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Survey Paper on Thermal Analysis of Refrigerator Compartment by using CFD

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ABSTRACT: Refrigeration systems are extremely important in daily life, especially in terms of preserving food, health, and comfort. The objective of this project work is to make some effective changes in the design of a conventional refrigerating system so that performance of the evaporator can be optimized. The effects of the normal and perforated fin on the velocity and temperature distribution at different levels. To make a comparative analysis between various cases of with and without the fin refrigerating system. The analysis and modeling through CFD for refrigerators based on diffusion-absorption is presented as a feasible tool for the purpose of evaluating proposals in the internal design of the refrigerator. The present study considers that significant improvements can be achieved on the thermal profiles, by researching an optimal geometric plate-evaporator, in which the airflow is included as a parameter of great importance in the operability of the refrigerator and therefore, in the preservation of food supplies.

KEYWORDS: refrigeration system, refrigerating compartments, shelves, maximum temperatures, boundary conditions.

I. INTRODUCTION

The refrigerator is indeed an innovation that's had a huge effect on our lives. It made it possible for everybody to keep food together for many days. The cool temperature inside of the refrigerator slows the growth of bacteria in food, allowing it to last longer. How is the refrigerator's interior kept cool.

A refrigerator (colloquially refrigerator) is indeed a refrigeration device that consists of even a thermally sealed compartment and a heat pump (mechanical, electrical, or chemical) that moves heat from the air to the outside atmosphere, allowing the interior to be cooled to something like a temperature lower than the ambient temperature. On developing countries, refrigeration is a critical food preservation technique. Since bacteria reproduce at a lower temperature, the refrigerator decreases the rate of decay. The temperature of a refrigerator is maintained a few degrees above the freezing point of water. Temperatures among 3 and 5 ° C (37 and 41 ° F) are useful for keeping perishable foods. [1] A freezer is indeed a related appliance that holds the temperature below the freezing point of water. The microwave, that had been a popular household gadget for nearly a decade and a half, was replaced by the refrigerator.
Refrigeration systems are extremely important in daily life, especially in terms of preserving food, health, and comfort. The basic function of a domestic refrigerator is to preserve the quality of perishable products, and this quality depends on a good refrigerator performance, which is highly linked to temperature distribution and the air flow inside the compartments [2, 3]. For refrigerators based on vapor compression, several studies have been conducted, particularly focusing on the temperature and air flow distribution of the compartments. In the literature we may find works related to the study of the air speed using the Particle Image Velocimeter technique, along with 3D numeric simulations using CFD software [4]. For instance conducted a numeric study of air flow and heat transfer in a natural convection domestic refrigerator. The development of a model for a frost-free refrigerator where they predict and experimentally compare temperature profiles, obtaining a certain discrepancy in their results. In order to improve the temperature uniformity and the air flow in a natural convection refrigerator [5]. Observed that the temperature distribution depends on the internal geometry of the refrigerator, specifically in the spaces between the refrigerator shelves and the liner bottom wall [6,7]. The present a numerical simulation of a forced convection refrigerator concluding that the freezer

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and the fresh food compartment are found in phase (synchronized) with one another. Through simulation the authors proposed a new internal design [8].

II. LITERATURE REVIEW

Söylemez et al. (2021) The computational fluid dynamics (CFD) For just a fresh food compartment of even a domestic refrigerator (DR), a study was undertaken using three separate turbulence models (viscous), to order to obtain an understanding for not just the cooling speed of both the fresh food compartment, but rather the air present as well as the temperature distribution inside the compartment once filled. The refrigerator is divided into three sections: fresh food (FFC), chill (CC), and freezer (FR) (FC). A Thermoelectric / Peltier Cooler (TEC) cool the FFC compartment, whilst the Vapor Compression System manages some other compartments (VC).

Du, X. Fet al. (2021) related to the effects of several other components including the fan, shelf, and plate evaporator The effect of a multi-outlet cover also on flow distributions of an antifreeze chiller are studied in detail using computational fluid dynamics (CFD) techniques in the this paper. The verification of turbulence models including mesh independence measurements was carried by using a CFD 1/2 3-D model, comparing the mass flow obtained from various configurations of both the model. A fine-level mesh is called mesh freedom, and the k-epsilon norm is deemed the much more suitable turbulence model choice.

Wie, Jae Hyuk et al. (2021) established a full numerical methodology which incorporates a porous media technique as well as a heat balancing approach and storage equations that control the flow or temperature fields throughout the top freezer refrigeration device. The numerical simulation has been carried out for real boundary state of the adiabatic wall throughout the presence of a evaporator as well as the multi-duct mechanism and in top freezer refrigeration system and use this numerical technique.

Pavithran et al. (2020) The numerical simulation of a PCM built-in refrigerator was the subject. The findings were predicted using the CFD simulation technique. The goal of this work is to explore the influence of integrating the PCM throughout the refrigerator, and that is why various classification arrangements of both the PCM for refrigerators were produced for such a analysis.

Khalil, Essam et al. (2020) focused on CFD simulation of the thermal performance inside a display cabinet refrigerator, containing a phase change material (PCM) placed at the bottom of each tray of the refrigerator. The PCM used in the present study is one of the organic type PCMs. A transient simulation for the thermal environment inside the refrigerator was carried out over a total period of 30 minutes, in case of that the compressor is in the off state.

Ye, Jianjunet al. (2020) discuss the design and manufacturing of a cylindrical refrigerator with rotating shelves. This design proves to be more efficient in terms of the percentage of useful volume by up to 19.94%. It equips the design with unique features that can improve the refrigerator's efficiency and prove to be more convenient in usage. The model also comprises a bottom-mounted freezer that can enhance its performance compared to the top freezer of conventional design. There is a lot of potential in future developments in this design, which will enhance the vapour compression refrigeration techniques and their use in cooling applications by implementing the optimized design.

Kim, Dong et al. (2020) The increased efficiency of both the refrigerator is investigated using three methods: adjusting the flow channel, working conditions, as well as changing the fan locations throughout the mechanical chamber (MCR) chamber. These methods of adjusting the flow channel in an MCR refrigerator are also used to change the upper flow area of both the condenser in a variety of ways, including in this study.

Söylemez et al. (2019) HHR I, a previously studied hybrid household refrigerator (HHR), was subjected to an experimentally analysis. A CFD test was conducted to analyze the best position and for thermoelectric cooler mounted in HHR I. Two new HHRs, HHR II and III, were developed and experimentally studied as both a result of both the CFD predictions. Besides that, experimental measurements reveal that HHR II and III have a substantial improvement in energy efficiency.

Masudet al. (2019) presented a complete transport model of the drying system using the heat lost from the engine exhaust. Using a laboratory small-scale IC motor exhaust results in the reduction of approximately 1,137.15 kg of CO2 per year that would be produced with a conventional food dryer of the same capacity. Furthermore, the low installation

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cost but payback time make the drying device a viable and cost-effective option. The suggested method also is capable of greatly lowering entropy. As both a result, successful implementation of the this proposed strategy would result in a low-cost, energy-efficient drying device that is also environmentally friendly.

Gao, Jia-Chenet al. (2019), two concept solutions towards enhancing the temperature distribution problem have been presented. Through Computational Fluid Dynamics (CFD) modeling and simulation, the best refrigeration concept was chosen and reviewed. The findings revealed that the temperature distribution within the refrigerator was more constant, which benefited food storage while lowering energy consumption.

Söylemezet al.(2018) Featured Two different hybrid chillers were built and tested, including vapor compression and thermoelectric cooling (TE) technologies. The series chillers was checked first to gather baseline data with comparisons. They used only vapor compression. Instead, in order, thermoelectric coolers (TECs) were attached to separate compartments of the these systems to create hybrid prototypes. Only refrigeration and fresh food compartments of refrigerators used TECs, while the fridge and fresh food compartments did not, those necessitate various temperature capacities Three different criteria were used to measure energy consumption, cooling and freezing power, including noise levels.

Devle, Milindet al.(2018) Emphasize Heat exchange performance is improved when solving two key factors: (1) air bypass and (2) hot air recirculation. One such research focuses on the recirculation of hot air in the system compartment for built-in multi-door refrigerator configurations.

Xiaofeiet al.(2018) presented the noise in the freezer compartment of the frost-free refrigerator, the distribution of the air duct noise and the main frequency are analyzed by using the sound intensity test system. The LES (Large Eddy Simulation) model is used to calculate the unsteady flow field of the air-cooled system and the aerodynamic noise is calculated using the FW-H equation of the acoustic analogy method based on computational fluid dynamics (CFD) method.

Bista, Subhanjanet al.(2018) A analysis of numerous research inquiries into the use of phase change material (PCM) of refrigeration systems is discussed. PCM clearly shows significant effect on the system performance, compressor on/off cycle, and reduced electricity consumption when used primarily throughout vapor compression refrigeration systems.

Ledesmaet al. (2018) The energy consumption of various shelf positions in either a featured household refrigerator was measured. That implementation of various techniques to evaluate and model the energy consumption of a domestic refrigerator while fresh food shelves were modified seems to be the work's key contribution. First, shifting average computer models were also used to assess energy consumption, Fourier transform but computational derivative Such simulations have been used to analyze shifts, periodic behaviors, or energy usage minimum, maximum, and average values. Second, prediction techniques such as cubic splines, bilinear methods, or artificial neural networks are often used to model energy consumption.

Biglia, Alessandroet al.(2018) The findings of a large-scale survey wherein the 998 refrigeration appliances in 766 properties in England were tracked have been reported. No previous study has analyzed such a vast data collection, and provides information on atmospheric temperature, cold appliance temperature (refrigerator and/or freezer), including cold appliance electrical use. In 2015, electricity consumption was estimated over seven days over a nine-month period. Owners were consulted in order to learn more about refrigeration equipment including their consumption habit.

Zeng, Jingweiet al.(2018) exhibited The CFD approach had been used to create a numerical model of the flow and temperature spectrum in an air-cooled refrigerator-freezer, which was then tested by tests. The simulation temperatures are significantly lower than the experimental temperatures, with a maximum relative error of 1.89 percent.

III. METHODOLOGY

The freezer and refrigerating compartments is studied for three configurations. In first configuration using Plate-evaporator without finned surface and in second configuration Plateevaporator with finned surface and In third configuration Plateevaporator with perforated finned surface. The CATIA provides the following approaches for model generation: Creating a solid model within CATIA. The ANSYS-FLUENT software is used for the CFD simulation of

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the compartment. The conservation equations to steady state were solved for the coupling of the velocity and pressure through a SIMPLE algorithm; a second-order upwind discretization scheme was used for momentum and energy equations and a standard scheme for the pressure. The laminar regime considering the Boussinesq´ s equation in the y-component of the momentum equation was applied. The convergence criteria were 103 for the momentum and continuity equations, 10-3 and 10- 6 for the energy equation. The convergence was reached with 420 and 380 iterations for the plate evaporator without extended surfaces and the plate with extended surfaces, respectively. Comparison of temperature profiles for different configurations ofrefrigerating compartment. The freezer and refrigerating compartments is studied for three configurations. The perforated finned surface gives best result.

Software used for the study Catia v5:- For the present work CATIA V5 is used for model design.CATIA V5 mainly used for design. CATIA supports multiple stages of product development (CAx), including conceptualization, design (CAD), engineering (CAE) and manufacturing (CAM). CATIA facilitates collaborative engineering across disciplines around its 3DEXPERIENCE platform, including surfacing & shape design, electrical, fluid and electronic systems design, mechanical engineering and systems engineering. ANSYS 15.0 For the present work ANSYS 15.0 programming is used. ANSYS Fluent programming is the most-capable computational liquid elements (CFD) device accessible, enabling you to go further and quicker as you advance your item's execution. To convey quick Fluent incorporates very much approved physical demonstrating capacities, precise outcomes over the amplest scope of CFD and multiphysics applications.

IV. CONCLUSIONS

Computational fluid dynamics will be used to measure different data such as temperature, strain, and velocity in the appropriate region of interest without the need for a physical component, simulating the test in a manner comparable to the real-world scenario. The CFD technique allows for quicker verification of outcomes with different design parameter adjustments that might otherwise necessitate further prototyping and testing time.
The present work concerned just the update of Fins of evaporator plate from the purpose of warmth exchange rate. There are some conceivable proposals which might be feasible for reception in future. 1. CFD investigation was led to test the temperature distribution of different finned. 2. The CFD simulation developed by our work can be further used as a tool to study the influence of operating conditions on the temperature and velocity fields: the evaporator temperature (parameter related to the thermostat setting by the consumer), the dimensions of the evaporator (parameter related to design) and the percentage of product-occupied volume in the refrigerating compartment.

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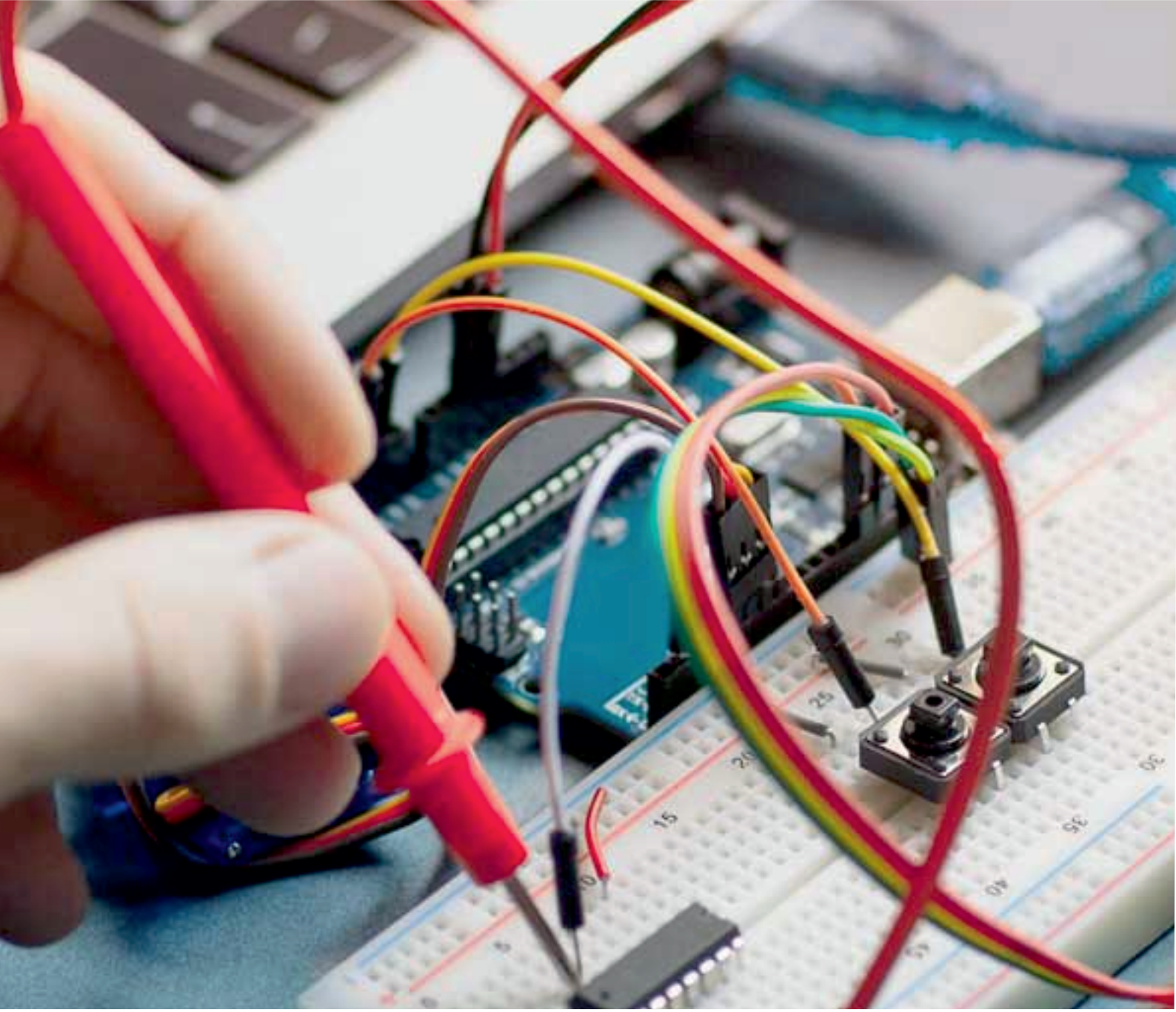

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