IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

HIGH INSULATION THERMAL BOX

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ABSTRACT

The present work is concerned with design & manufacturing of high insulation thermal box. The current model working on transportation or storage of any product at the range of one and half hour for specific size, we innovated the design by developing it into very high thermal insulation for the storage or transport. Our project envisages on design, manufacturing & analysis of thermal box. Analytical heat transfer calculations were done. Later, we manufactured the box and after that according to the need and design we procured insulating material and phase change material, and in accordance with the design we pasted it in the box. For maintaining required temperature for longer time, we have used low thermal conductivity insulating materials like polyurethane foam, glass wool, thermocol, etc. and for maintaining required temperature we have used passive cooling techniques like phase change materials such as ice packs. We have improved the efficiency of the box by increasing the time frame for blood samples to be stored and designed the box considering ergonomics.

Keywords: PCM, Polyurethane/foam, Thermocol, Glass Wool, ice packs, Ergonomics.

I. INTRODUCTION

Thermal abuse is a primary concern during the distribution of temperature-sensitive goods such as pharmaceutical, food, electronic and horticulture products, blood samples etc. Distribution and marketing of temperature-sensitive goods can be achieved by three different modes, namely carrier-controlled thermal chain, one-way systems and two-way systems.

Carrier controlled thermal chains provide refrigerated trailers for the transportation of goods over longer distances. They attempt to keep products within the required temperature range and allow the use of ground freight instead of air. The disadvantages of this method include the higher cost of shipping smaller lots and the restricted number of destinations and temperature ranges available.

One-way systems offer advantages of rapid package design and validation using various insulated shipping containers and phase change materials (PCMs).

Two-way systems are the third category of solutions available for the distribution of temperature-sensitive products.

Reusable shipping containers, which fall in this category, typically have an impact-resistant exterior and offer improved temperature control.

In our case, we have chosen One Way Carrier System for transporting blood samples. High Insulation Thermal Box is the reduction of heat transfer between objects in thermal contact or in range of radioactive influence. It can maintain product temperatures within acceptable ranges and slow down the deterioration of the product. It is a shipping container used for packaging and shipping of temperature sensitive products (in our case, blood samples etc.). They are used as a part of cold chain to help maintain product freshness and efficacy using Phase Change Materials like water, sodium sulfate, glycerin, paraffin.

To reduce the heat flow, we need insulation. The resistance of a layer is the thickness divided by the conductivity (t/c). Adding thickness or reducing the conductivity increases the resistance and reduces heat loss. Now a days, there are too many types of insulating materials used, for making insulating box, such as Mineral wool insulation, organic material, air, aerogel, vacuum insulation, wood fiber insulator, glass fiber, insulated plasterboard, multi-foil insulator.

Red cells and whole blood must always be stored at a temperature within 2 degree Celsius to 6 degree Celsius. Below 2 degree Celsius red cells in blood, become haemolysed. So, they must be never allowed to freeze. Haemolysed cells if transfused can cause renal failure and fatal bleeding problem. Hence high insulation thermal box is the system for storing and transporting blood and blood components so that they are kept at the correct temperature at all times from donor to administration to the patient.

1.1. Importance

High insulation thermal boxes are generally used for storage or transportation of any hot or cold product. By applying the insulation, we are decreasing the heat flow hence increasing the time of required temperature. Up to the date, the box is of single layer of insulation so it can’t maintain the required temperature for long time i.e. for 1-2 hours. The box is used for single purpose that is for hot storage or cold storage. Now we have designed the box which can easily maintain the required temperature for long time. We have used the different type of insulating materials and used the concept of composite wall so that it can store and transport cold or hot products at require temperature. In cold storage or transportation of the product we have used phase change material. The phase change material is capable of storing large amount of energy which results in maintained the require temperature. We have also increased the storage size of the box and also designed the box ergonomically for ease of the users. We have also tried to reduce the cost of the box available in market.

Our primary focus is on transportation of blood samples and then we have tried to increase the applications of the box in absence of blood camps.

1.2. Problem Identification

A visit to Ashwini hospital and blood bank Sholapur was conducted. We observed the problem faced by them that during the transportation of blood bags from camp area to the main refrigeration system, which is in the blood bank, they had to transport the box of blood bags within 1 or 2 hours each, because of this they travelled more. Another problem is the size of the box which is small so they were short of transporting more blood bags at a time. They were facing the problem during the transportation and the workers were often complaining about the design of the box and their inconvenience to handle the box.

1.3. Objectives of the Work

- To maintain the temperature 2 to 6 degree for long time.
- To increase size of box with composite insulation.
- To design and manufacture the box ergonomically well.
- To make a box multipurpose in order to serve hot and cold condition.
- To reduce the cost of the box as much as possible

II. TYPES INSULATING MATERIALS

Acetate: Acetates have good electrical insulating properties and is the material used to make movie and microfilm.

Ceramic: Ceramics are used to fabricate insulators, components, and circuit boards. The good electrical insulatig properties are complemented by the high thermal conductivity.

Delrin: This DuPont acetal resin is made from polymerized formaldehyde and finds uses similar to nylon. The material is rigid and has excellent mechanical and electrical properties making its use common in appliances and electronics.

Fiberglass/epoxy: This laminate is quite common due to its superior strength and excellent electrical properties even in humid environment. Most modern circuit boards are made from a grade of epoxy/fiberglass. (Grades include G10/FR4 and G11/FR5 extended temperature grade.)

Glass: Glass insulation comes in a wide variety of forms including solid glass, fiber tapes, fiberglass sheets and mats, woven tubing and cloth, and various composites. High temperature operation is a key feature.

Mica: Mica sheets or "stove mica" is used for electrical insulation where high temperatures are encountered. Thermal conductivity is high so mica insulators are useful for heat sinking transistors or other components with electrically conductive cases. Mica finds uses in composite tapes and sheets which are useful to 600 degrees centigrade with excellent corona resistance. Sheets and rods of mica bonded with glass can tolerate extreme temperatures, radiation, high voltage, and moisture.

Neoprene: Neoprene rubber is the material used for most wet suits. This black rubber is commonly used for gaskets, shock absorbers, grommets, and foams.

Nylon: Nylon has good resistance to abrasion, chemicals, and high voltages and is often used to fashion electro-mechanical components. Nylon is extruded and cast and is filled with a variety of other materials to improve weathering, impact resistance, coefficient of friction, and stiffness.

Silicone/fiberglass: Glass cloth impregnated with a silicone resin binder makes an excellent laminate with good dielectric loss when dry. (Grades include G7.)

Silicone rubber: A variety of silicone foam rubbers are available for insulating and cushioning electronic assemblies. Silicone rubbers exhibit a wish list of characteristics including superb chemical resistance,high temperature performance, good thermal and electrical resistance, long term resiliency, and easy fabrication. Liquid silicone rubbers are available in electrical grades for conformal coating, potting, and gluing. Silicone rubbers found in the hardware store should be avoided in electronic assemblies because they produce acetic acid. Silicone rubbers filled with aluminium oxide are available for applications requiring thermal conductivity.

Asbestos: The term asbestos is derived from a Greek word meaning "inextinguishable, unquenchable or inconsumable." It is a generic name for a group of fibrous silicate minerals, the most common of which are chrysotile, crocidolite and amosite. Asbestos is non-flammable even at very high temperatures and is extremely flexible and durable.

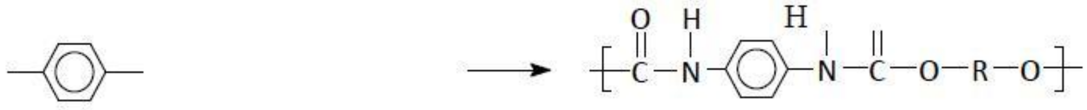
2.1. Selected Insulating Materials

2.1.1. Polyurethane/ foam

Polyurethane foam is generally described in the technical literature as having the lowest thermal conductance amongst a range of common thermal insulation material. Expanded polystyrene (EPS) and low density (20-50 kg/m³) rigid polyurethane foam systems significantly have gained the highest market acceptance for applications where low thermal/heat transmission is required in designed system-refrigeration cold rooms and in industrial /commercial applications where high insulation value systems are required. Foam products are primarily economical when applied in thin layers as part of a structural system. Foam products are a good choice to help seal air leaks.

Polyurethane foam is the most widely used flexible foam plastic. It is used to produce a wide variety of items including thermal insulation and packaging materials, comfort cushions, bed mattresses, carpet backings and resilient floor coverings.

Tolylene diisocyanate (TDI) and polyalcohol are the basic ingredients for the production of polyurethane foam. The basic reaction is as shown below:



OCNNCO + HO R OHH O

Blowing agent, such as methylene chloride and water, and various additives required.

Step 1 - Mixing of the raw materials.

During production, the raw materials (TDI, polyalcohol, blowing agents and additives) are pumped from their own storage tank to a common mixing chamber. Adequate dispersion can be achieved by the stirring of high speed impeller installed in the mixer.

Step 2 - Foam forming and settling

The foam gradually solidifies when travelling up the settling chamber by the action of paper conveyor. It is then cut into 2.2 m long blocks by an electric cutter after the foam is hardened.

Step 3 - Curing

The newly formed foam blocks are still very hot when transported to the storage area. They must be cured at room temperature for at least 18 hours before further processing.

Capillary processes control the formation and properties of foams in porous media. Foams for use in improvement are dispersions of micro gas bubbles usually with diameters/lengths ranging between 50 and 1000 μm. Foam in porous media exists as individual micro gas bubbles in direct contact with the wetting fluid of the pore walls. These micro gas bubbles are separated by liquid lamellae that bridge the pore walls and form a liquid partition on the pore scale between gas bubbles.

Fig shows a 2D slice of a generalized bulk foam system. The thin liquid films separating the foam gas bubbles are defined to be foam lamellae. The connection of the three lamellae of a gas bubble at a 120° angle is referred to as the Plateau border. In persistent bulk foams, spherical foam gas bubbles become transformed into foam cells, polyhedra separated by nearly flat thin liquid films. Such a foam is referred to as a dry foam. The polyhedra foam cells are almost, but not quite, regular dodecahedra. In three dimensions, four Plateau borders of a foam cell meet at a point at a tetrahedral angle of approximately 109°.Thermal conductivity=0.026 (w/m k).

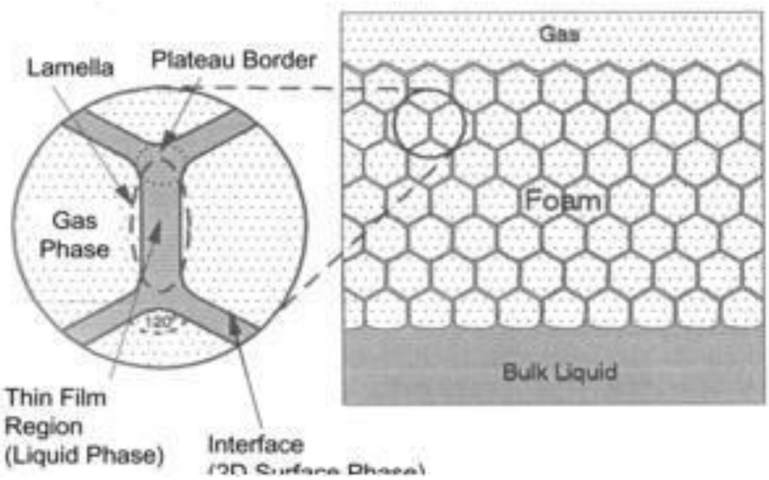


Figure 2.1 Generalized 2D slice of a bulk foam system

2.1.2. Glass Wool

Glass wool is an insulating material made from fibres of glass arranged using a binder into a texture similar to wool.

Glass wool Insulation is one of the most widely used forms of insulations world-wide because of its thermal and acoustic properties, light weight, high tensile strength and exceptional resilience. Glass wool is one of the most dominant types of insulations preferred in applications with service temperatures ranging up to 250C. Glass wool consist of fine, long, inorganic fibers bonded together by high temperature binder. These fibers (each of approx. 6 - 7 microns diameter) are distributed to trap millions of tiny pockets of air in it thereby creating it an excellent thermal and acoustic insulation. The light weight of Glass wool also offers significant advantages during transport and installation. In addition, Glass wool is chemically inert and has no impurities such as iron shots, Sulphur and chloride. The product is non-corrosive to metal and does not support mold grow. It is manufactured from renewable raw materials and is environmental friendly in every stage. Thermal conductivity of glass wool is 0.04.

Efficient thermal insulation, reducing energy consumption. Excellent acoustic insulation, reducing noise pollution and providing a safer workplace environment in areas where noise could cause hearing damage, whilst improving personal comfort and privacy in the work or home environment. No absorption of moisture from the atmosphere and a neutral pH, no risk of harmful chemicals leaching from the product or corrosion. Lightweight, easy to install and won't settle over time. Proven long term insulation performance and the most cost effective. Safe use based on extensive medical research.

2.1.3. Thermocol

The product is available in different sizes and densities and has applications like effective and efficient insulating for low temperature appliances, refrigerated vans, sound insulation and industrial refrigeration. Various properties of thermocol produced by the company: -It contains 3-6 million discreet cells per liter giving it excellent insulating properties. -It can be cut easily with simple tools like knife or a saw. -It can be painted with Plastic Emulsion paints or water bound distemper. -It has a high insulating efficiency, resistance to moisture, adequate structural strength. All these attributes explain the outstanding insulation properties and remarkable resistance to moisture vapor penetration, making it the ideal low temperature insulation material with the best combination of desirable properties. Thermal conductivity of thermocol is 0.033.

2.2. Phase Change Material

2.2.1. Physical, Technical and Economic Requirements

A suitable phase change temperature and a large melting enthalpy are two obvious requirements on a phase change material. They have to be fulfilled in order to store and release heat at all. However, there are more requirements for most, but not all applications. These requirements can be grouped into physical, technical, and economic requirements.

2.2.2. Physical Requirements, Regarding the Storage and Release of Heat

- *Suitable phase change temperature Tpc ⇒ to assure storage and release of heat in an application with given temperatures for heat source and heat sink.*
- *Large phase change enthalpy pch ⇒ to achieve high storage density compared to sensible heat storage.*
- Reproducible phase change, also called *cycling stability* ⇒ to use the storage material as many times for storage and release of heat as required by an application. The number of cycles varies from only one, when the PCM is used for heat protection in the case of a fire, to several thousand cycles when used for heating or cooling of buildings. One of the main problems of cycling stability is phase separation. When a PCM consists of several components, phases with different compositions can form upon cycling.
- Little sub-cooling ⇒ to assure that melting and solidification can proceed in a narrow temperature range. Sub-cooling (also called super-cooling) is the effect that a temperature significantly below the melting temperature has to be reached, until a material begins to solidify and release heat (fig.2.1). If that temperature is not reached, the PCM will not solidify at all and thus only store sensible heat.
- Good thermal conductivity ⇒ to be able to store or release the latent heat in a given volume of the storage material in a short time, that is with sufficient heating or cooling power.

If a good thermal conductivity is necessary strongly depends on the application and the design of the storage.

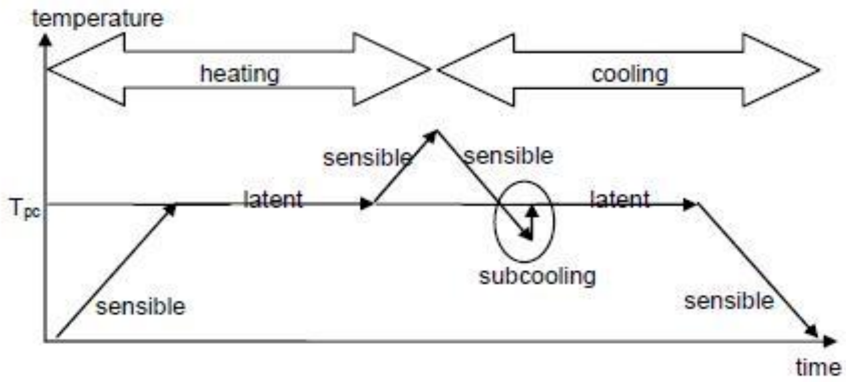


Figure 2.2 Schematic temperature change during heating (melting) and cooling (solidification) of a PCM with sub cooling

2.2.3. Technical Requirements, Regarding the Construction of Storage

- Small volume change ⇒ to reduce requirements of mechanical stability on a vessel containing the PCM

- Chemical stability of the PCM ⇒ to assure long lifetime of the PCM if it is exposed to higher temperatures, radiation, gases,
- Safety constraints ⇒ the construction of a storage can be restricted by laws that require the use of non-toxic, non-flammable materials. Other environmental and safety consideration can apply additionally.

2.2.4. Economic Requirements, Regarding the Development of a Marketable Product

- Low price ⇒ to be competitive with other options for heat and cold storage, and to be competitive with methods of heat and cold supply without storage at all
- Good recyclability ⇒ for environmental and economic reasons

2.3. Types of PCM

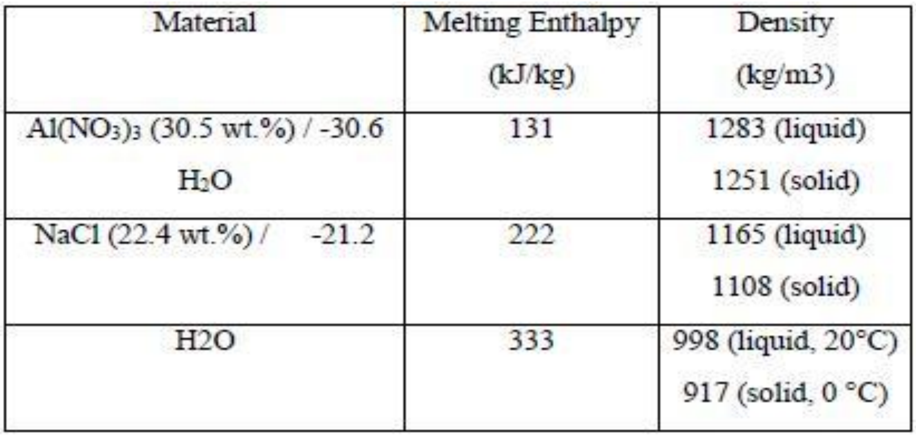
By far the best-known PCM is water. It has been used for cold storage for more than 2000 years. Today, cold storage with ice is state of the art and even cooling with natural ice and snow is used again. For temperatures below 0 °C, usually water-salt solutions with a eutectic composition are used. Several material classes cover the temperature range from 0 °C to about 130 °C. Paraffin, fatty acids, and sugar alcohols are organic materials. Salt hydrates are salts with a large and defined amount of crystal water. The theory of Richards shows that the melting enthalpy per volume is proportional to the melting temperature, the number of bonds per molecule, and the density divided by the molar mass that relates to the packing density of the molecules or atoms.

2.3.1. Inorganic Material

Inorganic materials cover a wide temperature range. Compared to organic materials, inorganic materials usually have similar melting enthalpies per mass, but higher ones per volume due to their high density (fig.2.2). Their main disadvantage is material compatibility with metals, since severe corrosion can be developed in some PCM-metal combinations. Eutectic water-salt solutions have melting temperatures below 0 ºC, because the addition of the salt reduces the melting temperature, and usually good storage density. Tab.2.1 shows a selection of typical examples.

Eutectic compositions are mixtures of two or more constituents, which solidify simultaneously out of the liquid at a minimum freezing point. Further on, eutectic compositions show a melting temperature and good storage density. The thermal conductivity of eutectic water-salt solutions is similar to that of water and they can subcool like water by several K or more. Water can cause severe damage upon freezing and melting for example like cracking stones in winter.

Table 2.1 Examples of eutectic water-salt solutions that have been investigated as PCM



Material	Melting Enthalpy (kJ/kg)	Density (kg/m3)
$Al(NO_3)_3$ (30.5 wt.%) / -30.6 H_2O	131	1283 (liquid) 1251 (solid)
NaCl (22.4 wt.%) / -21.2	222	1165 (liquid) 1108 (solid)
H2O	333	998 (liquid, 20°C) 917 (solid, 0 °C)

Water-salt solutions are chemically very stable, but can cause corrosion to other materials like metals. Compared to water, the addition of a salt usually makes the problem worse. Most of the salt solutions are rather safe, but should not leak in larger amounts. They are usually cheap, often less than 1 €/kg, and therefore the basis for many commercial PCM used in large-scale applications.

The temperature range between 5 ºC and 130 ºC is covered by salt hydrates. Salt hydrates consist of a salt and water in a discrete mixing ratio. The water molecules are located and oriented in the structure in a well-defined manner.

Salt hydrates often have comparatively high storage density with respect to mass, but even more with respect to volume due to their high density. Because salt hydrates consist of several components, at least one salt and water, they can potentially separate into different phases and thus show problems with cycling stability. In fact, phase separation is a common problem with salt hydrates. Their thermal conductivity is similar to that of water and eutectic water-salt solutions. Most salt hydrates sub cool, some of them by as much as 80 K. Salt hydrates melting close to or above 100 °C however show already considerable vapor pressure when melting. In most, but not all cases, salt hydrates are chemically very stable. However, many of them are potentially corrosive to metals.

2.4. Typical Material Problem and their Solution

2.4.1. Sub Cooling and Method to Reduce it

Many PCM do not solidify immediately upon cooling below the melting temperature, but start crystallization only after a temperature well below the melting temperature is reached. This effect is called sub cooling or super cooling. For example, liquid water can be cooled to temperatures well below 0 ºC; if highly pure and in small quantities even below -15 °C. During the supply of heat, there is no difference whether a PCM shows sub cooling or not. During extraction of heat however, the latent heat is not released when the melting temperature is reached due to sub cooling.

The effect of sub cooling makes it necessary to reduce the temperature well below the phase change temperature to start crystallization and to release the latent heat stored in the material. If nucleation does not happen at all, the latent heat is not released at all and the material only stores sensible heat.

2.4.2. Thermal Conductivity Improved by Composite Material

All non-metallic liquids, including PCM have a low thermal conductivity (tab.2.1 to tab.2.8). Since PCM store large amounts of heat or cold in a small volume, and because it is necessary to transfer this heat to the outside of the storage to use it, the low thermal conductivity can be a problem. In the liquid phase, convection can significantly enhance heat transfer, however often this is not sufficient. In the solid phase, there is no convection. When fast heat transfer is necessary, one possibility to increase the thermal conductivity of the PCM is to add materials with larger thermal conductivity. This can be done at a macroscopic scale, for example by adding metallic pieces or on a sub mm scale as mentioned before with composite materials. However, adding anything to the PCM will reduce or eliminate convection in the liquid phase; therefore, it is necessary to find out which option is better. One approach under investigation to improve thermal conductivity is to the PCM into metallic foam of different porosity and structure had advanced considerably.

III. DESIGN AND ANALYSIS OF BOX

3.1. Design of Current Box

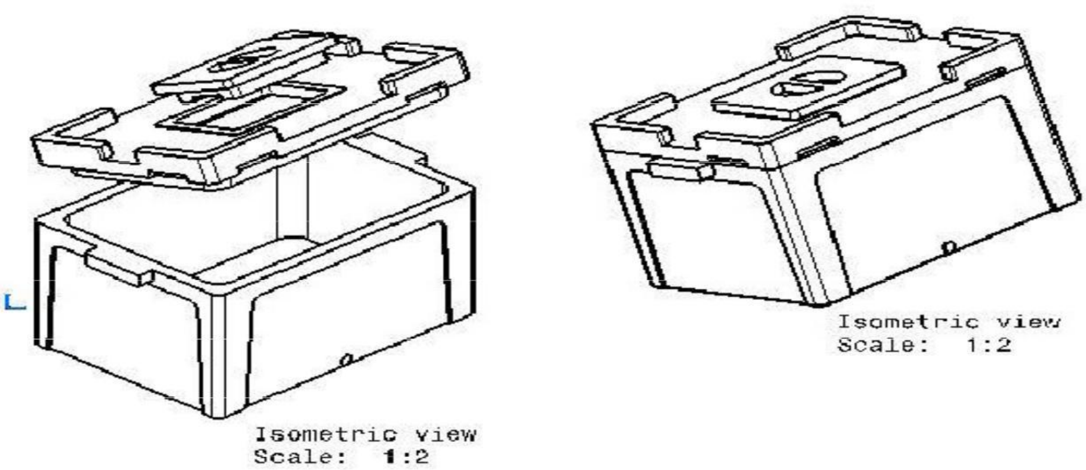


Figure 3.1 Design of Current Box

3.1.1. Calculation of Heat Transfer for Current Box

Volume=l*b*h

Where L= 51cm

B= 29cm

H= 35cm

V=51*29*35 = 5176cm^3

Capacity of box= 100 bags

Heat transfer = (area* temp difference) / (thickness of insulating material*thermal conductivity of material)

Where A= area

T= temp difference= (surrounding temp- inside temp= 33-2=31℃

L= thickness of insulating material

K= thermal conductivity of material

Q1 = (T*A)/(L/K)

Where T = 31℃

A = width* height = 0.35 × 0.29

(L/A)= Addition of three layers = 0.6020, we get.

Q1= 5.2267.

2) Heat transfer along long side;

Q1 = (T*A)/(L/K)

Where T= 31℃

A= 0.51*0.29

(L/K)= Addition of three layers=0.6020, we get

Q2= 7.61, we get

3) heat transfer top and bottom side;

Q1 = (T*A)/(L/K)

Where T= 31℃

A= 0.51*0.35

Q2= 7.61, we get

TOTAL HEAR TRANSFER THOUGH ENTIRE BOX= 2*(Q1+2)*(Q2+2)*Q3

= 44.057 watts.

The temperature range between 5 ºC and 130 ºC is covered by salt hydrates. Salt hydrates consist of a salt and water in a discrete mixing ratio. The water molecules are located and oriented in the structure in a well-defined manner.

Salt hydrates often have comparatively high storage density with respect to mass, but even more with respect to volume due to their high density. Because salt hydrates consist of several components, at least one salt and water, they can potentially separate into different phases and thus show problems with cycling stability. In fact, phase separation is a common problem with salt hydrates. Their thermal conductivity is similar to that of water and eutectic water-salt solutions. Most salt hydrates sub cool, some of them by as much as 80 K. Salt hydrates melting close to or above 100 °C however show already considerable vapor pressure when melting. In most, but not all cases, salt hydrates are chemically very stable. However, many of them are potentially corrosive to metals.

Because the melting enthalpy rises roughly proportional to the melting temperature given in K, salts with high melting temperatures often show a very high melting enthalpy. The thermal conductivity of salts can be quite good. Sub cooling, as far as data are available, is not more than a few K. Many of the salts are chemically stable; however, carbonates and nitrates can decompose under unsuitable conditions. Regarding the compatibility to other materials, salts can be corrosive to metals. Their safety differs strongly between different salts. The same hold for their price.

3.2. Design of New Box

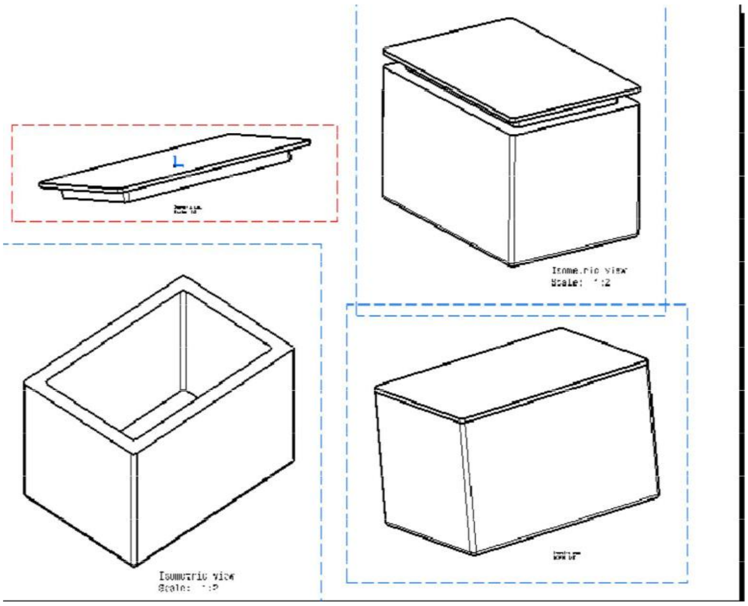


Figure 3.1 Design of New Box

3.2.1. Calculation of Heat Transfer and Temperature in between Two Layers

We have manufactured the size of box for 150 blood bags. If we take following dimensions, then we can easily accommodate 150 bags in the box. We have used insulating material in new box are

Thermocol

Glasswool

Polyurethane foam (PU)

Thermal conductivity of the insulating materials used:

A. A)Heat transfer along smaller side: There are two layers of insulation.One is thermocol and other one is PU.K value of thermocol is 0.033 and thermal conductivity of PU is 0.023.

Q1= $(A*(T_1-T_2) / (L_1/K_1)$

T_1=2℃

L_1=0.02

K_1=0.023

HENCE T_2= 19.31℃

B) Heat transfer along long side: = TxA / (L/K)

Obtained Q_2 = 7.61 watt

B)Heat transfer along top and bottom; : there are two layers of insulation, one is thermocol and other is glass wool,

Q3= (T*A) / (L/K)

Where A= width* height= 0.3*0.63

(L/K)= addition of two layers= 1.3727, we gwt

Q1= $(A*(T_1-T_2) / (L_2/K_2)$

T_1=20

L_1=0.025

K_1=0.023

HENCE T_2= 17.36℃

TOTAL HEAT TRANSFER THROUGH ENTIRE BOX= 2 × (Q1 + 2) × (Q2 + 2) × Q3

=24.03 watts,

IV. MANUFACTURING OF THE BOX

4.1. Steps Involved in Manufacturing of High Thermal Insulating Box

- First of all, for making sheet metal box we chose flat sheet of 24-gauge size and dimensions of (6×12Ft) for our high thermal insulation box purpose.
- Obtained sheet metal & metal that was thick enough to make for a sturdy box, but thin enough to bend. We started with a rectangular piece.
- Measured cuts and bends**.** Layout line on the sheet metal to designate where we would be cutting and bending. We would be bending the four sides up to make the walls, so measure out equal lines parallel to the edges. These lines would mark where the walls are bent.

- We also were bending over the top of each wall to hide the sharp edge. Drawn a parallel line a short distance down from each of the edges.
- Marked out equal squares on each corner of the rectangle. This square may already be present because of the bending lines that we drew earlier. This square would be cut out to create flaps that become the sides of the box.
- Then we bent the top edges over & once all of the squares were cut out, we were left with the four flaps.We then bent over the edges of these flaps to make smooth edges for the top of the box. Inserted the first edge into a bending brake. Made sure that it is lined up with the line we measured earlier. Bent the edge 90°. This created a lip.
- Hammered the lip down & continued the folding process by hammering the lip down so that it was flush with the flap. Repeated this process on all four flaps.
- Bent the walls up & now that the tops of the walls are finished, it was time to start raising them. Inserted one flap into the bending brake, lining up the bending line we measured earlier. Bent the wall up at a 90° angle. Repeated this process for each wall.
- Secured the corners & at that point, the box looked almost complete. The four walls were all up, and the top edges all folded over.
- Measured the height of the box. Cut four strips of metal, each long enough to reach from the bottom to the top of the box, and wide enough to be bent in half and secured.
- Inserted each strip lengthwise into the bending brake, with half in and half out. Bent each strip lengthwise at 90°.
- Attached the corner securing plates & once they were bent, placed a corner securing plate onto the corner of the box, and drilled holes through the plate and the box. Placed holes on each side of the fold, at the top and the bottom. Inserted rivets into each of the holes.
- Once all the rivets were set, the box was complete.

4.2. Manufactured Box

Figure 4.1 High Insulation Thermal Box

V. CONCLUSION

High insulation thermal box is developed using different thermal insulating materials. The design is done with the help of CATIA. We have used composite insulating material as well as PCM which is not harmful to environment that is ecofriendly. Also, the efficiency of the box has improved as the heat transfer to the surroundings has reduced by around 50%.

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