Influence of axial fan casing flow on temperature uniformity during the heat treatment process of large-size forgings in an industrial size electric furnace

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ABSTRACT

The effect of changes in the structure of the axial fans mounted on the ceiling of an industrial size electric heat treatment furnace on temperature uniformity during the tempering process of large-size steel forgings was investigated. Variable mechanical properties or microstructures could be obtained if the temperature distribution through the volume of the large size bloc is not uniform during the heating process. Therefore, it is important to study the influence of different variables on the temperature evolution during the heat treatment process. Such study will also result in increasing the energy efficiency of the furnace. Due to the difficulty of directly measuring internal velocities and temperature fields in furnaces, the numerical approach can facilitate the identification of the principal phenomena that govern thermal and fluid behavior within the furnace and could be helpful in improving furnace operation.

Two large size blocs, about three cubic meters each, made of medium carbon low alloy steel were used in this study. Three-dimensional finite volume modelling software ANSYS Fluent was used to simulate the thermo-mechanical phenomena associated with the various metallurgical phases of the material within the considered domain. Prediction results were validated by comparison between the simulation results and experimental measurement of temperature evolution at various points of the blocs during the heat treatment process. The influence of adding a casing to the axial fans of the furnace on the maximum and total temperature non-uniformity experienced by forgings was determined. Furthermore, the effect of this structural change on the surface to center temperature gradient of large blocs was investigated. The simulation results also showed that after eliminating the fans’ casing, a reduction in the duration of the non-isothermal heating cycle and an increase in the average heat transfer coefficient were observed.

Results revealed that modification of the fans’ structure would significantly affect the temperature evolution of the large-size blocs. For example, a significant decrease in the maximum and total temperature non-uniformity experienced by the blocs under the effect of eliminating axial fans’ casing was revealed; Likewise, such effect on the surface to center temperature gradient of large blocs was indicated. The simulation results also showed that after eliminating the fans’ casing, a reduction in the duration of the non-isothermal heating cycle and an increase in the average heat transfer coefficient were observed.