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Design of Ladle Shroud for Minimum Turbulence in Tundish Surface During Continuous Casting of Steel

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Abstract - *One of the key factors to improve steel quality is the steel cleanliness. In the continuous casting process, the tundish serves not only as a reservoir and a distributor of molten steel, but also as a metallurgical reactor to diminish the inclusion content in the final product. This research is aimed to study the flow behaviour inside the ladel shroud. commercial computational fluid dynamics software, SOILID WORKS, was used for simulation. The data of geometry and operating parameters were collected from the steel plant at Bokaro Steel Plant (BSP), SAIL JARKHAND INDIA. The simulations were performed under isothermal conditions. The results show that, with the implementation of flow control mechanisms, the velocity of the steel through ladel was decreased which would enhance the chance of inclusion removal and promote the steel cleanliness.*

Different cases have been analyzed, including a conventional ladle shroud (LS). Similarly, the new design of the shroud was studied under equivalent conditions.LS at different bore design, showing the detailed jetting characteristics of steel leaving the three types of ladle shroud.

Ladle shroud is a small but significant device in tundish metallurgy to facilitate both production process and steel quality. Past decades have witnessed its evolution from a simply shrouding tube to a multi-functional device in continuous casting processes. Advances in the functions of ladle shroud in tundish metallurgy have been reviewed in this work, including shrouding the teeming stream, fluid flow control, slag carry-over detection, and the potentials of heating and additive feeding. The features of various commercialized and novel ladle shrouds are discussed. The effect of practical operations, such as argon injection and misalignment, on the performance of ladle shrouds is also analyzed in this review.

***Keywords*: ladle shroud; tundish metallurgy; clean steel; flow control; casting operation.**

1. INTRODUCTION

The efficiency and optimization of the performance of the tundish requires detailed control of the flow of steel. If the molten fluid is not controlled adequately, the quality of the steel can drop during its transfer from the ladle to the moulds; therefore many efforts have been made in the research of fluid flows in tundishes, in order to achieve longer residence times and to eliminate all dead zones. Special attention has been taken to the design, equipment and arrangement of different flow control devices in order to modify the fluid flow inside the tundish. Less consideration has been given to the flow patterns that can be obtained when the molten steel is transferred through different ladle shroud designs. By the manipulation of the geometry of the ladle shroud, the fluid flow can be drastically modified prior to being discharged. For instance, one can decrease the momentum of the incoming jet, and as a consequence change the fluid flow patterns throughout the volume of the vessel. The present work is addressed towards the study of a new design of ladle shroud which can perform as a flow modifier. The possible advantages that this might bring, if working alone, include less preparation time, lower operating costs and higher availabilities at the caster. If used in conjunction with another flow modifier, longer residence times, less slag entrainment and decrease the erosion of the walls, could be anticipated.

2. OBJECTIVES

The main objectives of this study is

1. To compare the performance of the proposed ladle shroud design, the bell shape ladle shroud (Fig No.3 and 4)
2. Life of ladel shroud.
3. Velocity vector inside the ladle shroud.
4. Slag zone erosion.
5. Flow charsterstics in the tundish.

2.1. LADLE

In metallurgy, a ladle is a vessel used to transport and pour out molten metals. Ladles are often used in foundries and range in size from small hand carried vessels that resemble a kitchen ladle and hold 20 kilograms (44 lb) to large steel mill ladles that hold up to 300 tonnes (330 tons) (Fig No.1). Many non-ferrous foundries also use ceramic crucibles for transporting and pouring molten metal and will also refer to these as ladles.

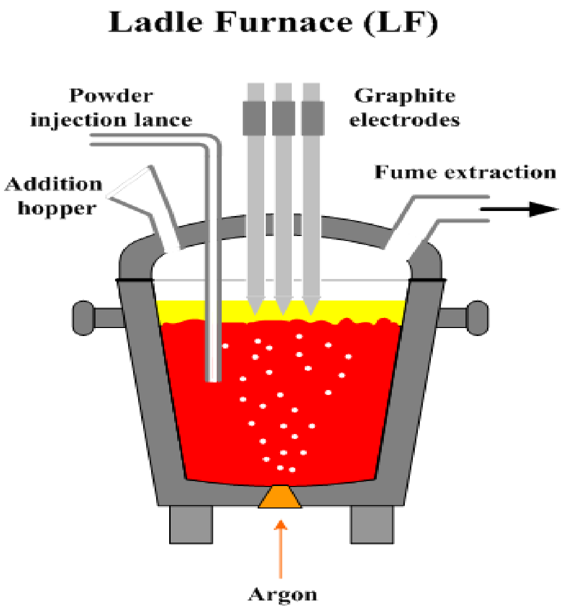


Figure 1. Ladel Furnace

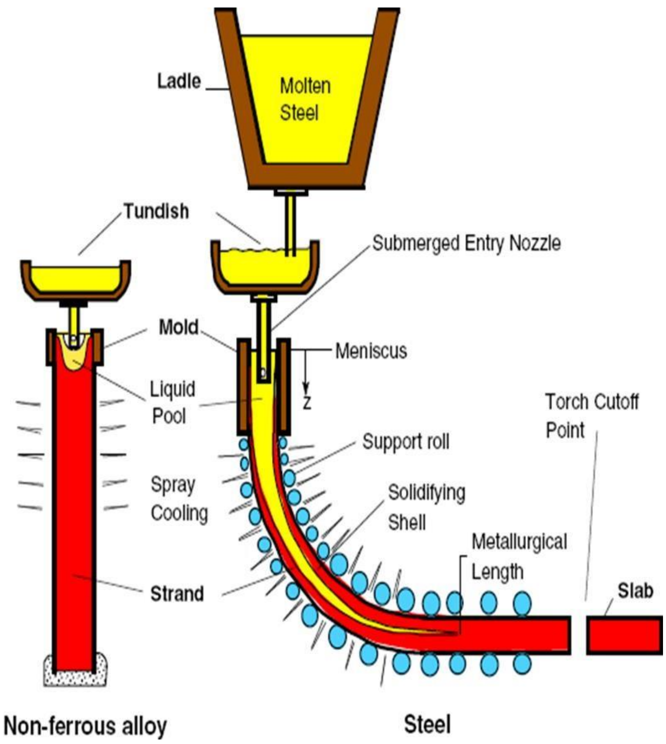


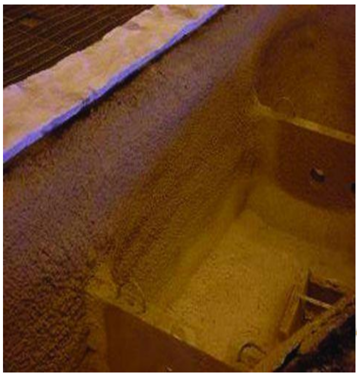
Figure 2. Schematic diagram of the elements and processes in the continuous casting machine.

2.2. Tundish

Continuous casting of steel is a widely used process and an important step in the production of steel (Fig No.2). The share of continuously cast steel around the world has increased significantly in the last 35 years or so. Presently this share is above 95 percent. However, concurrent with this increase in production levels, there are stringent quality requirements that have become crucial in the face of progressively increasing throughputs of continuous casting machines and larger dimensions of the cast products.

A tundish is often divided into two sections. The first section is called inlet section which generally has a pour box and where liquid steel is fed from the ladle. The second section is called outlet section from where liquid steel is fed into the mould. Different flow control arrangements such as dams, weirs, baffles with holes etc. are normally arranged along the length of the tundish. Longer path of liquid steel is preferred to prolong the residence time of liquid steel in the tundish to promote floatation of macro inclusions.

TUNDISH lining spray mass and DRY Vibration



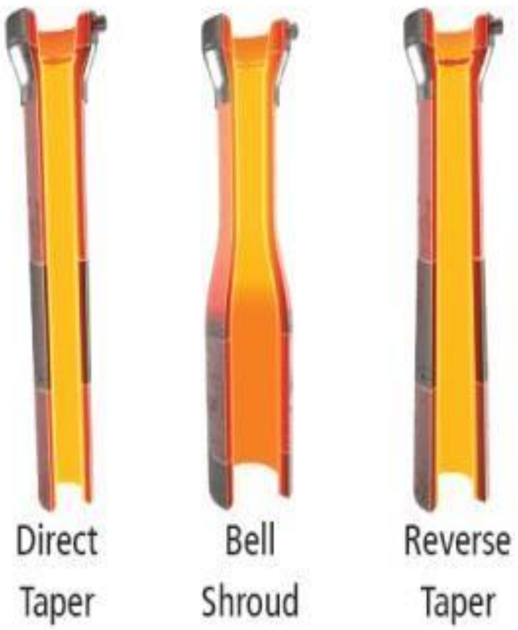


Figure 3. Ladel shroud types.

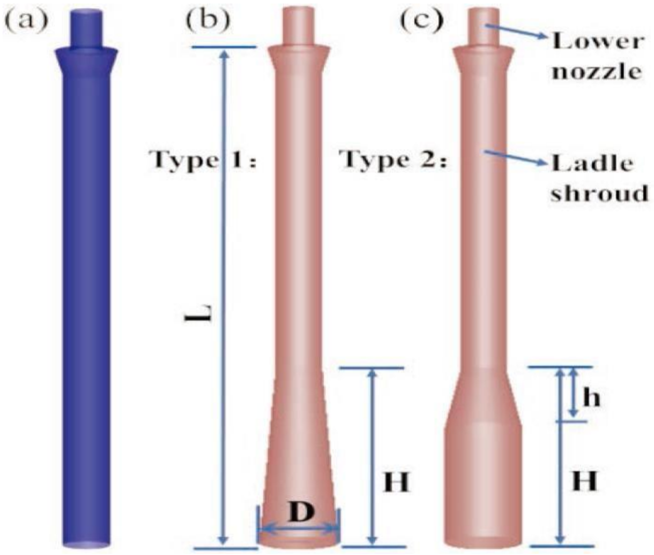


Figure 4. Ladel shroud types

3.MATHEMATICAL MODELLING

(1) Software used=Solid works

(2) Ladel capacity= 300000 kg

(3) Mass flow rate= 83.33kg/sec.

(4) **Ladel shroud with normal taper**

Bore ID= 99 to 97 mm.

(5) **Ladel shroud with reverse taper**

Bore ID= 99 to 110 mm(Straight taper)

(6) **Ladel shroud with bell shape**

Bore ID= 99 to 110 mm (Bell shape)

(7) Liquid =water

(8) Turbulence Model equations (standard k-€)

K-epsilon (k-ε) turbulence model is the most common model used in Computational Fluid Dynamics (CFD) to simulate mean flow characteristics for turbulent flow conditions.

It is a two equation model that gives a general description of turbulence by means of two transport equations (PDEs). The original impetus for the K-epsilon model was to improve the mixing-length model, as well as to find an alternative to algebraically prescribing turbulent length scales in moderate to high complexity flows

Model

Model Name: C:\Users\USER\Desktop\3008AA0255 3D DRAWING\NORMAL TAPER 99-97.SLDPRT

Fluid

Water

Table.1: Inlet Mass Flow 1

Type	Mass Flow Rate
Faces	<0>@Revolve1
Value	Mass Flow Rate: 83.3300 kg/s Temperature: 293.20 K

Type	Environment Pressure
Faces	<1>@Boss-Extrude1
Value	Environment Pressure: 101325.00 Pa Temperature: 293.20 K

Name	Unit	Value
Maximum Velocity	m / s	18.118

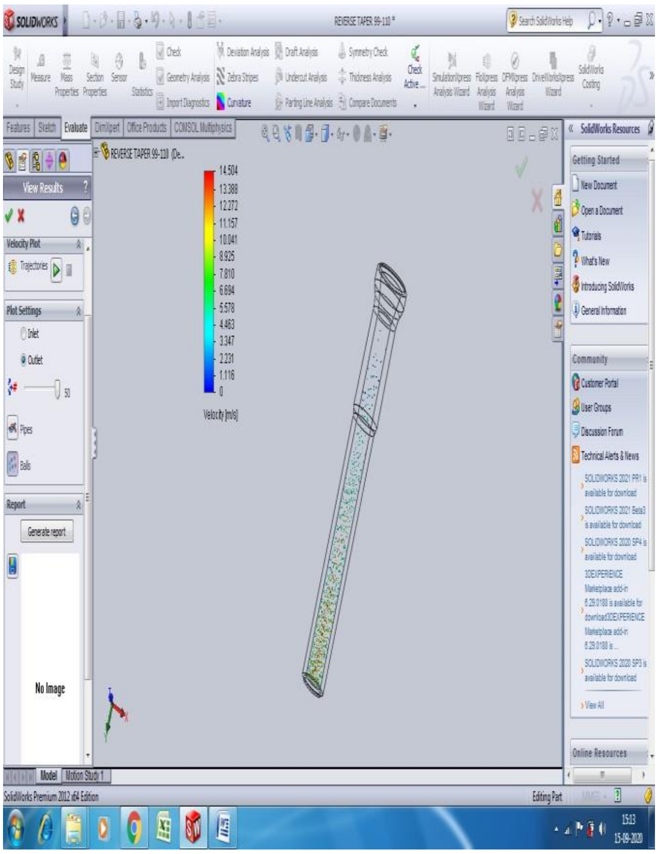


Figure 5. Step 7= Result

3.1. LADEL SHROUD WITH BELL SHAPE

Bore ID = 99 to 110 mm (Bell shape)
Step 1= Select model.

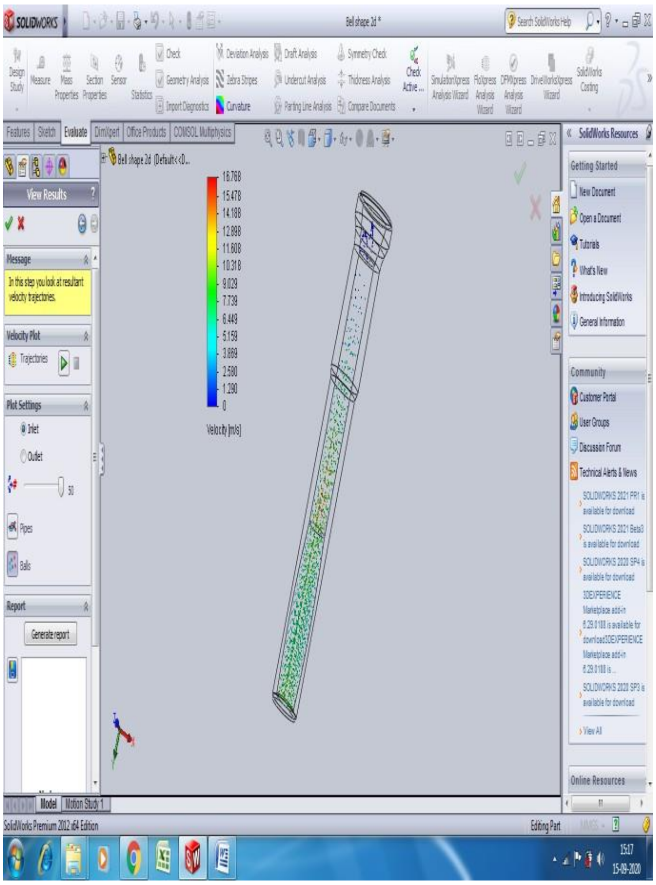


Figure 6.Step 7= Result

4.CONCLUSIONS

4.1. Velocity in

Ladel shroud with normal taper=18.11m/s

Ladel shroud with reverse taper=14.45m/s

Ladel shroud with bell shape =12.766 m/s

So bell shape ladel shroud is less steel velocity, this will better for tundish.

(1) Advantage for bell shape.

(2) Ideally protect the steel from re-oxidation

(3) Allow submerged opening

(4) Operate without the need of pre-heat

(5) Achieve longer life with specific finite-element flange designs

(6) Maximize shroud re-use by oxygen cleaning

A submerged shroud operation would be better than the non-submerged operation during a ladle change.

At high submergence depths there is very low turbulence and hence amount of slag entrained is less. Tundish operations with higher submergence depth of the shroud may eliminate the use of turbulence inhibitors and thereby reduce refractory consumption and cost.

REFERENCES

[1] Mazumdar, D., and Guthrie, R.I.L., The Physical and Mathematical Modeling of Continuous Casting Tundish Systems, ISIJ International, (1999) 39(6), pp 524-547.

[2] Guthrie, R.I.L., and Isac, M., The Process Metallurgy of Ladle- Tundish-Mould Operations for Continuously Casting Slabs, Blooms and Billets, Iron and Steel Making, (2003), pp 27- 32.

[3] Guthrie, R.I.L., Engineering in Process Metallurgy, Oxford University Press, (1992).

[4] Tanaka, S., Modelling Inclusion Behaviour and Slag Entrainment in Liquid Steel Processing Vessels, PhD Thesis, McGill University Montreal, Canada, 1989

[5] Krishnapisharody, K., and Irons, G., Studies of Slag Droplet Formation in Ladle Metallurgy: Part I. Physical Modeling, ICS 2008,pp-367-374

[6] Damle.C and Sahai.Y , A Criterion for Water Modeling of Non- isothermal Melt Flows in Continuous Casting Tundishes, ISIJ international, (1996) 36(6), pp 681-689

[7] Sahai, Y., and Emi, T., Tundish Technology for Clean Steel Production, World Scientific Publication Co. Pte. Ltd. (2008)

[8] Ghosh, A., Secondary Steel Making, Principles and Applications, CRC Press (2001)

[9] Lopez-Ramirez, S., Barreto, J De J., Vite-Martinez, P., Serrano, J A Romero, Duran-Valencia, C., Physical and Mathematica Determination of the Influence of Input Temperature Changes on the Molten Steel Flow Characteristics in Slab Tundishes, Metallurgical and Materials Transactions B, (2004) 35B(5), pp 957-966

[10] Vargas-Zamora, A., Morales, R. D., Diaz-Cruz, M., Palafox- Ramos, J., Garcia, D. L., Heat and Mass Transfer of a Convective- Stratified Flow in a Trough Type Tundish, International Journal of Heat and Mass Transfer, (2003), 46(16); pp 3029-3039.

[11] Craig, K. J., De Kock, D. J., Makgata. K. W., De Wet, G. J., Design Optimization of a Single-Strand Continuous Caster Tundish Using Residence Time Distribution Data, ISIJ International, (2001) 41(10), pp 1194-1200.

[12] Solhed, H., Jonsson, L., Jonsson. P., A Theoretical and Experimental Study of Continuous-Casting Tundishes Focusing on Slag-Steel Interaction, Metallurgical and Materials Transactions B, (2002) 33B(2), pp 173-185.

[13] Solhed, H., Jonsson, L., An Investigation of Slag Floatation and Entrapment in a Continuous-Casting Tundish Using Fluid- Flow Simulations, Sampling and Physical Metallurgy, Scandinavian Journal of Metallurgy, (2003) 32(1), pp 15-32.

[14] Debroy, T., and Sychterz, J.A., Numerical Calculation of Fluid Flow in a Continuous Casting Tundish, Metallurgical and Materials Transactions B,(1985)16B, pp 497-504.

[15.] Schwarze, R., Obermeier, F., Janke, D., Numerical Simulation of Fluid Flow and Disperse Phase Behaviour in Continuous Casting Tundishes, Modelling and Simulation in Materials Science and Engineering, (2001), 9(4); pp 279-287

[16]. Qinfu, H., Zongshu, Z., Comparison Between Standard and Renormalization Group k-ε models in numerical simulation of Swirling Flow Tundish, ISIJ International, (2005) 45(3), pp 325- 330.