

ANSYS SIMULATION OF TEMPERATURE DISTRIBUTION IN PLATE CASTING

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Abstract: Molten metal solidification is a complex phenomenon. During casting process many processes occur, flow of molten metal, heat transfer casting part to mould cavity then mould cavity to atmosphere. Heat transfer between the casting part, mould cavity and atmosphere plays vital role in the quality of final casting part. Thermophysical properties of the molten metal and mould cavity affect the casting part quality, in the present study molten metal (Aluminium) thermophysical properties (thermal conductivity, enthalpy) has been considered to be temperature dependent while mould cavity material properties are constant. In the present study two-dimensional numerical simulation will be carried out utilizing ANSYS software of Aluminium casting in green sand mould. Convective boundary conditions have been considered at the mould cavity walls which represent the actual physical scenario of the casting process.

I. INTRODUCTION

Metal casting is of the earliest and versatile manufacturing process known to human being in which molten metal is poured into mould cavity and allowed to solidify. After solidification of molten metal the product is taken out from the mould cavity. Using casting process one can create products from few grams size to several hundred tons. Many complex shapes can be produced by casting like engine blocks while it can also be used to produce simple shapes like watch cases. Casting has been widely utilized in manufacturing due to many applications and advantages. Tools required for casting moulds are very simple and cheap and any intricate shape, either external or internal can be casted that would be otherwise challenging or uneconomical to make by other methods. Almost any metal or alloy which can be easily melted is castable.

II. NUMERICAL SIMULATION

Solidification procedure includes phase, for this situation, the enthalpy is the right parameter to portray this process, in light of the fact that, enthalpy included latent heat that speaks to the phase change. Heat conduction partial differential equation for the transient nonlinear state that portrays this process can be represented as

$$k \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} \right) = \frac{\partial h}{\partial t} \quad (1)$$

At the interface where molten metal will the mould cavity wall heat transfer by convection has been considered.

Boundary conditions

$$\begin{aligned} \text{At } x = 0 \quad q &= k \frac{\partial T}{\partial x} = h_f (T - T_\infty) & \text{At } x = L \quad q &= k \frac{\partial T}{\partial x} = -h_f (T - T_\infty) \\ \text{At } y = 0 \quad q &= k \frac{\partial T}{\partial y} = h_f (T - T_\infty) & \text{At } y = H \quad q &= k \frac{\partial T}{\partial y} = -h_f (T - T_\infty) \end{aligned}$$

Where q = quantity of heat transfer, k = Thermal conductivity of material

These properties may be temperature-dependent then eq.1 is transformed into a nonlinear transient equation. h_f is the coefficient of convective heat transfer on the mould's external surface, T is the temperature, and T_∞ is the temperature of the environment.

Geometric model

Figure 1 represents the geometry of the model in which the casting will be done. Temperature distribution will be studied of the aluminium with temperature dependent thermal properties. While green sand which has been considered for the mould cavity material is constant. A rectangular part of same length and height has been considered. The model will be divided into different number of parts which will help in finding the temperature distribution accurately.

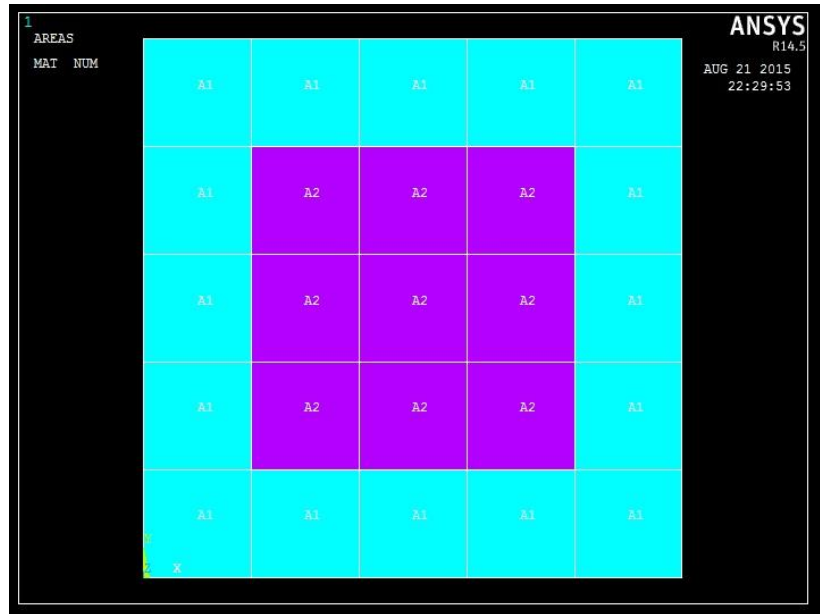


Fig. 1 Model of the casting part and mould cavity

Objective:

Objective of the present work will be to study the transient thermal analysis to obtain the temperature distribution during casting processutilizing ANSYS software. Solidification of pure Al with temperature dependent thermal properties thermal conductivity and enthalpy will be studied in the present work. Green industrial sand thermo-physical properties are constant, and convection phenomenon will be considered on the boundaries.

III. MODELLING AND SIMULATION

Figure 2 represents that the model has been divided into different number of parts to study the solidification process inside the mould cavity and casting part.



Fig. 2 Meshed and different areas of model

IV. RESULTS AND DISCUSSION

As molten material thermophysical properties are temperature dependent. Enthalpy variations with temperature represents the right physical scenario of casting process, if one want to see the effect of temperature dependent thermal properties on the casting process. Figure 3 represents the enthalpy and thermal conductivity variation with temperature respectively.

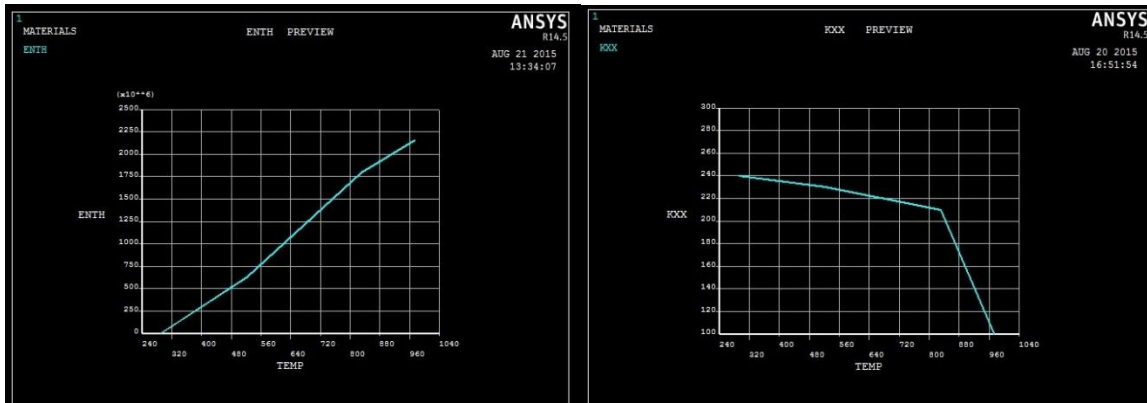


Fig. 3 Variation of enthalpy and thermal conductivity with temperature

Table 1 Thermophysical Properties of sand:

Properties	Green sand
Specific heat (KJ/Kg.K)	1172.3
Density (Kg/m ³)	1494.71
Thermal conductivity (W/m.K)	0.52

Table 2 Thermophysical Properties of molten metal:

Conductivity (k) for Aluminium (W/m-K)	
At 293 K	240
At 523 K	230
At 831 K	210
At 973 K	100
Enthalpy (h) for Aluminium (J/m ³)	
At 293 K	7.8886e-031
At 523 K	6.2967e+008
At 831 K	1.7961e+009
At 973 K	2.1527e+009

For transient thermal simulation initial temperature has been set as 973K because liquid aluminium has been poured at 973K temperature.

After setting the temperature boundary conditions transient simulation parameter has been set as follows ,

Table 3 Transient simulation setup

Total time of simulation	Time step	Maximum time step size	Minimum time step size
1 hour or 3600 seconds	36 seconds	900 seconds	3.6 seconds

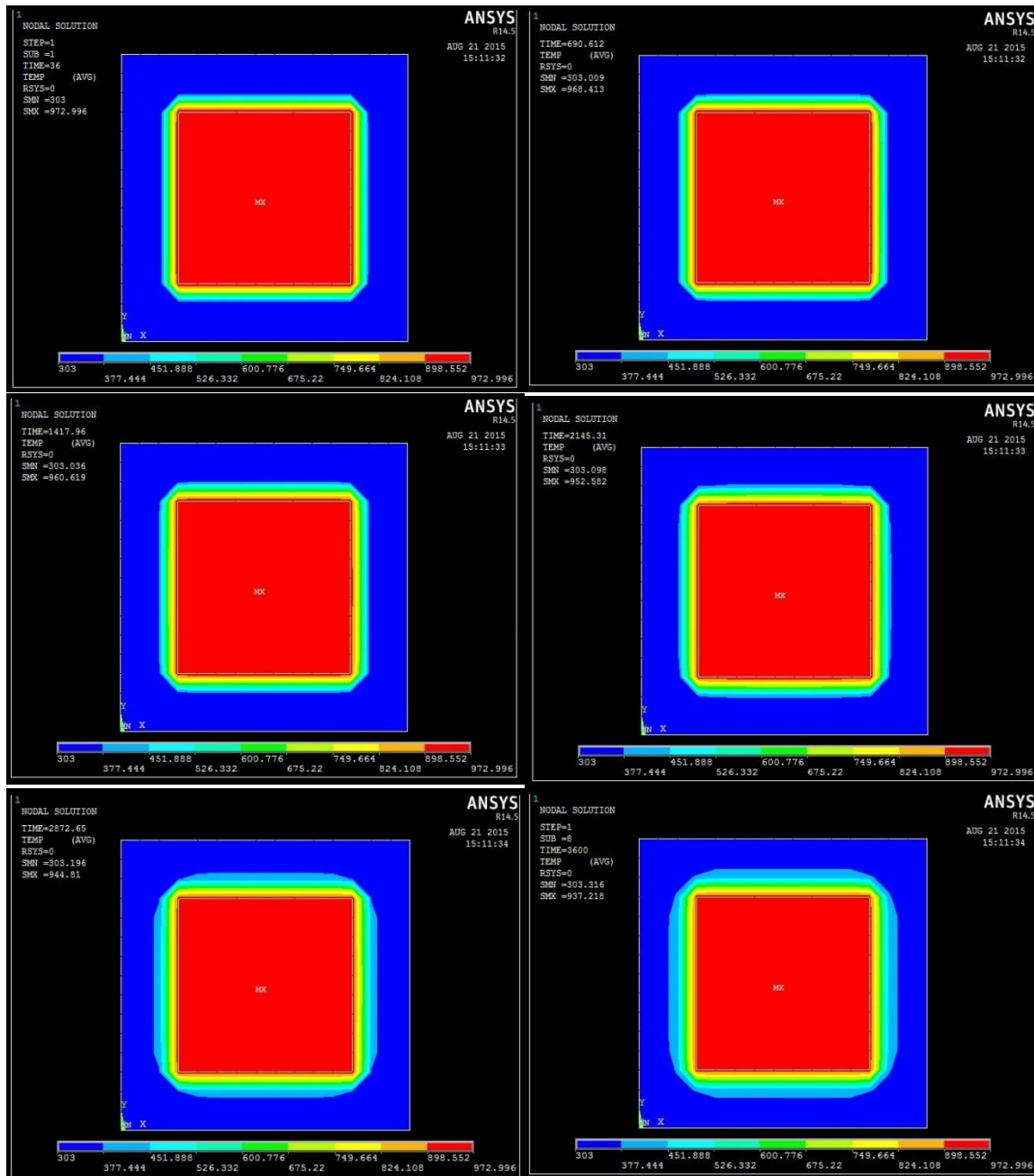


Fig. 4 Temperature distribution in the mould cavity and casting part

Figure 4 represents the contour plotting of temperature distribution in the whole casting assembly during process. One can easily notice that the temperature is highest in the casting part around 973K melting point temperature of the aluminium, while lowest temperature near the walls of the mould cavity around 303K

The HEATCRIT curve refers to the convergence criteria heat value. The graph of Absolute Convergence Norm v/s Cumulative Iteration Number for the simulation under consideration is shown in Fig. 5 (a). While Fig. 5 (b) represents the temperature at four different nodes in the casting part.

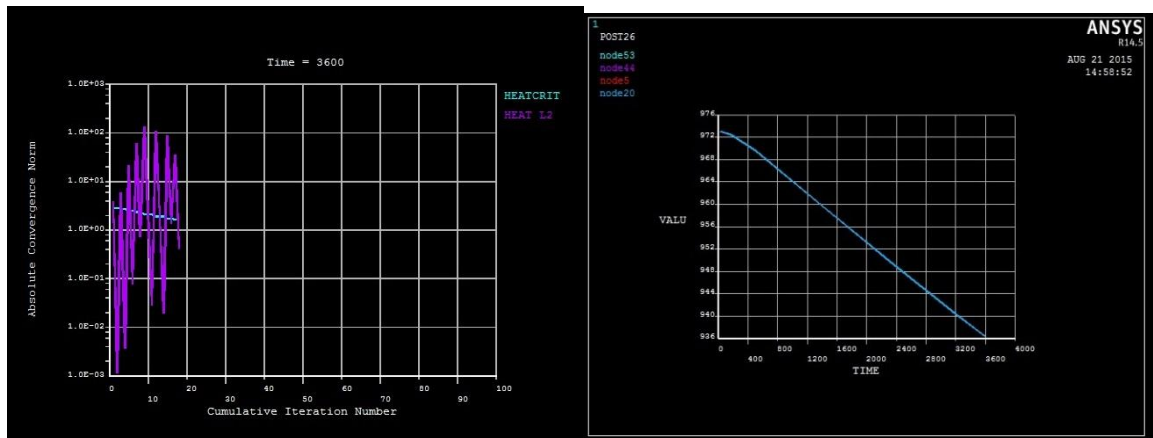


Fig. 5 (a) Convergence plot (b) Temperature at different points in the casting part

V. CONCLUSION

1. In the present work it has been shown that FEA software like ANSYS may play an important role in this regard
2. In this paper, casting simulation using ANSYS has been carried out to obtain the isotherms at various times.
3. These temperature variations are an important factor in improving the casting quality, reduced cost of development and speeding up the improvement of the product.

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