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RESEARCH ARTICLE

EXPERIMENTAL EVALUATION OF THE MELTING POINT OF SAND/PLASTIC WASTES MIXTURE

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ABSTRACT

This work concerns the study of the essential thermal parameters needed to design a furnace for the melting of plastic wastes namely: the melting point of the plastics, times of melting and kneading of the mixture and useful heat. A smelter of mark MASAT with maximum operating temperature of 950°C was used for the melting of the plastics. To determine the time taken for plastic wastes to melt, kneading time of the sand/plastic mixture and the best ratio for a perfect mixture, we carried out tests with the ratios of sand/plastic of 80/20; 75/25; 70/30; 65/35; 60/40; 55/45 and 50/50 with a total mass of the mixture being 800g. The analysis of the results shows that for a good kneading of the mixture, it is necessary that sand should be preheated to at least 200 °C before introducing it into the furnace. This step modifies the protocol suggested by Athanase in 2011.The optimal melting temperature of the PET is 250C.The kneading time decreases with an increase in the quantity of plastic in the mixture whereas the residence time is proportional to the increase in the quantity of plastic in the mixture. For a ratio of 50/50, the residence time is 3324 s and 2843 s respectively for non-preheated sand and preheated.

INTRODUCTION

One of the significant fields in the interaction between human activities and the environment is waste management. In low-income countries, the most used method is the setting in of dumping grounds. However, if this is the easiest and the least expensive to implement, the fact remains that it needs to reach its goal and follow certain rules, which is very rarely the case. There are several alternative waste treatment methods that correspond to each type of waste. The wastes consist of Fermentable, carton papers, other fermentable fuel, other non-fermentable fuels, glass, metals, other non-combustible, Plastics (Mbozo'o, 2010). Plastics are currently ubiquitous in industrial and consumer goods, and modern life is unimaginable without them (Thompson *et al.*, 2009). There is several waste treatment methods was follow: the use of dumping grounds which is the traditional approach of the management of waste (Swift, 2004). Incineration consists of collecting the wastes and burning them in an incinerator. It is often done with energy recovery. This method reduces the need for setting in dumping grounds of plastic waste; however, there is concern that hazardous substances can be released into the atmosphere in the process. The thinning of reducing the amount of packaging used per item which will reduce waste volumes. The economy requires that most manufacturers already use near minimum necessary material required for a given application (Thompson *et al.*, 2009). Recycling which is a process in which the materials constituting a product at the end of its lifetime are re-used in all or partly, salvaged and then re-used (Fisher, 2003). In some African countries, an interesting method is tested which is to establish manufacturing facilities of paving stones out of plastic, but with significant technical and financial difficulties. It is a question of manufacturing building materials starting from a hot mixture of sand and plastic sachets. Tests on an artisanal scale proceeded in Chad (process CERVALD, initiated in 1998, in CHAD, in Niger, in Cameroun, in Mali).

It is therefore essential to go further into this matter to determine the satisfactory conditions to ensure its sustainability. Although there are researches on the valorization of plastic wastes (PP, EP) like binder for the manufacture of the paving stones and the tiles (Sodje, 2010; Bagayoko, 2011, Athanase, 2011). At the limit of our knowledge, there exists little work done concerning the valorization of plastic wastes PET and the equipment used in the melting of sand/plastics mixture. It is according to this that our work is centered on the thermal characterization of the mixture of sand/PET for the designing of a furnace. More specifically, it will be a question of studying the thermal behavior of plastic waste PET, their mixture with sand and of determining the best characteristics of an improved furnace.

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MATERIALS AND METHODS

Equipment

The material is consisted of sand and the plastic. Sand used coming from Wak town in Adamawa region. A size range of 0/2 with a rate of impurities of 11%. The plastic PET resulting from the local market has a rate of absorption of 0.016, volume mass of 0.93, a density of 1395 m3.

Melting equipment

For the melting of the plastics, we will use a furnace of **Masat mark** whose maximum temperature is 950C. It is a furnace which has a 3 liters room cooking capacity.

Measuring materials

The mass of the samples was measured using the Satorus balance. A thermometer testo 405 was used to measure the temperature at the heart of the smelter.

Table 1. Plastic-sand ratios and the total weight of the mixture

Plastic-sand Ratio (%)	50/50	45/55	40/60	35/65	30/60	25/75	20/80
PET quantity. in g	400	360	320	280	240	200	160
Sand quantity. (g)	400	440	480	520	560	600	640
Total quantity. (g)	800	800	800	800	800	800	800

Experimental description of the protocol

The experimental protocol is described in 4 phases:
-The collecting, sorting and cutting phase;
-The heating and mixing phase;
-The moulding phase;
-And the cooling and removal phase.

Phase 1: collect, sort and cut

Plastic wastes were collected in the streets of Dang town. Sorting permitted us to extract only the PET. These PET are then cleaned, dried in the sun then cut out in fine particles (Figure 1).

Figure 1. Drying of the plastics

Phase 2: Heating, melting and mixing

The furnace is heated beforehand to250°C which is the melting point of the PET, sand is preheated to 200°C.This preheated sand is then introduced into the plastics to melt in the crucible of the furnace. The mixture is kneaded to norce a homogeneous paste. Figure 2 presents the operation of kneading in the Masat furnace.

Figure 2. Mix then knead

Phase 3: molding

The paste thus obtained is discharged through the bottom opening of the furnace into molds placed on a metal plate. These molds are then placed in a press and then pressed.

Figure 2. Molding

Phase 4: cooling and stripping

The resulting homogeneous block is cooled in the air for a few minutes, then stripped and trimmed.

Figure 4. Moulding of a sample

Determination of the melting the time

When we determined the exact melting temperature, we adjusted the furnace at this temperature. When it was ready we introduced the plastic. As soon as the plastic gains the liquid phase we noted the time and we introduced sand for the mixture.

RESULTS AND DISCUSSION

Melting point as a function of the percentage of plastic

Figure 5 presents the variations of the melting temperature in relation to the percentage of plastic in the mixture for the two types of protocols. The analysis of figure 5 shows that the melting point of plastic changes indifferently compared to the quantity of plastic contained in the mixture. The protocol of Athanase makes it possible to obtain a melting point of 250 $^{\pm 1}$ C whereas the same process modified during our work gives 250 $^{\pm 0.5}$ C. These results are in agreement with the literature which mentions that the melting point of the PET is of approximately 250C and that this temperature does not depend on the quantity of plastic in the mixture. However the fluctuations observed during handlings can be explained by the presence of the additives used in the formation of the products in PET.

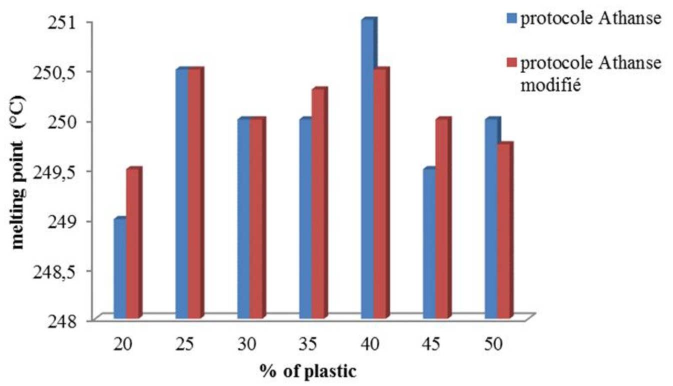

Figure 5. Melting point as a function of the percentage of plastic in the mixture

Melting Time as a function of the percentage of plastic

The plastics melting time in relation to the percentage of plastic in a mixture of 800 gramms is represented on figure 6.We note here that the melting time increases in a linear way with an increase in the quantity of plastic in the mixture for all protocol used. This time respectively changes from 1500s to 2200 for a percentage of 20 and 50 % of plastic in the mixture. This was expected since according to Figure 5, the melting temperature is constant, the increase in the mass of plastic results in an increase of the time required to reach the melting temperature.

Kneading Time as a function of the percentage of plastic

Figure 7 represents kneading times as a function to the percentage of plastic for the two studied protocols. This time is defined as the time necessary to obtain a perfectly homogeneous mixture. The analysis of the curves shows that for the Athanase protocol, the kneading time increases with the percentage of plastic whereas for the modified Athanase protocol (preheated sand to 200°C) this time decreases with the percentage of plastic.

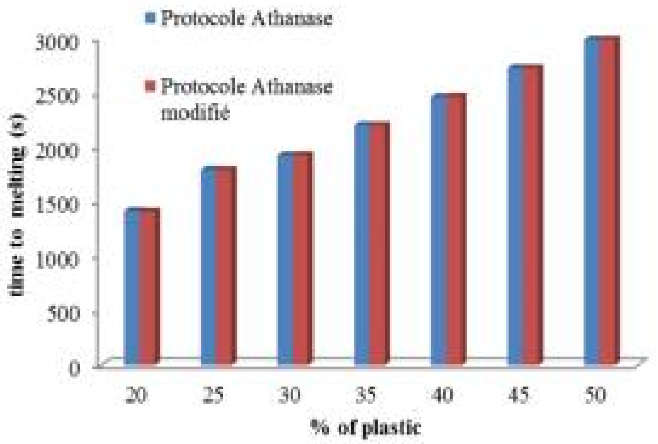

Figure 6. Time to melt based on the percentage of plastic

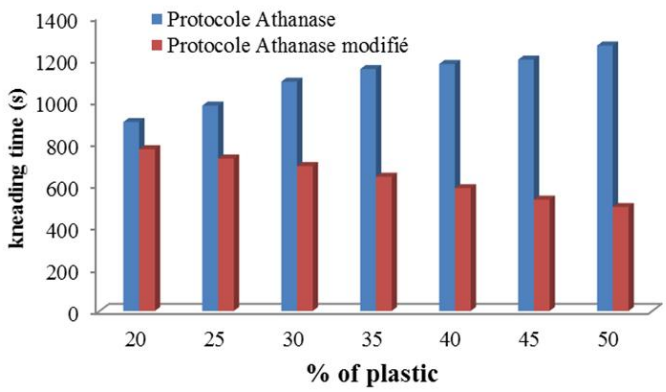

Figure 7. Kneading time as a function of the percentage of plastic

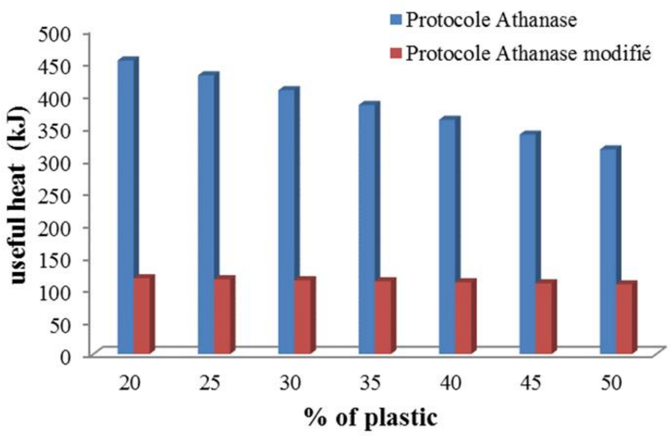

Figure 8. Consumed heat

Melting heat as a function of the percentage of plastic

Figure 8 represents the heat consumed according to the percentage of plastic. During the Athanase protocol, the useful heat for plastic melting decreases with the increase in the percentage of plastic in the mixture for the Athanase protocol modified this heat is practically constant for any percentage of mixture. For a percentage of 20, we obtain 480.44 kJ/kg with the Athanase protocol whereas this heat is worth 140.35 kJ/kg with the modified Athanase protocol that is to say we have a difference of approximately 340 KJ/kg. This difference remains higher than the heat of pre-heating of sand. These results allow us to conclude that we can economize energy by preheating the sand before its introduction into the melting furnace. This new approach is called "Gnepie et al protocol."

Conclusion

At the end of this work whose general objective was to characterize a Sand/PET mixture for the design of an improved furnace, we made an experimental analysis of the thermal characteristics of plastic waste, namely: the melting point, kneading and melting times and finally of the useful heat. The results show that the melting point of the PET is of 250C. We obtained an average useful heat of 112.28 kJ for 800g of mixture which is approximately 140.35 kJ/kg. This enabled us to determine the useful heat that must produce our furnace, which is of 403 500 kJ, for a ratio of 50/50 what gives us a fuel consumption of 25.5 kg sawdust. The results also showed us that for a good homogenization of the mixture, it is necessary to preheat sand to a temperature of at least 200°C before introducing it into the furnace.

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