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Full Length Research Paper

Polypropylene/Polyethylene(PP/PE) alloy as a phase change material for energy storage in a solar cooker

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Abstract:

As part of the continuation of our research work, we focused on the choice of phase change material (PCM). We chose polypropylene (PP) and polyethylene (PE). This choice is justified through a number of properties. Firstly PP is a semi-crystalline thermoplastic polymer of high consumption whose phase change temperature changes from 160 ° C to 170 ° C for the commercial grade. It has several advantages among other it is food (odorless and non-toxic) and recyclable. As for PE, it is one of the simplest and cheapest polymers and its phase change temperature ranges from 85 ° C to 140 ° C. We have constructed the solidification diagram to determine the phase change temperature of the PP / PE mixture. One of the most important PCM requirements is stability after a number of repeated fusion / solidification cycles. PCM should have the same or nearly the same thermal, chemical, and physical properties after repeated cycles. Once the composition has been identified, a thermal stability test is carried out to study the evolution of the temperature as a function of the heating cycle. We observe that the temperature evolves very little, which allows us to affirm the stability of the composition.

Keyword: PCM, polypropylene, polyethylene, energy storage, thermal cycle.

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1. Introduction

Faced with the scarcity of energy resources, many African states are embarking on a dynamic of liberalization of this sector. This is how the Ivorian government at its meeting of the Council of Ministers of 12 October 2016 issued decrees for liberalization of the energy sector. In recent years, we have witnessed a proliferation of solar systems, such as solar cookers, solar water heaters and many others. Given the intermittent nature of this cheap energy a problem that remains is that of its storage. Several materials have been studied for their classification and use [1]. The difficulty has so far been with the cooking temperature, which does not often exceed 120 ° C [2,3]. In this work we want to study the stability of the polypropylene / polyethylene alloy as a phase change material through the determination of the influence of thermal cycle melting / solidification on its thermo-physical properties; such as the melting point and latent heat of fusion, to be used as a storage medium inside a solar cooker. The coupling of these two materials allowed in principle to reach a temperature between 140 ° C and 160 ° C.

2. Literature Review

D. Buddhi, S. D. Sharma et al. [2] designed and developed a solar cooker with a phase change material storage unit to store solar energy during sunshine hours. The phase change material used is commercial acetamide having a melting temperature of 82 ° C. In this same vein, Klemens Schwarzer and Maria Eugenia Vieira da Silva [4] presented in their work the experimental results of solar cooking systems with or without heat storage. Their two basic components of the system are solar collectors with reflectors and a cooking unit. When thermal storage is required, a tank filled with rollers is added to the system. The working fluid, usually a vegetable oil, which circulates in a natural flow thermosiphon, through a copper pipe that in expanded graphite a paraffin / graphite composite phase transfer as a storage material. The melting is connected to components. While Zhengguo Zhang and Xiaoming Fang [5] prepared by paraffin absorption in expanded graphite a paraffin / graphite composite phase transfer as a storage material. The melting temperature of this compound is 65°C. In such a composite, paraffin serves as a latent heat storage material and expanded graphite acts as a support material. The paraffin and expanded graphite preparation as a phase change material had a large thermal storage capacity and thermal conductivity and did not leak liquid during its solid-liquid phase change. However, A.A. El-Sebaii et al. [6] proceeded to the determination of the influence of the rapid thermal fusion / solidification cycle of magnesium chloride hexahydrate ($MgCl_26H_2$ O) commercial type on its thermo-physical properties; such as the melting point and latent heat of fusion, to be used as a storage medium inside solar ovens. After analyzing the various studies, we note that despite the problem related to the exposure of the housewife to the sun for the direct cookers, another problem which is that of the temperature level still arises. Indeed, the temperature level still remains below 120ºC. We have seen all the work done. We opted for the implementation of a material that will squeeze from PCM in a cooker under cover. Of the different energy storage techniques, latent heat storage offers many possibilities. However, it will overcome major problems related to this type of storage namely material selection and storage efficiency. A large number of phase change material has a melting temperature in the temperature range (0-170 ° C). However, they can only be used as storage materials when they have certain thermodynamic, kinetic, chemical and economic properties. Could not our study look at the possibility of coupling two plastic materials that would reach the temperature range of 140 ºC to 160 ºC ? So the material we chose is a polyolefin (polypropylene / polyethylene).

3. Methodology

The experimental part consisted in determining the influence of the melting / solidification, thermal cycling of a mixture (PP / PE) on its thermo-physical properties; such as the melting point and the latent heat of fusion, to be used as a storage medium inside the solar cookers. It is a question of determining experimentally the temperature at which each composition changes phase. Fig.1 shows the view of the experimental device temperature at which we observe the merger of each composition. Once these temperatures are determined we opt for the alloy whose melting temperature reaches 160 ºC. The tests are carried out in the INP-Center's chemistry laboratory, with the following equipment: 100 g of polypropylene (PP), 100 g of polyethylene (PE), the characteristics of which will be given later, 4 hotplates RSLAB- 1C, 10 pyrex beakers, 2 PN2AP thermocouples, 1 WUNDER Sa.Bi electronic scales, spatulas. The composition (PP, PE) identified being (80; 20); we will integrate it into our cooking system which is inspired by the model of Antonio Lecuona et al. [7]. They examined relevant issues about solar cooking in a device that incorporates a daily storage utensil. Note that their model uses paraffin and erythritol.

4. Experimental work

4.1. - Characteristics of polypropylene

It is part of the family of thermoplastics, hot formable without chemical modification and are easily recyclable. Characterized by its high inertia to chemical attack, its high resistance to shocks and its melting temperature is between 160ºC and 170ºC. The PP has many advantages: it is cheap, food (odorless and non-toxic), very resistant to fatigue, very sparse.

4.2.- Characteristics of polyethylene

One of the simplest and cheapest polymers. It belongs to the family of polyolefin. It is one of the most widely used thermoplastic resins in the world and concerns an untold number of industries and applications. It is non-toxic and inert, with excellent resistance to chemicals and shocks. Its melting temperature is around 85ºC.

4.3.- Operating mode

The goal of these different manipulations is:

-Determine the melting temperature of the different PP / PE mixtures, Fig.1 and Fig. 2 .

-Determination of the temperature of the composition (80/20) after a few cycles.

-Experimental protocol

Place a glass beaker on the electronic scale, then tare the scale.

Into this beaker the solid polypropylene and polyethylene in the chosen proportions, until the balance marks 50 g.

Put the beaker on the hotplate, heat it to and wait until the mixture melts completely.

With the help of the thermocouple, the temperature of the liquid phase is raised.

Raise the temperature again just before all the mixture cools and solidifies.

Then proceeded to the temperature measurement of the composition (80/20) over several cycles of which ten are shown in Fig. 3. This PCM will be incorporated in a cooker whose exploded schematic is illustrated through Fig. 4.

4.4.- Results

Figure 1: View of the experimental device

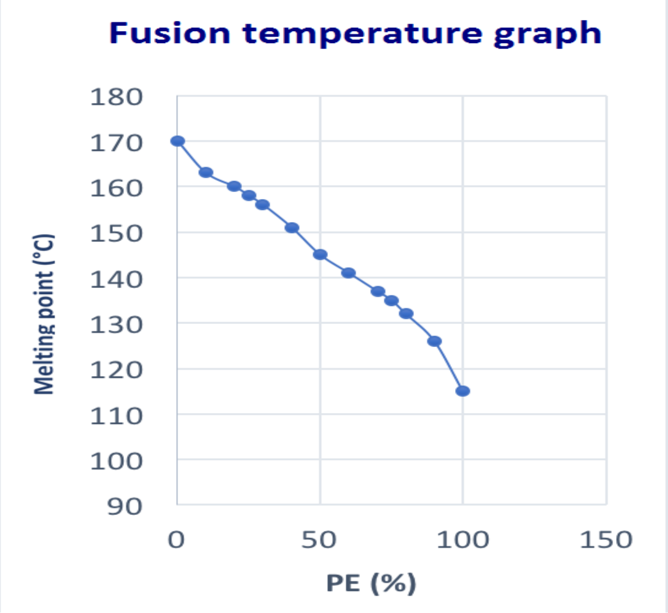

Fig. 2: Melting Temperature Curve

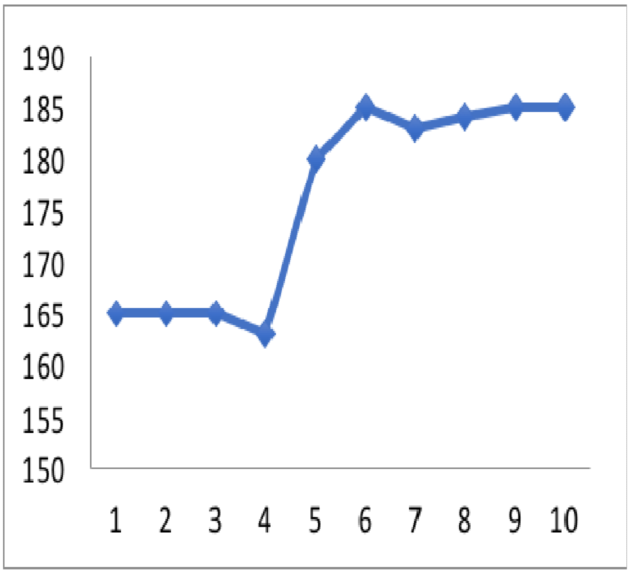

Fig. 3: Melting temperature curve with respect to cycle

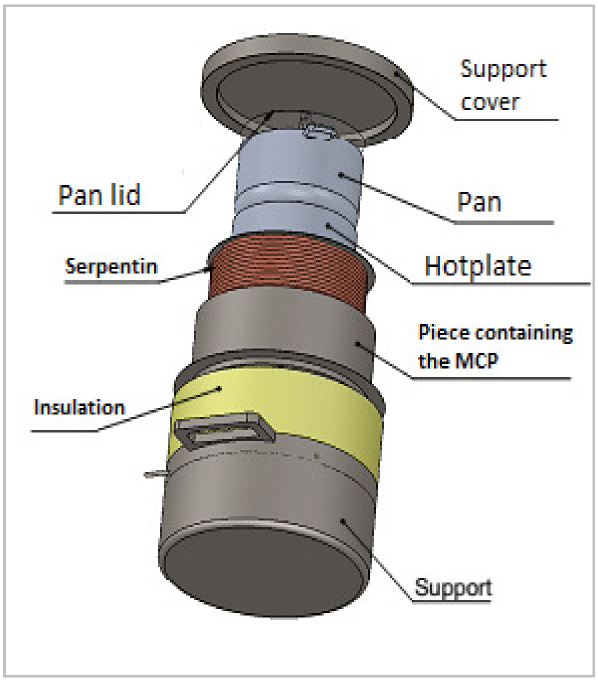

Fig. 4: exploded diagram of the cooker

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