UNIVERSITI TEKNOLOGI MARA

NUMERICAL STUDY OF NOZZLE DIAMETER EFFECT IN FLUID IMPINGEMENT COOLING ON CYLINDRICAL SURFACE

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ABSTRACT

Abstract—Jet impingement cooling method is an improved technique used to cool down the equipment and appliances in the industries and plants. This upgraded technique is replacing the old technique method by increasing the heat transfer rate and high efficiency. In this research, air was used as the cooling medium for cooling the equipment that have a curvature surface as most industrial equipment have a cylindrical shape. The objective of this study is to develop computational fluid dynamics model of jet impingement heat transfer on nozzle diameter effect towards curvature surface. The nozzle diameter B/D of 0.013, 0.027, 0.04, 0.053, 0.067 and 0.08 were used with constant Reynold number at 23700. The temperature of the fluid inlet is at 298.15 K and the heat flux, q″ is at 5633 W/m2. CFD simulation was run and using (k-Ɛ) turbulence model. The result is shown and calculated by using Navier-Stokes equation of energy, continuity and momentum equation. The numerical result shows that the turbulence kinetic energy is higher on the surface wall impingement at the larger diameter B/D = 0.08. This is due to the high momentum results from the high velocity gradient along the wall surface. The velocity increase with the increasing of the nozzle diameter which attributes to the higher Nusselt number and surface cooling rate.

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TABLE OF CONTENTS

CHAPTER 1

INRODUCTION

1.0 Research Background

Cooling process of equipment is important to achieve the desired temperature and to reduce runaway that will cause an explosion. There are many applications for these phenomena such as for heating treatment, cooling of electronic components, heating of optical surfaces for defogging, cooling of turbine blade, cooling of critical machinery structures, and other cooling processes involves in plant and industries (N. Zuckerman & Lior, 2006).

The improved cooling technique is important to avoid the sudden temperature rising in the system. Jet impingement technique whether using the air or liquid is one of many methods of cooling that widely used which to provide the desired thermal environment. This research is using the water as the liquid cooling. A directed liquid that strikes from a jet impingement nozzle to a surface enhanced the coefficient for convective heat transfer. There are many types of jet impingement nozzles such as round nozzle, array round nozzles, slot nozzles, array slot nozzles depending whether jet impingement used is single jet or multi jet impingement. This study is focusing on single round nozzle since single jet impingement is being used. Previous researchers did an experiment mainly towards a flat surface. However, since the existing of evolving equipment and cooling process in the industries such as for cooling the turbine blade, the flat plate is no longer suitable for the studies (G. Yang, Choi, & Lee, 1999). Thus, the study on curvature surface is important to differentiate the phenomena of flat surface and curvature surface and to investigate the effect of curvature effect on heat transfer rate of jet impingement.

There are various parameters effect the jet impingement performance which include Nusselt number, Reynold number, nozzle diameter, height of jet, and surface curvature. Parameter that will be used in this experiment is nozzle diameter. The variation of diameter is used and studied to indicate the suitable measurement and choosing the right diameter to enhance the cooling rate of cylindrical surface. Reynolds number also needs to be considered in this study to determine the Nusselt number which will affect the transfer rate.