CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Impingement heat transfer is considered as a promising heat transfer enhancement technique. Among all convection heat transfer enhancement methods, it provides significantly high local heat transfer coefficient. At the surface where a large amount of heat is to be removed /addition, this technique can be employed directly through very simple design involving a plenum chamber and orifices. For instance, in gas turbine cooling, jet impingement heat transfer is suitable for the leading edge of a rotor airfoil, where the thermal load is highest and a thicker cross-section enables accommodation of a coolant plenum and impingement holes. This technique is also employed in turbine guide vanes (stators). Other applications for jet impingement could be combustor chamber wall, steam generators, ion thrusters, tempering of glass, electronic devices cooling and paper drying, etc.

Jet impingement cooling (or heating as well) is a very effective heat transfer mechanism. The main reason is that jet impingement flow forms a very thin boundary layer, as shown in the top plot in Figure 1.1. 'Impingement' means 'collision' that the coolant flow collides into the target surface and guarantees a thin stagnant boundary layer at the stagnant core for cold coolant contacting the hot surface without damping. The bottom plot in Figure 1.1 shows that the heat transfer coefficient decays as radius increases except that a second peak occurs when jet is close enough to target surface (small z).

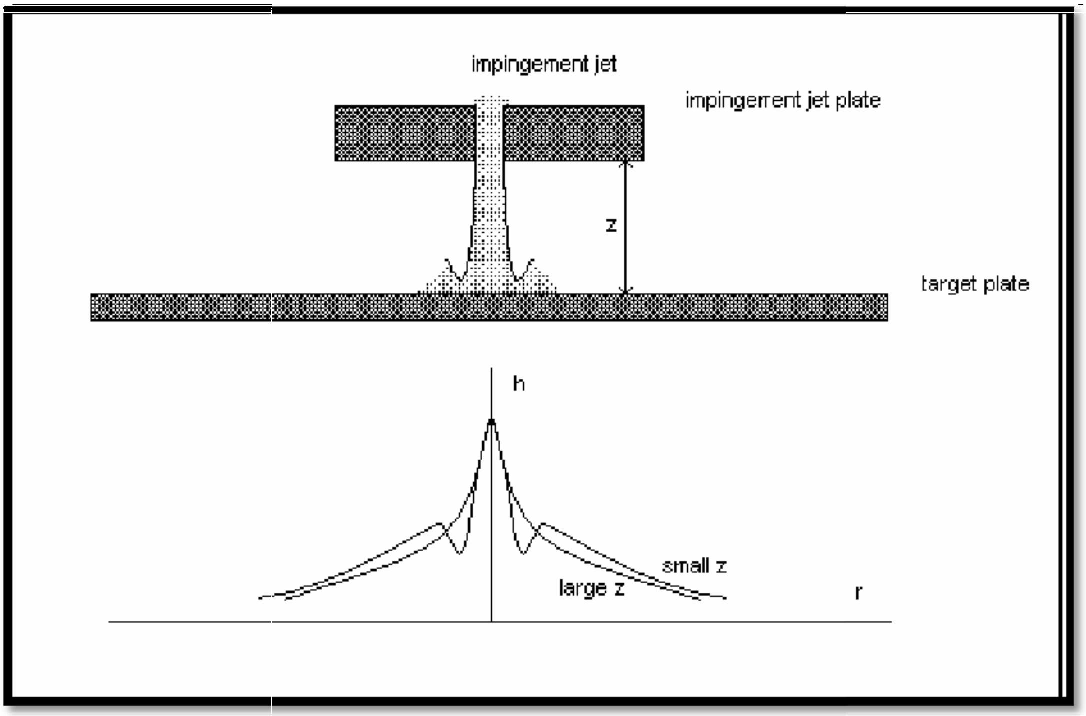

Figure 1.1: Jet impingement heat transfer mechanism

Source: Osama M. A. Al-aqal, (1999).

1.2 PROBLEM STATEMENT

A wealth of information exists on the basic cases on individual and array jet impingement heat transfer. This information is widely used within the gas turbine design community for applicable impingement configuration and flow parameters. However, lately, newer and more specific cases of cooling design require additional information to account for affect on the impingement heat transfer of film coolant extraction, prefilm impingement chamber, compartmentalized or zonal impingement, roughened target surfaces, and confined impingement within various wall structures. The present study is undertaken to investigate the effects of nozzle diameter on impinging jet heat transfer and fluid flow. Nusselt numbers are determined for a submerged air jet issuing from a long straight nozzle. Of interest in such geometry is the heat transfer on the target surface or impingement wall. In integral structures of airfoils, end walls, or liners, the total heat transfer distribution is important to the proper assessment of thermal mechanical loading in the component.

1.3 PROJECT OBJECTIVES

Experimental studies of an impingement jet cooling system. The primary objectives are:

- To study about the effect of nozzle diameter on the jet impingement cooling.
- To define the relationship between the heat transfer coefficient, h with the Reynolds number, Re and the distance from end nozzle to the heat source, S.

1.4 PROJECT SCOPES

This experimental study was carried out using air as the coolant medium that impinge with laminar flow region from the nozzles to the heat source which has Reynolds number in the range of 500 – 2300 (500, 950, 1960, and 2300). The diameter of nozzle was varies for the purpose of this study by use three different diameter of nozzle, started with 0.5cm,1.0cm and 2.0cm. The heat source will be at constant temperature with 100°C which used steel as the material and had dimensions (12 x 12 x 0.8) cm with 6.5cm diameter impingement region. But the nozzle length is constant for this case with 50cm and the material of nozzle is PVC (diameter-2.0cm) and the other of the diameter use vinyl as a material. The dimensionless parameter that was defined in this study is diameter ratio, *D/d* (3.25, 6.5, and 13) and the dimensionless jet to heat spacing, *S/d* (6, 8, 10, and 12). Then, the temperature effect is measured on the heat source plate by using Non-contact Thermometer by pointing on the heat source plate point prepared. The nozzle jet impingement was designed and fabricated with the appropriate dimension (diameter and length) of nozzle.