Heat Transfer and Flow Structure of Multiple Jet Impingement Mechanisms on a Flat Plate for Turbulent Flow

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***Abstract*— Many heating or cooling-based engineering and industrial application use impinging jets, due to their higher convective heat transfer coefficient values. Here, the researchers stated that there was less available information regarding an increase in the heat transfer rates, when twin impingement jets were placed horizontally, at a distance from the stagnation point. Some studies made use of a twin impingement jet process for numerically and experimentally increasing the heat transfer values. In this study, the researchers carried out a numerical simulation that was based on an RNG k-ε turbulence model, in order to determine the cooling process for the heated surface of an aluminium plate. For this purpose, they used a Twin Jet Impingement Mechanism (TJIM), which consisted of 9 models. Furthermore, they also studied the effects of the nozzle-nozzle distances, nozzle-plate distances and Re number of the convection heat transfer for calculating the heat transfer coefficient, Nu number and a thermal enhancement factor. Some of the main conclusions observed in the simulation study were further used for validating all the experimental results and determining all major parameters that could affect the heat transfer rate, Nu number and distribution of the static pressure. The arrangements of all jets showed that Model 1 was ideal for calculating the Nu number when S/D= H/D=0.5. Meanwhile, Model 9 displayed the worst results, where S/D= 1.5 and H/D= 5.5. The results also showed that an irregular distribution of a local Nu number (Nu) on the impinged surface occurred due to a decrease or increase of the flow turbulence. Various twin jet arrangements showed that Model 9 displayed the worst results, where S/D= 1.5 and H/D= 5.5. All numerical results were validated after comparing the simulation and experimental results for the TJIM. This further described the temperature distribution on a flat metal surface for different models. Here, the researchers have calculated the enhancement factor using different nozzle arrangements in 9 models. This value ranged from 6.4% and 24.3%, in the case of simulation studies, whereas in the actual experiments, it ranged from 5.3% to 37.9%. The simulation model showed a 12-41% increase in the average heat transfer rate for the complete aluminium plate. Based on the validation model, the experimental and numerical tests indicated an 8.5% error percentage.**

Hypothesis: Nusselt number and heat transfer coefficient were impacted by the spacing between nozzles and the distance between nozzle and plates. Characteristics of heat transfer could be enhanced if the researchers selected an appropriate impingement mechanism and selected the optimal levels of other factors.

***Index Term*— Heat transfer enhancement; impingement jet; Nusselt number, Fluent; CFD**

1. INTRODUCTION

The heat transfer enhancement was seen to be an effective technique that could improve the industrial and engineering applications. In the past few years, many applications have used the impingement jets, which were a heat transfer process, for enhancing the heat transfer rate [1]–[3]. Here, the researchers used a numerical simulation for investigating the twin impingement jet flow and the impingement heat transfer. Simulation and experimental results were further analysed and discussed, and the heat transfer effects occurring because of the impingement of twin jets on the hot aluminium plate surface were noted. This study also assessed the twin impingement jet flow and investigated the effects of the various parameters like the nozzle-plate distance and the Nozzle-Nozzle distance [4]–[6]. The flow characteristic of the twin jets incorporated the air jet velocity into the external hole if the Reynolds number was 17,000. All heat transfer-related issues were correlated using the factors that affected the heat transfer, and the researchers investigated the heat transfer enhancement related to the twin jet impingement.

Here, the researchers conducted some numerical and experimental studies with regards to the cooling of the industrial and engineering components, for increasing the heat transfer rate [7]–[9]. The jet impingement can significantly affect the cooling of the flat surfaces and even the electrical applications [10], [11]. In the past few years, many researchers were motivated by the heat transfer characteristic involved in a cooling process [12]. Some studies investigated the heat transfer and flow characteristics of the single jet impingement mechanism on a protrusion surface with the help of the numerical simulations and Particle Image Velocimetry (PIV) [13]. One study [14] used a ground fast cooling simulation