Characteristics of Recycled Plaster of Paris At Several Different Temperatures Between 150℃ - 190℃ During Recycling Process

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ABSTRACT

A significant amount of solid waste is dumped by the ceramics sector, which is a worry for the environment. As well known, Kuala Kangsar, Perak, Malaysia is the location to a large ceramics industry. In Malaysia, there are landfills, but not all of them can manage solid waste perfectly. As a result, many waste disposal contractors look down on solid waste management such as for Plaster of Paris (POP). This is even more complicated when there are a handful of them who take the easy way out by disposing of POP waste by planting or dumping it into rivers and seas. This causes various problems to the environment and health. The aim of this study is to identify how to recycle waste mould into new plaster without affecting their casting performance. This paper shows the study of the effect of characteristics Recycle Plaster of Paris (RPOP) compared to New Plaster of Paris (NPOP). Drying temperatures are performed at (150℃,160℃,170℃,180℃ and 190℃) for RPOP and use the same 60% of material and 40% of water ratio and tests for porosity, absorption, setting times and particle size are performed. The results indicate that all samples of Recycled Plaster of Paris performed well and can function similarly to New Plaster of Paris at different temperatures.

Keywords: *Recycle Plaster of Paris (RPOP), New Plaster of Paris (NPOP), Temperature, Drying*

INTRODUCTION

As reported by Muhammad Yusri (2020), the waste disposal in Malaysia increases dramatically every year. This is because of the daily waste production among. Malaysians recorded an increase of 100.71% to 38,142 tons in 2008 compared to 19.00 tons in 2005. The cause for solid waste dumping is due to the growth of resources or increase in population, socio-economic and lifestyle of Malaysians, unsystematic solid waste management and indifferent society (Bee, 2016). Dumping of wastes in open fields and rivers is common even until today and a study of waste disposal behaviour in Kuala Lumpur indicated that 31.9% of waste were disposed-off of by open burning, while 6.5% were dumped into the river system as discussed by Murad and Siwar (2007). Hence the environmental safety concern in Malaysia was secondary and most municipalities had a tough time in finding new disposal sites as the existing disposal sites were nearly exhausted. The problem of solid waste in Malaysia is increasingly worrying many parties, especially in the Ministry of Housing and Local Government. A total of 1552,238 tons of solid waste was disposed-off of from January to June 2019. The Government has implemented various efforts to reduce the delivery and disposal of solid wastes to landfills to prevent environmental pollution.

In general, ceramics is a material with desirable properties such as high strength and hardness, high melting temperature, and chemical humidity. Ceramic products require necessary processes such as forming, drying, and firing. The forming process required for the use of Plaster Of Paris (POP) is the main material used in this process called casting Roux, (2016). The clay will leather hard for 1-2 days and become green ware before firing. After firing the product during reaching up to 800℃ - 900℃ is called bisque firing. At the time of bisque ware, the product will be glazed and fired at a temperature of 1200℃ to get the finished product. Some ceramic products such as electrical insulators, dinnerware and tiles may then undergo glazing process.

Keane (1916) reported that Plaster Of Paris is a solid material originally made from white powder Calcium Sulfate Hemihydrate that will harden when it is mixed with water and left to dry until it becomes solid. The material is used in various fields including for construction, medicine, industry and some universities that make this material as a topic subject for learning in lectures, especially in the field of ceramics. The basic material used for Plaster of Paris (POP) is gypsum. The POP in the powder form will be mixed with water into desired form. Once the POP is set, it will be hardened and firmed. It will also become heavy. The chemistry after the POP set affects the physical properties of the POP. Hence, this problem needs to be addressed to understand the reusability of the used POP. However, it is a problem for universities and students to provide this raw material in large quantities and for free because it is expensive as Mould is used in ceramic to support and form clay. It is made from a porous material to draw moisture from the clay. This is commonly plaster, although simple press-moulded forms can be made from low-fired bisque. There are two types of mould. First, press mould, which is used in conjunction with hand-building techniques for making pieces such as functional dishes and bowls, architectural details, large shapes, and sculptures. According to Sharma and Prabu (2013), press mould allows the maker greater control during construction and suit forms that would be difficult to throw or slip cast, second is slip casting, which involves pouring liquid slip into a plaster mould. The water content of the slip is absorbed into the plaster, leaving behind a unified skin of clay. Making a mould for slip casting requires a certain degree of accuracy, which some makers find very appealing. It is excellent for producing crisp forms and multiples of an object, each one being identical to the next.

Plaster of Paris should be consistently stirred with clean utensils that are free from set plaster. The optimum stirring time is dependent on the size of the batch and the dimension of the stirring device. Plaster of Paris will not be evenly mixed if it is not stirred long and if stirred too long the mixture becomes too thick. In both cases this has a negative effect on product characteristics. Longer stirring generally leads to great strength, reduced absorption capacity and shorter setting time. Plaster which is vacuum-mixed has lower absorption capacity, reduced expansion, and increased strength. Plaster of Paris and water are mixed in proper proportion to create the mould utilised in the ceramic industry.

According to Pinheiro and Camarini, (2015), the gypsum plaster waste in Brazil is 4 percent to 15 percent of waste for building and demolition. Environmental legislation recommends that this waste is meant to be recycled to prevent soil and groundwater pollution. The purpose of this research is to demonstrate that recycled gypsum plaster preserves its functionality when submitted to similar periods of recycling. The recycled gypsum plasters have been produced over three consecutive recycling cycles by grinding and burning the waste. The products which were recycled were assessed according to chemical and physical properties. The findings obtained indicate that both recycled and industrial gypsum plaster is equivalent to that used in the building industry. The aim of this study is to identify that used POP can be recycled and reused as new plaster without affecting its casting performance. This Recycle Plaster of Paris (RPOP) method is environmentally friendly when reused. The resulting recycling process begins by finely grinding the Plaster of Paris waste and drying the fine powder in an oven at a temperature of 180℃ for 3/hour as reported by Bardella & Camarini, (2012). However, in this study the researcher has changed the drying period of RPOP. Therefore, some tests have been done on the RPOP sample to find out the reaction.

RPOP needs to preserve the properties of the plaster. When the RPOP is ready to be used for the mould making process, the absorption test is studied to ensure that the RPOP mould can absorb the water content in the slip just like a new mould. In addressing the goals of this study, several research problems need to be identified.

METHODOLOGY

Six types of samples were used in this study: New Plaster of Paris (NPOP) and Recycle Plaster Of Paris (RPOP) with five different temperatures. The samples were tested with NPOP as a comparison guide or controller to perform all the tests to investigate characteristics of RPOP. The RPOP was obtained from waste mould from Perbadanan Kemajuan Kraftangan Malaysia Perak Branch. After the collection, the waste material was crushed and sieved in a suitable machine to filter particles smaller than 1.25 mm. The powder RPOP was then put in the dryer at five different temperatures – 150 ℃, 160 ℃, 170 °C, 180℃ and 190℃– at intervals of 1 hour. This study was proceeded by checking the compressive strength of the concrete bars, porosity test and water absorption. Compressive strength analyses are tested by using the Compressive Strength Testing Machine (ASTM Standard).

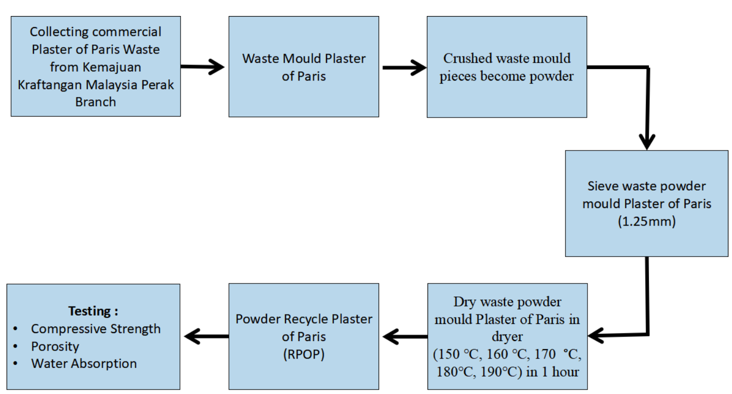

Figure 1: Process of preparing Powder Recycle Plaster of Paris (RPOP) and Testing

RESULTS AND DISCUSSION

Preparation of New Plaster of Paris (NPOP) And Recycle Plaster of Paris (RPOP)

Sample mould Recycle Plaster of Paris that had been prepared by using powder Recycle Plaster of Paris that was dried in dryer at different temperatures (37°C,150°C,160°C,170°C,180°C, and 190°C) and mixed with water will be blended with water for the plaster to harden. However, at 37°C, RPOP does not solidify because the air content in the RPOP powder is not reduced by the drying method. Plaster is poured into the container and sifted with a spoon. For this sample, the ratio was 40g of water to 60g of NPOP or RPOP material. In this study, 7 samples were tested, as shown in Figure 2.

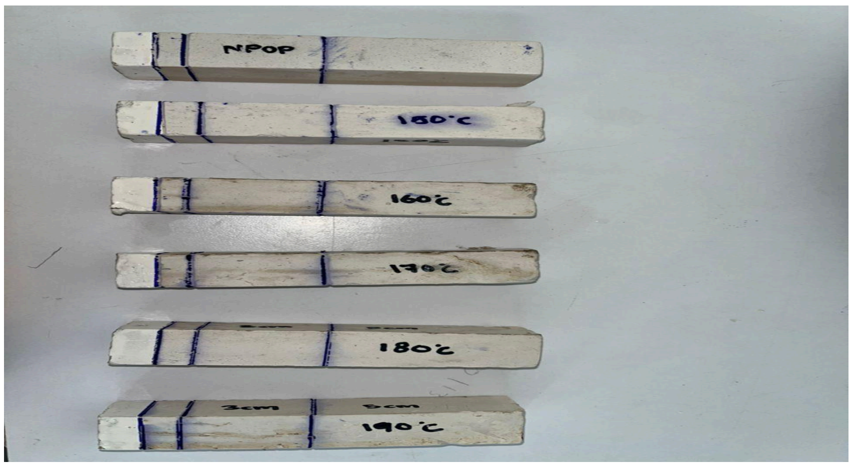

Figure 2: Hard set samples NPOP and RPOP (37℃,150℃,160℃,170℃,180℃,190℃)
(Source: Author's collection)

Compressive Strength

According to the results in Figure 3, the compressive strength at a drying temperature of 150 °C is highest when a ratio of 40:60 is used, obtaining a compressive strength of 4.36 kN. At a temperature of 160°C, the compression strength is 2.58 kN, which is the lowest recorded and the result is nearly identical to NPOP, which is 2.63 kN, with a difference of 0.05 kN. However, at 170°C, compressive strength began increasing 0.48 kN and dropped 0.11 kN inconsistently, then decreased to 180°C and increased again at 190°C. The amount of water present, as well as the temperature at which the RPOP is mixed and dried, have an impact on this. According to Li et al. (2018), gypsum shows varied dehydration characteristics and physical properties, as well as hemihydrate activity, depending on the temperature of production. The compressive strength measurements show that at 160 °C, the values are nearly identical to NPOP. Extraction of water from the medium recycling process at 160 °C improves the water content and density of the RPOP mixture during mixing.

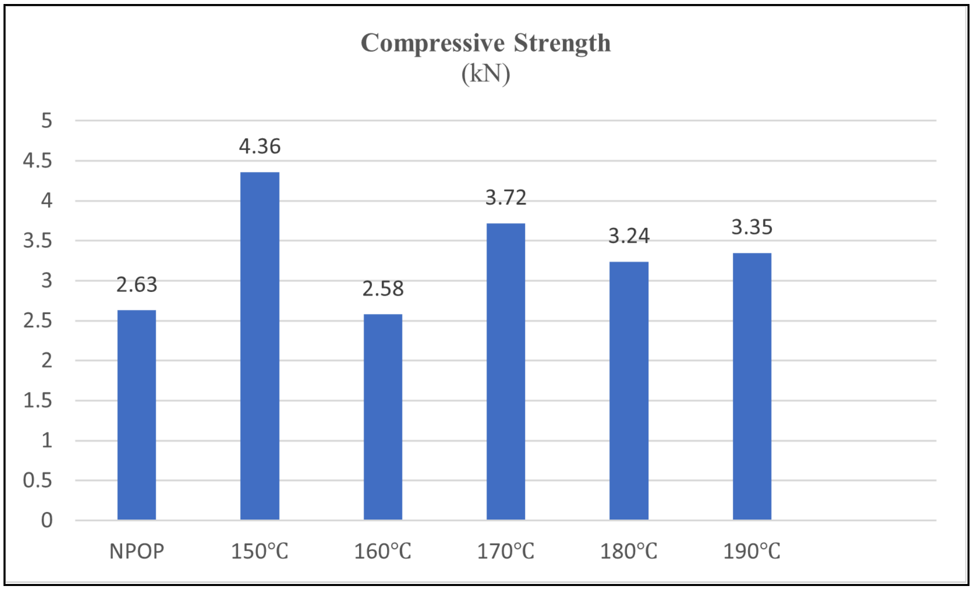

Figure 3. Compressive strength at Different Drying Temperatures

Porosity

Figure 4 shows the percentage of porosity for NPOP and RPOP at various drying temperatures. The graph plot shows that RPOP 180°C has a lower porosity percentage of 144%, whereas RPOP 160°C has a higher percentage of 157%. According to Nawi and Badarulzaman (2015), the percentage of porosity decreases can happen because the number of empty space porosity decreases in each sample analysed, which is determined by the temperature used. When the number of temperature is added, the fraction of voids in the sample will decrease and the bonding between particles will increase which will cause low strength in the sample. According to Nawi and Badarulzaman (2015), data shows that the percentage of porosity decreases from 950 °C to 1050 °C. At temperatures as high as 1050 °C, the number of pores and empty spaces may decrease. Furthermore, because POP is a very porous ceramic material with a large internal surface comprised of interlocking crystal, additive POP wastes increase the percentage of porosity. This analysis shows that the study's control sample, 160°C, is almost equivalent to NPOP.

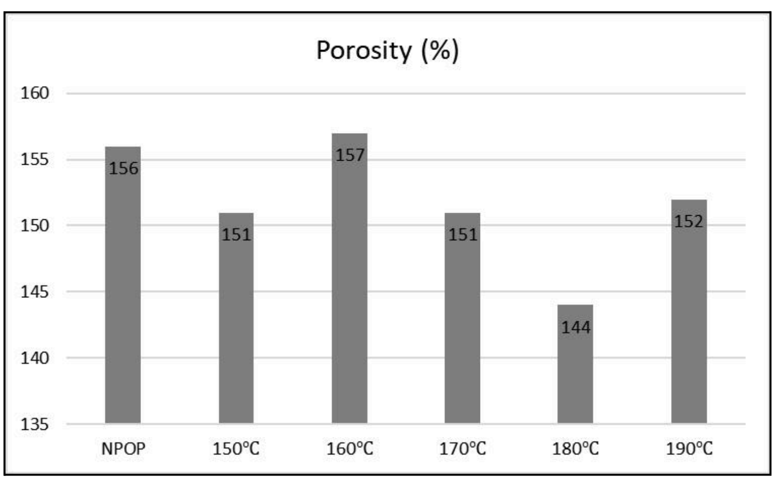

Figure 4: Percentage of porosity at Different Drying Temperature

Water Absorption

The samples of NPOP (150℃, 160℃, 170℃, 180℃ and 190℃) were dried for 4 hours at a temperature of 55℃ before water absorption was tested. As shown in Figure 6, the percentage of absorption decreases from 150℃ to 160℃, an increase of 1.56% however the percentage decreased from 170℃ until 190℃. This is because differing drying temperatures might have an effect on it. Therefore, even though the ratio of water to RPOP powder is constant, the percentage of water absorption decreases as the temperature increases. According to Madu (2016), the amount of water used causes the rise in hardness in Plaster of Paris. When the volume of water increases, the fraction of voids increases, while bonds between particles decrease and resulting in a low sample strength.

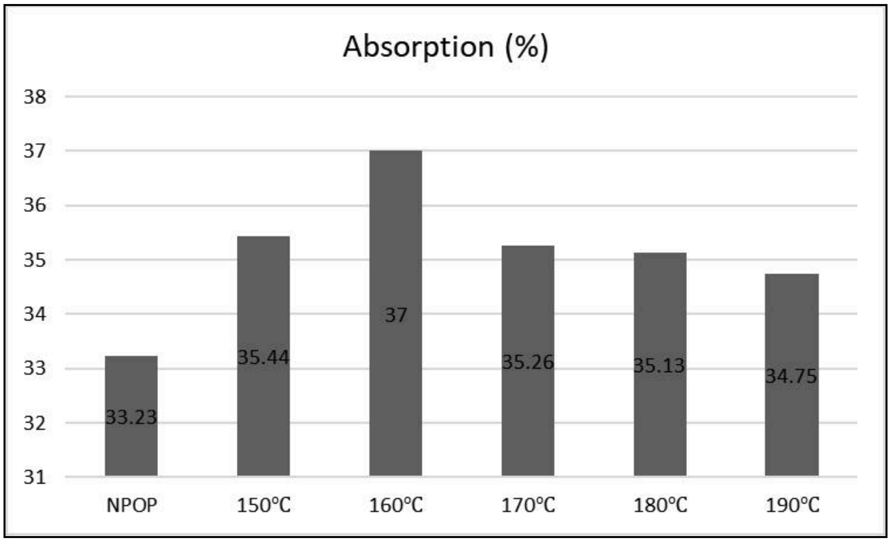

Figure 6. Percentage of water absorption

CONCLUSIONS

The use of various temperatures (150°C, 160°C, 170°C, 180°C, 190°C) for 1 hour produces a finding that all these temperatures can be utilised in the recycling process. The result of this study shows that RPOP is recyclable and may be relied on to produce mould casting as well as through the recycling process. However, this study shows that the RPOP can be recycled at the optimum temperature of 160°C for the same purpose as the original binder. As a result of this research, RPOP is recyclable through the recycling process. For the results of compressive strength and porosity, 160℃ is the closest to NPOP. For the results of water absorption at a temperature of 190℃ is needed, which is almost the same as NPOP, however, this RPOP can still be used to make moulds or model products. RPOP 160°C has the same physical and chemical properties as NPOP, but the water absorption at 190℃ has almost the same result as NPOP. RPOP can still perform the same process as NPOP if it is shaped into a mould.

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