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PHYSICAL MODELING OF HYDRODYNAMICS PROCESSES IN LADLES OF SMALL CAPACITY AT THE COMBINED METHOD OF HASHING STEEL

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The results of physical model operation of hydrodynamics for metal in a foundry ladle at electromagnetic interfusion and simultaneous blowing out through ground lance are offered. Regressive dependences of speed of metal streams in the volume of ladle are found.

Keywords: foundry ladle, model operation, hydrodynamics, electromagnetic mixing, inert gas, blowing

Reducing of time of out-of-furnace treatment of metal is caused the necessity of increase for intensity of convective streams by means of application of additional methods of interfusion. World experience [1,2] testifies that the best results of influence on quality of steel arrive at the use the combined methods of intensification of streams liquid metal.

During research of hydrodynamics of metal in the process of its combined treatment in foundry ladles used the methods of physical modeling. In particular, a liquid metal was replaced by water, inert gas – by air, and device of electromagnetic interfusion – by the special apparatus which recreated the characteristic for electromagnetic interfusion contour of hydrodynamic streams of melt. Speed of liquid streams was determined by means of «tracers» method. Additionally for the receipt of high-quality pattern of influence of metal to fettling bottom of ladle covered by the even layer of silvery graphite. Speed of homogenization of metal bath was determined by the way of introduction of the coloured liquid.

The physical modeling of hydrodynamics of metal in foundry ladles in the laboratory of department for casting production of black and coloured metals of the Dneprodzerzhinsk state university was executed on transparent experimental apparatus in a scale 0.6 the real one tonnage ladle.

Circulation contour of liquid streams, that by a form is characteristic for the electromagnetic method of interfusion hashing of steel in a ladle, provided due to the use of the special device, that set in the set place of volume the models of ladle by means of the worked out mechanical fastening with possibility of moving for device depending on the tasks of experiment. As streams of melt, created by blowing out gas (intensity of giving 1.2-3.2 l/(min·t), are directed from botton-up, in all investigational cases the streams of metal, induced by the device of electromagnetic interfusion of metal (DEMIM), are directed downhill, assisting interfusion of all volume of bath of ladle thus. The feeding of electric motor of device executed by means of regulated direct-current. For the modeling of blowing out of metal by inert gas the moved blowouting unit, to which with surplus pressure gave air which acted on a flexible hose from a compressor. Pressure of air and its expense was controlled on the

reading of manometer and rotameter.

At the location of place of imposition of electromagnetic influence on height of 0.25 from the bottom of ladle the streams of metal from DEMIM appear close enough to the bottom and were directed in its side. It is defined, that at that case there will be destruction of fettling bottom in the place of blow of metal stream. As a result of the ladle of stream of metal reversed from a bottom a bend appeared to the lending of plume for gas-metal mixture in its underbody, which increased on the measure of increase of power of DEMIM at the constant expense of gas. With the increase of gas expense, regardless of power from DEMIM, the effect of curvature to the plume decreases and practically became unnoticeable at maximal intensity of giving air. In area of bottom from the axis of lance to the wall of ladle a stagnant area which diminished on the measure of increase of gas expense appeared, however it is not disappeared fully.

At the location of DEMIM on height of 0.5 from the bottom of ladle kinetic energy of blow of stream from DEMIM at the bottom of ladle decreased. With increase of DEMIM there was displacement downward of area of curvature to the plume power. There are looked after intensification of interfusion, circulation streams are raised in volumes on 15-20 %. A stagnant area is disappeared for axes at the bottom of ladle; however a stagnant area was obviously visible from the axis of lance to the near wall of ladle down. It almost fully disappeared at the maximal expense of gas, but at that case in the place of gas make from bath an «eye» appeared on the surface of metal. In this case speed of homogenization for bath of metal was higher, than at the location of DEMIM on height of 0.25 from the bottom of ladle. Thus, for prevention of origin of «eye» on the surface of metal it is expedient to apply DEMIM with small power at the small specific expanses of gas.

At the location of DEMIM on height of 0.75 from the bottom of ladle energy of stream from DEMIM at a blow at a bottom decrease already at small power of DEMIM, but above it a «crater» appeared on the surface of metal. It resulted to dragging of slag into a metal. The bend of plume was displaced downward for its axes. A stagnant area appeared between lance and near wall. Circulation streams met in one large contour, but, with increasing power of DEMIM, there are divided into two contours: large – down *и* small – above. With the increase of specific expenses of gas the bend of flume some diminished, but, on the average, was anymore comparatively with previous experiments, a stagnant area between lance and wall diminished, the geometrical sizes of «eye» of metal had increased.

Thus, most effective, from the point of view of diminishing of time for complete interfusion of metal, there is a location of place of application of electromagnetic interfusion in the distance of a 0.5-0.6 height of ladle at small power of the electromagnetic field and specific expense of gas through bottom lance 2.2 l/(min·t), located on to a 0.5 radius near the opposite wall of ladle.

On results statistical calculations (the confidence interval of authenticity in all calculations is accepted 95%) regressive dependence of speeds of streams of metal is found inplane, which passes through the axes of ladle and bottom lance:

$$W = 0.173 + 0.112P + 0.069I + 0.028V - 0.035r + 0.193H + 0.006P^2 +$$

$$+0.016\,I^2 + 0.026\,V^2 + 0.032\,r^2 + 0.211H^2;\quad R = 0{,}49\ , \qquad (1)$$

where P is a height of location of place of imposition of electromagnetic influence from the bottom of ladle, relative units; I is intensity of expense of blowing, l/(min·t); V is a speed of movement for layers of liquid in the area of location of DEMIM, relative units; R is a coefficient of correlation.

Analyzing the got dependence, it is possible to assert that on the function of review most influences height of location of control points. The least speed is observed at the location of DEMIM in the underbody of ladle and at minimum intensity of blowing out of bath of metal. It follows notices subzero enough value for the coefficient of correlation of regressive equation. This fact means high turbulence of streams of liquid which can not be described by equations of the second order and requires application of instrument of mathematical modeling.

However, the decision of task of optimization of multiextreme function (1) allowed to define that high speed of streams reaches near the wall of aggregate from the side of lowdown unit near-by the surface of metal at the location of DEMIM on height of a 0.75 pouring of metal for the charges of blowing 3.2 l/(min·t). Thus, exactly in this point of internal space of ladle for the above-mentioned conditions it follows to put additional, including dispersible materials.

However, at such position of area of the forced interfusion above it's a «crater» on the surface of metal which results in contamination of metal the slag brought over to it will appear.

Poet, more acceptable is other extremum that foresees the location of area of putting of additional materials approximately on 0.5 heights of pouring of metal in a ladle on diminishing of intensity of gas expense to 2.2 l/(min·t). Also it defined, that reagents beside the purpose to enter in bath of ladle on height of a 0.63 pouring of metal in the distance 0.26 from the axis of ladle to side location of bottom lance.

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