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THERMAL ANALYSIS ON FLOW OF MOLTEN METAL BY VARYING PORT ANGLES

D.LAKSHMI SRAVANTHI
Associcate Professor,
Department of Mechanical Engineering

K.L.KISHORE
Sr. Assistant Professor, Department of Mechanical Engineering,
Thermal Engineering, Aditya Engineering College

A.RAVINDRA
P.G Scholar, Department of Mechanical Engineering
Aditya Engineering College

ABSTRACT

The analysis of temperature distribution is considered in this paper by changing port angles in casting process. As the demand for casting always rise in high level this paper deals about the theoretical analysis by considering the die casting process and changing port angles using a submerged entry nozzle. So that this results in good casting products with less effects such as no wastage in casting product so that steel makers will be able to give a good quality casting products. The complete analysis is done by using ANSYS workbench. The purpose of using submerged entry nozzle is it can go deeper into the mould cavity compared to the regular nozzles. Heat flux, velocity magnitude rate and temperature distribution are discussed

Keywords:
Die casting, heat flux and temperature

Introduction

Casting process is oldest manufacturing process .This is used to produce components such as pistons, mill rolls wheels, cylinder blocks, liners, machine tool beds. Thedesignofthe mould cavity is very important in order to obtain the desired product since the obtained product is replica of the mould. Know the two-Dimensional flow is carried out by placing the submerged entry nozzle. If the flow is not proper in the mould it leads to several defects such as improper shape of the casting product and also other internal defects. Even though the flow is proper it can't be sure that good product can be obtained one more important parameter is cooling of the product if less amount or insufficient cooling is obtained means it also leads to lack of defects on its structure. So this is one of the best method in order to increase the effectiveness of the product and decrease the defects. Flow control, nozzle dimension its depth, casting speed and some more parameters were their which influence the particular product which reduces the effects. The main role among these is the fluid flow which results in better steel product. In order to get a better product first here we are designing a copper mould and here our molten metal is steel that means our casting products were steel material. Know we were introducing a submerged entry nozzle which is capable of going deep into the mould so that the molten metal flows deeper into the cavity and it discharges directly into particular position so that it results in less turbulence effects. This requirements can be fulfilled by designing the submerged entry nozzle.

Literature Review:

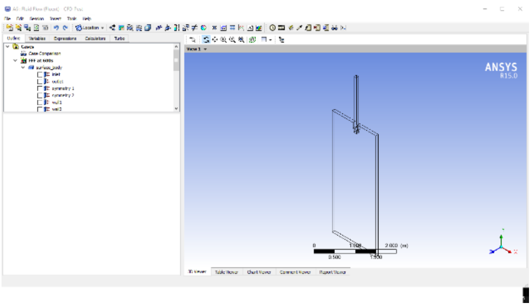
The fluid flow behaviour during continuous casting has important implications with regard to both the qualities of the final product, the case of operation and productivity of the process. In general, prior to the wide spread adoption of the continuous casting process, only two parameters were considered necessary to characterize the condition of the steel during steel making and casting process. These two parameters were temperature and composition. However, recent innovations in post-furnace steel making practice such as ladle treatments and particularly continuous casting procedures have third parameter to be added to the previous two in order to characterize the steel completely at any position in the processing sequence. This parameter is fluid flow. The condition of fluid flow exerts a significant influence on:

1. The ability to remove inclusions from metal to slag.
2. The degree of re-oxidation which occurs by atmospheric contact during pouring conditions.

Flow velocity can be characterized according to the velocity, flow pattern and turbulence intensity. None of these parameters are readily apparent by simple visual observation of steel making or casting operation.

Brian G. Thomas in his recent investigation stated various defects that can be formed in a flow phenomena. Various meniscus defects may rise if the super contained in the steel is very low. Various modelling effects has to be carried out in order to avoid these defects that means it needs in better design of the nozzle .so here we will be designing the nozzle with various upward and downward angles and the flow is carried out and by using various angles we can get improvement in various thermal factors such as heat flux, temperature, velocity vectors and some which were discussed over here. Chaudhary, R work stated about the design of the nozzle and similar factors such as velocity with turbulent model. Cesar Real et al. performed objective of this study is to characterize the dynamical behaviour of the mould Submerged Entry Nozzle (SEN) based on computational models. The numerical results validation was performed by direct comparison with experimental data .Craig K. J et al. states the design parameters of the nozzle in order to obtain minimum effects.

Geometry of the file:



Geometry of the die with mould

In this paper at first a block is plotted and then a nozzle is kept and had been computed to required design in ansys workbench. Then names were given to walls and block and inlet and outlet and after completing the geometry then meshing is carried out.

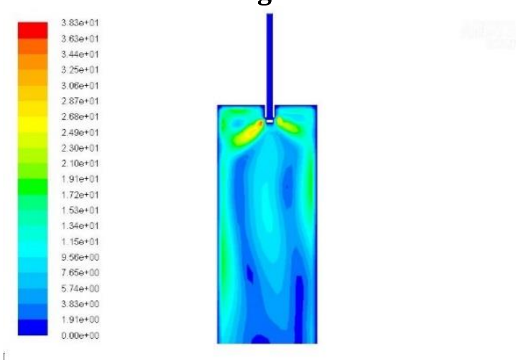
Analysis:

The design geometry was shortened to label the flow inside the mould cavity by varying position of nozzle and port angles in various cases. In the meshing model of fluent panel the imported geometry is finely meshed.After that the boundary conditions were specified by naming the boundary, wall, inlet for molten metal to enter into the cavity and outlet to deliver through the ports. The flow of the molten metal is considered to be turbulent and the study is made in transient state. The design model selected were energy k-ϵ(2-eqn). Velocity of the molten metal is considered for obtaining heat transfer analysis through those equations. The flow of the molten metal in the mould cavity and the analysis was analysed by Ansys Fluent.

Results and discussions

The following were obtained during the casting process and various thermal factors such as stream function , entropy etc. were found by giving the inlet and outlet values to the nozzle and indicating the names to walls

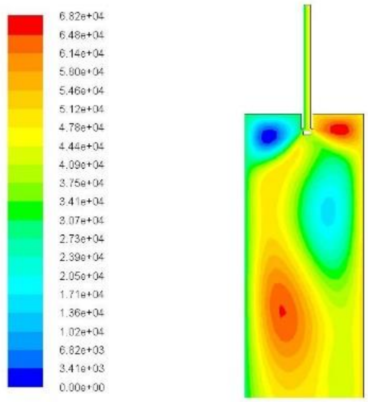
Fig: 1



Contours of velocity magnitude

The above represents the velocity magnitude in casting process in which solidification was going on by using steel as molten metal and copper as mould cavity.

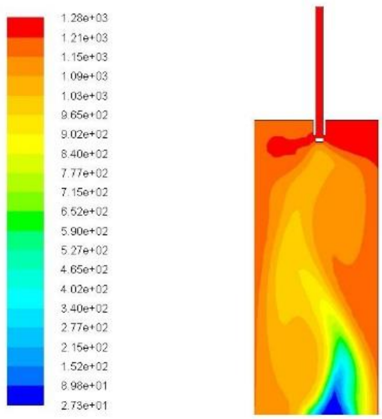
Fig: 2



Contours of stream function

The above represents the stream function for the given molten metal steel and for the molud cavity copper during the die casting process .

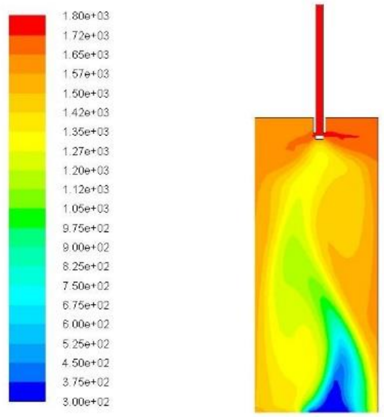
Fig: 3



Contours of enthalpy

The above represents the contours of entropy during the solidification process and by changing the port angle to 25^0 downward.

Fig: 4

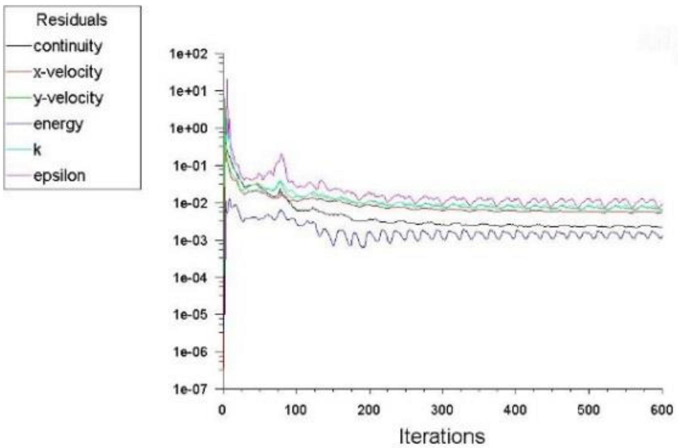


Contours of static temperature

The above one represents the temperature distribution in a die casting process coil in which the molten metal is steel and the mould cavity is copper and it represents the temperature of the metal under solidification.

Graph 1:

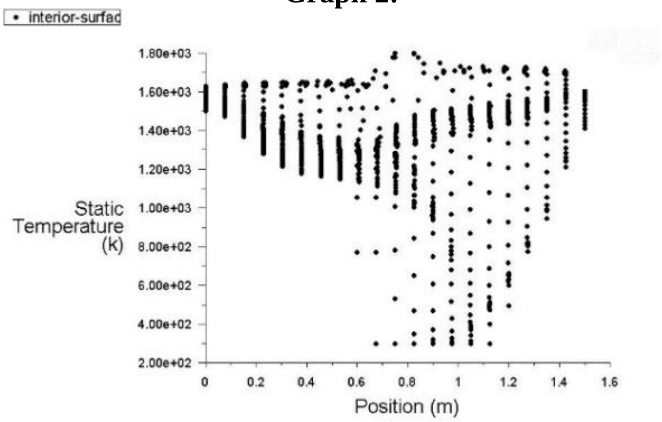
The above drawn graph represents the mass flow rate in interior surface body based on iterations which indicate the state of molten metal as per time intervals.



Scaled residuals

The above drawn graph represents the scaled residuals according to that particular iteration.

Graph 2:



Static temperature

The above drawn graph represents the static temperature distribution on the interior surface of the casting process with respect to positions.

CONCLUSION:

The following conclusions are drawn from the present investigations

- 25^0downward port angle gives high jet velocity and low frequency.
- 25^0downward port angle nozzle gives high surface velocity and high frequency.
- -15^0port angle nozzle gives the optimum condition. That is in this case results in high solidified layer along the narrow face wall and minimum wall shear stress.
- The effective discharge angle of the liquid jet issuing from the submerged entry nozzle (SEN) was found to be always greater than the normal port angles.
- The bulk steel flow from the port of the SEN where entering into the mould splits into two, giving to upper and lower recirculation zones in the mould.
- Flow over the narrow face wall is smooth and heat transfer rate is high for downward port angles.

Surface heat flux is maximum at impingement point and high this high value results in casting defects. The same procedure is carried by changing the depth of the nozzle.

Future Scope:

In present work only seven types of nozzles were taken for simulation. Further investigations can be carried out by considering the following parameters.

- Circular port nozzles can be used instead of rectangular nozzle.

- The further work can be carried out for different cross section of the mould that is for different mould width, thickness, and length of the mould.
- Jet discharge angles and flow pattern in the mould can be studied for different operating conditions. Different casting speeds.
- Heat transfer rates can be investigated by varying convective heat transfer coefficients

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