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Influence of Reinforcement WT. % on Time Temperature Curve and Hot Spot Location

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Abstract: In the present work effect of the reinforcement on the time-temperature curve and hot spot location has been studied. Aluminium and SiCas molten metal material and reinforcement material have been considered in the present work while green sand a mould cavity material is considered. Reinforcement wt. % is varied from 0 to 15%. Thermal properties of aluminium are considered to be temperature dependent and green sand properties are considered to be temperature independent. Effective properties of the composite made from pure aluminium and SiC are calculated from physical mixture rule. Convective type of boundary condition has been considered on the walls of the mould cavity as they represent the actual physical scenario of the problem. Time-temperature curve has been plotted inside the casting part as well as inside the mould cavity.Temperature distribution is also plotted for different time intervals inside the casting assembly. From the results it has been found that hot spot occurs in case of pure aluminium (Al = 100%, SiC =0%), while its size gets lower with addition of the reinforcement in the base materials (Al = 95%, SiC =5%). Result also reveal that increment in reinforcement wt. % from 5 to 10 vanish the hot spot region from the casting.

I. INTRODUCTION

Casting quality depends on the hot-spot occurrence. Present paper focus on identifying the hot spot region inside the casting. When the molten metal is poured in the cavity it loses it heat and gets solidified. The rate of losing heat is controlled by the number of resistances to heat flow as shown in figure 1.

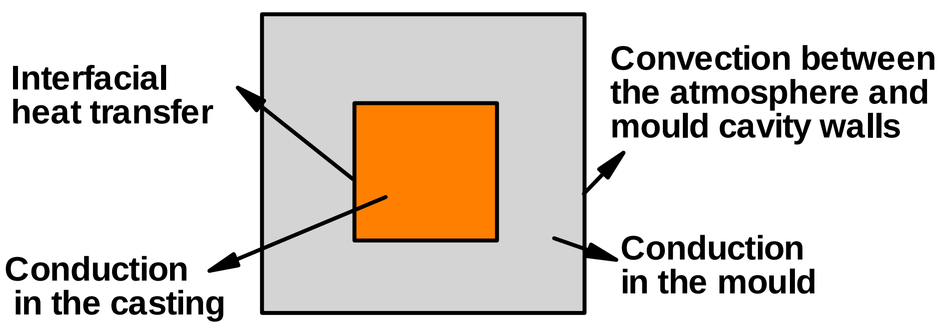

Figure 1 Heat transfer schematics in casting

II. LITERATURE REVIEW

Riyaz and Raikar in year 2015 conducted the study on improving the yield of cast part using computer aided simulation. They directed their study towards finding the optimum feeding and gating designed system to remove the internal defects, improve the casting quality and yield. They targeted their study towards eliminating the hot spot. Nimbulkar and Dalu in year 2015 conducted the study on minimising the gas porosity using casting simulation for sand casting. They directed their study towards eliminating the defects like hot spot and blow hole. Magdum and Jadhav in year 2015 conducted the design and development of casting process using simulation in foundry for improving the yield. Khade and Sawant in year 2014 conducted CAD modelling and casting simulation for riser design optimization based on the feeding rules. They analysed casting of break disc and targeted their study towards lowering the casting yield. They modelled the three dimensional geometry using a modelling tool and analysed the model using e-foundry simulation technique.

Jayakumar et al in year 2014 conducted the design and analysis of gating system for pump casting process. They utilized CATIA V5 and Pro-E for modelling of the geometry then imported the geometry drawn to the WINCAST software for analysis purpose. They used pressurized gating system, trapezoidal type of runner, circular cross section sprue and parting line gating system. Jadhao and

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Salunke in year 2014 reviewed the simulation based casting work conducted in the literature. They concluded that casting simulation is necessary because of the quality improvements, yield improvement and rapid development. Bhatt et al in year 2014 conducted the design optimization of feeding system for cast iron solidification process.

Ambekar and Jaju in year 2014 conducted the review study on optimization of gating system for reducing the defects. They studied different optimization approaches like Multi-Objective Evolutionary Algorithm (MOEA), Theory of Inventive Problem Solving (TRIZ) and Design of Experiments (DOE).Majunath et al in year 2012 conducted the design optimization of front axle housing gating system using fluid flow and solidification simulation. They used ADSTEFAN casting simulation software. They found that defect free casting can be obtained by changing the gating ratio, location of riser and sprue. ADSTEFAN software used by them uses the finite difference method technique. To model the front axle with essential elements they utilized CATIA V5 software.Choudhari et al in 2013 conducted the study on design and analysis of riser for sand casting. They targeted their study towards finding the temperature history and heat flow inside the casting as well as in the mould cavity. They found that there are different methods of riser design Caine's method and modulus method etc.

III. METHODOLOGY

A. *Casting assembly modelled*

Figure 2 represent the model geometry drawn in ANSYS. Time-temperature history and heat transfer inside the casting and mould cavity at each and every node has been studied. Outer portion represents the mould cavity part and inside portion represents the casting part.

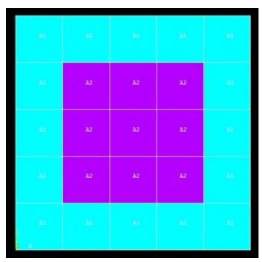

Figure 2 Model of the casting assembly

During solidification process, temperature changes occurs in the form of energy change, this can be represented in the form of conduction equation. Conduction equation is a partial differential equation, involves spatial directions, time and temperature.

$$k\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}\right) = \frac{\partial h}{\partial t}$$

B. *Boundary conditions*

Convective boundary conditions at the walls of the cavity can be represented as

At x = 0 $q = k\frac{\partial T}{\partial x} = h_f(T - T_\infty)$At x = L $q = k\frac{\partial T}{\partial x} = -h_f(T - T_\infty)$

At y = 0 $q = k\frac{\partial T}{\partial y} = h_f(T - T_\infty)$At y = H $q = k\frac{\partial T}{\partial y} = -h_f(T - T_\infty)$

At z = 0 $q = k\frac{\partial T}{\partial z} = h_f(T - T_\infty)$At z = W $q = k\frac{\partial T}{\partial z} = -h_f(T - T_\infty)$

Where, q is quantity of heat transfer in (W), kis thermal conductivity of material (W/m-K), $h_f$isconvection heat transfer coefficient, T is reference temperature and T_∞ = temperature of the environment.

C. *Reinforcement equations*

$$\rho_{eff} = \rho_b(1-\phi) + \rho_r\phi$$

$$C_{P_{eff}} = \frac{\rho_b C_{P_b}(1-\phi) + \rho_r C_{P_r}\phi}{\rho_b(1-\phi) + \rho_r\phi}$$

$$k_{eff} = k_b(1-\phi) + k_r\phi$$

Above equations represents the reinforcement equations. Subscripts b and r represents the base material (aluminium) and reinforcement material (SiC). The above equationsare known as physical mixture rule.Notation ρ, C_P and k represent the density, specific heat and thermal conductivity respectively. Φ represents the wt. % of the reinforcement added to the base material.

D. Materials

In the present work aluminium as a molten metal material and green sand as mould cavity material are considered. Conductivity and enthalpy of the molten metal are considered to be temperature dependent while mould cavity material (green sand) properties are independent of temperature. SiC as a reinforcement material has been considered whose wt. % has been varied from 0 to 15% as shown in table 1. Table 1 below shows the property of the material considered.

Table1 Thermal properties of aluminium and reinforcement

Properties	Al	SiC	Al - 5 % SiC	Al - 10% SiC	Al - 15% SiC
Specific heat (J/kg-K)	896.3	1300	916.2	936.4	956.6
Density (Kg/m^3)	2690	3200	2725	2750	2775
Thermal conductivity (W/m-K)	237	100	230.15	223.3	216.45

Aluminium thermophysical properties are temperature dependent in the form of enthalpy and thermal conductivity variations with temperature. Figure 3 represents the enthalpy and thermal conductivity variation with temperature respectively.

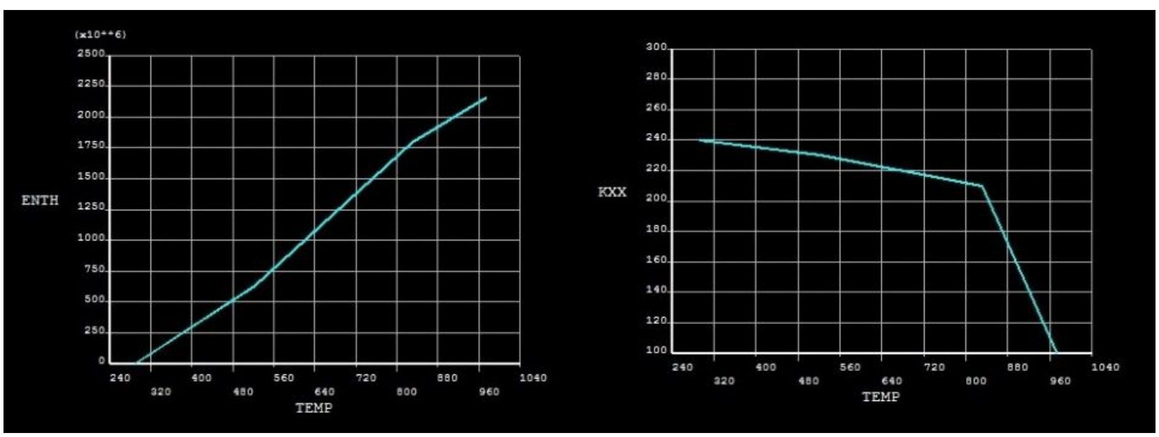

Fig. 3 Variation of enthalpy and thermal conductivity with temperature

III. RESULTS AND DISCUSSION

Figure 4, 5, 6 and 7 show the temperature distribution inside the casting for different values of reinforcement. Wt. % of the reinforcement has been varied from 0 to 15 %.Simulation has been run for the duration of 1 hour (3600 seconds) and results have been represented for three time steps. From the results it can be noticed that hot spot occurs in case of pure aluminium (Al = 100%, SiC =0%) and in case of (Al = 95%, SiC =5%). Hot spot is occurring at the centre of the casting, this is due to the fact that centre region is furthest from the walls and takes maximum time to get cool down. With increment in the wt. % of the reinforcement hot spot is getting vanished which one can observe from figures 4, 5 and 6.

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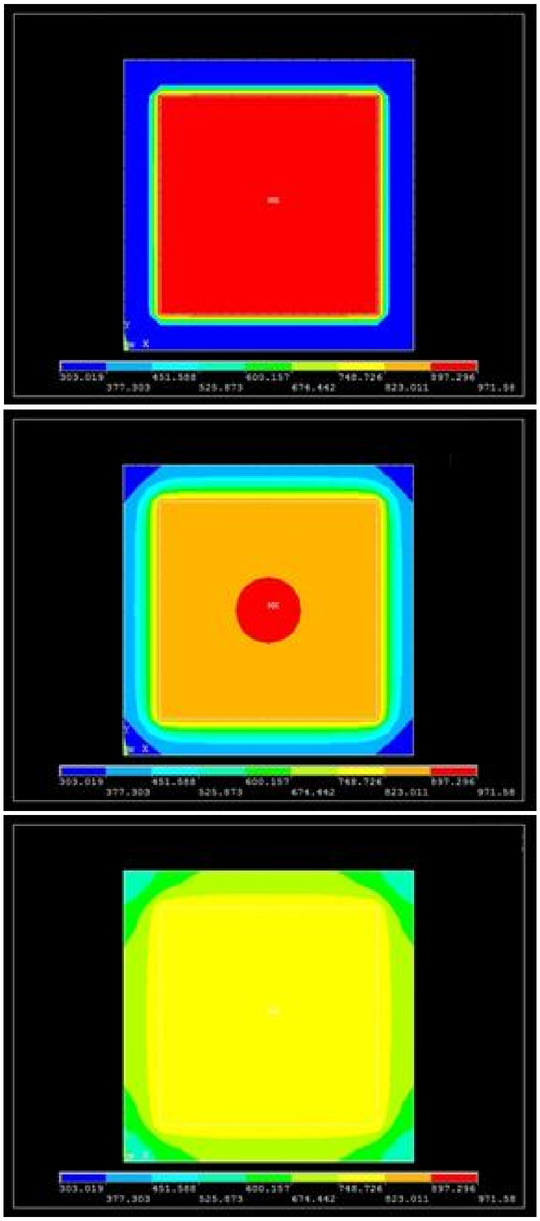


Figure 4 Temperature distributions inside the casting part for (Al = 100%, SiC =0%)

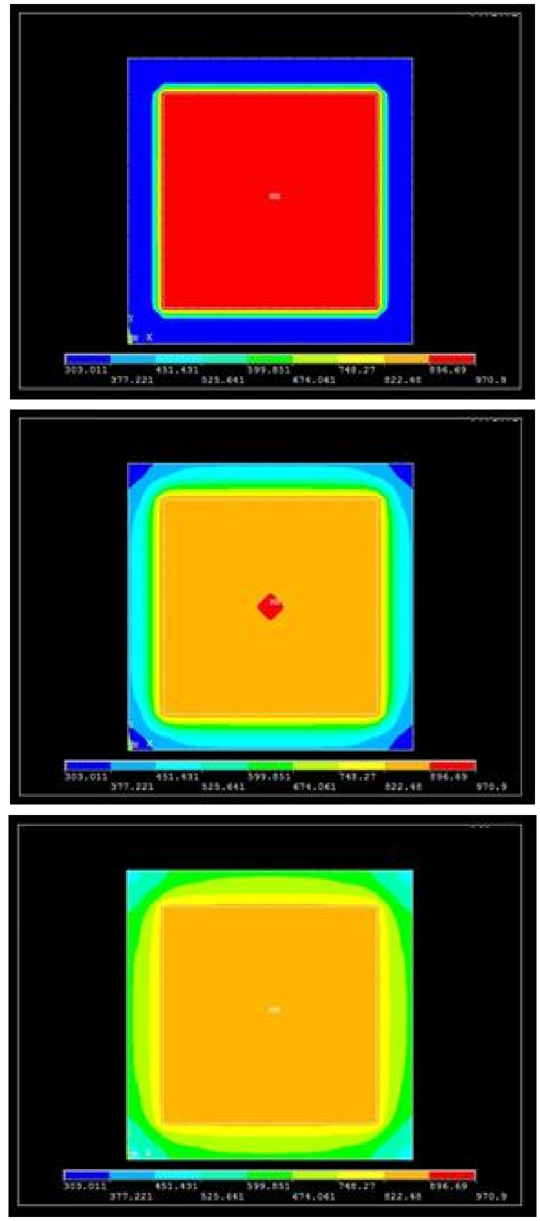
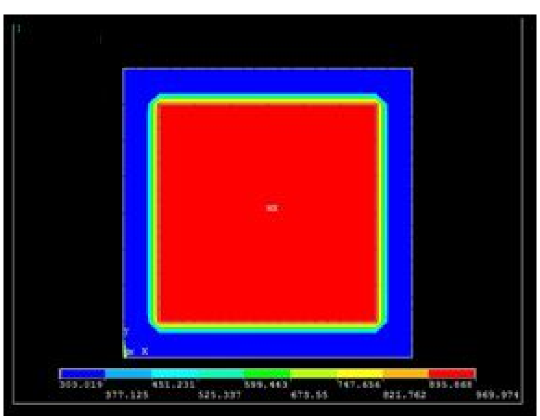
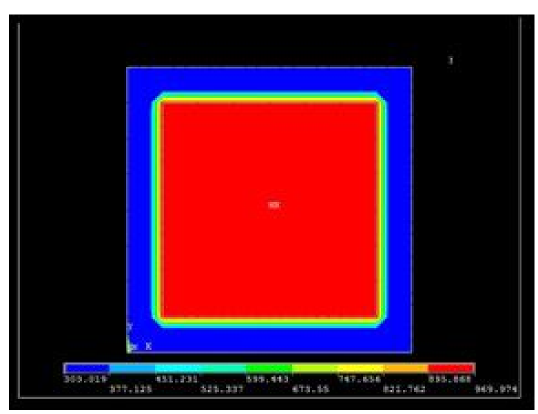


Figure 5 Temperature distributions inside the casting part for (Al = 95%, SiC =5%)





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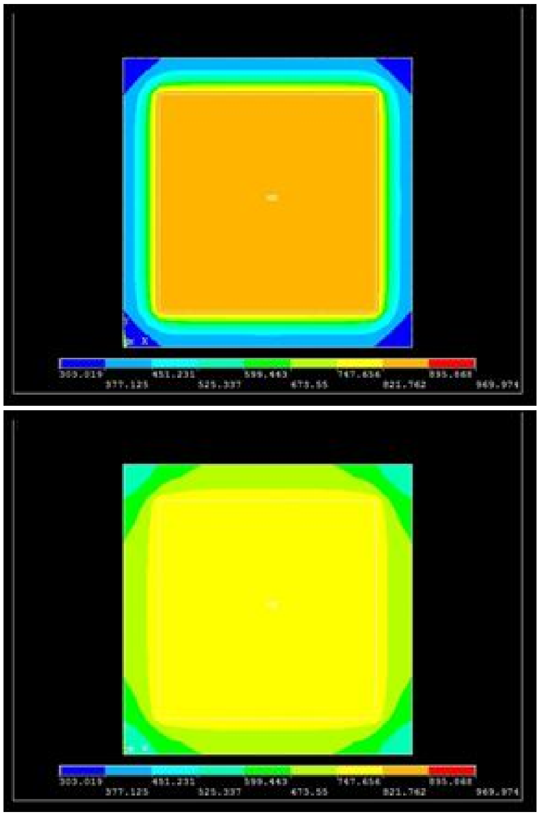

Figure 6 Temperature distributions inside the casting part for (Al = 100%, SiC =0%)

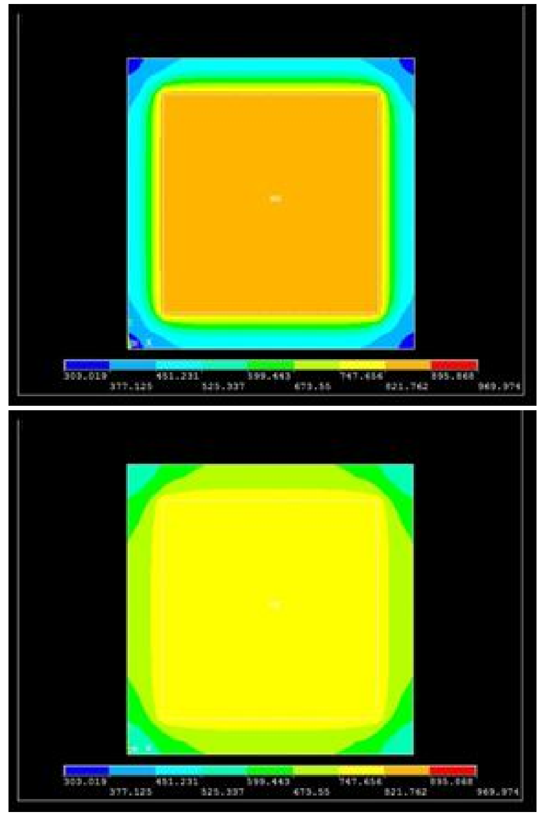

Figure 7 Temperature distributions inside the casting part for (Al = 95%, SiC =5%)

Figure 8, 9, 10 and 11 represents the time-temperature curve inside the casting for four wt. % of SiC reinforcement. From the figures it can be observed that the temperature is decreasing continuously for all the cases considered. During solidification process interaction between the casting-mould cavity and mould cavity-atmosphere occurs and heat gets release from the walls of the mould cavity to the atmosphere which reduces the temperature of the casting. Different lines represent the time-temperature curve for different location inside the casting. It can be observed from the figure that for pure aluminium case (Al = 100%, SiC =0%) all the lines follow the same variation and there is much deviation, while with increment in the wt. % of the SiC reinforcement one can observe the gap between the different lines.

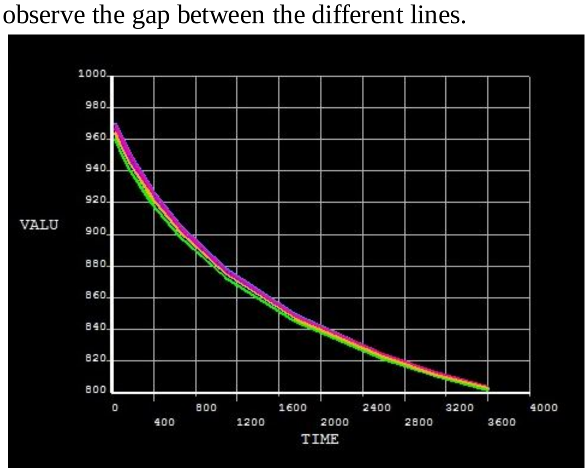

Figure 8 time-temperature curve inside the casting (Al = 100%, SiC =0%)

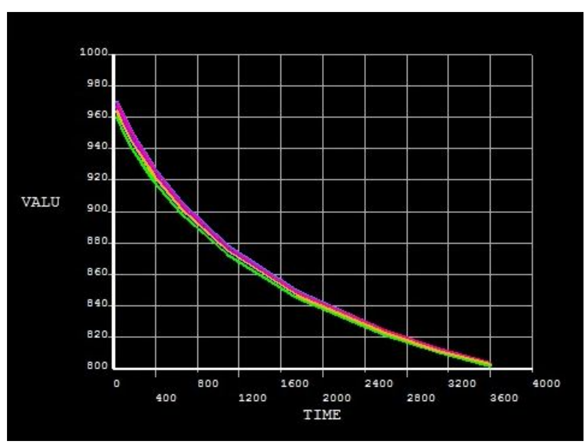

Figure 9 time-temperature curve inside the casting (Al = 95%, SiC =5%)

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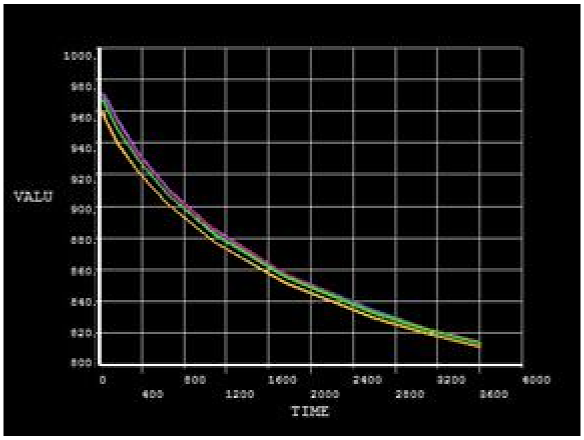


Figure 10 time-temperature curve inside the casting (Al = 90%, SiC =10%)

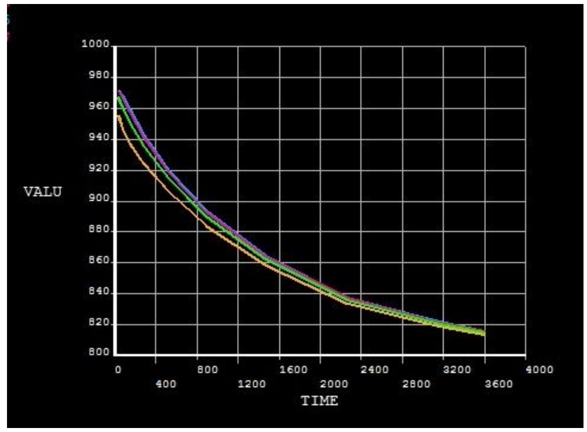


Figure 11 time-temperature curve inside the casting (Al = 85%, SiC =15%)

Figure 12, 13, 14 and 15 represents the time-temperature curve inside the mould cavity for four wt. % of SiC reinforcement. From the figures it can be observed that the temperature is increasing continuously for all the cases considered. From the figures one can notice that with increment in the wt. % of the reinforcement maximum temperature obtained by mould cavity at the end of the solidification process is increasing. This is due to the fact that addition of the reinforcement increases the heat transfer rate.

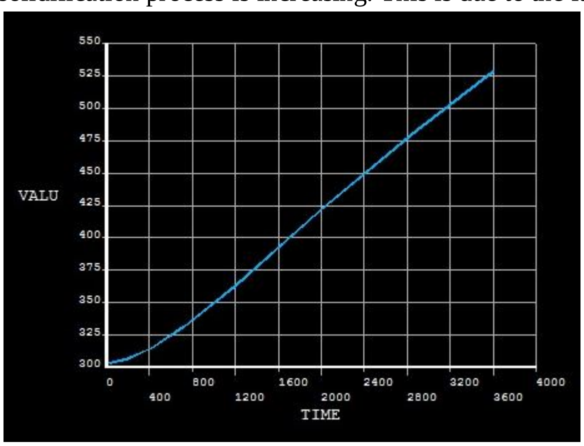


Figure 12 time-temperature curve inside mould cavity(Al = 100%, SiC =0%)

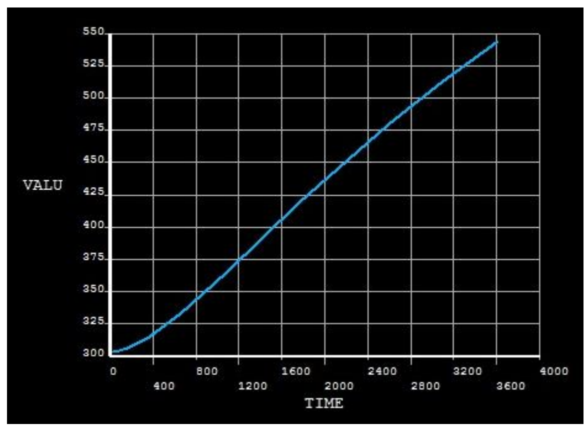


Figure 13 time-temperature curve inside mould cavity (Al = 95%, SiC =5%)

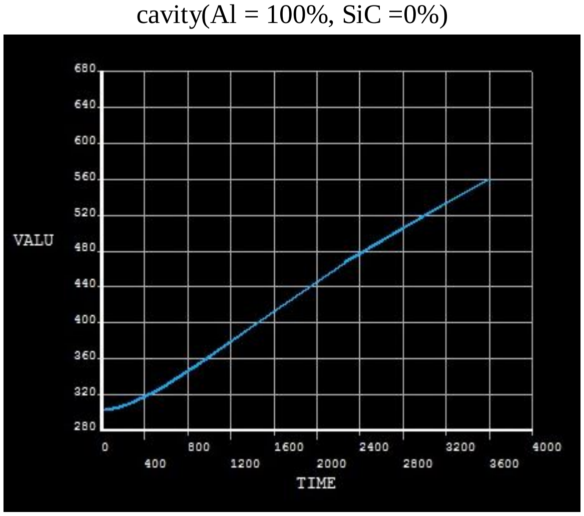


Figure 14 time-temperature curve inside mould cavity (Al = 90%, SiC =10%)

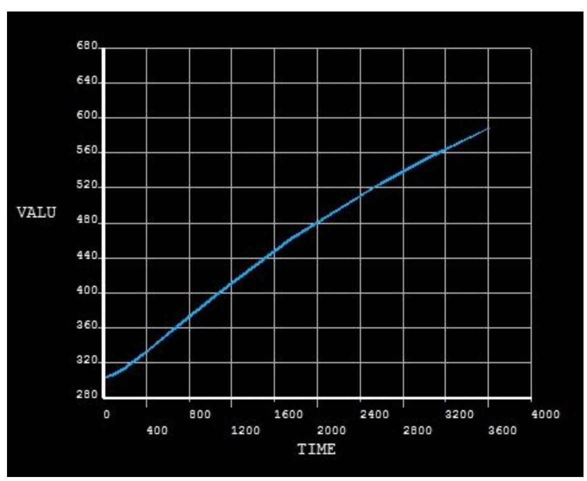


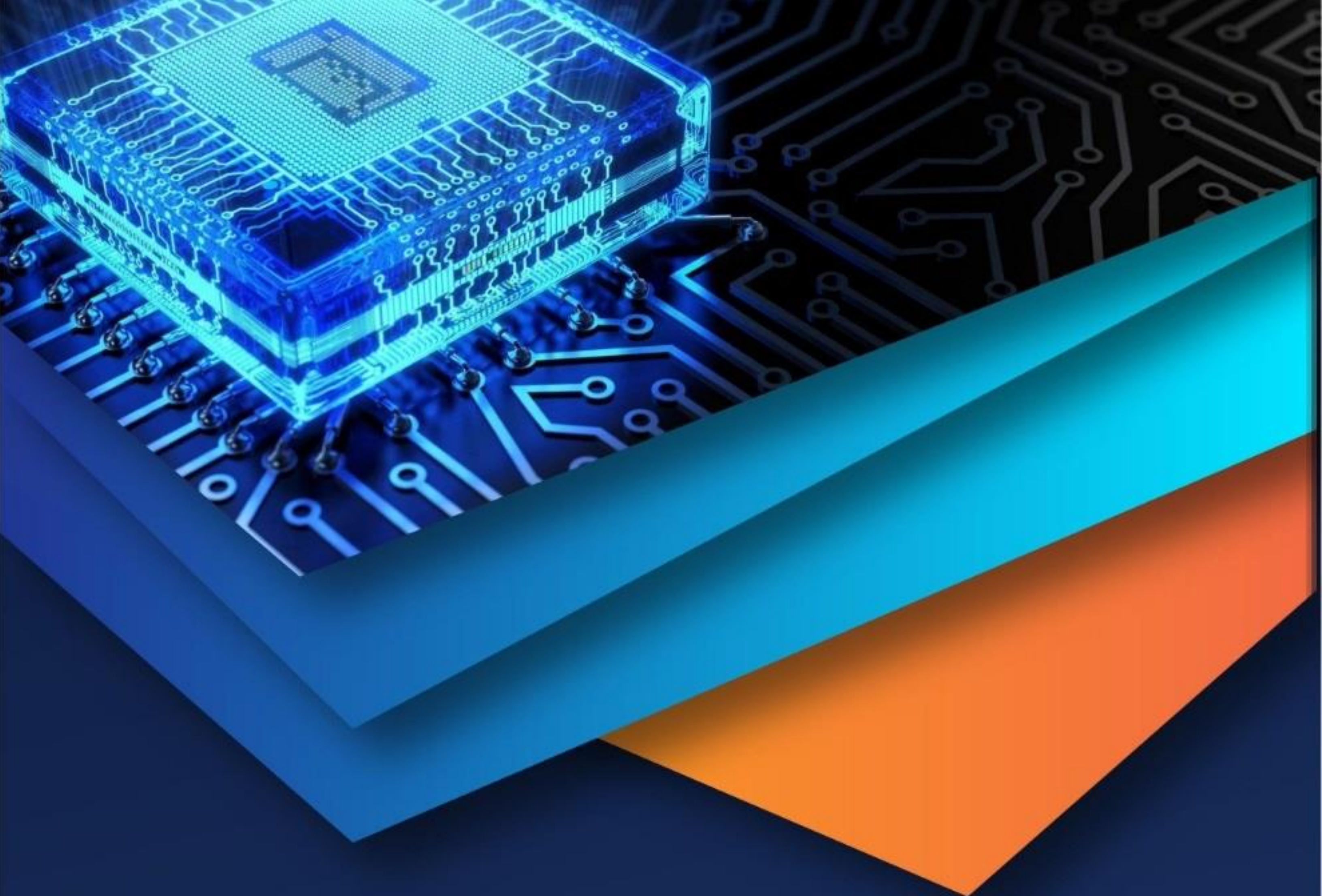
Figure 15 time-temperature curve inside mould cavity (Al = 85%, SiC =15%)

IV. CONCLUSION

A. Simulation helps in getting accurate results before going to actual production.
B. Simulation helps in saving the time, material cost, labour cost and material quantity.
C. Hot spot has been identified at the center region of casting for pure aluminium case (Al = 100%, SiC =0%).
D. Increment in the wt. % of the reinforcement helps in removing the hot spot region from the casting.
E. Not hot spot has been observed for 10 and 15% reinforcement wt %.
F. Addition of the reinforcement augments the heat transfer process.
G. Increment in the reinforcement wt. % increases the time temperature cooling rate.

REFERENCES

[1] Riyaz M. S. H. and Raikar P. U., 2015, Yield Improvement of Cast Part Using Computer Aided Casting Simulation, International Research Journal of Engineering and Technology, Vol. 2, Issue 4, pp. 858-862.
[2] Nimbulkar S. L. and Dalu R. S., 2015, Minimization of Gas Porosity through Casting Simulation Tool for Sand Casting, International Journal for Scientific Research & Development, Vol. 2, Issue 11, pp. 553-557.
[3] Magdum S. S. and Jadhav B. R., 2015, Design and Development of Casting by Simulation Technique for Yield Improvement in Foundry Industry, International Journal for Research in Applied Science & Engineering Technology, Vol. 3, Issue 6, pp. 98-105.
[4] Khade U. and Sawant S., 2014, Riser Design Optimization based on Feeding Rules using 3D CAD Modeling and Casting Simulation, International Journal of Mechanical And Production Engineering, Vol. 2, Issue 5, pp. 63-68.
[5] Jayakumar N., Mohanamurugan S. and Rajavel R., 2014, Design and Analysis of Gating System for Pump Casing, International Journal of Engineering and Technology, Vol. 6, Issue 5, pp. 2421-2425.
[6] Jadhao V. S. and Salunke J. J., 2014, Review Paper on Simulation Based Casting, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 11, pp. 17370-17374.
[7] Bhatt H., Barot R., Bhatt K., Beravala H. and Shah J., 2014, Design Optimization of Feeding System and Solidification Simulation for Cast Iron, Procedia Technology, Vol. 14, pp. 357-364.
[8] Ambekar S. A. and Jaju S. B., 2014, A Review on Optimization of Gating System for Reducing Defect, International Journal of Engineering Research and General Science, Vol. 2, Issue 1, pp. 93-98.
[9] Choudhari C. M., Narkhede B. E. and Mahajan S. K., 2013, Optimum Design and Analysis of Riser for Sand Casting, Proceedings of the IEEE IEEM, pp. 1151-1155.
[10] Manjunath S. H. M., Natraj J. R. and Prasad C. S., 2012, Design Optimization of Gating System by Fluid Flow and Solidification Simulation for Front Axle Housing, International Journal of Engineering Research and Development, Vol. 4, Issue 6, pp. 83-88.



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