

OPTIMIZATION OF THE COOLING PROCESS OF ALUMINUM INGOT BY MEANS OF INVERSE PROBLEM APPROACH

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The investigation of the optimization of the cooling process of aluminum ingot is presented within the frames of current research. The well-known method of Adaptive Iterative Filter (AIF) [1] for the solution of the appropriate Inverse Heat Transfer Problems (IHTP) has been proposed. The number of modifications of AIF method were previously used as a mathematical and numerical instruments for identification of thermophysical and technological parameters including simultaneous identification of different thermal parameters [2 – 4], for solving IHTP [3, 5 - 7] and optimum control problems [1, 8], for thermal system simulation [1, 5, 8] just to name a few.

The suitable numerical algorithm of Adaptive Iterative Filter was applied for solving the variety of non-linear unsteady external and combined IHTP that appeared during investigation. Specifically, AIF has been proposed to identify the influences of the sprayer properties on the convection heat transfer coefficient of two-phase regime during the process of intensive cooling of aluminum ingot.

As it is very well known, the inverse problems are ill-posed problems in the sense of existence, uniqueness and stability and, as such, in general case, they do not have a universal solution. Therefore, on the stage preceding the actual solving real inverse problem, the theoretical research or numerical simulating inverse analysis should be conducted. This analysis, which includes the solution of methodological inverse problems, is required to investigate the range of stability and uniqueness of the obtained results as well as convergence of the iteration and recurrent processes. Based on the analysis and simulation it was able:

- To design the test plan. Design includes but is not limited to the determination of the influence of position of temperature measured devices on the accuracy of the identification results, the affect of the number of thermocouples on stability and convergence of the identification process.

- To optimize the numerical algorithm of AIF that allows the refinement of the sensitivity matrix and updating the covariance matrices to indicate the reliability of the estimates.
- To optimize a weight matrix of AIF associated with every problem under study at each iteration of the numerical calculation process.

Our research has shown that heat transfer between hot aluminum surface and cooling system depends upon several parameters. The most important and decisive parameters are the sprayers geometrical dimensions and the fluid-dispersing coefficient. This coefficient represents the ratio between the amount of pulverized cooling fluid and the temperature of the cooled surface. The experiments were conducted in the specifically built test rig. Series of tests involving several sprayers of different geometry and various dispersing coefficients were conducted and appropriate temperatures were measured. The obtained results are in compliance with temperatures of two-phase high volume boiling regime. The change from nucleating boiling regime to film boiling is observed at a mean critical temperature.

The proposed approach and obtained results can be utilized at the aluminum manufacture facilities to optimize the properties of fluid's spray during the cooling of the aluminum ingots. The method of Adaptive Iterative Filter could be used as a powerful instrument for solving the similar inverse problems as well as inverse problems for porous materials and for cooling electronic systems.

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