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GEOMETRIC MODIFICATION OF THE TUNDISH IMPACT POINT (Format: Style – IaSM2019\_Title, font 12 b., BOLD, CENTER, gaps 12 and 6 , line spacing 1,15)

Branislav Bul’ko 1,\*, Ivan Priesol 2, Peter Demeter1, Peter Gašparovic 3, Dana Baricová 1 (Format: Style – IaSM2019\_autors, full name and surname of the author and all co-authors, font 11 pt., line spacing: 1,15)

1Faculty of Metallurgy, Technical University of Košice, 04200 Košice, Slovakia; peter.demeter@tuke.sk (P.D.); dana.baricova@tuke.sk (D.B.); martina.hrubovcakova@tuke.sk (M.

2 IPC REFRACTORIES s.r.o., Magnezitárska 11, 04013 Košice, Slovakia; ipc@ipc.sk

3 Faculty of Aeronautics, Technical University of Košice, 04200 Košice, Slovakia; peter.gasparovic@tuke.sk

\*Correspondence: branislav.bulko@tuke.sk; Tel.: +421-55-602-3169

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Abstract (Format: Style – IaSM2019\_main\_title, font 10 pt, bold letters, gap 18)

In connection with the increasing requirements for cleanliness in conticast steel, it is necessary to develop original solutions. The tundish, as the last refractory-lined reactor, gives enough space to remove inclusions by optimizing the flow of steel. The basic component of the tundish is the impact pad, the shape of which creates a suitable flow of steel, thus making it part of the tundish metallurgy. The optimal steel flow in the tundish must avoid creating dead zone areas, or the slag “eye” phenomenon in the slag layer around the ladle shroud, and is intended to create conditions for the release of inclusions by promoting reactions at the steel-slag phase interface. The flow also has to prevent excessive erosion of the tundish refractory lining. This paper compares the standard impact pad with the “Spheric” spherical impact pad using computional fluid dynamiscs (CFD) tools and physical modelling. The evaluation criteria are residence time and flow in the tundish at three different casting speeds. (Format: Style – IaSM2019\_text, font 10 pt, gaps 0 and 6). The abstract should contain totally about 200 words.

**Keywords:** continuous casting; tundish; residence time; computional fluid dynamiscs (CFD), max. 5 (Format: Style – IaSM2019\_text, font 10 pt, gaps 0 and 3)

1. Introduction (Format: Style – IaSM2019\_main\_title, font 10 b., bold, gap 18, In order to correct review your paper, it is essential that it is submitted in grammatically correct English. We recommend you that you have your paper professionally edited. )

Current trends show that more than 96% of the steel produced in the world is processed by continuous casting [1]. In view of this, there is a naturally increasing pressure on producers of refractory materials used in the continuous casting process. A key part of the continuous casting plant is the tundish, which can significantly affect steel cleanliness. In connection with the constantly increasing ratio of high-grade steel in the product portfolio, development in the field of tundish metallurgy is essential. A fully operational tundish is chosen in terms of covering and refining powders and the proper slag regime. The basic requirement for a properly functioning slag system is the controlled flow of steel in the tundish so that inclusions can be released from the steel into the slag and chemical reactions have good conditions to run at the steel–slag phase interface [2]. From this perspective, the most important criterion is the geometrical adjustment of the steel impact point in the tundish. In practice, this is solved by the use of an impact pad, which has the role of reducing the erosion of the bottom of the tundish refractory lining [3–5]. (Format: Style – IaSM2019\_text, font 10 pt, gaps 0 and 3)

1.1. The Impact Pad “Spheric” (Format: Style – Title2, font 10 pt, italics letters, gaps 12 and 6)

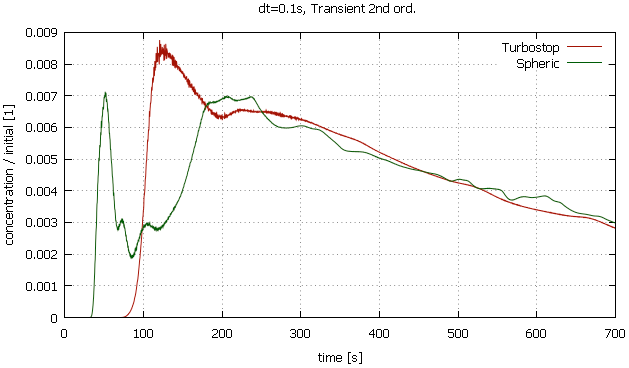
The shape of the spherical impact pad was developed in order to decrease the hydrodynamic drag force of the impinging stream of molten steel. Dimensional analysis of the drag force F provides the dependence.

F = 1 C·ρ·S·v (Format: Style – equations, font 10 pt, gaps 10 and 10) (1)

where: C—coefficient of drag, ρ —specific mass of fluid, S—size of the reference area (planform area of the pad), and v—references the velocity of impinging stream.

2. Experimental Materials and Methods

The initial idea of the “Spheric” impact pad was verified using CFD simulation tools, (Figure [1](#_bookmark3)) (Minimum 1000 pixels width/height, or a resolution of 300 dpi or higher).



**Figure 1** Comparison of C-curves for the “Spheric” impact pad and for standard impact pad @ 0.8 m*·*min*−*1—CFD simulation.

In Table 1 is a comparison of minimal and maximal residence times for each configuration. The numbers in brackets indicate the percentage difference related to the minimum residence time of the alternative with standard impact pad for similar conditions.

**Table 1** Comparison of residence times for all tested configurations.

|  |  |  |  |
| --- | --- | --- | --- |
| Configuration | Casting speed | Minimal residence time (sec.) | Maximal residence time (sec.) |
| Standard impact pad | 0,8 m.min-1 | 57 | 98 |
| 1,2 m.min-1 | 55 | 137 |
| 1,6 m.min-1 | 39,5 | 119 |
| Spheric impact pad | 0,8 m.min-1 | 40,5 (71%) | 119 |
| 1,2 m.min-1 | 42 (76%) | 127 |
| 1,6 m.min-1 | 42 (106%) | 104 |

3. Results and discussions

Numerical simulation of the flow was computed in the software Ansys Fluent v19.2. Ansys Fluent computes discrete values of the time-dependent Navier-Stokes equations, that is, conservation equations of the momentum in x-, y-, and z-direction, and conservation equation of the mass. Time-dependent details of turbulent eddies is removed from the Navier-Stokes equations by Reynolds averaging, and the effect of the turbulent motion on the transport of momentum in averaged flow is assumed by Boussinesq hypothesis which defines the turbulent viscosity. The turbulent viscosity increases basic, molecular, viscosity of the fluid. Computation of turbulent viscosity requires additional equations, which are based on the k-omega SST model (Menter's k-omega model).

4. Conclusion

The design of the spherical impact pad with a convex surface was inspired by the differences between the flow past a flat plate and the flow past a sphere. CFD simulations were utilized for the initial testing and approval of this shape of impact pad. Compared to the standard impact pad at a corresponding casting speed of 0.8 m·min−1, the spherical pad was found to shorten the residence time, but on the other hand the flow pattern created by this impact pad could have the benefit of reducing dead zone areas and eliminating any slag “eye” in the slag layer around the ladle shroud. The proposed impact pad has no tendency to short-circuit the flow. The “Spheric” impact pad was therefore subjected to further, more extensive testing using a 1:3 scale physical model of a tundish at flow rates simulating different casting speeds.

Acknowledgement All the sources of funding of the study should be published. Please clearly indicate grants that you have received to support your research study and if you received the financial funds to cover publication cost.

This research was funded by [VEGA MŠ SR a SAV] grant number [1/0868/17].

References Your references would be numbered in the order as they go in the text (including table captions and figure legends) and listed at the end of paper. Bibliography softer package is recommended (EndNote ReferenceManager or Zotero) in order to avoid mistakes and duplicity.

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