Sand Casting Manufacturer with Material Additive to Permeability and Green Compressive Strength Characteristic

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Abstract

Sand casting as a main material in the casting process. To result the product in good quality sand casting must be standardized such as high temperature resistance, good permeability to gas flow, high strength to enough to hold the load press, and high shear strength to accept shear force. This study to aims effect of material addition on green sand as sand casting to find the best composition on permeability, green compressive strength, and green shear strength. Glass powder in sample A and feldspar in sample B used to material binder selected an alternative beside bentonite because have high Silica (SiO) and Alumina (Al_2O_3) to optimizing the sand casting characteristic. The binder material meshing in < 80 Mesh with 10%, 20%, 30%, 40%, and 50% composition respectively with 10% constant addition of water. Every sample three times testing included clay content, Grain Fine Number based on SNI 19-0312-1989 while permeability, green compressive strentgh, and green shear strength. The result show the permeability directly proportional with glass powder addition has maximum 63.67, while the addition of feldspar effeted decrease the permeability value with minimum 51.67. The higher green compressive strength obtained from 10% w/t glass powder with value 96.87 kN/m^2 inversly proportional with green shear strength with value 76.27 kN/m^2 in 10% w/t addition.

Keywords: *Sand, casting, permeability, strength, powder*

Abstrak

Pasir cetak merupakan komponen utama didalam pengecoran. Untuk menghasilkan produk cor yang baik, pasir cetak harus memenuhi standar pasir cetak seperti ketahanan terhadap temperatur yang tinggi, permeabilitas yang baik untuk melewatkan gas, kuat tekan yang cukup untuk menahan beban tekan, dan kuat geser yang cukup untuk menahan beban geser. Penelitian ini bertujuan untuk menganalisa pengaruh penambahan serbuk kaca (sampel A) dan Feldspar (sampel B) pada pasir yang berasal dari pasir Juwono Jawa Tengah sebagai pasir cetak. Serbuk kaca dan feldspar dipilih sebagai bahan tambah alternatif selain bentonit karena memiliki kandungan Silika (SiO) dan Alumina (Al_2O_3) yang tinggi untuk memperoleh optimalisasi pasir cetak. Pasir ditambahkan serbuk kacapada sampel A dan feldspar pada sampel B dengan ukuran mesh < 80 dengan komposisi 10%, 20%, 30%, 40%, dan 50% dengan penambahan air 10% konstan. Sampel dilakukan pengujian kadar air, kadar lumpur, dan GFN menggunakan standar SNI 19-0312-1989 sedangkan pengujian permeabilitas, kuat tekan, dan kuat geser dilakukan tiga kali pengulangan menggunakan metode pengujian SNI 15-0312-1989. Hasil pengujian menunjukkan bahwa nilai permeabilitas berbanding lurus dengan penambahan serbuk kaca dengan nilai maks. 63,67, sedangkan penambahan feldspar berakibat penurunan nilai permeabilitas dengan nilai min. 51,67. Kuat tekan basah tertinggi diperoleh dari penambahan 10% serbuk kaca yaitu 96,87 kN/m^2. Hal ini berbanding lurus dengan kuat geser basah dengan penambahan 10% serbuk kaca yaitu 76,27 kN/m^2.

Keywords: *Pasir, pengecoran, permeabilitas, kuat tekan, serbuk*

INTRODUCTION

Metal casting industry has an important position as a basic industry in manufacturing industry. Indonesia has been making effort to become an industrialized country through broadening and deepening its industrial structure and through small-scale industries promotion and creating intra and inter industrial linkages. The key of the success of this effort is developing and strengthening its supporting industries[1]. Sand as a main material in castingproduction that is used in all type of foundry. According to American Foundrymen's more than 90% of casting industry used green sand as sand casting [2].This reason because the green sand has economic value, can produced in large amount, and can recycle. The green sand not in green colours but "green' in the meaning of used in wet condition, green sand mixture 75% until 85% of silica sand (SiO) or chromite sand (FeCrO), or zircon sand (ZrSiO), or olivine, or staurolite, or graphite, 5% until 11% of bentonite (clay), and water. Sand casting is the basic manufacturing methode involving pouring molten metal into sand mold. The factors deterimined by the sand are casting surface finish, gas permeability of the mold, and mold strength [3]. Some research have been done to find optimally the green sand characters among others by mixture a material with sand as a green sand[4]–[7], researching about effect of bentonite binder to permeability and green compressive strength in green sand and the result shows the higher permeability obtained from the mountain sand and 4% of bentonite about 24.71 cm^3/min and the highest of green compressive strength obtained from sea sand mixture by 8% bentonite which is about 0,78 N/cm^2. Other researcher, Rohman and Sidharta (2014), researched about variation of wood powder additive mixture with cement binder in green sand to the porosity of casting product. The porosity of casting product tend to decrease in each composition because wood powder increased the permeability of green sand. Increassingly the permeability, increasingly too the air velocity in the cavity of sand to release effect of preassure from liquid metal, so the porosity decreased [8].

Bentonite is often used as a binder for green sand[9]–[11] with the basic chemical composition are alumina, but the price of bentonite on the market is quite expensive when compared to other materials[12]. Based on kumar et al, 2014, added the pure alumina 0.6%, 0.4%, 0.2% on green sand as a binding material, result show the positive effect of sand casting[13]. Other research also showed the material base silica make possible as sand casting. Toni Prahasto and Sugiyanto, 2007, use fly ash as sand casting and the result showed the silica from fly ash effected the hardness of the product [14]. However, in metal casting the addition of pure alumina and silicain the green sand requires expensive. Therefore need to research for substitute material beside of bentonite to obtain alternative materials that use as a binder in sand casting. The glass powder and feldspar selected in this research is intended to obtain alternative materials that can be used as binding materials on green sand. The glass powder and feldspar has high silica and alumina content with a low oxidation iron content. Silica and alumina are binding elements on the green sand that can be found in clay so that the green sand can be easily shaped and high temperature resistance[15]. This study aims to obtain the characterization of green sand that is in accordance with the standard sand mold.

RESEARCH METHOD

In this study, characterization of sand will be carried out using a mixture of glass powder on sample A and sand with feldspar in sample B with variations in addition 0%,10%, 20%, 30%, 40%, and 50% w/t. The chemical content in the glass powder is obtained from testing in the laboratory FMIPA Chemistry University of North Sumatra with the results as shown in Table 1. While the mineral feldspar content as shown in Table 2.

Figure 1. Sand Casting

Figure 2. Glass Powder

Figure 3. Feldspar

Table 1. Content of a glass

Element	Glass Powder
SiO_2	91.008%
Al_2O_3	0.1273%
FeO_3	0.0026%
CaO	0.1084%

Table 2. Mineral feldspar content

Element	Glass Powder
SiO_2	67.30
Al_2O_3	14.02
FeO_3	2.24
CaO	2.25
K_2O	4.59

Permeability Test

Permeability show the mold capability to release the gases trapped in sand mold. Permeability closely related with surface condition of castings. The small permeability caused smothness the skin of casting because air buble stuck in the mold and resulted surface deffect in the castingproduct. Permeability cauntable by equation [16]:

$$\boldsymbol{P = \frac{Q.L}{p.AT}} \quad (1)$$

Where P is permeability, Q is air volume that passes the speciment (1000 cm^3), L is speciment length (5 cm), A is sliced area of the specimen (19.625 cm^2), p is air pressure (column air), T is time to passes the air volume Q through the speciment (seconds).

Green Compressive Strength And Green Shear Strength Test

The examination done at Politeknik Manufaktur Ceper Laboratorium. Test methode based on SNI 15-0312-1989. The test done as much three times and taken on average. Green compressive strength and green shear strength test stated in kN/m^2.

Water Content Test

Water content test done by take 100 grams sample of sand and than dried in oven at 105 ^oC - 110 ^oC until a constant weigh is obtained. Water content obtained by equation 2 [17]:

$$\text{Water content} = \frac{initial\ weigh - final\ weigh}{initial\ weigh} \text{ x 100 (gr)} \quad (2)$$

Clay Content

The dried sample from the moisture content determination was washed four times till the surface was clean. It was then dried again and weighed. The difference between the weight of the washed and its initial weight expressed in percentage was taken as the clay content [18].

$$\text{Clay content (\%)} = \frac{initial\ weigh - final\ weigh}{initial\ weigh} \text{ x 100} \quad (3)$$

Grain Fine Number Examination

The examination of Grain Fine Number (GFN) used Sieve Shaker RX-812 type and sieve arrangement. Sieves used size of 20, 40, 60, 80, and 100 mesh. The dry sand taken and weighed as much 50 g. The sand than poured in sieve wich has been aranged based on mesh size and vibrated during 15 minutes. Furtermore, the sand weighed in each sieve size. The percentage of weigh each sieve calculated by equation 4 [17]:

$$\text{Percent (\%)} = \frac{the\ weigh\ of\ sand\ on\ each\ sieve\ (gr)}{total\ weigh\ the\ specimen\ (gr)} \text{ x 100} \quad (4)$$

Grain Fine Number determined by formula 5, by mulplied weigh of sand on sieves with serial number Sn.

$$\mathrm{F.N} = \mathrm{F.N} = \frac{\sum(\mathrm{Wn\ .Sn})}{\sum \mathrm{Wn}} \quad (5)$$

Where FN is Fine Number of sand, Wn is weigh of sand from each sives (gram), and Sn is Serial Number

Grain Shape Examination

Grain shape examination by observation under mycroscope at 100 optical zoom after the sample washed and sifted. Grain shape the sand devide i.e verry angular, Angular, Sub-angular, Sub-rounded, Rounded, Well Rounded. Grain shape determined by the most dominan from the sample[17].

RESULT AND DISCUSSION

Grain Shape

The grain shape of sand mold with additional of glass is sub angular, where some of the grain side sand are angled and some rounded as can be sen on Fig. 2.

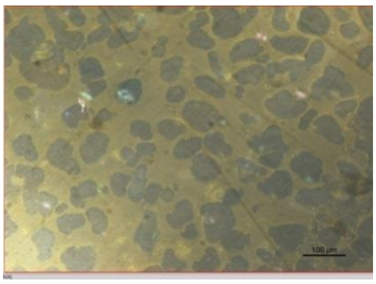

Figure 4. Grain Shape Green Sand

The grain shape take effect with the bonding strength between sand grain.

Permeability, green compressive strength, and green shear strength

Graphic in Fig. 5 indicate the relation of the glass powder (sample A) with permeability and the percentage of feldspar (sample B) with permeability of sand mold. In Sample A, addition glass powder form 10% - 50% show enhancement permeability value from 52 to 63.67. from the graph can be seen if the addition of 10% to 40% glass powder has decrease valuethe permeability of Raw Material, while the addition 50% make increase permeability value from 60.67 being 63.67. The addition of sand molds with glass powder not so significant. However, when reviewed from the Fig. 5, the addition 10% to 50% glass powder showing the trend continues to rise, the permeability value of sand mold directly proportional with increased Silika (Si) composition. This matter verry different with sample B, where the addition of feldspar from 10% to 50% w/t consequences with decreased permeability value from 59.33 to 51.67.

Green compressive strength of sand mold in sample A obtained on 10% addition glass powder in the amount of 96.7 kN/m^2. Furthermore, in addition 20% to 50% of glass powder the value of green compressive strength decrease from 84.53 kN/m2 until 59,63 kN/m2. Figure 6 indicate to obtain the green compressive strength of sand mold the addition of glass powder should not be more than 10% w/t. The graph of sample B show the decreased value of green compressive strength from addition 10% until 50% w/t. The green compressive strength value with feldspar addition as much as 30%, 40%, and 50% average value about 53 kN/m^2, under value of Raw material without feldspar.

Green shear strength of sand mold with glass powder and feldspar addition shown in Figure 7 not much different from green compressive strength. The higher green shear strength with glass powder addition obtained from 10% w/t that is 76.27 kN/m^{2}more higher 2.37 kN/m^{2}than raw material wich is only 73.9 kN/m^2, while in other concentration the value lower than raw material both in the addition of glass powder or feldspar.

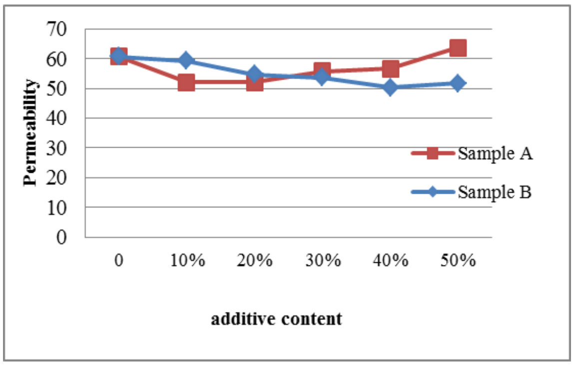

Figure 5. Permeability of Green Sand

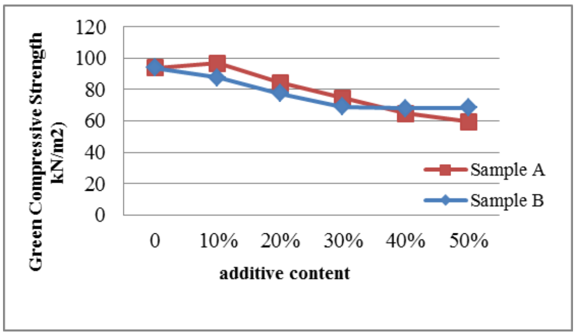

Figure 6. Green Compressive Strength Vs Additive Content

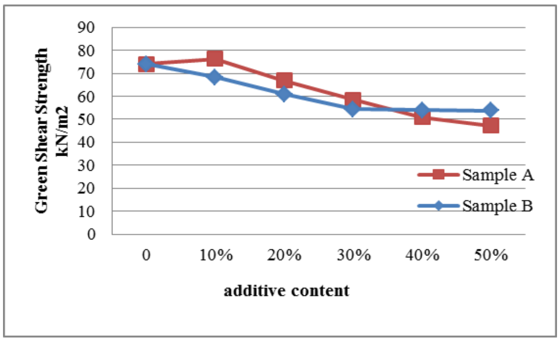

Figure 7. Green Shear Strength vs Additive Content

Clay Content

The addition of additive material to sand mold affected to percentage of clay content as shown in Figure 8. The addition of 10% to 50% w/t glass powder affects the clay content significantly percentage as shown as in Graph of sample A wich is 47.2% in 10% w/t glass powder until 75.13% in 50% w/t glass powder. This phenomena happen because the small size of glass powder with highes grain distribution in 200 mesh, so the glass powder dissolves when clay content examination with water washing method, so from the washing process left the sand or quartz which has more high density than the glass powder. Graph B shows different behavior where the addition of feldspar make decrease the clay content in sand mold.The physical character of feldspar where are higher until same with size of sand caused to the percentage reduction in clay content.

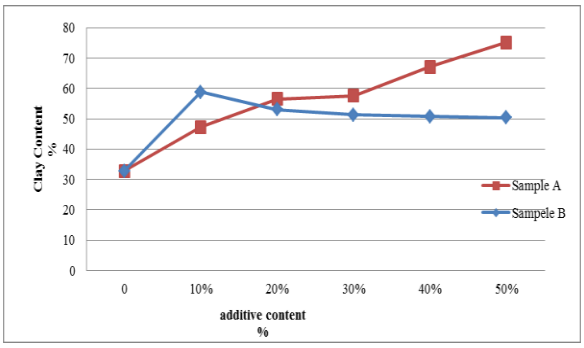

Figure 8. Clay content vs additive content

X Ray Fluorisence Result

X- Ray Fluorisence result shown in Table 3 indicate the sample A increased Silica (Si) content along with glass powder addition. More over, there are new chemical element formed after addition the glass powder but in small procentage *i.e*V, Cr, Sn, Te, Ba, Eu, Yb, Hg, and Pb. Addition Si most significant occurs in sand mold with 20% glass powder which is from 25.725% to 46.893% comparred with other percentage only increased about 2% to 3% Si. Similiarly with Ca, increased 10% in addition with 20% from 2.661% to 12.807%. the addition of feldspar affected the increasingly of Si, Al, dan K. However, the other chemical like Mg and Ca actually decreased.

X-Ray Difragment Result

The result of X-ray Fluorisence sample A shown in figure 9 and sample B shown in figure 10. The main Mineral in sample A is SiO as quartz. Other than quartz there are Anorthite consist of element Ca, Si, Al, and O as oxydizer. Magnesium chemically bound with Ca and Si into Diopside. There is no different element in sample A with glass powder addition simmiliarly with sample B there are three main mineral i.e. Quartz (SiO), Anorthite (Ca, Si, Al), and Diopside (Mg, Si, Al). The main elements in sample A and sample B consist of Silica (si), calcium (Ca), Alumina (Al), and Magnesium (Mg).

Table3. Sample "A" X-ray Fluorisence Result

Element (unit)	**Glass Powder**				
	10%	**20%**	**30%**	**40%**	**50%**
Na (%)	0,609	1,972	3,137	4,325	5,355
Mg (%)	0,766	1,518	1,806	2,032	2,265
Al (%)	8,487	11,863	9,895	7,204	4,462
Si (%)	25,725	46,893	48,417	51,805	54,818
K (%)	0,669	2,559	2,052	1,625	1,194
Ca (%)	2,661	12,807	14,503	16,580	19,182
Ti (%)	0,333	1,053	0,861	0,632	0,431
Mn (%)	495,5	0,198	0,174	0,131	975,7
Fe (%)	4,352	19,870	18,017	14,524	11,113

Table4. Sample "B" X-ray Fluorisence Result

Element (unit)	**Feldspar**				
	10%	20%	30%	40%	50%
Mg (%)	0,853	0,975	0,469	0,337	0,219
Al (%)	20,388	23,232	26,363	27,271	29,243
Si (%)	43,621	44,114	46,597	47,784	49,438
K (%)	4,519	4,888	5,440	6,626	6,824
Ca (%)	7,060	5,830	4,457	3,549	2,693
Ti (%)	1,125	0,975	0,781	0,664	0,527
Mn (%)	0,247	0,249	0,197	0,225	0,180
Fe (%)	20,852	18,793	14,628	12,513	9,888
Zn (%)	0,243	0,204	0,152	0,137	0,109

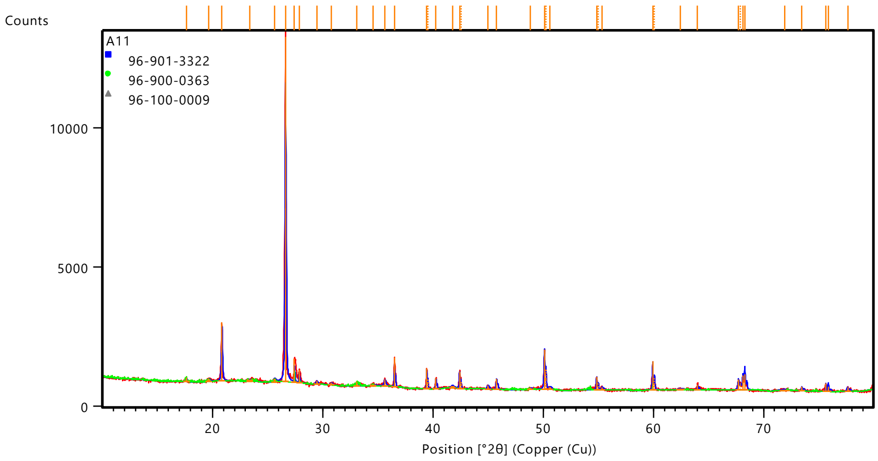

Figure 9. XRD Sample A

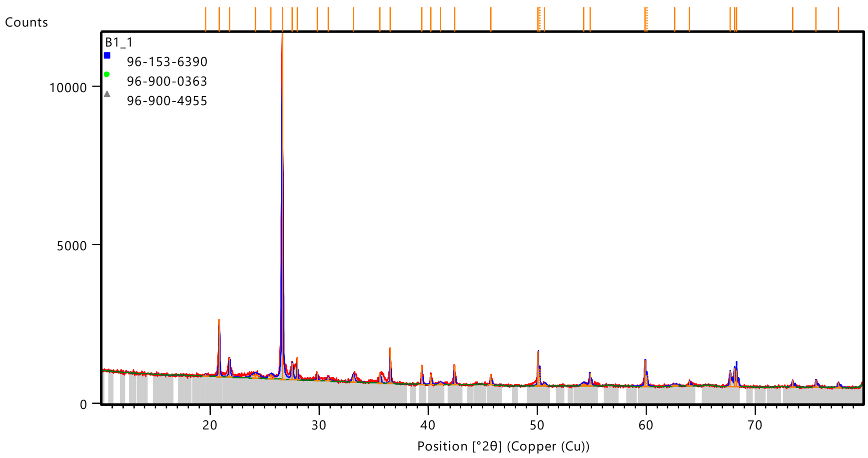

Figure 10. XRD Sample B

CONCLUSION

The utilization of glass powder as an additive in sand mold can be used but not more than 10% w/t of the sand. mineral feldspar not recomended to use as an additive material in sand mold because make decreased the green compressive strength and green shear strength. Feldspar used as an additive material in sand mold not effected on increasing green compressive strength and green shear strength.

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