Thermodynamic Modeling of Vapor Absorption Cycle-An Overview

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Keeping in view the scope and wide range applications of cooling systems and refrigeration cycles, there has always been a dire need of developing economic and efficient cooling systems. In this regard, current research paper provides an overview of how the optimization of vapor absorption cycle-the most economic refrigeration cycle-can be carried out and suggests the means of its thermodynamic modeling for obtaining its better output. This will lead to accomplishing the target of providing an economic and efficient method of producing refrigeration effect.

Keywords
Cooling Effect, Vapor Absorption Refrigeration Cycle, Thermodynamic Modeling.

1. Introduction

Today, cooling (refrigeration) systems have gained vital importance in engineering arenas due to their wide range applications in industrial sectors, especially thermal power plants. [**Mali et al. 2013], [Xu and Wang, 2014**]. It is also pertinent to mention that out of all the refrigeration systems currently in practice at above mentioned engineering zones, the scientific community prefers those which are highly economic and reasonably friendly towards environment [**Young et al. 2015**]. Therefore, keeping the above mentioned context in view, Vapor Absorption Refrigeration Systems (VARSs), ranging from small to large scale [**Güido et al**. **2018], [Jayasekara and Halgamuge, 2014**], being economic [**Lethwala et al. 2018**]and eco-friendly amongst all the other refrigeration systems, absolutely meets the said demand criteria [**Sharma et al. 2012], [Srikhirin and Aphornratana, 2001] - [Xu at el. 2013**].

A Vapor Absorption Refrigeration Cycle consists of evaporator, absorber, generator and condenser [**Srikhirin et al. 2001**]. The refrigerant flows out of the evaporator and goes into the absorber. Inside absorber, the absorbent forms a solution by mixing with the refrigerant. This solution enters into the regenerator. The regenerator increases the temperature of the solution. At this point, the solution is rich in refrigerant and hence is called strong solution. This strong solution enters into the generator where it is heated so as to attain the temperature of the condenser. The refrigerant and absorbent are separated by means of a rectifier which is paired with the generator. The absorbent now flows out of the rectifier and enters again into the regenerator to increase the temperature of refrigerant-absorbent solution, entering into the generator, when the cycle is repeated. On the other hand, the refrigerant from the rectifier now passes into the condenser where its temperature decreases. In this way, each cycle of a vapor absorption refrigeration system is completed [**Fan Y. et al. 2007**]. A VARS is shown in Figure 1.

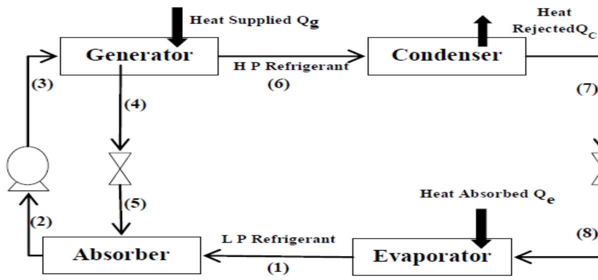

Figure 1**: A** simple vapor absorption refrigeration cycle [16].

However, besides all the merits and pros of VARSs as mentioned above, the biggest demerit of VARS is their low Coefficient of Performance (COP), as compared to other refrigeration systems [**Cengel and Boles, 2015**], [**Kaushik and Singh, 2014**], as shown in Figure 2.

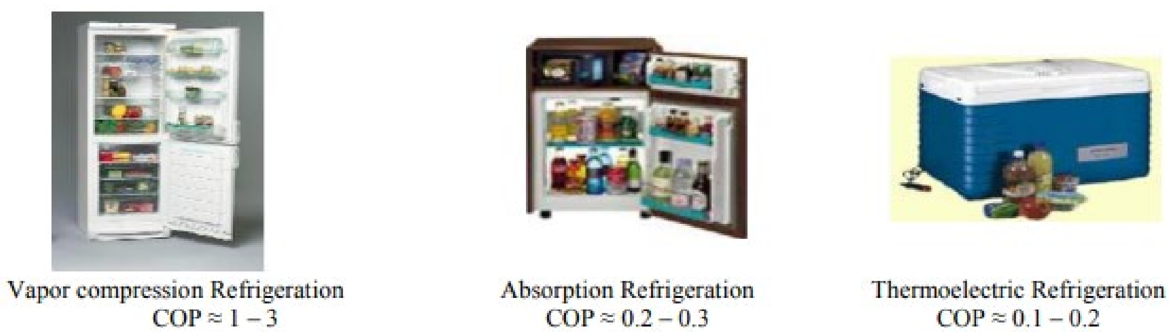

Figure 2: COP of different refrigeration systems [**Eng. Naser R.M. and Al-Ajmi, 2015**], [**Taib M.Y. et al. 2010**]

Nevertheless, there have been so many measures proposed till date for the performance/COP improvement of VARSs such as parametric study of a VARS [**Patrick and Marri, 2018**], employing a solar tracking system added with stepper motor and solar tracking system [**Ingle and Navadagi, 2015**], using triple pressure level [**Sözen and Özalp, 2003**], and Mathematical modeling, after design modifications of a simple Vapor Absorption Refrigeration System [**Kaushik and Singh S., 2015**], [**Xie et al., 2006**]. Off all the methods mentioned above and others employed for the purpose of raising the COP of VARS, thermodynamic modeling is preferably presented in this research paper.

2. Thermodynamic Modeling of Vapor Absorption Refrigeration System

Thermodynamic modeling of a Vapor Absorption Refrigeration System have been developed using various approaches in the past, including using Visual Programming Language [**Kaynakli, 2014**], Linear Mathematical Modeling [**Micallef D. and Micallef C., 2010**], Matlab based Simulations [**Priyank, 2013**], Two Stage Vapor Compression-Absorption Refrigeration System [**Patel et al. 2016**], and First and Second Law Thermodynamic Analysis [**Kaynakli O. and Yamankaradeniz, 2007**].

In this research study, the thermodynamic model of a single stage Vapor Absorption Refrigeration Cycle has been developed using software called "Engineering Equation Solver (EES)". The software, viz EES, was preferred due to its inbuilt feature of solving non linear

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equations simultaneously. The software also facilitates the user to by offering thermodynamic and transport databank of wide range of substances, including fluids and refrigerants as example [**Klein and Alvarado, 2000**], [**Lebrun, 2001**].
The thermodynamic model has been developed for a Vapor Absorption Cycle installed at a 880 MW Thermal Power Station (TPS), Jamshoro, Sindh, Pakistan. Figure 3 shows the data obtained from the said power station.

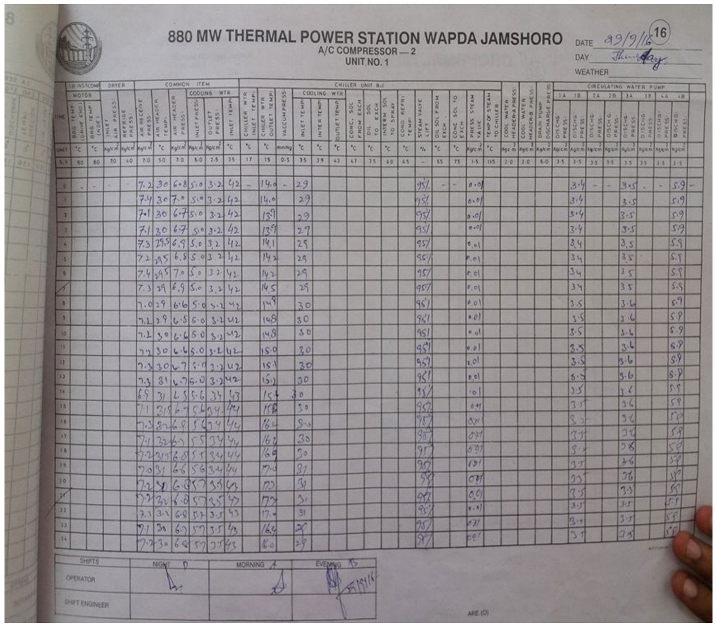

Figure 3: Chart showing values of Temperature, Pressure, Mass Flow Rate and other Variables at VARS, TPS, Jamshoro, Sindh, Pakistan

The values in the chart provided in Figure 2 were used to develop a thermodynamic model which is as shown in Figure 4.

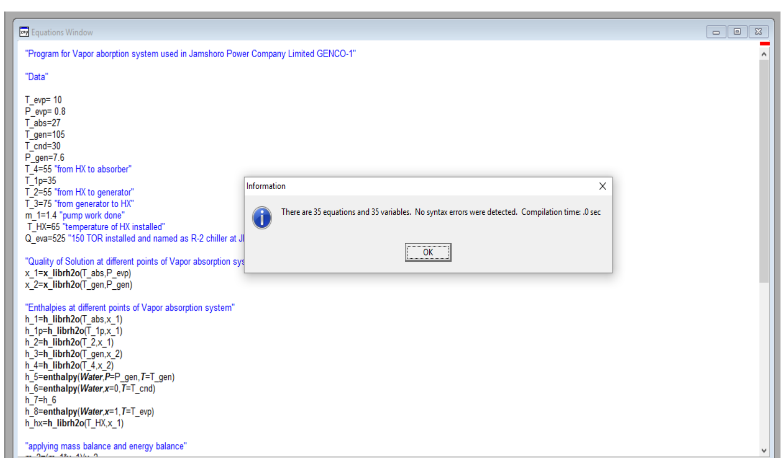

Figure 4: Thermodynamic Model of VARS, TPS, Jamshoro, Sindh, Pakistan, developed using EES

The thermodynamic model developed using EES, as shown in Figure 4, involved thirty-five (35) numbers of equations and thirty-five (35) numbers of variables. It was developed using the energy and mass balance equations, applied to each component of the VARS, TPS, Jamshoro, Sindh, Pakistan. The model was validated using the same software, viz EES. The validation results are clearly depicted in Figure 4. As shown by Figure 4, no errors in the thermodynamic model were detected.

Conclusion

This research paper presents the idea of thermodynamic modeling of Vapor Absorption Refrigeration Systems (VARSs) for improving their Coefficient of Performances (COP). The endeavor has been accomplished in previous research papers as well. However, this research paper offers a new approach for the development of thermodynamic model of a VARS and that is by using software called Engineering Equation Solver (EES). The model of a VAR developed using EES can be put to a parametric analysis which would help in suggesting design modifications in a VARS for the improvement of its COP.

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