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PHYSICAL MODELING OF HYDRODYNAMICS FOR LIQUID METAL IN THE FOUNDRY LADLE EQUIPPED WITH THE FILTERING PARTITION

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The results of physical modeling for hydrodynamics of metal in the foundry ladle equipped by filter partition during its blowing by noble gas through the bottom lance are given. Quantity relations and directions of the velocities for metal flows are dependent from the place and constructive specialties of filter partition in the foundry ladle in given intensity of gas blowing are determined.

Key words: physical modeling, hydrodynamics of metal, filter partition, ladle, gas blowing, gas

Frequently the quality of metal production depends on the cleanliness of metal according to the quantity of nonmetallic inclusions. The quantity, structure and the sizes of nonmetallic inclusions are defined in the ways and regimes of metal processing. The extraoven processing of metal is one of the most modern methods for the improvement of metal quality.

An installation of filter partition is the most rational technological resolution among the all known ways of excision of the nonmetallic inclusions.

The efficiency of using the filter partitions presupposes the increase of intensity of the convective liquid streams. For getting an appropriate result you should use different devices for metal interfusion. It can be neutral gas, which moves through the bottom lance devices. It is still undiscovered: in which way the disposition of partition in the ladle and an intensity of gas blowing influence the hydrodynamic of a liquid bath.

The purpose of the given researches is the delimitation of rational disposition for a filter partition inside the foundry ladle, and the intensity of gas supplied from the below and their influence on the hydrodynamic settings of a liquid bath.

The solution of the given problem was experimented by means of the approached physical modeling method on the positions of the theory for similarity.

The analog study of the liquid's hydrodynamics on the physical model of a foundry ladle (geometrical measure 0.6) was prosecuted by giving the neutral gas to metal with the help of the bottom lance tuyeres (with the drain 1.2-3.2 l/(t·min) of the liquid steel). Construction of the tuyeres gives an opportunity for free movement on the ladle's bottom. Model of the filter partition (made from the organic glass), contains the holes of different sizes and configuration and can be set in the certain place foundry ladle.

The defining modeling hallmarks are numbers La , Ar , Ho . Number Re belongs to the area of automodeling.

The vegetable oil was used as the simulator of integumentary slag. Visualization of liquid streams of a was carried out by using the polystyrene balls (in diameter by 0.3-1.5 mm) which have zero buoyancy, and also by input the stain «eye» on a water surface of a painting liquid. The direction and speeds of streams were defined by visual supervision and fixing of a hydrodynamic picture on a digital videocamera.

During the process of modeling studied the general character of distribution for a liquid streams speed of liquid streams, character of its behavior and gas in foundry a ladle there is volume a one ton, were studied.

The experiments allowed to find out that filter partition must have a shape of half a horizontal section for a ladle and be installed symmetrically over bottom lance device.

In all of the investigated cases the homogenization time decreased, according to the process of growth for intensity during the giving of gas with the best tuyeres disposition on distance about 0.5 radiuses of a ladle from its axis. It has predetermined the carrying out of the further researches at the specified position of bottom lance tuyere.

The character of behavior liquid-gas streams depends on height of a disposition for a partition over the tuyere and its sizes, and also a configuration of the holes in a partition. The allocation of the hydrodynamic streams in vertical section is more strongly marked than in cross-section. Firstly, the intensity of gas giving through must tuyere is defined. There are approximately 6-8 stable closed hydrodynamic streams during the all researched modes of bottom scavenging and with heights of the partition's dislocation. The difference of speeds for liquid streams in various quadrants is 9-20 % in average.

The general tendency in all investigated cases is the emergence of additional streams for metal which bend around a partition around vertical axial section of a ladle. Positive line in all cases was absence of the surface for metal bared from slag over the tuyere, which explains the «disseminating» effect of a filter partition.

Table 1 - Absolute values of speeds of metal streams

| Position of a filtering partition | Intensity of a purge, l/(t·min) | Speeds of streams of metal, m/s |
|-----------------------------------|---------------------------------|---------------------------------|
| 0.25 | 1.2 | 0.019-0.081 |
| | 2.2 | 0.025-0.096 |
| | 3.2 | 0.041-0.154 |
| 0.50 | 1.2 | 0.025-0.093 |
| | 2.2 | 0.031-0.112 |
| | 3.2 | 0.053-0.173 |
| 0.75 | 1.2 | 0.022-0.087 |
| | 2.2 | 0.027-1.104 |
| | 3.2 | 0.045-0.151 |

In general the presence of partition has led to more steady current of a liquid in all zones of a ladle, and to simultaneous reduction of quantity and volume of stagnant zones in comparison with a purge of a ladle of a usual model.

According to the height a ladle can be divided (provisionally) into four parts: under the partition, above it, and two areas in free position from the partition. The direction of the metal streams is constant but accruing to the recession of the partition from the bottom of ladle an intensity of the liquid streams decreases during the increase of volume for circulating streams.

In table 1 absolute values of speeds for metal streams in the vertical plane of the investigated foundry ladle passing through an axis of a ladle and an axis tuyere are resulted, during the giving of gas with specific intensity of 1.2-3.2 l/(t·min) and various position of a filter partition. In process of increase of specific intensity for a scavenging time decreases with In process of increase of specific intensity of a scavenging time decreases with simultaneous growth of speeds for metal streams. The increase in the relative area of apertures in a partition also positively affects the reduction of time for a liquid modernization.

The creation of the compulsory convection in the full ladle volume is an important condition which provides a directive motion, unification, agglomeration and flowing of the nonmetallic inclusions to the slag cover. The vertical structure of metal volume allows to integrate the nonmetallic inclusions as fast as possible and only to create conditions for carrying out in a slag zone, but also to promote detention by their filter partition. It would be better to involve metal volume by vortex formation as more as possible to provide contact to a slag cover and to reduce probability of formation of stagnant zones. Dispersal of allocation of gas phase from metal volume, increase in duration of vials, stating in liquids, and reduction of the area of the bared mirror of metal will positively affect the quality of steel unequivocally, in particular, on removal of gas and nonmetallic inclusions.

Thus, for a more complete and intensive refining process of metal inclusions should increase the path of movement of the metal to the slag cover. It was determined that in this filter septum relative cross-sectional area of holes in which approximately 40% must be provided with openings with angles nucleonic axis bucket from 0 to 45°, which locates relative to the vertical plane of symmetry of the bucket and the distance from its bottom.

Conclusions. The features of metal's hydrodynamics in the foundry ladle (equipped with the filter partition) by means of a physical modeling method at the set intensity of a purge by inert gas through tuyere device. The rational location of a filter partition in volume of found ladle and the relative area of apertures in it are found it gives an opportunity to accelerate removal nonmetallic inclusions and gases.