MODELLING OF FURNACES AND COMBUSTION SYSTEMS

(671) - (*) - EXPERIMENTAL AND NUMERICAL ANALYSIS OF A GAS DIRECTLY-FIRED BATCH FURNACE.

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This paper compares the results of a Computational Fluid Dynamic (CFD) simulation with experimental data for three different operating conditions of a gas directly-fired batch furnace.

With the accessibility of low cost gas supplies, the industrial gas-fired batch furnace has been used for over 70 years to enable the heat treatment of metallic components and improve their inherent material characteristics. While batch furnaces could be considered a mature technology, they are still largely developed and operated from empirical based approaches. This is not too surprising when the complex thermo-metallurgical processes are considered: from the non-uniform and heterogeneous radiative and mixed convective heat transfer resulting from the combustion processes to the metallurgical phase change processes within modern complex alloys. However, the need for continued improvement in material quality with tighter control of phase precipitates and reduction in residual stresses has resulted in a renewed interest in understanding the heat treatment processes better.

The modern heat treatment challenge is not trivial, with component temperatures needing to be controlled to margins of 10 °C at levels of 1000 °C using only the gas temperature as an indicative measure of the component condition. The enabler for possible improvements has been the significant improvement in the physical understanding and modelling of heat transfer processes over the last 30 years and their transcription into advanced computational tools in the form of CFD codes. Motivated by the needs for more repeatable heat treatment, this work seeks to validate a Multiphysics CFD simulation of a research batch furnace of 200kW. The simulation (implemented in commercial software Fluent) develops a three dimensional temperature field that combines radiation, convection and conduction heat transfer originating from the turbulent combustion of Natural gas at the burners.

To validate the results, multiple temperature measurements from the simulation and the physical research furnace were compared for three different furnace configurations. During the experiment, the furnace was operating underload and at steady boundary conditions (thermal power, pressure, combustion equivalence ratio) with temperature measurements from walls, working volume, load and flues. The results give insights into the limitations of the current Multiphysics model although in certain furnace configuration, prediction of temperature can be computed within 10% or better.

Palavras-chave : Gas Batch furnace, CFD modelling, Experimental data, Heat Transfer, Combustion

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