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# Performance Analysis Of Domestic Refrigerator By Using 662 S-Silicone Grease Coating On The Evaporator

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***Abstract :-***

*In* present days, Refrigerators are cyclic devices working fluid in refrigerator is called Refrigerant. The performance of refrigerators is expressed in terms of coefficient of Performance. And the cooling capacity of a refrigerating system is expressed in terms of Tonne of Refrigeration. Frosting is an unavoidable phenomenon either in domestic refrigerator or in industrial installations. Different methods are available to remove the frost accumulation like water defrost, electric defrost and hot gas defrost methods. Very few techniques are available to reduce the frost accumulation in the evaporator. The main objective of the present work is to reduce the quantity of frost by using coating on the evaporator coil. The coating chosen is to be very smooth, sustain the low temperatures and non wettable . so that there is a chance of forming of frost layers in the evaporator. By doing so, water drips can roll off easily, the dust and other impurities deposited on the surface can be easily removed. Commercially available 662 S - SILICONE GREASE coating material is chosen as coating material. A domestic refrigerator of 165litres capacity working with refrigerant 134a was procured and its pull down characteristics was determined to analyse proper working condition of the refrigerator without coating on the evaporator walls the load was kept inside the refrigerator and the amount of frost deposited was measured for various time intervals. The above process was repeated for various loads. Then the evaporator was coated with 662 S-SILICONE GREASE. The amount of frost deposited on evaporator was measured with the same loads used for without coating for various time intervals. By comparing the experimental results the amount of frost deposited was found to be reduced when 662 S-SILICONE GREASE coating was used. Due to reduction of frost accumulation the power consumption also was found to be reduced.

*Keywords*: **Refrigerator, evaporator, R134A, frost accumulation, 662 S-SILICONE GREASE coating, COP, power consumption**

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## INTRODUCTION:-

“Refrigeration is the science of providing and maintaining temperature below that of surrounding (ambient) temperature. Removal of heat from a body at lower temperature is possible only with the aid of external agency according to the Second Law of Thermodynamics.

Condensation occurs on any surface exposed to moist air whenever the temperature of that surface is below the dew point[2] .The condensate will freeze and a layer of frost will form on the surface. This process occurs continually on the evaporator coil of any refrigerator freezer. In evaporators that consist of a plate fins and tubes, this layer can grow and decrease the performance of the system .If the growth becomes large, it will decrease the amount of air flow over the coil and thus decrease the heat transfer. To keep the flow at a constant rate, the power delivered by the fan motor must be increased. due to this evaporator efficiency will be decreased.

Frosting is transient process with properties changing over time. At lower temperatures, the condition of the frost will be light and fluffy. At the freezing point, the frost becomes hard and dense, and eventually forms into solid ice as freezing occurs. At temperatures below the freezing point there is usually less moisture present, thus the formation of frost is slower than at near freezing point conditions.

A review of the articles that pertain to the accumulation of frost will be discussed in this section. Although these surfaces do not directly apply to large warehouse evaporators, the qualitative relationships for frost growth and frost properties should still apply. An extensive review of studies on simple geometries, such as flat plates, cylinders and annuli. As well as finned tube heat exchangers, was done by Heflin. Another review on finned tube heat exchangers was done by the review in this paper will be concerned mainly with studies done on the effects of frost on heat transfer and on the heat transfer coefficient during the operation of finned tube heat exchangers.

## LITERATURE SURVEY:-

*A. Frosting*

There is every possibility of formation of ice on the surface of the cooling coil if the air is used as source on heat either in primary circuit or in secondary circuit.because the moisture is the air will come out in the form off dew when the air is cooled in the cooling coil below its dew pint temperature. The dew collected on the surface of the cooling coil is breezed and deposited . Therefore the moisture from the air will not only condense but also freeze on the coil surface. Hence for such applications, frost formation on the evaporator coil is inevitable. Also it obvious that lower the evaporator temperature, greater will be frost formation. A finned coil should never be allowed to frost because the accumulation of frost between the fins reduces the capacity. The frost on the evaporator coil also acts as insulator and retards the heat transfer rate between the air and the cooling coil . If the frost is allowed to accumulate further even liquid flood back to the compressor can occur due to a substantial reduction of the evaporator capacity. And thus the bond between the fin and the evaporator tube gets lost. Once this happens the evaporator capacity will come down substantially. It has been found that 25mm frost can have the same insulating effect as 12mm cork. Hence to maintain coil efficiency, it must be defrosted periodically.

The frosting is unavoidable process either in domestic refrigerator or in industrial installation. For the efficient operation of system, the defrosting of cooling coil is essential. Period of defrosting depends upon the type of evaporator method used for defrosting. Bare tube evaporators used in cold storage plants and breweries are defrosted once or twice in a month on the other hand.

*B. Defrosting*

For the reasons above frost formed should be defrosted periodically for efficient operation of the system. The various methods used for defrosting the evaporators are as follows

1. Manual defrosting method
2. Pressure control defrosting method
3. Temperature control defrosting method
4. Water defrosting method
5. Reverse cycle defrosting method defrosting method
6. Simple hot gas defrosting method
7. Automatic hot gas defrosting method
8. Thermo bank defrosting method
9. Electric defrosting method

*1) Manual defrosting method :*

It is the earliest and the simplest method of defrosting [1]. In this method either the compressor is stopped or the refrigerant to the evaporator is closed until the accumulated frost or ice is melted. At that point, the compressor is started or the refrigerant valve is re-opened. This method is still employed on large installations. The major drawback of this system is that it requires along period for defrosting.

*2) Electric defrosting method :*

The electric defrosting method is popularly used for low temperature evaporators. In this system the heating coils for heating may be installed within the evaporator[3]. Special evaporators are required for installing this type of system. In one of the electric defrosting method, the electric heater is mounted under the evaporator, drain pan and the drain line. In its operation the compressor is stopped and the liquid line closed the refrigerant from evaporator is pumped down. A thermostatic control returns the refrigerating systems to normal operation.

The length of the defrost period is determined by the degree of frost accumulation. The length of defrost period depends upon the method of defrosting used. A particular temperature in the evaporator is essential to preserve the perishable products. it is necessary to provide some means for defrosting as the frosting comes in the way of maintaining the required temperature.

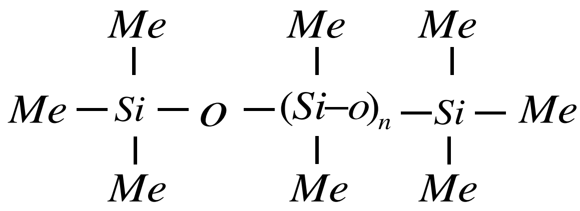
Humidity and surface temperature influence the frost growth more than the air velocity and air temperature.There may be other factors affection conductivity such as plate temperature and frost surface temperature. There also disagreement on the role Reynolds number has on frost growth. Schneider showed Reynolds number to be unimportant whereas O'Neal and tree found that frost growth increased with increasing Reynolds number had negligible.

The evaporator in a refrigerator obviously will have to be at temperatures lower than 00 c .The freezing point of water therefore it is subjected to the accumulation of the frost.This frost acts as an insulation that reduces the heat transfer rate between the air and the cooling coil. causing the compressor to operate at lower suction pressure which further reduces the refrigerating capacity and C.O.P of the system. Therefore removal of frost or defrosting done by manually putting "off" the refrigerators. In Present days refrigerators are equipped with push-button defrost thermostats. A push-button is provided in the centre of the thermostat knob. Defrosting can be initiated by simply pressing the push button. This causes a mechanical leverage in thermostat to break and keeps the electrical constant of the thermostat opened. until the evaporator temperature rises above freezing point and defrosting takes place.

**662 S- SILICONE GREASE COATING :-**

*A. Introduction:*

The name "silicone" was given in 1901 by Kipping to describe new compounds of the brut formula R2SiO [7]. These were rapidly identified as being polymeric and actually corresponding to polydialkylsiloxanes. Among them, the most common are polydimethylsiloxanes (PDMS), trimethylsilyloxy terminated with the structure:



**or**

$$Me_3SiO\ (SiMe_2O)_n\ SiMe_3$$

Where n=0,1,……….

The methyl groups along the chain can be substituted by many other groups (e.g., phenyl,Vinyl or trifluoropropyl). The simultaneous presence of "organic" groups attached to an "Inorganic" backbone hence silicones a combination of unique properties and allows their use in fields as different as aerospace (low and high temperature performance), Electronics (electrical insulation), health care (excellent biocompatibility) or in theBuilding industries (resistance to weathering).


Figure 1:Picture of 662 s-silicone grease coating material

*B. Properties Of 662 S- Silicone Grease Coating*

662 s-silicone grease coating as selected to coat on the evaporator .The selected 662 s-silicone grease coating consist of all below properties. 662 s-silicone grease coating consist of the following properties[8].

1) Low thermal conductivity
2) Low chemical reactivity
3) Low toxicity
4) They have high gas permeability.
5) Smooth surface finish.
6) Thermal stability (constancy of properties over a wide temperature range of −100 to 250 °C).
7) It resist to low temperature.
8) Non wetting in nature.
9) The ability to repel water and form watertight seals, although silicones are not hydrophobic.
10) Does not stick to many substrates, but adheres very well to others, e.g. glass.
11) Does not support microbiological growth.
12) Resistance to oxygen, ozone, and ultraviolet (UV) light.
13) This property has led to widespread use of silicones in the construction refrigeration industry and automotive industry.

## EXPERIMENTAL SETUP AND PROCEDURE:-

*A. Experimental set up*

The experimental setup consists of the following apparatus.

1) Refrigerator
2) Energy meter
3) Measuring jar
4) Temperature indicator

*1) Refrigerator details:*

5) Gross volume=165litres
6) Storage volume=123 litres
7) Voltage applied=220+10%, AC 1Φ,50 HZ
8) Refrigerant used=R134a

Figure 2: Domestic refrigerator

*2) Energy meter details:*

Name plate details: 240 V, 50Hz, AC single phase 270 C±20 C.

Figure 3: Energy meter

*3) Measuring Jar details:*

250ml standard Measuring jar is used for measuring frost quantity.

Figure 4: Measuring Jar

*B. Experimental procedure*

Figure 5: Experimental set up for 20 litres of water without coating

1. The refrigerator is loaded with 20 litres of water without any coating and run continuously for 25, 50, 75 hours.

2. Temperature is measured at evaporator; power consumption and frost quantity are tabulated as shown in the table 1.

| Time (hrs) | Evaporator initial reading ($^0$C) | Evaporator final reading ($^0$C) | Energy meter initial reading (kWh) | Energy meter final reading (kWh) | Power consumption (kWh) | Frost quantity (ml) |
|---|---|---|---|---|---|---|
| 25 | 31 | -18 | 22.35 | 25.30 | 2.95 | 420 |
| 50 | 32 | -16 | 43.55 | 49.30 | 5.12 | 1750 |
| 75 | 31 | -17 | 25.30 | 34.55 | 9.25 | 2036 |

Table 1: Temperature drop, power consumed and Frost quantity with a load of 20litres of water in a tray in the refrigerator.

3. The refrigerator is loaded with 20 litres of water with 662 s-silicone grease coating and run continuously for 25, 50, 75 hours.

4. Temperature is measured at evaporator, power consumption and frost quantity are tabulated is shown in table 2.

| Time (hrs) | Evaporator initial reading ($^0$C) | Evaporator final reading ($^0$C) | Energy meter initial reading (kWh) | Energy meter final reading (kWh) | Power consumption (kWh) | Frost quantity (ml) |
|---|---|---|---|---|---|---|
| 25 | 34 | -14 | 92.28 | 94.57 | 2.29 | 382 |
| 50 | 34 | -16 | 94.57 | 99.50 | 4.93 | 1360 |
| 75 | 33 | -17 | 99.5 | 107.7 | 8.2 | 1850 |

Table 2: Temperature drop, power consumed and Frost quantity with a load of 20 litres of water in a tray in the refrigerator with 662 s-silicone grease coating.

*C. The following photographs show the frost development with and without coating*

Figure 6 : Formation of ice on chillier without coating in the experiment with 20litres of water load run for 25 hrs.

Figure 7: Frost covering the ice formed in an the experiment with 20 litres of water load run 25hrs on a coated evaporator.

Fig ure 8: Formation of ice on chillier without coating in the experiment with 20litres of water load run for 50 hrs.

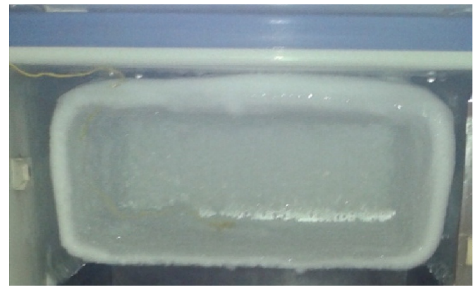


Figure 9: Frost is covering the ice formed in an the experiment with 20litres of water load run 50hrs on a coated evaporator.

**RESULTS AND DISCUSSIONS:-**

*A. Experiment 1*

Time taken by the refrigerator (using R134a as refrigerant) to reach a evaporator temperature of 70C is observer to be 45 minutes, when the average room temperature is around 320C. Energy consumed is 0.05kWh the refrigerator pull down characteristics are very good.

*B. Experiment 2*

The evaporator with coating and without coating is run continuously with varying water quantity and time of 20litres of water with varying time as 25, 50, 75 hours.

1) From the table 1 it can be seen that the frost collected is 420ml without coating in the experiment with water load as 20litres over time of 25hours
2) The water vapour sources within the refrigerator badly affect the performance of the refrigerator by causing frost formation and further accumulation over time.
3) By applying 662 s- silicone grease coating on both sides of evaporator the frost reduced from 420ml-382ml with water load as 20litres over time of 25hours as shown in table 2.
4) The frost collected is 1750ml without coating in the experiment with water load as 20litres over time as 50hours as shown in table 1.
5) The water vapour sources within the refrigerator badly affect the performance of the refrigerator by causing frost formation and further accumulation over time.
6) By applying 662 s- silicone grease coating on both sides of evaporator the frost reduced from 1750ml-1360ml with water load as 20litres over time of 50hours as shown in table 2.

7) The frost collected is 2036ml without coating in the experiment with water load as 20litres over time of 75hours as shown in table 1.
8) The water vapour sources within the refrigerator badly affect the performance of the refrigerator by causing frost formation and further accumulation over time.
9) By applying 662 s- silicone grease coating on both sides of evaporator the frost reduced from 2036ml-1850ml with water load as 20litres over time of 75hours as shown in table 2.
10) From the below figures 10 & 11 as the time and water load increased the frost is greatly reduced by applying coating on the evaporator.

The result from the data collected is shown in the foregoing discussion in the form of plots:

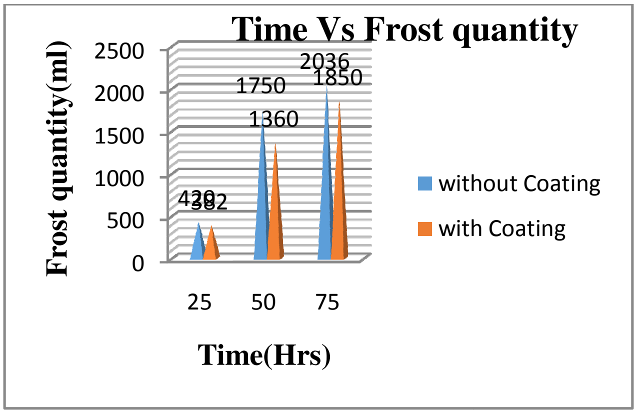



Figure 10 : Graph between Time Vs Frost quantity without and with coating for 20 Litres of Water from table 1 & 2.

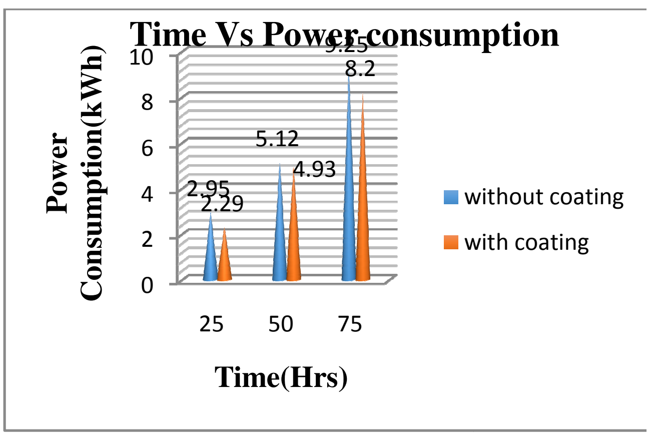



Figure 11: comparision of power consumption drop over time with water quantity as 20litres with and without evoparator coating from table 1 & 2.

## CONCLUSIONS:-

In this project work the evaporator of a domestic refrigerator was coated with 662 S - SILICON E GREASE coating. The experiments were conducted with 662 s - silicone grease coating on the evaporator with varying water quantity such 10litres, 20litres and time as 25hours, 50hours, 75hours.

*A. For 20litres of water*

1) In 25hrs the frost quantity reduced from 420ml to 382ml.
2) In 50hrs the frost quantity reduced from 1750ml to 1360ml.
3) In 75hrs the frost quantity reduced from 2036ml to 1850ml.

*B. For 20litres of water*

1) In 25hrs the power consumption reduced from 2.95 to 2.29kWh.
2) In 50hrs the power consumption reduced from 5.12 to 4.93kWh.
3) In 75hrs the power consumption reduced from 9.25 to 8.2kWh.
4) The frost quantity reduction as 9.04% to 9.13% for 20litres of water from the figure 10.
5) The power consumption reduction as 22.37% to 21.8% for 20litres of water from the figure 11.
6) Thus, it is concluded that by using 662 s- silicone grease coating on evaporator .The frost formation is reduced and also accumulation is lessened with increase in the water (load) quantity in the refrigerator.
7) At higher loads the power savings are considerable.

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