REVIEW ON THE UTILIZATION OF WAX PHASE CHANGE MATERIALS (WPCMs) IN CHINA

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Keywords: review; wax; phase change; materials; utilization

The utilization of wax phase change materials (WPCMs) as raw material has been reviewed in the present article. Additional use of WPCMs into the solar energy system, the construction system, the air conditioning system and the textiles products has also been discussed. The melting point, fusion heat and the properties of commercial WPCMs have also been compared. The complete utilization of WPCMs has been resulted in good economical and social benefits.

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INTRODUCTION

Presently the utilization of thermal storage capacity of wax phase change materials (WPCMs) is under intense focus because of their high temperature thermal storage capacity, high thermal efficiency and also keeps energy at a constant temperature etc. WPCMs not only change their phase but also absorb or release a lot of latent heat with the change of the reaction temperature.[1] These are having the advantages of high latent heat capacity during the phase change process, no super-cooling, low steam pressure during the melting process, no chemical reaction taking place, stable performance, almost no change of phase temperature and phase latent after absorbing or releasing latent heat several times, no phase separation, no corrosive properties and low price also. Therefore, WPCMs are widely used in the different areas such as solar energy, residual industrial heat, waste heat recovery and saving energy during construction etc. [2]

In the present paper, authors have discussed the use of WPCMs in different areas such as the solar energy, the construction, the air conditioning systems and the textiles products have been discussed and a comparison to the melting point, fusion heat and the properties of commercial WPCMs also.

DISCUSSION

The melting point and fusion heat of commercial wax phase change materials [3] are shown in Table 1. Astorstat is a product coming out from Astor Paraffins/Waxes Honeywell, had number one melting point range. However, Micronal (microcapsule) from BASF had observed a minimum melting point range. On the other hand, Rubitherm RT's fusion heat had the wide range as compared to Astorstat and Micronal (microcapsule), which had no fusion heat range, therefore the properties of Rubitherm RT were found better than that of other products.

Table 1. The melting point and fusion heat of commercial wax phase materials

Name	Melting point (°C)	Fusion heat (kJ/kg)	Manufacturer
Astorstat	0-148.9	-	Astor Paraffins/Waxes Honeywell
Rubitherm RT	-7-100	130-214	Rubitherm GmbH
Rubitherm GR (granulate)	27-80	64-72	Rubitherm GmbH
Rubitherm PX	41-82	110-117	Rubitherm GmbH
Micronal PCM (microcapsule)	23-26	-	BASF
Outlast Thermocules (microcapsule)	6-79	160-200	Outlast

The properties of wax phase change material [4]

Table 2 shows the heat properties of n-paraffins. The melting point of even-numbered n-paraffins increased with an increase in the molecular weight. Further it has been noticed that, even-numbered n-paraffins had higher melting heat than that of odd-numbered n-paraffins. However, odd-numbered n-paraffins did not follow any rule with the molecular weight.

Utilization of wax phase change materials in the solar energy system

The energy storage for solar power as a clean and unconventional energy source is widely studied and used. Its phase change storage has large developing markets because of high temperature thermal storage capacity, maintaining at a constant temperature. Wax used in the solar heating water system and the solar air conditioning system is one of the phase change materials. The solar heating water system with phase change materials transfers heat energy from cold water heated during daytime to wax phase change materials. Its storage energy is kept through the melting process. Phase change materials release energy to cold water during night. This is one cycle system. [5] Feng Xiaojiang [6] introduced a wood solar drying device with latent heat storage system, where WPCMs were added with a multi-row pipe. The result showed that time of exothermic reactions gradually decreased with an increase in the multi-row pipe (5, 7, 9 and 11), however, the heat transfer coefficient increased with the increase in the multi-row pipe. Their average values were 17.8, 22.1, 24.7, 26.4W/(m^2·°C), respectively. It was supposed that the other parameters except the number of pipelines were kept constant. When the number of pipelines was less than 5, the variation of heat transfer coefficient with temperature was very low. When the number of pipelines was more than 11, the storage of sensible heat was not neglected. On the other hand, it was supposed that the other parameters except the wind speed were kept constant. The heat transfer coefficient increased with the increase in the wind speed. When the wind speeds were 1.0, 1.5, and 2.0m/s respectively, ratio of exothermic reaction rates was 0.89:0.94:1.00 respectively.

Utilization of wax phase change materials in the construction system

Zhou Dunbai [7] produced paraffins/montmorillonite nanometer sized phase change materials (NSPCMs) and studied on its utilization on the surface of the wall. NSPCMs were prepared by using unmodified montmorillonite with paraffins. Adding NSPCMs into concrete generated phase change construction materials. The temperature distribution in phase change construction materials was analyzed with ANSYS software. The fluctuation in room temperature decreased with adding NSPCMs and the living comfort was improved.

Table 2. The heat properties of n-paraffin wax

Molecular formula	Molecular weight	Melting point (°C)	Melting heat ($J·g^{-1}$)
$C_{16}H_{34}$	226	16.7	236.81
$C_{17}H_{36}$	240	21.4	171.54
$C_{18}H_{38}$	254	28.2	242.67
$C_{19}H_{40}$	268	32.6	-
$C_{20}H_{42}$	282	36.6	246.86
$C_{21}H_{44}$	296	40.2	200.83
$C_{22}H_{46}$	310	44.0	251.04
$C_{23}H_{48}$	324	47.5	234.30
$C_{24}H_{50}$	338	50.6	248.95
$C_{25}H_{52}$	352	53.5	-
$C_{26}H_{54}$	366	56.3	255.22
$C_{27}H_{56}$	380	58.8	234.72

Utilization of wax phase change materials in the air conditioning system

Wang Yue [8] used WPCMs to recover the residual heat from the air conditioning system. Cold water was heated through WPCMs. It not only reduced the domestic electricity consumption / prices but also decreased impact of the air conditioning system on the environment.

Utilization of WPCMs in the textiles products

Wang Xiaopeng [3] introduced that outlast technology, firstly served for NASA, used WPCMs that absorbed, stored and released heat for living comfort. WPCMs was permanently stored and protected in a polymer shell. Their name called microencapsulated phase change materials Thermocules ™. This Thermocules ™ was absorbed into fabrics and fibers that were able to adjust skin's microclimate. When the skin become hot, the heat was absorbed. When the skin become cool, the heat was released.

CONCLUSION

Based on the above discussion and review, WPCMs are widely used in different areas such as the solar energy, construction, air conditioning systems and the textiles products, etc. It is an urgent need for *Chinese* scientists to study on the properties of WPCMs, e.g. wax density is increased and its coefficient of thermal conductivity does not change at the same time therefore its thermal capacity is also increased. Best WPCMs used in the different areas should also be produced. Nano-technologies combine with wax to produce a new nano scale sized phase change material should also be considered. Wax is added into macromolecular materials to generate multiple phase change materials.

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Received: 20.10.2012.
Accepted: 29.10.2012.