REFRIGERATOR MANUFACTURED IN COMPOSITE MATERIAL

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Abstract. *It is presented a low cost alternative refrigerator, chest freezer type, made of composite material using gypsum, cement, and EPS with an internal volume of about 250 liters. PET bottles of 250 ml in the back were used, forehead and at the sides of the proposed refrigerator. It will be presented the processes of construction and assembly of the prototype. The prototype will be tested and the results demonstrate the thermal energy, economic and material produced feasibility of the fridge. The aim is also study a refrigeration cycle using solar concentrator parabolic cylinder. The main users of this cooling system will be fishing communities in coastal strips of our region, enabling the conservation of fish for a time able to make economically viable commercialization.*

Keywords*: Refrigerator, cooler, composite material, recycling, conservation of fish.*

1. INTRODUCTION

The rapid deterioration of the fish after their capture is one of the serious problems faced by fishermen, inducing them to sell almost immediately the product of their work. This leads to considerable damage by the fall in its marketing price (1).

Once out of the water, the fish becomes a highly perishable food. Upon exiting the water the fish is usually left in contact with refrigerated ice and is marketed well (2).

Because they have enough protein, fish is an excellent source for microbial growth. The high moisture content available in meat (70%) facilitates the action of these microorganisms.

One of the reasons why the fish is highly perishable is the colloidal structure of its muscle protein, with large amounts of nitrogen free extractive substances, intermediate products of metabolism of amino acids and trimethylamine oxide. These substances are also free extractive primarily responsible for the aroma and taste of fresh fish (2).

If the fish is struggling to liberate themselves from the network, or die in agony in fishing boats, their reserves of energy (glycogen) will be exhausted, giving a chance to decay faster and more intense.

It is noticed that the fish is spoiled by the bad odor and lysine, for example, is hydrolyzed to putrescine and appearance of the volatile products of the reaction. The gills become dark, the scales come off, the flesh softens as it loses water and protein-bound eyes become concave and with blood stains. Observing the external phenomena of deterioration is possible to avoid buying a bad product (3).

This present study aims to present a contribution to the problem faced by the fishermen, almost all low-income workers, which has the fish as a subsistence crop. It is proposed a temporary holding room, which can turn into a refrigerator by using a renewable thermal-powered electrical energy. It was built in composite material of low cost, and can have any size to minimize the problem of the urgent requirement of the marketing of fish after capture.

2. REVIEW

Upon exiting the water the fish traveled several hours to marketing. The only way to slow the deterioration is to use an agent that slows enzymatic reactions and inhibit bacterial action, even temporarily. The cold is that agent. On the ice, the temperature decreases, but remains constant. There will be fluctuations and the temperature rising as the ice melts. If the fish is not sold it goes back to the refrigerator (where the effects of enzymes and microorganisms becomes slower) and it can be sold in the next day.

According to the Regulation of Industrial and Sanitary Inspection of Animal Products, Ministry of Agriculture, in its 439Article, the fish in nature may be:

1) fresh
2) cold
3) frozen

§ 1: It is understood by "fresh" the fish consumption given without any preserving process, unless the action of ice.

§ 2: It is understood by "cold" the fish properly packed in ice and kept at temperatures between -0.5° C and -2° C (minus half a degree Celsius and less than two degrees Celsius).

§ 3: It is understood by frozen the fish treated by appropriate processes of freezing, in a temperature not exceeding -25 ° C (twenty-five degrees Celsius).

§ 4: After being subjected to freezing the fish should be kept in cold storage at -15 ° C (minus fifteen degrees Celsius).

Paragraph: The fish once thawed cannot be taken back to the cold room (4).

Fish that have good marketing "in natura", or fresh, must be placed on ice immediately after captured to achieve the needed time for conservation. This cooling can keep the fish for a limited time of up to 8 days, but the deterioration continues slowly. At a temperature of 4.5° C in a common refrigerator, for example, in 12 to 24 h, the bacteria can multiply two times. The storage on ice will retain the quality lost after the catch. The average life of a fish is 8 days at 0°C, 1 day at 22°C and 1/2 day at 38°C (5);

3. MATERIALS AND METHODS

The studied refrigerator as a thermal box was constructed using a composite material made of gypsum, powder EPS (Expanded Polystyrene), cement and water, obeying the following mixture proportions by volume: 1.0 cement + 1.0 gypsum + 1.0 EPS + 0.3 of total volume of water.

The EPS was powdered using a disk with handmade multiple perforations attached to a 0.75 HP electric motor.

The mold used for obtaining the proposed thermal box was made of 15 mm thickness plywood. The mold elements were joined to form the box through small plates and screws. At all the elements of the mold were applied a layer of petroleum jelly to make it easier to remove the mold.

The powdered EPS, plaster and cement were placed in a polyethylene drum and then mixed to produce a composite homogeneous mass. Then the mass was placed in another barrel containing the predetermined volume of water. Mixed by hand and obtained the desired composite. Figure 1 shows the preparation process of the composite.

Figure 1. Preparation process of the studied composite.

The composite was positioned inside the mold in layers, to allow the replacement of 150 ml of the volume with PET bottles. The mold was removed after the initial grip the composite, after ten minutes.

The covers were made separated from the refrigerator, using a different wood mold.

After complete drying the refrigerator received a waterproofing layer internally and externally, using respectively a mixture of cement, glue and sugar. As the desired impermeability was not obtained, a part of the refrigerator was internally shrouded with EPS boards of 15 mm thickness for the heat test. Figure 2 shows the manufactured refrigerator.

Figure 2. Refrigerator manufactured from the studied composite material.

To diagnose the thermal efficiency of the composite, its thermal conductivity was measured.

To evaluate the mechanical strength of the composite, compression tests were performed on six samples for the composition of 1.0 cement + 1.0 gypsum + EPS 1.0 + 0.3 of total volume of water.

To evaluate the thermal resistance of the proposed storage chamber, a part of it was filled with ice, then the lid was closed and its internal and external temperatures and temperature at every elapsed hour were measured. The placement of the ice test was preceded at nine o'clock.

Measurements of temperature were performed with thermocouples attached to a digital thermometer. Figure 3 shows the box in cold test.

Figure 3. Refrigerator in the thermal box test.

4. RESULTS AND DISCUSSIONS

The measured values of thermal conductivity for samples of different compositions in the composite manufacture are shown in Table 1.

Table 1. Measured values of thermal conductivity for 1.0 EPS + 1.0 G + 1.0 C.

SAMPLE	K (W/m.K)
1	0.312
2	0.299
3	0.304
AVERAGE	0.305

With respect to the measured values it may be noted that they were closer to the corresponding conductivity value of gypsum, 0.48 W / m. K, than the value of EPS of around 0.03 W / m. K. Yet such a composite has a low thermal conductivity coefficient, a characteristic of a good thermal insulation, which makes it feasible for the application purpose. Table 2 shows the values of compressive strength for the composite samples, gypsum+ EPS + cement + water.

Table 2. Values of compressive strength in the composite specimens.

PREPARATION OF BODIES OF EVIDENCE						
COMPOSITION	**BODIES OF EVIDENCE**				**Average Kgf**	**Average MPa**
	1º Sample	**2º Sample**	**3º Sample**	**4º Sample**		
C.G.I.	700	600	500	600	600,0	3,00

The values of compressive strength are compatible with the rule that points, regarding this type of test blocks for sealing, around 2.5 MPa. This shows good mechanical strength of the storage tank built. Table 3 shows the values of the thermal test chamber used as the refrigerator store.

Table 3. Thermal test chamber cold storage.

Time (Hour)	**Temperatures**		
	$T_{environment}$ (°C)	**$T_{internal}$ (°C)**	**$T_{external}$ (°C)**
9:00	**26.6**	**-0.7**	**25**
10:00	26.6	-0.8	26.5
11:00	27.2	-0.9	26.9
12:00	27.2	-0.9	27.0
13:00	28.6	-0.8	26.0
14:00	28.6	-1.0	25.1
15:00	26.9	-1.3	24.6
16:00	26.0	-1.2	23.5
17:00	25.5	-1.0	23.8
18:00	25.3	-1.0	24.2
19:00	25.2	-1.2	23.1
20:00	25.2	-1.3	23.1
21:00	22.0	-1.3	22.5
22:00	23.5	-1.3	22.0
9:00	27.5	-0.3	26.1
AVERAGE	**24.6**	**1.0**	**25.9**

The table data presented demonstrate the good thermal efficiency of the cold storage chamber proposal, where there is a small thermal gradient between ambient and that of its outer wall. The temperature of the ice contained within the chamber was for 24 hours at 0° C and only 72 hours after the start of the test is that the ice became completely liquid.

The graph in Figure 4 shows the behavior of the external temperature of the cabinet and the ambient temperature, which prove its good thermal efficiency. The graph in Figure 5 shows the behavior of the internal temperature of the cabinet.

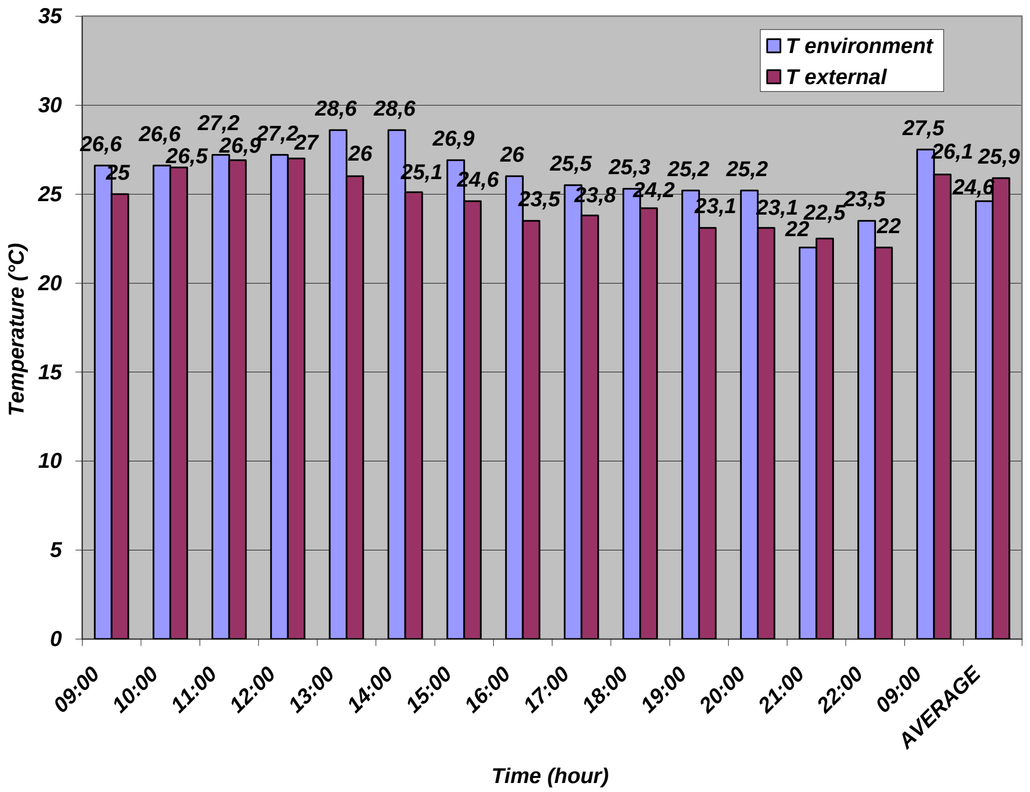

Figure 4. Behavior of the external temperature of the refrigerator and ambient temperature

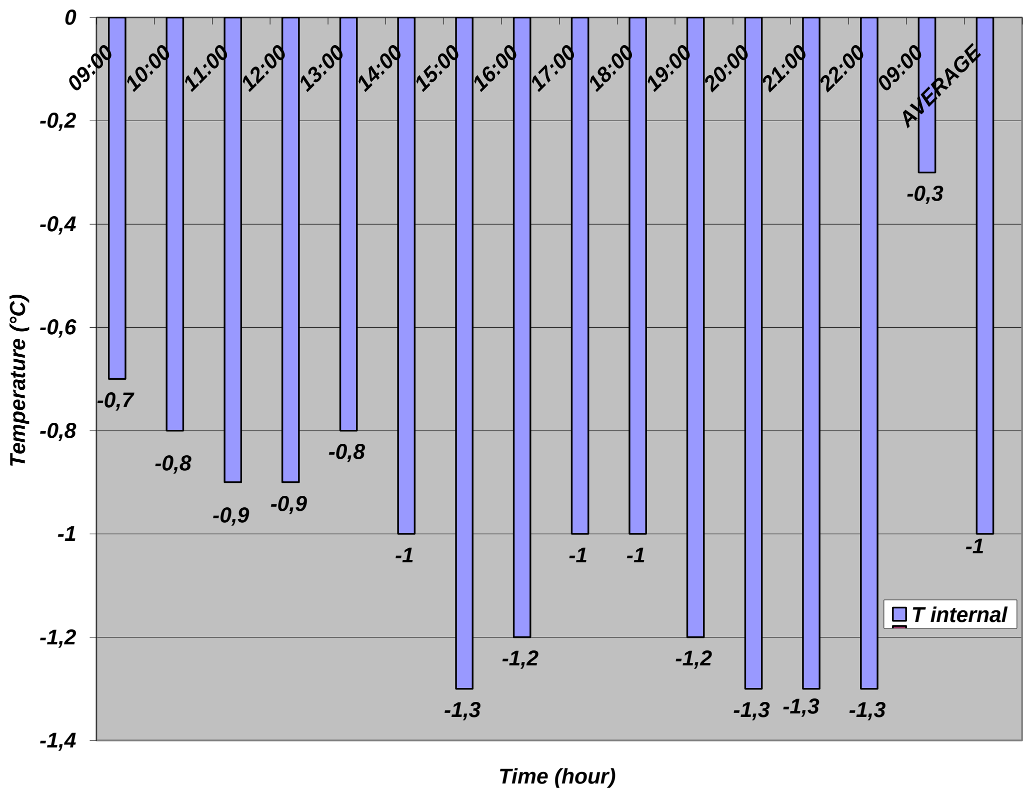

Figure 5. Behavior of the internal temperature of the cabinet.

The manufacturing cost of the 250 liters volume refrigerator is around $100.00, representing a value of low cost, affordable to most fishers and communities.

The aim is to use a refrigeration cycle driven by thermal energy produced by a 2.0 m² area cylinder-parabolic concentrator to remove heat the internal space of the refrigerator. This prototype was built and tested by Filho (2008) and is shown in Figure 6.

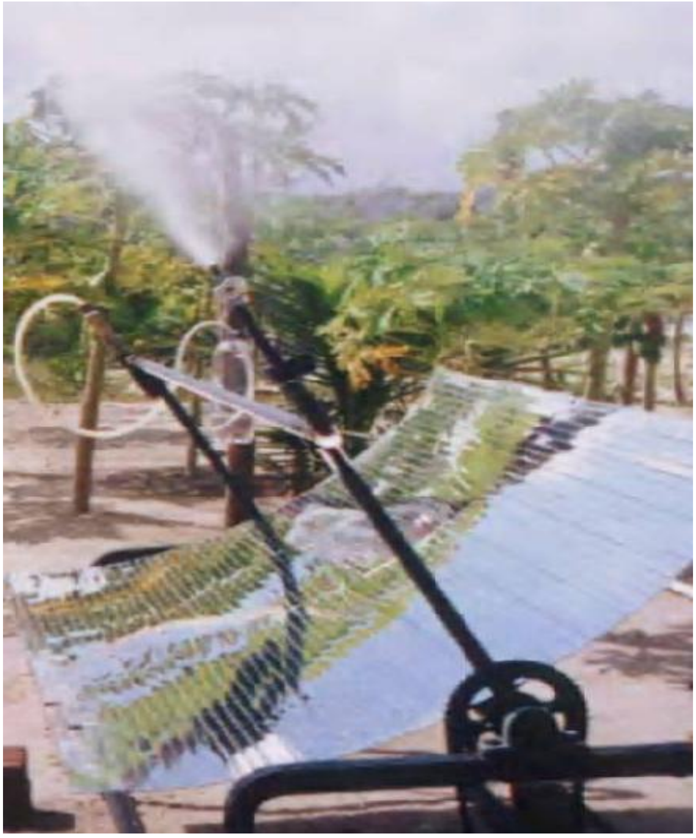

Figure 5. Cylinder-parabolic solar concentrator to be used on the refrigeration cycle for the studied refrigerator.

5. CONCLUSIONS AND SUGESTIONS

In line with the objectives, which are: simple manufacturing technology, low cost and good thermal and mechanical efficiencies, it can be stated:

1. The manufactured refrigerator for temporary storage of fish after capture proved to be thermally efficient;
2. The manufacturing cost of the proposed chamber is low and is accessible to the population which is intended;
3. The manufacturing process of this camera is simple and can be passed on to the fishing communities to produce their own temporary storage;
4. The camera proposal has good mechanical strength;
5. The camera has shown itself capable of storing ice in the solid state for a period exceeding 24 hours, making it efficient for the proposed end;
6. It is needed to study its performance for extended periods to accurately diagnose the thermal efficiency of the camera for the proposed end;

7. It is necessary to test the refrigerator when powered by a conventional and after by an alternative source to diagnose its thermal performance. The aim is to use solar power to activate a refrigeration cycle to remove heat from the internal environment of the manufactured refrigerator.

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