DESIGN AND ANALYSIS OF SCREW- SHAPED CASTING WITH SLEEVE USING ANSYS

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ABSTRACT:

Solidification of metals involves more complexity and has urged the scientists and engineers to simulate the process before actually carrying out the casting procedure. Finite element method is used to simulate the heat transfer process accompanying the solidification process. The metal and the mould along with the air gap formation is accounted in the heat transfer simulation. In this paper, solidification of Screw-Shaped casting is presented. Various parameters viz; thermal gradient, solidification time and temperature distribution are studied using ANSYS.

Keywords

Design, analysis, riser, sleeve, sand casting

1. Introduction

The metal casting industry plays a key role in all the major sectors of our economy. Castings are used mainly in locomotives, cars, trucks and aircraft, Industries. Metal casting is one of the oldest manufacturing methods. In metal casting, metal is melted and poured into a cavity and after solidification of the metal in the cavity, the metal takes the exact shape of the cavity. The solidified object is then taken out from the cavity either by breaking the cavity or taking the cavity apart. The solidified object is called the casting. Depending upon the shape complexity and the metal, the size of the mould may differ with the size of the product requirement. Using sleeve as a feed aid helped in reducing riser dimensions form 60 mm to 50mm and thereby increasing the casting yield [1,2].

Solidification of molten metal after being poured into a mould cavity is an important phenomenon in casting and is of great interest to physicists, metallurgist, casting engineers and software developers. Even though casting is made by taking care of all the parameters, some defects may be formed in castings like hotspots inside the casting. The main aim of the work is to design a riser having higher value of modulus as compared to casting and simulate the process for Screw-shaped castings

2. Simulation of Castings

Casting simulations:

Design any casting process on the computer using ANSYS to check feasibility of process. The use of simulation is to enhance the quality, yield and reduce the number of attempts before doing casting.[4,5]

Simulation protocol as shown in Fig.1

Fig: 1. .*Simulation protocol*

Data gathering :

In this stage the data like types of materials used, part model, process parameters, method design, existing parameters are gathered. This is the most important stage in which collection of incorrect or incomplete data leads to wrong conclusions.

Methods design:

The design of the Screw-Shaped pattern is done in the software with required dimensions and also modeling of feeders and gating system is developed.

Simulation:

In this stage the created T-Shaped pattern is meshed with optimal element size. The mesh must cover the entire model without gaps. The second set of inputs involves the boundary conditions like interfacial heat transfer coefficient and the simulation is done to see the final result.

Method optimization:

In this stage imp0rovements are made to design to eliminate defects and improve yield. For existing casting, the simulation results are first compared with observed defects to ascertain the cause of defects. Then the method design is modified.

Final result :

The result of the casting in the form of an animation can be seen in the software. Some of the defects can be measured accurately using software.

3. Problem Description:

An T-shaped sand casting solidification has been selected as a subject of study for transient heat transfer analysis. The objective is to track the temperature distribution in the steel casting and the mold provided with proper insulation during the solidification process, which occurs over duration of 4 hours. The casting is made in a rectangular-shaped sand mold with Screw-shaped pattern. Convection occurs between the sand mold and the ambient air.

In present study, 4 noded quadrilateral elements are chosen to form the mesh of the domain. A node is a point of intersection of two lines in a grid and is common to many elements. The Finite Element Analysis works on the same principle that it calculates the value of an entity in the element using all the values of all the nodes surrounding that particular element. Figure 2 shows the meshed domain of the T shaped casting.

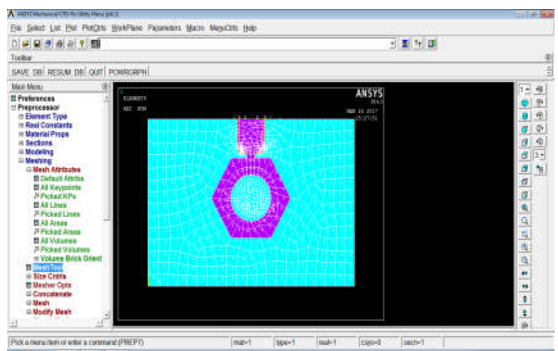

Figure 2. Mesh of the screw Shaped casting

4 Material Properties of Sand and Steel

ANSYS software requires material properties of the sand and steel. Table 1 represents the material properties of sand and Table 2. Represents the material properties of steel.[3]

Table 1. *Material Properties for Sand*

Material Properties for Sand	**Values (units)**
Conductivity (KXX)	0.025 Btu/(hr-in-°F)
Density (DENS)	0.054 lb/in^3
Specific heat (C)	0.28 Btu/(lb-°F)

Table 2: Material Properties of steel

Conductivity (KXX) for Steel	Values (units)
at 0°F	1.44 Btu/(hr-in-°F)
at 2643°F	1.54
at 2750°F	1.22
at 2875°F	1.22
Enthalpy (ENTH) for Steel	
at 0°F	0.0 Btu/in^3
at 2643°F	128.1
at 2750°F	163.8
at 2875°F	174.2
Initial Conditions	
Temperature of steel	2875 °F
Temperature of sand	80 °F
Convection Properties	
Film coefficient	0.014 Btu/(hr-in^2-°F)
Ambient temperature	80 °F
Material properties for insulator	
Conductivity(KXX)	0.0015 Btu/(hr-in-°F)
Specific heat(C)	0.20 Btu/(lb-°F)
Density(DENS)	0.28 in^3

5. Approach and Assumptions

A 2-D analysis of a one unit thick is taken into consideration. The mold material (sand) has constant material properties. The casting (steel) has temperature-dependent thermal conductivity and enthalpy; both are input in a table of values versus temperature. The enthalpy property table captures the latent heat capacity of the metal as it solidifies. Radiation effects are ignored.

Solution control is used to establish several nonlinear options, including automatic time stepping. Automatic time stepping determines the proper time step increments needed to converge the phase change nonlinearity. This means that smaller time step sizes will be used during the transition from molten metal to solid state.

6. RESULTS AND DISCUSSION

Temperature vs. time.

Since the temperature of molten steel is 2875 F initially, the time taken for molten steel to fill the cavity is shown in figure 3.

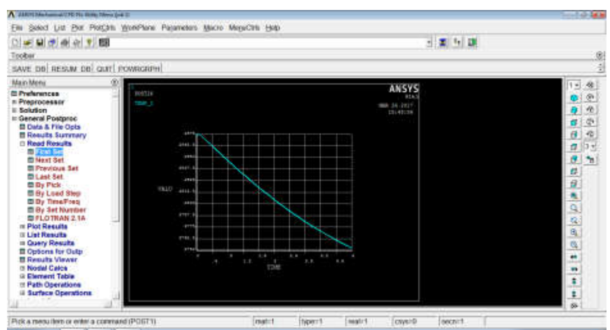

Figure 3. Shows the temperature distribution with time

The animation of these models yielded in the following results.

LOCATION OF HOT SPOT WITHOUT SLEEVE:

Hot spot defect was observed inside the castings “screw” with the riser of diameter 60mm without sleeve after animation using ANSYS. Therefore, in order to eliminate the hotspot defect inside the casting riser dimensions were altered and sleeve (insulation) was incorporated around the riser for both “Screw” shaped castings as shown in figure 4

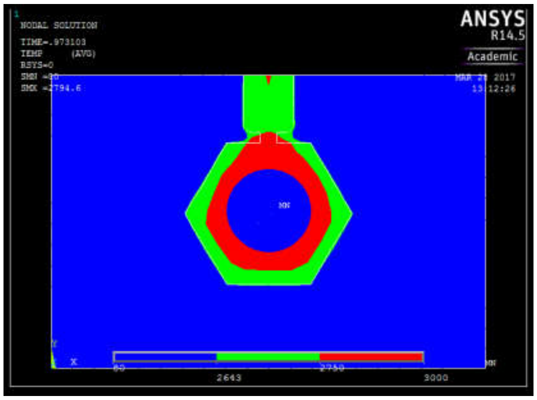

Figure 4. Location of hot spot without sleeve

LOCATION OF HOT SPOT WITH SLEEVE:

Hot spot was observed inside the riser thereby, eliminating the defect inside the castings "screw" with the riser of diameter 50mm with 5mm sleeve, after animation using ANSYS as shown in figure 5

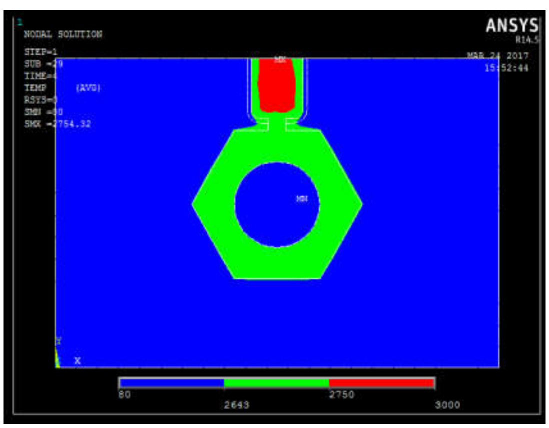

Figure 5. Location of hot spot without sleeve

7. CONCLUSION

Simulation of the solidification process helps in identification of the last freezing regions or hot spots. Optimum location of riser based on ANSYS software has helped in minimizing the solidification related defects, thereby, providing a defect free castings. Castings "screw" shaped with riser of diameter 50 mm along with sleeve of thickness 5mm has shown better result when compared with the riser of diameter 60mm without sleeve. Therefore, the riser dimensions based on simulation were optimized. Using sleeve as a feed aid helped in reducing riser dimensions from 60 mm to 50mm and thereby increasing the casting yield.

8. References

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