CHAPTER 1
INTRODUCTION

1.1 Introduction

Currently, refrigeration and air-conditioning systems are regarded as one of the major form of energy consumption for domestic, commercial, and industrial sectors. The need have been continuously increased over the past decades. This is because they an play important role in human life. The most widely used refrigeration cycle is a vapour-compression cycle in which a mechanical compressor is used to elevate the refrigerant pressure. The compressor is the part that highly consumes energy, mostly in the form of electrical energy. This means that the fossil fuel must be burned increasingly in order to support the energy demand. This also brings about the production of large amount of green house gas (GHG) emission. Therefore, the refrigeration and air-conditioning may be considered as a problem of the global warming.

At present, the other forms of energy or renewable energy are being promoted in order to reduce the GHG emission. To respond this promotion, heat-powered refrigeration cycle is one of alternative systems to be introduced. Heat-powered refrigeration cycle is a refrigeration cycle which requires energy input in the form of thermal energy in the range between 100°C and 200°C to drive the cycle. Thermal energy in this temperature range is normally available as waste heat from industrial processes or from renewable source such as biomass, geothermal, or solar energy.

There are two well-known types of heat-powered refrigeration cycles: *an absorption refrigeration cycle* and *a jet refrigeration cycle*. Even though, the absorption refrigeration systems provide a better coefficient of performance (COP), the jet refrigeration is preferred by some researchers. The jet refrigeration cycle is relatively simple to design, construct, and operate. It can use only single-component working fluid (refrigerant only). Moreover, the jet refrigeration cycle is the only refrigeration cycle that can use water, the most environmentally friendly and cheapest fluid, as the refrigerant (for a steam jet refrigeration system). Therefore, at present, the jet refrigeration cycle becomes the distinctive appliance in order to utilize the thermal energy to produce useful refrigeration. However, the main disadvantage of the jet refrigeration cycle is its relatively low COP compared with others type of refrigeration. If this disadvantage is eliminated, the jet refrigeration system may become more preferable to the others type of refrigeration cycle.

A schematic diagram of a steam jet refrigeration cycle is shown in figure 1.1 (more detail will be provided in the next chapter). In this system, the refrigeration effect is produced by evaporating the liquid refrigerant at low temperature and low pressure at the evaporator. In order to reuse this refrigerant, the pressure of the evaporated low pressure refrigerant is elevated to a higher pressure. The high pressure refrigerant vapour is then cooled at the surrounding temperature and condensed to liquid. This is very similar to that in a commonly used vapour compression refrigeration cycle. Unless, the mechanical compressor used in a vapour compression refrigeration cycle is replaced by the boiler, the ejector, and the liquid pump for the steam jet refrigeration cycle.

In this steam jet refrigeration cycle, the ejector is regard as a critical component because it is a driving-part of the cycle. From the available literature [2, 3 and 4], it was found that the coefficient of performance (COP) of jet refrigeration cycle is strongly dependent on the ejector equipped. Therefore, many researchers in this field of refrigeration have been emphasized on the improvement of ejector.

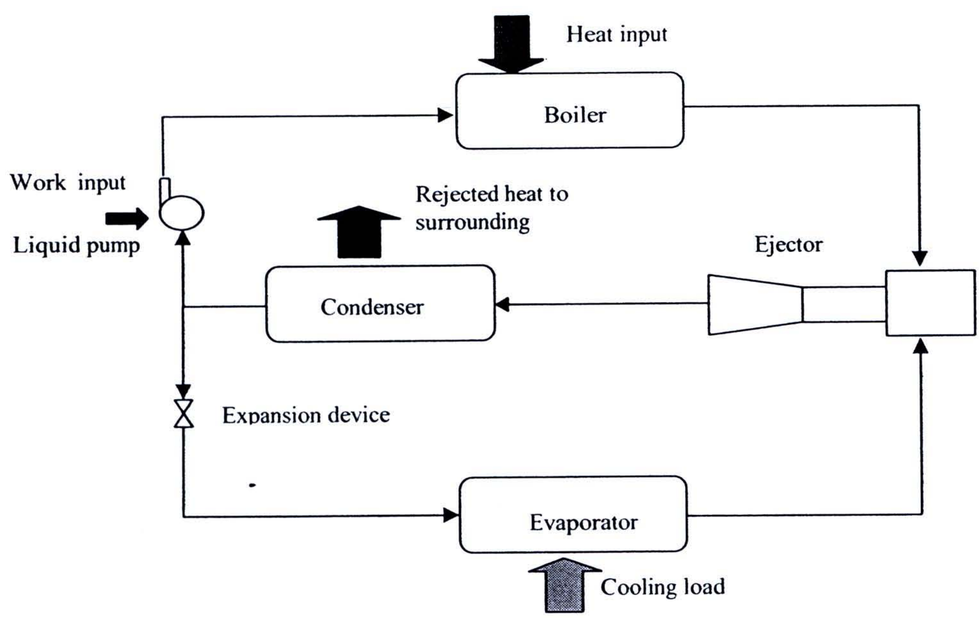

Figure 1.1: The schematic diagram of jet refrigeration cycle.

To improve the performance of the ejector, an understanding of the flow behavior inside the ejector is first considered. Currently, due to rapid development of the computational fluid dynamics (CFD technique), many commercial software packages are created. This CFD software package can provide an adequate mathematical model for supersonic flow field inside the ejector. In addition, the flow behavior inside the ejector can be presented graphically by CFD technique. This helps the researcher to understand the flow behavior and mixing process which is useful in order to improve and analyze the performance of ejector. In the past decade, several researchers used the CFD technique in the filed of ejector's improvement.

1.2 The main objective

The aim of this study is to investigate the performance of an ejector used in a steam jet refrigeration system. In this study, the interested parameters consisted of ejector's operating condition (boiler saturation temperature, evaporator saturation temperature, and condenser pressure) and the primary nozzle's throat size. The entrainment ratio and the critical condenser pressure were used to indicate the ejector performance. The ejector was investigated experimentally and numerically (using CFD technique).

In the experimental part, an experimental steam jet refrigerator was used and tested with the boiler temperatures of 130, 140 and 150°C, the evaporator temperature of 5, 7.5, and 10°C. Three primary nozzles with throat diameter of 1.4, 1.7, and 2.0 mm were used. The condenser pressure was varied until the ejector failed to operate.

In the numerical part (CFD technique), a commercial CFD software package, Gambit 2.3 was used to create a physical model of the experimental ejector. Meanwhile, a commercial software package code FLUENT 6.3 was used to apply the mathematical model of the tested ejector. Two turbulence viscosity models provided by FLUENT 6.3 were used to govern the turbulence characteristic which was suitable with supersonic flow field. The simulated results were validated with experimental values in order to ensure that the simulated results were creditable. The filled contour of Mach number from simulation was employed to explain the flow behavior and mixing process. It was found that the CFD model developed was able to predict the performance accurately and could be used to efficiently explain the flowing process inside the steam ejector.

1.3 Organization of the Thesis

This thesis is composed of 7 Chapters. The concerned background theory and literature review are provided in Chapter II. In Chapter III, the details of the experimental steam jet refrigerator and its instrumentation are given. In Chapter IV, the introduction of CFD technique is proposed. The detail of creating the physical model, grid structure and solver set up are also described. In Chapter V, the validations of the simulated results with experimental results are presented. In this case, the entrainment ratio and the critical condenser pressure are considered as the performance of ejector. Overall, it can be concluded that the CFD technique provides quite a high proficiency in predicting the ejector's performance. In Chapter VI, the filled contour of Mach number which represents the flow behavior inside the ejector is presented. This will be used to describe the occurred phenomenon and mixing process inside the ejector in Chapter VII. In Chapter VII, the effects of interested parameters are discussed by the filled contour of Mach number. The background from Chapter VI is employed to discuss and to analyze. In the last chapter of this thesis, Chapter VIII, the conclusions and the recommendations for the future study are proposed.