IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 4 Ver. II (Jul. - Aug. 2015), PP 27-29
www.iosrjournals.org

Review on Phase change material to maintain the Human comfort inside the car

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Abstract:*In this paper, temperature inside the car is maintained by introducingphase change material which is able to bring comfort for human. Nowadays to bring human comfort in car, air conditioning is used but the problem behind the usage will raise the fuel consumption and causes Environmental problem. To overcome this problems a renewable source of material (phase change material) is used to sustain the comfort condition inside the car. The phase change material is a substance which absorbs the heat and melts to change its phase and delivers thelatent heat. In this paper polyethylene glycol is used as a phase change material to bring the human comfort zone inside the car.*

I. Introduction:

The temperature inside the car has been increased especially during daytime (12 noon-2.30PM) which leads to affect the human comfort and even causes death. In order to overcome this we are in need of air conditioning. The usage of air conditioning increases the fuel consumption and causes environmental problem. Due to the above mentioned problem in the usage of air conditioning phase change material is used to maintain the temperature.

Phase change material is a latent heat storing material. Thermal energy transfer occurs when a material changes their phase. Phase change materials absorbs and release heat at a nearly constant temperature. They store nearly 5-14 times more heat than the sensible storage material water.

Organic materials are further described as paraffin and non paraffin.. Organic materials have congruent melting means melt and freeze repeatedly without phase segregation and non-corrosiveness.

Paraffin wax consists of a mixture of mostly straight chain n- alkenes $CH3–(CH_2)–CH_3$. The crystallization of the (CH_3) chain releases a large amount of latent heat. Both the melting point and latent heat of fusion increase with chain length. Due to cost consideration, however, only technical grade paraffin may be used as PCMs in latent heat storage systems. It is good in their chemical properties and lags in their thermal property.

Non-paraffin organic are the most numerous of the phase change materials with highly varied properties. Each of these materials will have its own properties unlike the paraffin's, which have very similar properties. Abhat et al. and Buddhi and Sawhney have conducted an extensivesurvey of organic materials and identify fatty acids suitable for energy storage. These organic materials are further subgroups as fatty acids and other non-paraffin organic. Some of the features of these organic materials are as follows: (i) high heat of fusion, (ii) inflammability (iii) low thermal conductivity.

Fatty acids have high heat of fusion values comparable to that of paraffin's. The general formula describing all the fatty acid is given by$CH_3(CH_2)$2n COOH and hence, qualifies as good PCMs. Their major drawback, however, is their cost, which are 2–2.5 times greater than that of technical grade paraffin's.

Inorganic materials are further classified as salt hydrate and metallics. These phase change materials do not super cool appreciably and their heats of fusion do not degrade with cycling.

Salt hydrates may be regarded as alloys of inorganic salts and water forming a typical crystalline solid of general formula AB nH2O. The solid–liquid transformation of salt hydrates is actually a dehydration of hydration of the salt. It is good in its thermal properties and poor in its chemicalproperties.

Metallics include the low melting metals and metal eutectics. These metallics have not yet been seriously considered for PCM technology because of weight penalties. They have high thermal conductivities. A major difference between the metallics and other PCMs is their high thermalconductivity but cost is high. Some of the features of these materials are as follows: (i) High thermal conductivity (ii) Cost is high (iii) Less promising materials.

However, for the use of phase change materials these materials must exhibit certain thermal, chemical and physical properties. Moreover, economic and availability of these materials have to be kept in mind. The latent heat should be as high as possible, to minimize the physical size of the heat store.High thermal conductivity would assist the charging and discharging of the energy storage.

Thermal Properties:
(i) Suitable phase-transition temperature.
(ii) High latent heat of transition.
(iii) Good heat transfer.

Selecting a PCM for a particular application, the operating temperature of the heating or cooling should be matched to the transition temperature of the PCM. The latent heat should be as high as possible, to minimize the physical size of the heat store. High thermal conductivity would assist the charging and discharging of the energy storage.

Physical Properties:
(i) Phase equilibrium.
(ii) High density.
(iii) Small volume change.

Phase stability during freezing melting would help towards setting heat storage and high density is desirable to allow a smaller size of storage container. Small volume changes on phase transformation.

Chemical Properties:
(i) Chemical stability and No toxicity.
(ii) No fire hazard.
PCMs should be non-toxic, non-flammable and non-explosive for safety.

Economic Properties:
(i) Abundant.
(ii) Available.
(iii) Cost effective.
Low cost and availability of the phase change materials.

Properties of Polyethylene glycol 600:

PCM Selection for cold storage includes the following properties: It should have,Suitable phase transition Temperature, Inflammable, Non-toxic, Chemical Stability, Thermal stability, Non corrosive, Abundant, Cheaper and available, No super cooling.

Mostly the above properties are achieved by the organic phase change material (non paraffin).

Property of PCM :

Phase change material	Polyethylene glycol 600
Melting point	24^{o}c
Latent heat	146 KJ/Kg
Thermal conductivity	0.21 W/MK
Density	0.951 Kg/m^{3}

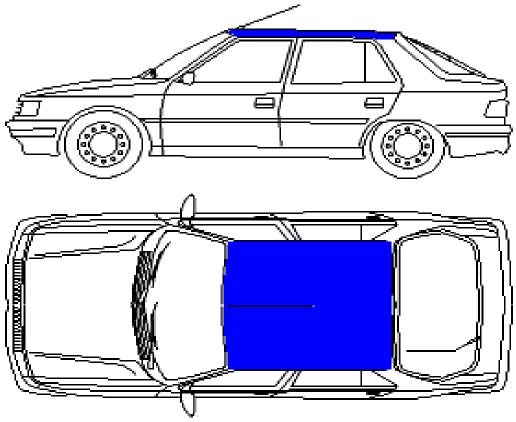
Filling of Phase change material:

Filling the PCM is a major problem. It consists of two methods:
1. Encapsulation.
2. Filling the PCM as a layer.

Filling the PCM as a layer increases the cost so we are going for encapsulation method. The selected Phase change material is filled in the aluminium foil pouches and sealed to avoid the leakages during the phase transformation. So that number of aluminium pouches are filled and sealed, and then installed at the top of the car cabin.The advantages of encapsulation are:
1. Reducing PCMs reactivity towards the outside environment.
2. Controlling the changes in the storage material when phase change occurs.

Experimental Layout:

In mid size cars, solar radiation is incident mostly on the top most cover. Due to this, the temperature gets higher and affects the human comfort. So that the air conditioner is used to extract the heat inside the cars nowadays, but the usage increases the load which increase the fuel consumption and causes the environmental pollution.



In order to avoid those problems, the usage of air conditioner is replaced by the phase change material. In this case, the air conditioner is taken out and top cover is filled with the phase change material. The Phase change material is filled in the aluminium pouch and sealed. These pouches are installed inside the car at the top cover. Thus Phase change material extracts the heat inside the car. The amount of heat extracted is depends on the mass of the phase change material.

Calculation:
The Source of heat to the phase change material from cabin and the ambient air around the car. The Total heat inside the car is given by the,

$Q_{total} = m \times c_p \times \frac{dT}{dt}$

In the above equation, m is the mass of the air in the cabin that for a mid-size car and at 40 °C is equal to 3670 g.

Temperature inside the car is ranging from 73°c to 40°c and Q_{total} is calculated,

Q_{total} =182 KJ.

So that the amount of phase change material filled to extract heat is determined by,

$Q_{total} = m_{pcm} \times \lambda_{pcm}$

m_{pcm} = 1245 grams.

II. Conclusion:

Thus for the above work the amount of Phase change material used for extracting the heat inside the car during the parked or driving on sunshine is calculated to be 1245grams to maintain the human comfort condition.

Further the performance can be increased by increasing the quantity of the phase change material and also by proper phase change material with high storage capacity.
PCM filled pouches are installed on the cabin easily at low cost further it is eco-friendly.

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