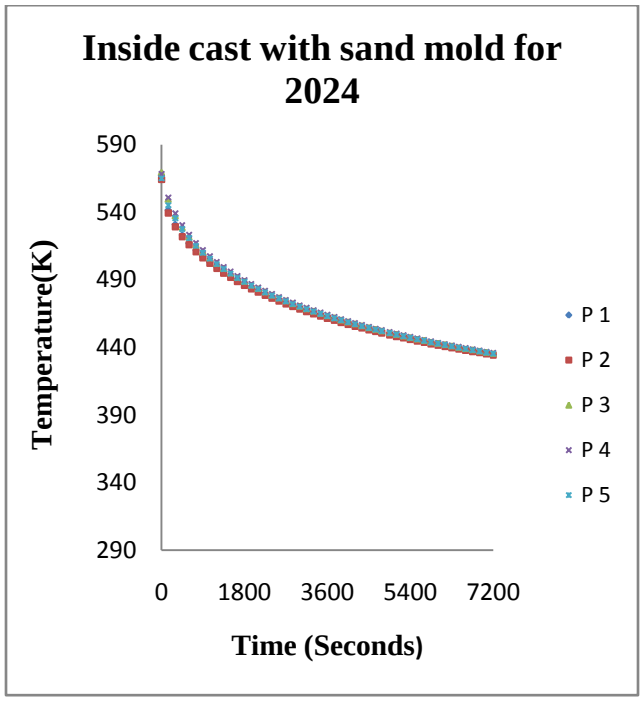
Uniformity of Slope of cooling curve for cast in sand mold shows thatsolidification taken place very slowly than to cast inside of the mullite mold.



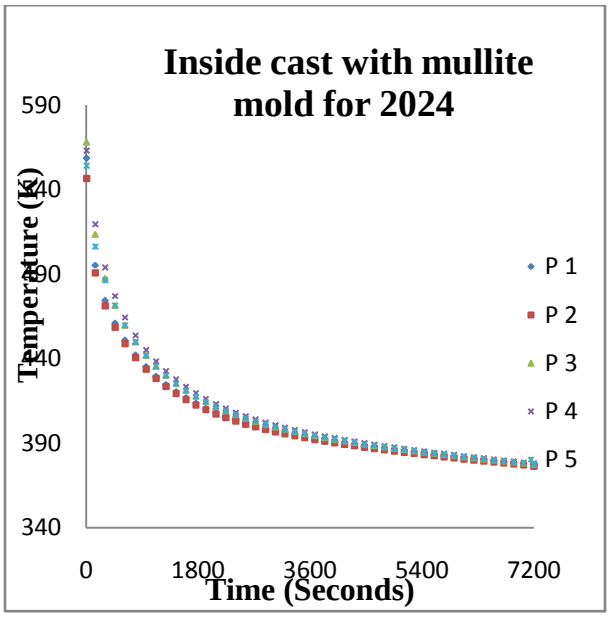
January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209



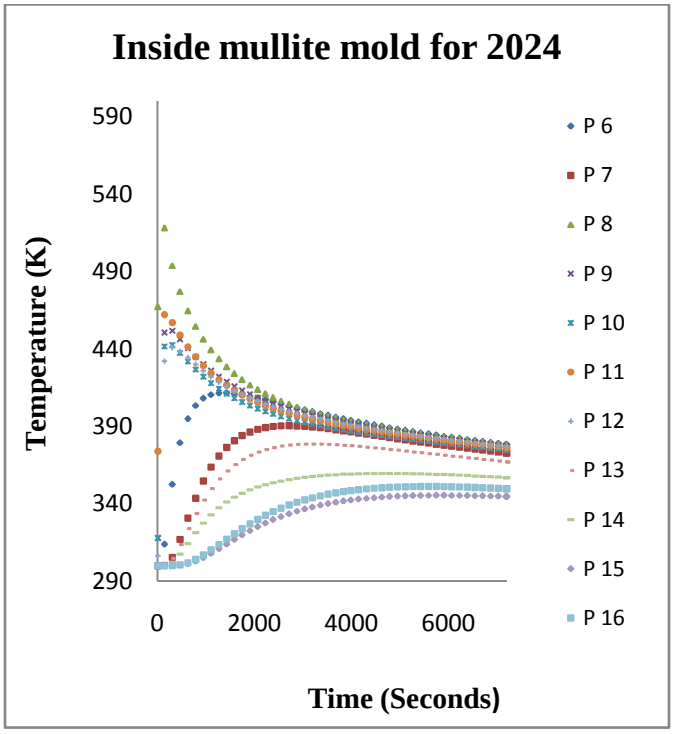
It observed in both systems, cooling curves convers but it is faster in case of the mullite mold.heating and cooling curves for mullite is more than sand this indicate addition heat transfer in mullite.



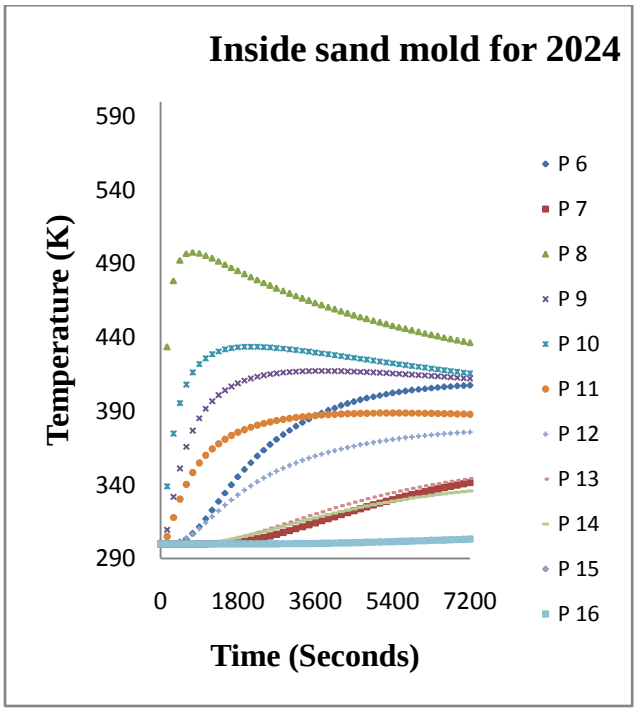
January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209



Steepness of cooling curve for cast in sand mold is uniform, showing slow solidification with respect to cast inside of the mullite mold.



January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209



Due to suddentemperature decrement and increment showsan emphasizeddrop, with compare tothe sand mold.In heating curves the mullite molding are presented with points P14, P15, and P16 reason behind it thatthe location of these points are at a considerable distance from the casting.And other side, cooling curve inside the mullite mold does not exist.

CONCLUSIONS AND FUTURE SCOPE:

solidificationof Aluminium alloys casting with use of numeric simulation done in this studyfor sand and mullitemoldfor a periods of 2hrs. variation for thermal gradient,heat transfer, as well as thermal flow,the temperatureat variousplaces observed. The outcomes wasdifferent very marginal in these systems.Because of different physical properties for different molds.

Sand system shows slower cooling ratewithinas compare to mullite system. Result of that thermal flow rate in sand system is higher it mean thermal gradient is also higher than in the mullite. It occur mostly in coldzone of casting ,at solidification starts.

It was conjointly find out that within the convergence method the mullite system required more number of iteration variety, most likely as a result it reached at the temperature below than that of sand systemthroughout an equivalent time of solidification within the cooling graph at many points of the sand system, showing phase change, which is failed to be happen within the mullite system, this development are often described by the very fact that within sand system cooling rate is slower as compare to mullite system. Presumably within the sand system the diffusion development prevails. the mechanical properties majorly depend on cooling behaviour because it decide the grain size on which properties dependent, hence attributable to the small grain size of metal formed in mullite system, this type of mold shows higher mechanical properties. Conjointly process of heating as well as

January - February 2020
ISSN: 0193 - 4120 Page No. 4201 - 4209

cooling observed in details, shown the rapid cooling as well as rapid heating takes place but in both sand and mullite system we get only converge curves

Future scope:

Observation of heat transfer in interfaces of casting with the consideration temperature dependent effect.Present this observation has it's limitation to ferrous sand casting.

REFERENCES:

1. Campbell, J., 1991, "Casting",Butterworth-Heinemann,Oxford.
2. Campbell J., "Casting practice the 10 rules of casting,"Elsevier Butterworth-Heinemann, Oxford, 1st edition,2004.
3. Pariona, M.M., Bolfarini, C. dos Santos, R.J. andKiminami, C.S., 2000, "Application of MathematicalSimulation and Factorial Design Method to theOptimization the Atomization Stage in the Forming of aCu- 6% Zn Alloy", Journal of Materials ProcessingTechnology, v.102, n.1, pp. 221-229.
4. Prabhu K.N., Chowdary B. and Venkatraman N., "Casting/Mold thermal contact transfer duringsolidification of Al-Cu-Si Alloy(LM 21) plates in thick and thin molds," Journal of Material Engineering andPerformance, Vol 14, No. 5, pp. 604-609, 2005.
5. K N Seetharamu, R Paragasam, Ghulam a Quadir, Z Azainal, B Sathya Prasad and T Sundararajan "Finiteelement modelling of solidification phenomena" Journalof Material Engineering and Performance, Vol. 26,pp.103–120, 2001.
6. Miguel Cervera, Carlos Agelet De Saracibar andMichele Chiumenti ''Thermo-mechanical analysis ofindustrial solidification processes", Int. J. Numer. Meth.Engng, 46, 1575-1591, 1999.
7. Sunanda Das, Dr. Rakesh L. Himte "Design &Analysisof Pure Iron Casting with Different Molds"International Journal of Modern Engineering Research(IJMER), Vol. 3, Issue. 5, Sep-Oct. 2013 pp-2875-2887.
8. Qiao Yin-hu, Zhang Chun-yan, Chen Jie-ping "CastingForming Process simulation of Aluminium Flywheel"TELKOMNIKA, Vol. 11, No. 4, April 2013, pp. 1930-1933.
9. T.R. Vijayaram, S. Sulaiman, A.M.S. Hamouda, M.H.Ahmad "Numerical simulation of casting solidificationin permanent metallic molds", Journal of MaterialsProcessing Technology 178 (2006) 29–33
10. A.A. Canales, J Talamantes-Silva, D Gloria, S. Valtierra,R. Colas "Thermal Analysis During Solidification ofcast Al-Si alloys", ThermochimiaActa 510 (2010) 82-87.
11. C.G. Kang, Y.I. Son, S.W. Youn, "Experimentalinvestigation of semi–solid casting and die design bythermal fluid-solidification analysis", Journal ofMaterial Processing Technology 113(2001) 251-256
12. Prashant R. Anerao, Yashwant S. Munde "Thermalanalysis of feeder neck using FEM for metal casting"International Journal of Emerging Technology andAdvanced Engineering ISSN 2250-2459, Volume 2,2012.
13. Sergey V.Shepel, Samuel Paolucci "Numericalsimulation of filling and solidification of permanentmold casting" Applied Thermal Engineering 22 (2002)229-248.
14. Campbell J., "The new metallurgy of cast metals:Casting," Elsevier Butterworth Heinemann, Oxford, 3rd edition, 2003.