REVIEW ON THE BIODEGRADABLE RESIN BONDED SAND CASTING

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ABSTRACT: Resin bonded sand casting is widely used for manufacturing automotive parts especially those made of Aluminium Alloys. In general, resin bonded sand casting use alkaline resin as binding agent. Typically, they are from non-biodegradable materials that have issues on reclamation and disposal of the sand as well as cause hazard to the environment. Therefore, this became a motivation to propose a biodegradable resin as the binding for the resin bonded sand casting mould. Review of this study is reported in this article. From the review, biocure starch resin with water or methyl ester made from plants was selected as binder. Feasibility to make resin bonded sand mould out of this resin need to be established. Further, the sand and cast material should be characterized and analysed for their microstructural and mechanical properties. Indeed, the review has given insight to the gap of this field of knowledge and aid in the development of aim and objectives of the research.

KEYWORDS: *Resin bonded sand casting, biodegradable resin binder, starch, mechanical properties of sand.*

1.0 INTRODUCTION

Resin bonded sand casting is one of the sand casting processes introduces in the metal casting industry since there was a demand for manufacturing parts made of copper. In this process, resin is used as binder and catalyst is used for self-hardening the mould at room temperature [1]. The conventional foundry casting are comprised this three components held together with sand acts as filler comprising 97 - 99% of core, 1 - 3 wt% binder of sand [2]. However, there are limited research [3-8] was conducted to study the use of binders made of biodegradable material especially for the application in the field of sand casting process. In this article, review of the present information in regards to the modified starch resin for sand casting mould is reported.

Resin binder is typically used for binding agent in the sand foundry to form a mould and/or core [9]. Phenolic and furan resin are the most common binders used in this field. Although some of these materials are organics but they are non-biodegradable. Starch, a natural polymer, is a polysacchraride derived from the seeds, roots and leave of plants [10]. The starch could be extracted from corn, wheat, rice, tapioca and sago. Modified starch could be applied to be used as adhesive in various applications for example glue for wood joining. From these applications, starch was seen to be potential to become binding agent for foundry sand.

2.0 REVIEW ON STARCH MATERIALS

In Thailand, cassava or tapioca is one of the economically important crops and cheapest raw material for starch production [4]. Starch can easily degrade into the soil. However, the natural starch was proven not feasible to act as binding agent that could meet with the optimum properties of foundry sand [3,6]. While in [5] studied a novel kind of foundry core binder from modified potato starch. Liquid water soluble modified starch binder (WMSB) was developed from material as listed in Table 1. Calcium Bentonite was added in the WMSB binder. Bentonite was selected due to its good properties in terms of high dry bonding strength, high compressive strength, low permeability, and excellent lubricity [5].

Table 1: Nominal composition of WMSB (in wt %) [5]

Components	Potato starch	Formaldehyde	Phosphoric acid	Polyvinyl alcohol	Urea	Water
Content	28–30	1	0.1	2	1	Balance

As shown in [6] used native corn starch in the new synthesis method for carboxymethyl starch (CMS) [6]. This study modified the corn starch by using new dry method with addition of catalysts i.e. methanol and sodium hydroxide. The properties of the CMS binder and catalysts were tested to used in resin bonded sand mould. Whereas in [7] proposed the used of yam flour starch as a new binder for their foundry industries. This new binder was proposed due to the expensive cost of the current imported binder.

Based on this review, it was understood that natural starch has low specific bonding strength and poor hygroscopicity-resistance due to the molecule structure. These are the limitations in making natural starch as the main ingredient in forming binder for sand moulding

[8]. Therefore, the starch must be modified as to improve the chemical bonding and structure property.

3.0 REVIEW ON METHODS

3.1 Tensile And Compressive Strength

As reviewed in previous section, [5] used WMSB modified potato starch as binder for core making. The sand core was made from silica sand (Bal.), calcium bentonite (2-3%), water (0-1%) and WMSB (4-7%) [5]. Figure 1 shows the dry tensile strength of WMSB bonded core sand. From this figure it is apparent that the dry tensile strength increased with the increased of WMSB and the decreased of Bentonite.

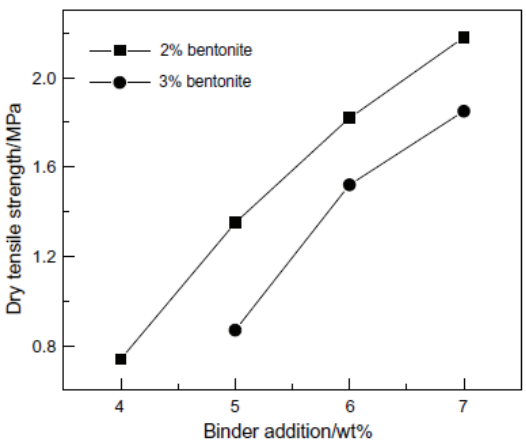

Figure 1: Effects of binder content on the dry tensile strength of core sand [5]

Figure 2 shows the effect of binders on the wet pressure strength of the core sand. Wet pressure strength increased with the increasing bentonite contents. After the 5.0% WMSB, the wet pressure strength decreased. Therefore, this study suggested 5.0% of WMSB as the optimum value. Bentonite has good physical properties such as high compressive strength, low permeability, high dry bonding strength and low compressibility [9] in which giving the bentonite benefits the synthesis. The 2% bentonite gave lower wet pressure strength as compared to the 3% bentonite. This also proved that increasing the percentage of bentonite improved the wet pressure strength on the core sand.

For the corn starch bonded sand core, [6] studied for the sand compressive strength and dry tensile strength as shown in Table 2. The

σ_0 shows the green compressive strength of the core and σ_1 shows the tensile strength. The table suggested that increasing the CMS degree of substitution, the compressive and tensile strength also increased.

As in [7] used yam flour starch as the binding agent (5-30%), silica sand and distilled water to make the sand mold. The green compressive strength was determined form six samples with different percentage of binder content i.e. 5, 10, 15, 20, 25 and 30%.. Figure 3 shows the green and dry compressive strength of the samples. Both of the strength increased with the increased of binder percentage. However at 25% of binder, both of the strength decreased. The result showed that at 25% binder, maximum green and dry compressive strength were obtained at 54 kN/m2 and 309 kN/m2, respectively.

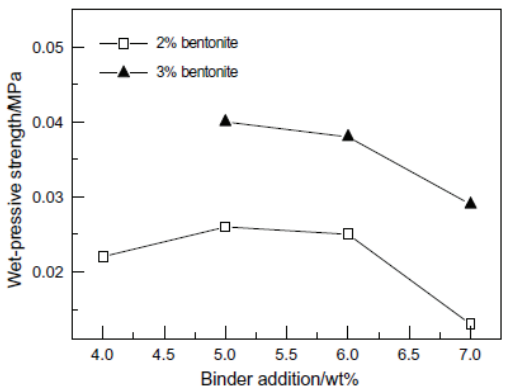

Figure 2: Effects of binder content on the wet pressure strength of core sand [5]

Table 2: Performance of CMS bonded core sand

Binder	σ_0 (MPa)	σ_1 (MPa)	δ (%)	V (ml/g)
CMS (DS = 0.25)	0.051	1.54	50.6	16
CMS (DS = 0.52)	0.062	2.05	44.9	14
CMS (DS = 0.78)	0.070	2.18	43.1	13
Type II furane resin	–	1.23	42.7	18

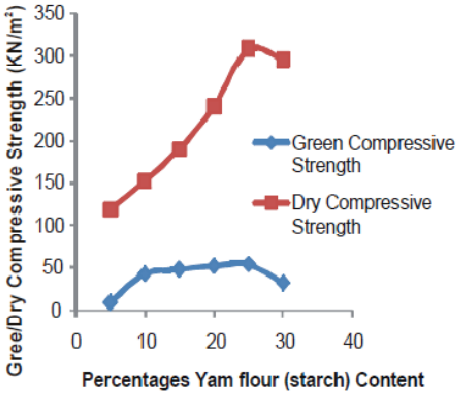

Figure 3: Green/Dry Compressive Strength of Dukku silica sand mould with yam flour content

3.2 Other Characteristics

The moisture absorption test was conducted by using constructive method for WMSB resin binder [5]. This testing was carried out with dextrin sand, CO2 water glass sand, furan resin, baked clay sand, core oil sand and baked water glass sand as shown at Figure 4.

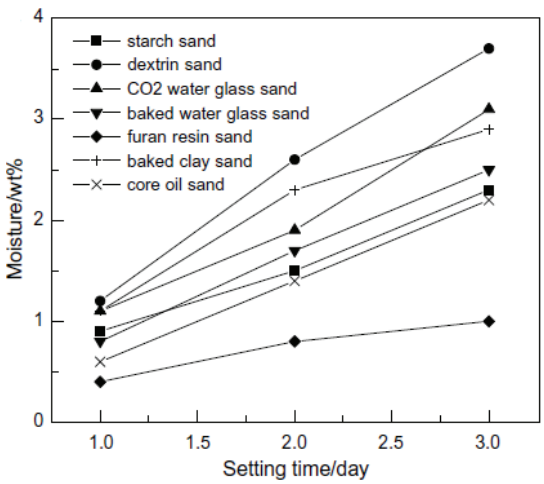

Figure 4: Moisture absorption of WMSB sand compared with others under natural moisture absorption conditions [5].

Figure 4 shows that the moisture content increased with the increasing of the setting time exposing the core sand under the natural conditions. The dextrin sand has the highest moisture content when compare with other resin sand. The moisture content of WMSB sand is lower than that of all water glass sand, clay sand and dextrin sand. But the level is

closed to the level when furan and core oil sand were used. Therefore, the WMSB has acceptable moisture absorption resistance [5].

Table 3 presents the moisture absorption content for the yam flour binder. The moisture content increased with the increasing of binder content. While [7] states this is probably due to fact that the binder and sand were exposed to environment, took up some moisture, and further increased the moisture in sand mould.

Table 3: Moisture absorption of Sand mould bonded with yam flour additive binder [7]

Sample. Yam Flour (starch)	A	B	C	D	E	F
Binder Content (%)	5	10	15	20	25	30
Moisture Content (%)	2.0	3.0	4.0	5.0	6.0	7.0

When it is compared to the WMSB sand mould, the yam flour resin has higher moisture content when it is exposed to natural humidity. The moisture content for 6 samples (A – F) of yam flour resin is 2.0%, 3.0%, 4.0%, 5.0% 6.0% and 7.0%, respectively. As explained by [6] that the moisture absorption coefficient is as listed Table 2. The moisture increased steadily until 6% of the binder content. This result showed that the 25% of binder content with 6% moisture content is the optimum ratio mix for moulding sand [6].

Permeability test is a measurement of amount of air passed through the sand mould [12]. The permeability is affected significantly by the shape and size of sand grains, type and amount of binder and moisture contents of sand [12]. Figure 5 shows the green permeability of yam flour resin. The permeability test of yam flour resin was determined with 9.8x102 N/m2 standard air pressure passed through the specimen tube of the yam flour resin sand. When the binder content increased, the green permeability number of sand decreased gradually. Fewer pores in the mold will allow gas to pass through during casting mould. This study also shows that the resin is suitable for casting non-ferrous metals, light grey iron and malleable iron. The properties of resin binder agreed with the standard values material [7].

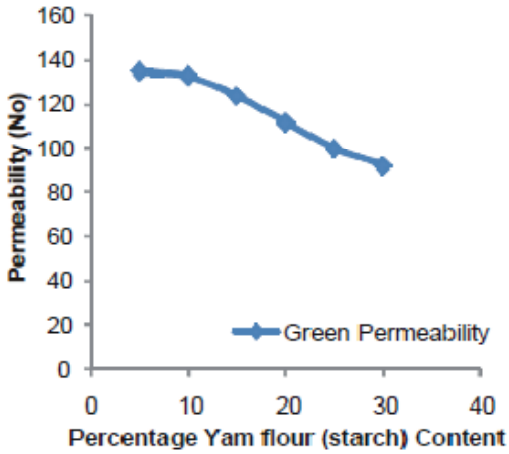

Figure 5: Green permeability of Dukku sand mould bonded with varying percentages of Yam Flour Starch content [7]

4.0 CONCLUSION

From the review on the various starches, it is conclusive that the starch can be used as a resin binder for foundry application. This is because starch has the good properties such as in mechanical or physical properties. Starch came from plants where when develop or modified with other material or chemical it could become a resin binder. Therefore, starch has good properties and highly potential to be used in sand mould casting as binder.

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