Chapter 5
Ejection Refrigeration Cycles

Dariusz Józef Butrymowicz
Białystok University of Technology, Poland

Kamil Leszek Śmierciew
Białystok University of Technology, Poland

Jerzy Gagan
Białystok University of Technology, Poland

Jarosław Karwacki
Institute of Fluid-Flow Machinery of PASc, Poland

ABSTRACT

The chapter presents the development of ejector refrigeration technology that strongly reduces the greenhouse gas emissions by using natural refrigerants and also dramatically reduces the need for the electric power. This is accomplished by using free or inexpensive heat – either solar or waste heat, as the main source of energy instead of electricity. Nowadays, the thermal driven refrigeration system, especially with low-temperature heat source became more and more popular. The operation of the ejection cycle using low-temperature heat source can be considered as very attractive and the ejection cycles becomes truly competitive in comparison with the absorption refrigeration systems.

INTRODUCTION

An ejection refrigeration systems are a novel approach to the vapour compression cycle for air-conditioning in buildings or even in mobile applications. The specific innovation in the ejection air-conditioning system that:

- Utilizes natural refrigerants and therefore operates without any ozone depletion effects;
- Utilizes the solar or waste heat energy as a main source of energy;
- Eliminates a mechanical compressor, which is a main user of electricity.

While similar systems were proposed in the past (but mostly with CFC or HCFC refrigerants), none of them has ever emerged as a commercial product, mainly due to difficulties in matching the ejector geometry to the specific thermodynamic cycle. By eliminating the mechanical compressor from a cycle, the ejection system has the potential of providing the same amount of refrigeration (cooling capacity) with using only a fraction of electrical energy (for a pump only) as compared to conventional vapour

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compression systems. This is due to a thermodynamic principle that compressing the liquid requires substantially less work than compressing vapour. Less electricity results in a considerable reduction in emission of carbon dioxide and other greenhouse gases. Additionally, by using the natural refrigerants we are completely eliminating ozone layer depletion effect.

The schematic diagram of the ejection system is shown in Figure 1.

Momentum transfer from motive vapour (primary fluid) to vapour leaving the evaporator is the basis of functioning an ejector. The motive vapour passing through the nozzle undergoes expanding and achieves large velocities. Expanded and the sped up driving vapour sucks vapour leaving the evaporator, thanks to the momentum exchange between primary and secondary streams. Momentum transfer of motive vapour flowing from the generator is the driving force of ejection process. Therefore heat supplied to the vapour generator is motive energy source for the discussed system.

The current direction in research in the area of refrigeration concentrates on decreasing and/or elimination of adverse environmental effects. Refrigeration systems are the source of two types of pollution: ozone-depletion from chlorofluorocarbon refrigerants and greenhouse gas emission from electricity production. This creates the urgent need to replace the conventional refrigerants with environment-friendly working fluids as well as applying renewable and non-polluting energies to run these systems. Approximately 15% of the world electrical consumption is used for refrigeration and air-conditioning applications, and additionally, the demand for air-conditioning is proportional to solar radiation. Therefore the utilization of solar energy is a logical way to meet the increasing demand for cooling and consequently, much research has been conducted on this subject in recent years but it was concentrated on the absorption cycle. Unfortunately, current absorption systems have low efficiency and require high temperatures to regenerate the refrigerant, usually not achievable with presently used flat panel solar collectors.

There are limited available literature where experimental or numerical results of ejection cooling cycles are presented. From the practical point of view COP is the crucial parameter describing the ejection cooling device. The basic feature of the ejection refrigeration systems is relatively low value of COP in comparison with classical vapour compression systems. COP strongly depends on the working fluid and operating parameters, i.e. condensation pressure, evaporation pressure, and vapour generation pressure. Selection of the working fluid for the refrigeration or air-conditioning system is the crucial

Figure 1. Schematic diagram of ejector solar air-conditioning system