A Review on A Two-Door Frost-Free Refrigerator Subjected to Periodic Door Opening and Evaporator Frosting

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Abstract— An evaporator is mainly used in different application like used in food and beverage industry, in the pharmaceutical industry, one of the most important applications of evaporation is in the Air-conditioning system. Refrigerator-freezers energy consumption is greatly affected by room temperature, door opening and thermostat setting position. Two frost free household refrigerator freezers of the same capacity were tested in the laboratory to determine the sensitivity of their energy consumption to various usage conditions. Purpose of this Review paper is to assess some aspects of the design of evaporator and get the maximum heat transfer rate, pressure drop and efficiency

Key words: Heat transfer, Refrigeration, evaporator frosting, Emission

I. INTRODUCTION

Evaporation is an operation used to remove a liquid from a solution, suspension or emission by billing off a portion of the liquid.Refrigeration is an enabling technology in a wide range of applications from air conditioning for occupant comfort to freezing as required in food preservation. Evaporators are the critical component responsible for extracting heat from conditioned spaces or processes.

Modern refrigerator design is aimed at energy savings and also at product robustness in relation to evaporator frosting. In this regard, standardized tests as well as tests under real usage conditions, that is, with doors opened regularly allowing moisture to enter the refrigerated compartment and frost to accumulate on the evaporator are procedures commonly carried out by most manufacturers. Nevertheless, since the experimental procedures for frost-free refrigerators and freezers are costly and time consuming simulation models have been devised to improve the product development process. None of them, however, can predict the refrigerator performance degradation due to periodic door opening and consequent evaporator frosting.

Recently, some researcher put forward a transient simulation model that is suitable to predict the time evolution of the compartment air temperature and the power consumption taking into account the door opening, and the resulting evaporator frosting.

II. LITERATURE SURVEY

This paper presents the detailed literature review on a two-door frost-free Refrigerator subjected to Periodic door opening and evaporator frosting. Finally, this paper concludes with the scope of the present work.

According to B. Gin et al. [1] the application of PCM into a freezer has beneficial effects in minimizing temperature variations inside the freezer. Analysis of the performance during defrosting has shown that PCM helps to limit the peak air and product temperatures reached (respectively 2.9 0C and 10C lower with PCM) with a defrost cycle of 30 min. The positive effect of the PCM limiting the rate of temperature increase in the freezer is seen during defrosting and power loss because the PCM provides the major source of cooling when the compressor is ‘‘OFF”.

Energy consumption tests have shown that heat loads resulting from door openings and defrost cycles increase the energy consumption of the freezer by 11–17% and 15–21% respectively. The inclusion of PCM into the freezer has decreased the energy consumption during a defrost cycle by 8%, and by 7% during door openings for this system.

M. Hasanuzzaman et al. [2] have been researched the increase in energy consumption due to heat transfer was about 53% higher when the variables were set to their maximum values than for their minimum values, and 71% of this transfer occurred through the walls and doors, which shows the significant influence of operating variables. The load and ambient tempera- ture had a greater impact on energy consumption than the other variables. These findings are important since refrigerators consume about 26% of household energy, and they have implications for both national energy usage and environmental impact.

Xiangzhao Meng et al. [3] the experimental research on the air flow characters of the supply-air openings in a transparent BCD-190W type household frost-free refrigerator model was carried out based on the similitude theory. The experiment results indicate that DPIV technology used for the model experiment could overcome the difficulty on measuring the flow field in the prototype refrigerator, and the accurate air flow performance at the supply-air openings were obtained. The measurement results show that all the supply-air openings in this refrigerator should be improved.

Y. Yusufoglu et al. [4] Performance of two types of refrigerators were investigated, using different PCMs developed for this study. The evaporator and condenser temperatures were increased in the order of 2 to 4°C for all PCMs. Compressor on/off times were optimized. The best savings achieved for refrigerator 1 and refrigerator 2 were 8.8 % and 9.4%, respectively.

Shuqing Wang et al. [5] Intelligent thawing household refrigerator avoids the quick thawing destroying the taste and nutrients of frozen foods. It's very convenient that frozen foods are thawed automatically at the user's appointment. Due to design of multiple independent insulation freezers and cooling capacity of freezers flowing into the crisper, intelligent thawing household refrigerator saves energy compared with normal one.

According to A.C. Marques et al. [6] the compressor performance analysis demonstrated that in general, larger compressors are more efficient, with isentropic efficiency increasing by 50% as the displacement

increased from 4 to 8 cm3. An energy reduction of 19.5% was predicted for the static refrigerator by replacing the 4 cm3 with an 8 cm3 compressor, for continuous operation. However, in a conventional refrigerator a larger compressor would result in more on/off cycling reducing the efficiency. The method proposed to exploit the superior performance i.e. efficiency, of larger compressors is to accumulate their excess cooling capacity in a PCM increasing the refrigerator autonomy i.e. off-cycle period, without power supply, from a few minutes to several hours.

Der-Yeong Liu et al. [7] as the door of HRF is opened, the compartment temperature will rise and the energy consumption will also increase simultaneously. Two HRF samples with variable and fixed frequency driving control were tested following some testing standards to reveal the door opening effect on performance of HRFs. The energy consumption was increased with 10% by door opening test procedure. If the door opening time and frequency were increased, the energy consumption would also increase as well. Proper control method can minimize this effect due to door opening.

G. Sonnenrein et al. [8] in this experimental study, a standard wire-and-tube condenser was equipped with different sensible and latent heat storage elements and their impact on power consumption was compared to the corresponding off-the-shelf household refrigerator. The results show a significant impact of heat storage on the condenser temperature and consequently on power consumption.

R. Saidur et al. [9] observed that room temperature has the higher effect on energy consumption, followed by door opening. Thermostat setting position has the lower effect on energy consumption. More detailed tests were performed under different room temperature, thermostat setting position and door opening conditions. With the experimental results, a first order mathematical model has been developed to investigate their combined effect on energy consumption.

R. Mastrullo et al. [10] examined a transient model of a vertical freezer is developed to study the trend of cabinet temperature and of energy consumption with time, taking also into account door openings, air leakage, frost formation and defrost effect. The model is validated with the experimental data, both with in-house data and with data available in the open literature for frost formation. The results are presented with varying operating conditions, such as air temperature, air humidity, frequency of door opening and defrosting.

Bruno N. Borges et al. [11] observed that the model predictions followed closely the experimental trends, with deviations for the working pressures and power consumption not exceeding the 10% thresholds and predictions for the compartment air temperatures being within ±2 C error bands. The model was also used to predict the frost distribution over the evaporator coil and it was observed that the frost accumulates mostly in the first three rows, the third row being crucial in terms of frost clogging because of the higher number of fins and thus lower free flow passage of air.

N.F. Aljuwayhel et al. [12] carried out an experimental analysis has been conducted in order to measure the in situ coil cooling capacity of a large-scale industrial evaporator coil as frost builds up on its surface.

III. Conclusion

The present review paper gives the analysis of a two-door frost-free Refrigerator subjected to Periodic door opening and evaporator frosting. It is concluded that there is wide applicability of finite element analysis and design of experiment method in Evaporator which improve heat transfer rate, pressure drop and better overall efficiency and effectiveness of evaporator.

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