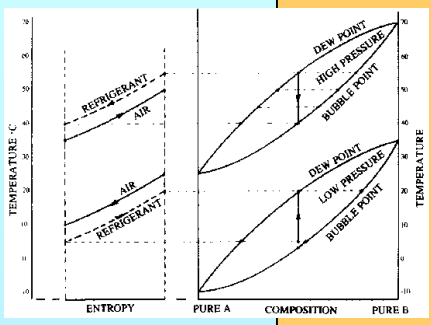
MSc in Energy - Tsipras Evangelos

" Use of zeotropic working fluid mixtures to improve the performance of heat pumps in district heating applications"

Aims and Objectives

The aim of this project is to examine the contribution of zeotropic mixtures when used as working fluids in heat pump systems. Specifically, the improvement on the performance of heat pumps in district heating applications that zeotropic refrigerant mixtures occur are thoroughly discussed.

In order to achieve this aim, a set of **objectives** has been established, as follows:



- Introduction of the thermodynamic and environmental advantages that zeotropic mixtures offer compared with single component (azeotropic mixtures) refrigerants.
- Find out applications of heat pumps in district heating where the use of zeotropic mixtures improves the total system performance. This leads to the acceptance that zeotropic mixtures are energy advantageous.
- Estimation of the coefficient of performance (COP) for these increased performanced applications.
- Comparison of the different zeotropic mixture's COP's for these specific applications.
- Suggestion of the most suitable zeotropic mixtures for the heat pump applications referred.

Methodology

The methodology which will be followed in order to achieve both a successful focus of the subject and a right timescale schedule is presented below:

Firstly, the analysis of the topic is of essential importance. As the project has already been chosen, it is very important to meet the supervisor. This would be very beneficial in order to understand as better as it gets the dissertation's subject as well as the demands that are required.

The second stage includes the Literature searching. The student is required to search books, articles and other knowledge sources such as journals, dissertations and internet sites.

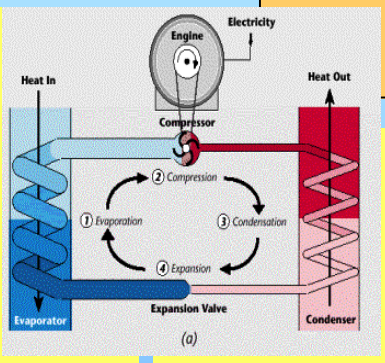
After the search of the Literature, the analysis of the collected material which includes the first reading process is definitely necessary. At this point, the classic theory and the basic principles of heat pumping have already been read and a further specific search about the zeotropic mixtures that are used in heat pump applications is of great importance too.

The critical reading is the next stage. We must study the thermodynamic properties that zeotropic mixtures offer in heat pump systems. By this process, we are able to estimate the increased coefficient of performance that provoke on heat pump systems. Comparison between different zeotropic working fluid mixtures will help us to estimate the total improvement of the systems. As a result of that, the ability to suggest the most suitable refrigerant mixture for the applications that will be examined comes true.

After the inferences which will be extracted, the next stage of the dissertation plan is the total evaluation of both the Literature collected material and the results of the calculations that were made in order to start the writing process.

Background

A book, in which the whole Heat Pump Theory is presented, is titled *'Heat Pumps'*. In this significant knowledge material, the writers, D.A. Reay and D.B.A. Macmichael [1], present the history of the Heat Pump technology and its development during the decades. Moreover, D.A. Reay and D.B.A. Macmichael [1] present Pressure-Enthalpy diagrams of some important refrigerants in order to analyze the thermodynamic and environmental properties of them.

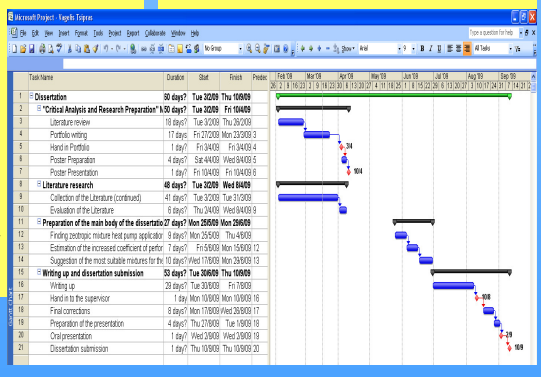


Park, Shim and Jung [2] made a comparison between two refrigerants in order to present which of them has better performance in residential heat pump applications. They tested the R22 refrigerant with the azeotropic mixture R432A [2]. The results showed that the heat pump which used the R432A refrigerant had a rise (8.7%) in the term of coefficient of performance compared to R22 heat pump system.

Leelananda Rajapaksha [3] studied the influence of a special attribute (temperature glide) on the design and operation of heat pump systems. Refrigerant mixtures with significant temperature glide (about 5^0C or larger) can improve the performance and energy efficiency of a heat pump system.

A study related to the temperature method of selecting working fluids investigated by P.C. Zhao, L. Zhao, Ding and Zhang [4]. This study introduces the temperature-matching method of selecting working fluids for a geothermal heat pump and it is shown from the results that this method contributes to energy saving [4]. The coefficients of performance of binary and ternary high-performance mixtures find to be 4.85 and 4.74 respectively while of pure refrigerants was 4.12 under the same ambient conditions [4].

A. Bensafi and G.G. Haselden [5], in their study, made a comparison between different refrigerants in order to estimate if power saving can achieved in air conditioning and heat pump systems. Indeed, the test took place in a laboratory where an R22/R142b mixture was compared with a conventional R22 system. The results were noticeable and shown that a heat pump which uses a refrigerant mixture whose temperature glide in the condenser and evaporator matches the temperature intervals through which air is heated and cooled can achieve power savings as high as 25% compared with the R22 system [5].



Outcomes

The fundamental subject of this project will be the study of the heat pumps, in district heating applications where the use of the modern refrigerant mixtures leads to an increased coefficient of performance. Indeed, these zeotropic mixtures due to the thermodynamic properties (like temperature glide) that they provide, contribute not only to a more efficient but also to an environmental friendly system with reduced energy consumption heat pump operation. In addition, in the dissertation, a comparison between refrigerants was carried out in order to test their ability in terms of improvement the system's performance. The estimation of the increased COP is of great importance and absolutely required for the selection of the appropriate working fluid mixture for the examined applications.

References

[1]. Reay D.A., Macmichael D.B.A., (1988), Heat Pumps 2nd ed. Oxford, Pergamon Press.

[2]. Park Ki-Jung, Shim Yun-Bo, Jung Dongsoo, (2009), Experimental performance of R432A to replace R22 in residential air-conditioners and heat pumps, Applied Thermal Engineering 29 p.597–600.

[3]. Rajapaksha Leelananda, (2007), Influence of special attributes of zeotropic refrigerant mixtures on design and operation of vapour compression refrigeration and heat pump systems, Energy Conversion and Management 48 p.539-545.

[4]. Zhao P.C., Ding G.L., Zhang C.L., Zhao L.,(2003),Temperature matching method of selecting working fluids for geothermal heat pumps, Applied Thermal Engineering 23 p.179-195.

[5]. Bensafi A., Haselden G.G., (1993), Wide-boiling refrigerant mixtures for energy saving, Rev. Int. Froid, 17 (7).