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AN APPROACH OF DESIGNING A MOBILE FRIDGE-FREEZER

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Abstract: *This paper aims to propose a new product regarding the consumers liking of the current safety norms. Due to the desire of people to travel and to explore new places, their expectations rose from one trip to another and one of the most important of them refers to the thermic voyage equipment. From basic human needs to expectations of people from our days, numerous models of fridges and freezers were developed to create the desired comfort of every user.*
Key words: *design, freezer, fridge, mobile model.*

1. INTRODUCTION

Due to the desire of people to travel and explore new places have increased their expectations from one trip to another and one of the most important is the thermal travel equipment. From this point of view were created many models of refrigerators and freezers to create the comfort desired from each user. These products appeared for thermal transport of food and beverages. The models are varied, and it is understandable that technologies are evolving precisely to bring customers easier use, higher comfort, and lower energy consumption. We made an interview form, and the answers were concentrated around the next conclusion regarding the customer's needs:

- The cooling capacity to be the minimum -6 degrees in 2 minutes
- Adapting a timer
- Minimum volume capacity: 30 litres
- Wheels for easier transport
- Electronic display and temperature control

A refrigerator-freezer can be used in terms of space in a car, in a trunk or in a back seat, but the armrest should be folded down and the refrigerator attached to the belt, in a minibus, large van and truck between the front seats.

The concept developed is shown in Figure 1. It offers a variety of features such as control panel, beverages and sandwiches stand. Also, it offers a feeling of quality due to the shape and other small components that are designed for long term use. This model offers comfort through the serving panel with four places for beverages cans and one place for casserole or sandwich, and some accessories for the protection of the case.

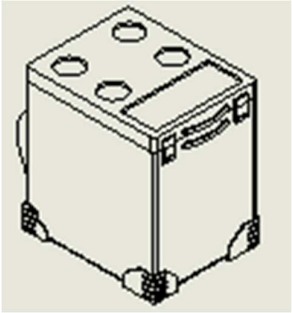

Fig. 1. The concept of the mobile fridge-freezer [1]

In Figure 2 is described the case of the fridge and the the assembly of it.

For assembly are necessary 50 pieces of black self-tapping screws M2/M2.5, 8 pieces of self-tapping screws 4.0x35, 2 pieces of metal locks, self-tapping tool, and bit.

The hinges with self-tapping screws will be assembly on the cover and on the case as well as the metal locks, handles and corners for protection. The control panel was assembly with

4.0x35 self-tapping screws only after the cooling system was assembled [1].

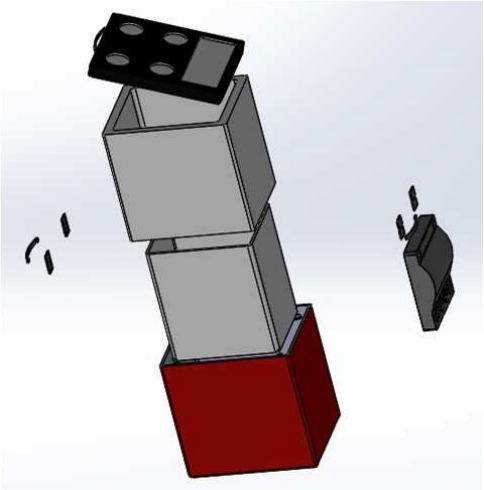

Fig. 2. The case assembly [1,6]

2. MANUFACTURING PROPOSALS

The refrigerators-freezers need thermal insulation, otherwise the cooling system the cooling system would run at full load continuously, which we do not want. The manufacture of the case is made in 3 layers, the first outer layer but also the inner one can be made of plastic, namely polypropylene (PP). Between these two layers is inserted thermal insulating foam, in this way it takes a complex shape and precisely insulates the entire cooling space.

But the cooling system is also very important to ensure a complete circuit of the housing it is necessary a route consisting of pipes through which the coolant passes.

The difference between a high-class refrigerator-freezer, is the quality of the materials used, firstly the less voluminous the foam and the better the insulator the higher the quality of cooling, and secondly the inner and outer casing must be resilient [2].

2.1 Materials chosen for the product

For a good product quality, for a longer life and a certified warranty of over 2 years, most manufacturers offer only 2 years, it is necessary to design a product from the best and most efficient materials. Convinced of these strengths of a product, the Polypropylene housing will be built, namely HDPE (high density polypropylene), this housing will be flexible but also hard. The flexibility of a case helps to reduce impacts or shocks as it is a portable product, it is subject to movement in different environments.

The housing will be built as a sandwich, two exterior walls made of SIDS and the interior made of high concentration polyurethane foam for space saving.

The other elements mounted on the housing such as the handles will be built of metal, over the middle part will be mounted a rubber insert for high comfort on the hands, closing the sheet metal cover 0.5 mm thick steel [3].

2.2 Cooling system installation

This operation is made with four screws in the space intended for the cooling system, as far to the left as possible, looking from the back of the housing. The refrigeration condenser will be assembly on four screws on the right side of the compressor parallel to it.

In Figure 4, in the part indicated with an arrow and highlighted in the rectangular frame, the evaporator will be mounted in polyurethane foam, polystyrene detachable will be used between the two walls of the housing to be parallel. Applying the foam is easy and taking care to cover the entire space between the two walls. (Figure 3)

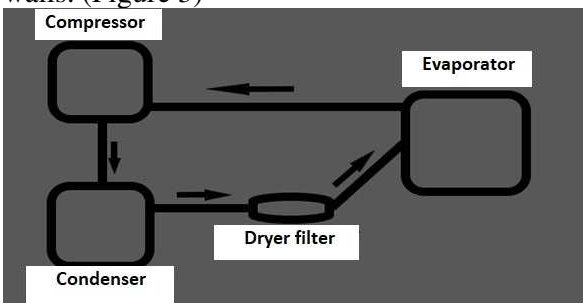

Fig. 3. Cooling system assembly diagram

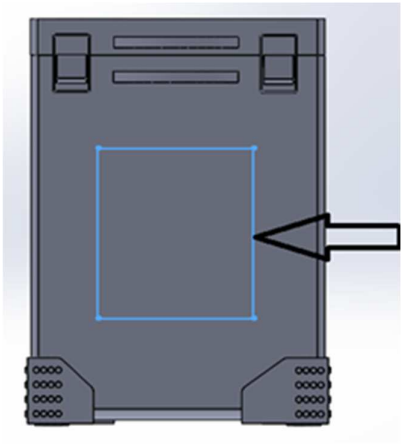

Fig. 4. The location of evaporator

3. THE CASE SIZING

The compartmentation of the product is simple and efficient: in the back, at the bottom of the refrigerator is the compressor with the installation, practically a stage is built in the housing, on the front in a vertical position will be the evaporator between the two layers of the housing, much better cool that part, where there is better place for bottles of drinks. On the "step", it is the place for food, the compartmentalization being done with a metal grill.

The product sizing at overall dimensions is presented in Figure 5.

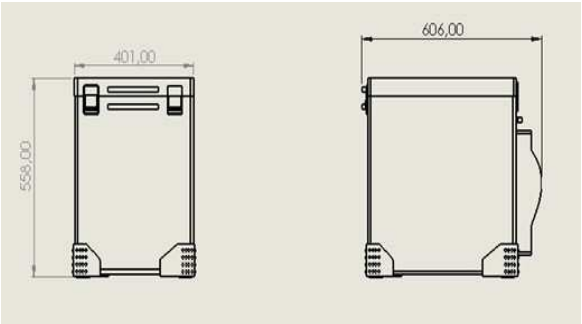

Fig. 5. The overall dimensions of the product

4. THE COOL SYSTEM TESTING

To test the performance of the cooling system, we will simulate the outside temperature of 20 ° C, we want a cooling temperature inside the refrigerator of -5 ° C.

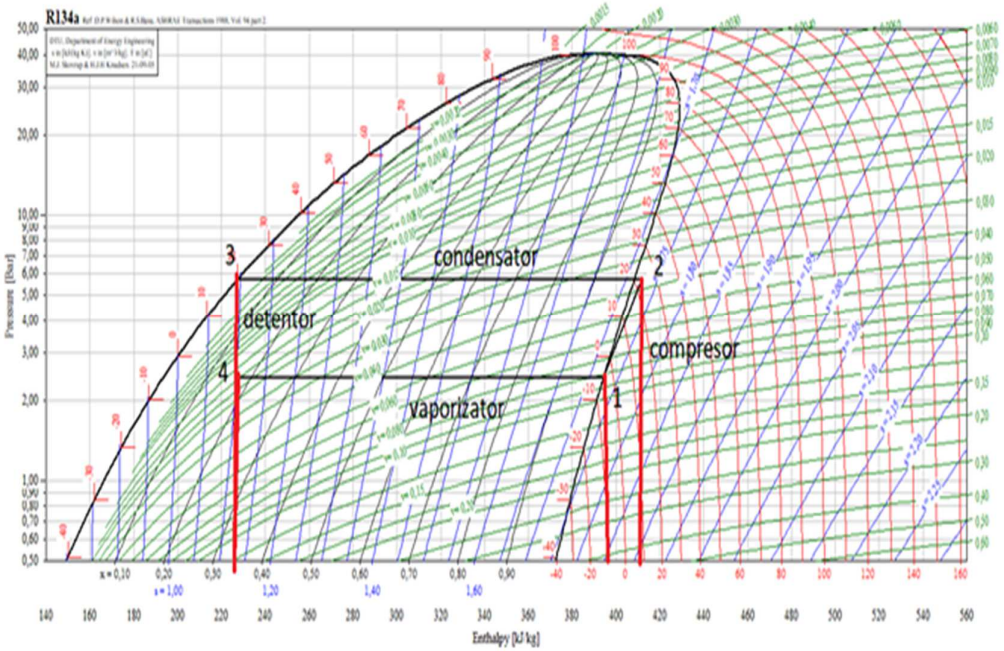

Fig. 6. The simulation diagram on specific-pressure and enthalpy

For this calculation we need:

Q_e – heat flow taken up by the vaporizer

Q_c – the heat flow given off in the condenser

m – refrigerant flow

$W_{compressor}$ – the compressor power

Of all these we know only the compressor power $W_{compressor} = 0.040$ kW

$$W=\dot{m} \times (h2-h1) \quad (1)$$

$$\dot{m}=W/(h2-h1) \quad (2)$$

h1=390 kJ/kg, h2=412 kJ/kg, h3=h4=225 kJ/kg (3)

$\dot{m}$=0,040kW x (412-390) $\dot{m}$=0.88 kg/s (4)

Qc= $\dot{m}$ x (h2-h3) (5)

Qc= 0.88 x (412-225) Qc=164,56 kJ/kg (6)

Qe= $\dot{m}$ x (h1-h4) (7)

Qe= 0.88 x (390-225) Qe=165 kJ/kg (8)

The cooling system is implemented using the equipment:

4.1. Danfoss BD35F 101Z0200 refrigeration compressor, with the following characteristics, as is shown in Figure 7:

- Weight: 4.26Kg
- Frequency: DC-12V
- Dimensions: 178mm x 100 mm x 96mm (LxWxH)
- Short-term winding temperature: 135 ° C
- Refrigerant: R134a [4]
- Danfoss compressors offer the best quality, the energy level of the application is direct current, and the motor is brushless. The package is sold together with the electronic starting part, in fig. is the connection diagram of the equipment. The compressor has three pipes, an inlet for loading refrigerant through a valve, an inlet and an outlet for recirculating the refrigerant. [4]

Fig. 7. Danfoss compressor BD35F

The wiring diagram of the Danfoss equipment is shown in Figure 8.

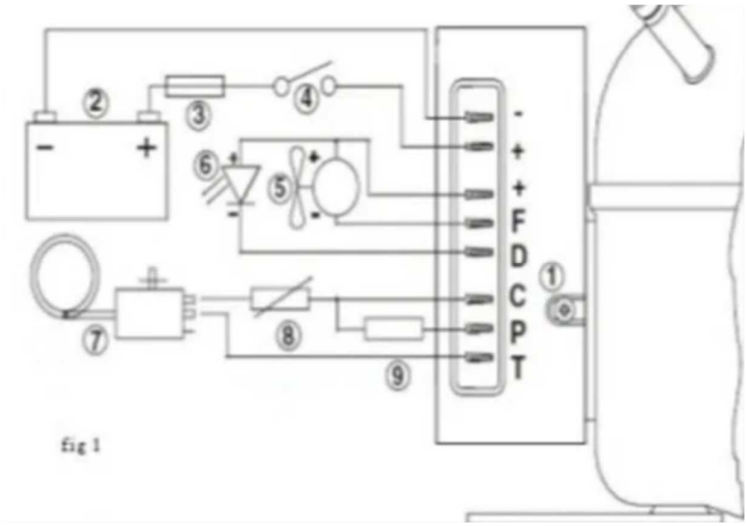

Fig. 8. The wiring diagram of Danfoss equipment

4.2. Refrigerated condenser with a EURO-LINE SK-0750 fan, 8MM, with the following characteristics (Figure 9):

- Dimensions: 244mm x 193mm x 203mm (LxWxH)
- Fan diameter: 172 mm
- Power / DT 15 ° C: 750W

Fig. 9. Refrigerated condenser with a fan

4.3. Evaporator without capillary tube, with the dimensions: 400mm x 260mm (LxW) as is shown in Figure 10 [5].

Fig. 10. Evaporator without capillary tube

4.4. Refrigerator dryer filter 15gr. SKU F15 which can be seen in Figure 11.

Fig. 11. Refrigerator dryer filter

4.5. Soft capillary tube for refrigeration installations shown in Figure 12.

It is needed the other materials, as the following: polyurethane foam, burner with gas cylinder and alloy for welding copper pipes.

Fig. 12. Soft capillary tube

After the completion of the product design and assembly stage, it will be tested to provide a guarantee to buyers. The tests will last 2-3 days, the product will go through several series of tests at the level of resistance on the housing (shocks, blows) at the level of reliability and operation in the parameters of the cooling system (24h cooling in a cold environment / 24h in a warm environment), in terms of reliability and prevention of possible errors in the control panel (sudden use of controls, connection from different devices with different operating systems, control of the influence of humidity on the motherboard).

The estimated weight of the product will be between 20 and 24 kg.

The final product concept [6] is shown in Figure 13.

Fig. 13. The final mobile fridge-refrigerator concept

5. CONCLUSIONS

This paper incorporates the process of manufacturing of the case, with all its component elements, the equipment's of the cooling system and the technological process of assembling it and finally of the product.

The essential function is the possibility for the same device to cool as well as to freeze, by providing a control panel that allows temperature regulation. It is appreciated that through the same device, users can enjoy the functions of two different products.

The final concept of the product incorporating in the unique design the following characteristic functions: 49l capacity, low consumption, control panel with electronic display and possibility of remote control, LED lamp, lid opening or full detachment, intelligent compartmentation, easy maintenance, case protection and concentrated insulation.

6. REFERENCES

[1].Chiriac, Constantin., Dobocan, Corina-Adriana *The mobile fridge-freezer*, Paper license, (2021).

[2].Dobocan, Corina-Adriana, *Sisteme de fabricatie in mediul industrial*, Ed. Mega., ISBN: 978-606-020-362-9, (2021).
[3].Hancu, Liana., Iancau, Horatiu., *Tehnologia materialelor nemetalice. Tehnologia fabricării pieselor din materiale plastice*, Ed. ALMA MATER, ISBN 973-8397-34-0 (2003).
[4].„Danfoss101Z200" https://store.danfoss.com/ro/ro/Climate-Solutions-pentru-refrigerare/Compresoare/Compresoare-pentru-refrigerare/Compresoare-comerciale-u%C8%99oare-Danfoss-pentru-refrigerare/Compresor-reciprocare%2C-Curent-continuu%2C-BD35F/p/101Z0200 (accessed Aug 16, 2021)
[5].Tat Wah Li „USD802029S – Portable refrigerator – Google Patents," (2017).
[6].Comes, Radu., Buna, Zsolt-Levente, Rozsos, Raul-Silviu, *Solidworks-Indrumator de laborator*, Ed. UtPress, ISBN 978-606-737-450-6, Cluj-Napoca, (2020).

O ABORDARE PENTRU PROIECTAREA UNUI FRIGIDER-CONGELATOR MOBIL

Rezumat: Prezenta lucrare urmărește să propună un nou produs care vizează consumatorii care doresc să respecte normele de siguranță actuale. Datorită dorinței oamenilor de a călători și de a explora locuri noi, așteptările lor au crescut de la o călătorie la alta iar una dintre cele mai importante dintre ele se referă la echipamentele termice de călătorie. De la nevoile umane de bază până la așteptările oamenilor din zilele noastre, au fost dezvoltate numeroase modele de frigidere și congelatoare pentru a crea confortul dorit fiecărui utilizator.

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