Theoretical Study of the novel control strategy of Hybrid Solar Air Conditioning System

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Abstract— **In this paper, a theoretical study of the thermal performance for hybrid solar air conditioning system was presented to investigate the system performance and suitability for the hot climate with a new control system strategy. The system consists of a vapor compression unit combined with evacuated tubes solar collector and water storage tank. A three-way valve is controlled by a proportional integral derivative (PID) controller to regulate the 3-way valve opening towards the solar system to achieve the minimum temperature of refrigerant leaving the condenser (degree of subcooled), in order to enhance the overall COP of the unit. The governing thermal equations concerning the hybrid solar air conditioning system was applied and solved using engineering equation solver (EES) Software. The results showed that the compression ratio of the uncontrolled hybrid solar system is lower than the compression ratio of the conventional one by 5 %, and this ratio could be increased to 28 % when the control system has been used. Also, the minimum value of the power consumption is 830 W at R=0.1 and T_{amb} =45 °C, while the maximum value is 994 W at R=1 for the same conditions. The power consumption of the uncontrolled system is lower than the power consumption of the conventional one by 7 % and increases to 23 % by using the control system. An acceptable agreement can be achieved when validating the theoretical model results with experimental results.**

Keywords— Hybrid; solar air-conditioning; PID controller; EES Software

I. INTRODUCTION

Heating, ventilation and air conditioning (HVAC) system are liable for more than 50% of the total energy consumption in the building. Which led to demand of fossil fuel and the main causes of the greenhouse gases and ozone layer depletion (ODP) [1].

The demand of A/C systems has been increased in last few years, due to the requirements for better comfort conditions inside buildings, the greenhouse effect of the world and global warming potential (GWP). This has led to a dramatically increased in use of air conditioning systems based on traditional vapor compression technology, therefore significant expanded of energy consumption in summer season, and frequently the upper limits of electric system capacity could be reach [2].

Comparing with conventional energy solar energy has many advantages, such as cleanness and cheapness, and simplicity. Recently decision-makers, governors, and engineers have become interested in solar energy systems. There are a wide range of solar collecting systems, like flat plate type, double tube vacuum type, concentrated type, heat pipe type, etc. have been available in market. It is appreciated that this source of energy can at best be complementary rather than being competitive with conventional energy sources [3].

Mustafa (2006) [4] analyzed and studied the effect of outdoor air temperatures on the instrumented air-conditioner unit performance. The main program was formulated in FORTRAN language to simulate a vapor-compression refrigeration cycle with a real condensing and evaporating temperatures. R134a was used as a refrigerant

Saaed (2006)[5] developed a computer program to study and simulate the working and performance of an air conditioning system, two types of refrigerant R-22 and R-407C were used. The effect of varying design parameters of Plate-Fin-and-Tube heat exchanger working as a condenser and direct expansion evaporator was covered. Loss and efficiency model were used to simulate the compressor, an element by element scheme was used to simulate the condenser, evaporator and capillary tube. The variation in air side heat transfer coefficient and air temperature from row to row was considered. The studied parameters were facing air velocity over condenser, evaporator and degree of superheat of refrigerant, tube diameter, transverse tube spacing, longitudinal tube spacing and fins per inch. The test showed a good agreement with the theoretical program for different ambient temperatures, and the maximum deviation in COP was 7.1 %. The theoretical results exhibited that the COP for the system of R-407C was less by (5% - 20%) of that of R-22 for the range of ambient temperature of (35-47 °C), respectively.

Khalifa et al. (2017) [6]focused on the condenser design to find an optimum air conditioning unit at the lowest cost