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The Effect of Curing Time on Water Content in the Metal Casting Process

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Abstract— *Silica sand is one type of sand that is often used by industries engaged in metal casting. This is because silica sand is used as a molding material. Besides being easily formed, this silica sand when mixed with chemicals such as resins and catalysts will achieve maximum hardness. In order to achieve the maximum strength of the sand mold, a curing time process is needed. After the molding material is mixed and stirred, the drying time starts to be calculated. Achieve maximum strength because the mixture reacts during curing time. This study aims to observe and study the effect of differences in curing time on the water content of alphaset molds. Curing time variations are at 2 hours, 4 hours, 6 hours, 8 hours, 24 hours, 48 hours and 72 hours. This research went through several stages of testing, including: sand distribution testing, compression test, water content test, LOI testing and SEM testing. The focus of this research is testing the water content. A good sample used for alphaset molding is one that has no water content. The results showed that samples that could be used were those that had curing time of 6 hours, 8 hours and 72 hours. This is because at the curing time it has a water content of 0%.*

Keywords— *silica sand, alphaset molding, curing time, metal casting.*

I. INTRODUCTION

One of the manufacturing production techniques that is often used is metal casting technique. As technology develops, manufacturing production also develops according to industry needs, especially for metal casting. Metal casting techniques are still used today so that the results of castings are obtained in accordance with industry demand. In the casting process, of course, it passes through the mold process. The surface roughness and shape of the metal are greatly affected by this molding process. Sand mold is one type of mold that is still used today. In order for the metal to become a unified whole, a binding agent is needed in the mixture. Commonly used binders include catalyst, resin, bentonite and catalyst. In sand molds and soil molds contain these binders.

The use of sand molds in metal casting techniques has many advantages. The advantage of using this sand mold, among others, can be used repeatedly. If sand molds are used repeatedly, this can save production costs. Another advantage is that the sand mold is easy to form. This can facilitate the production process and can save production time. Making sand molds for casting techniques can use several types of sand, namely silica sand, zircon sand and olivine sand.

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In the casting process, one important factor is testing the water content. The best molding is the lowest water content value. This is because during the process of mixing the alphaset sand mold material, resin and catalyst will adhere optimally so that there will be no water that can stick to the sand bond.

II. LITERATURE STUDY

A. Silica Sand (SiO2)

Sand that is often used in every metal casting industry is silica sand. This is because this sand has properties that are suitable for the metal casting process and are easy to obtain. Silica sand cannot be obtained immediately. The way to produce silica sand is done by destroying silica stones. After it is destroyed, the process is then filtered so that the required granules are obtained. Location to get silica sand is very easy. Many found on beaches, rivers and mountains. Cast metal molds of copper, iron, cast steel, aluminum alloy are types of molds that often use silica sand. Silica sand has properties, including:

1. Melting point 1700 oC.
2. Gray white.
3. Specific gravity 2.65 kg/dm^3.
4. During the process of heating undergoes crystallographic changes, they are:

- Changes in α> β quartz with an expansion of 1.5% - 2% at 573^{o}C.
- β quartz> α Tridymite (shrinkage occurs) at 870 ^{o}C.
- α Tridymite> α Kristobalit which is hard at 1470 ^{o}C.

5. Silica sand reacts easily with liquid metals, especially steel and has a PH of <7. After reacting, it forms compounds that are attached to the pouring surface. This causes the surface of the casting to be rough. This reaction is called sinter. Fayalite is a compound formed from a hard sintered process.
6. Metals that have Manganese (Mn) alloys are reactive to silica sand.

B. Sand Molding Resistant to High Temperatures

In casting metals the temperature produced from liquid metals is very high. Therefore the mold must be able to adjust the temperature of the liquid metal. So the sand molding must have a higher temperature resistance than the temperature of the molten metal. Following is Table I which shows the sintered temperature for silica sand.

Table I. Silica Sand Sintered Temperature

Sand	***Sintering point* (°C)**
high purity silica sand, 99% quartz	1.450
Medium purity silica sand, 96% quartz	1.250
Sea sand (High Shell Content)	1.200
Natural clay bonded sand	1.050 - 1.150

C. Mold Binder

Binder is a material that has a strong attraction to an object. Binding in this case is a material that can bind to the grains of molding sand. These binders are usually solid or liquid. This binder has a function to tie the printed sand. This causes the sand to be easily shaped as needed. In addition, the function of this binder can facilitate the process of making patterns, so as to produce the expected quality of strength and permeability. Binders that are often used as additives to the sand mixture include:

1. Resin

The properties of the resin include a rather thick liquid tends to be transparent, insoluble in water, flammable and will harden quickly. Phenol resins and furan resins are binder resins commonly used as molding sand binders.

2. Catalyst

Catalyst is a substance used to accelerate the rate of reaction. However, the use of this catalyst does not change the type and amount of the reaction product. The use of catalysts will reduce the activation energy of the reaction. But this does not change the reaction enthalpy change. It provides the reaction stage with lower activation energy reactions caused by changes in the catalyst reaction mechanism.

D. Curing Time

The minimum time needed to mold sand with resin and catalyst as a binder so that maximum hardness is achieved is called curing time. The factors that determine curing time are:

1. Type of resin binder.
2. Types and process of making sand.
3. Temperature of sand and room.
4. Amount of resin and catalyst.

E. Water Content Test

The amount of water contained in the molding sand is called the water content. Total water content is expressed in percentage (%). The water in the molding sand serves to activate the binding capacity of the clay. If the binding capacity of the clay is active, the molding sand binds to each other. The range of water content that binds to mold sand on clay is 1.5% - 8%.

Fig. 1. Water Test Equipment

The first process to test the water content is to weigh as much as 50 grams of silica sand in a pan. The next process is to insert the sand sample into the heating oven. Then the sample is set with a temperature of 65ºC - 80ºC to be heated for 15 minutes. After 15 minutes, the sand sample is weighed to a constant. The final process is to calculate the constant sample water content with the equation:

$$Water\ Content = \frac{w1-w2}{w1} \text{ x } 100\% \qquad (1)$$

Where:

Water Content = %

W1 = First Weight of Warming (15 minutes)

W2 = Second Weight of Warming (5 minutes)

II. RESEARCH METHODOLOGY

The methodology used in this study is illustrated in Figure 2.

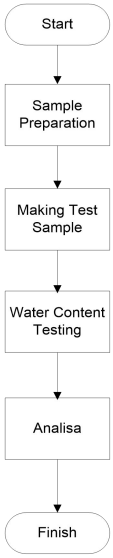

Fig. 2. Research Methodology Flowchart

A. Sample Preparation

Several steps are required to make a sand mold sample, including:

1. Prepare sample making materials, they are:

a) Used sand, weight 3 kg

b) Alphast phenolie resin 2% by weight of sand

c) Catalyst/hardener 25% by weight of resin

2. Calculate the weight of resin and catalyst.

a) Resin, 2% x 3000 g = 60 g

b) Catalyst, 25% x 60 g = 15 g

3. Prepare sand test specimens.

Fig. 2. Wood Mold

B. Making Test Sample

After all the preparation materials for making samples are available, the next sample is making test sample.

1. Sand, resin and catalyst are mixed and stirred manually by hand until even and fast because the effect of the catalyst makes the sand harden quickly.
2. Insert the sand into the mold and compact the sand using a rubber hammer until it is completely solid. After that the remaining sand on the surface is cleaned so that the results are even and maximum.

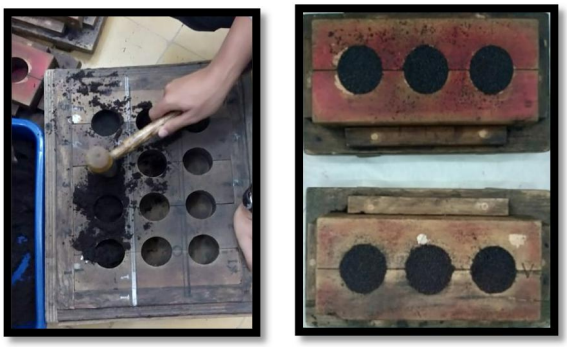

Fig. 3. Sand Compaction

3. After 1 hour, the specimen is removed from the mold and starts calculating the curing time as needed.

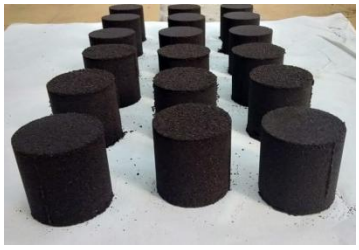

Fig. 4. Curing Time Sand Mold

C. Water Content Test

The water content testing procedure is as follows:

1. Prepare used sand with a weight of 50 g then crushed until smooth.
2. Heat the sand into the test machine by:

- Insert the tray into the test machine.
- Turn the time selector to 15 (indicating heating for 15 minutes).

3. Re-weigh the final weight of the sand after heating it for 15 minutes.
4. Reheat for 5 minutes.
5. Calculate the final weight of the sand after it has been heated for 15 minutes and 5 minutes using equation (1).

III. RESULT AND DISCUSSION

D. Water Content Testing Data

Testing the water content in used sand can be done after going through variations in the sample curing time. The test method is to pound 50 grams of sand until smooth and then warm up the Moizter Analizy tool for 15 minutes and repeat the reheating for 5 minutes. Moisture test data is shown in table II.

Tabel II. Water Content Testing Data

Time (minute)	**Weight (gr)**						
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
0	50	50	50	50	50	50	50
15	49,18	49,17	49,29	49,28	49,11	49,16	49,10
5	49,17	49,15	49,29	49,28	49,10	49,14	49,10
Water Content	0,02%	0,04%	0,00%	0,00%	0,02%	0,04%	0,00%

E. The Effect of Curing Time on Water Content Test

From the water content data shown in table II, the following graph is produced:

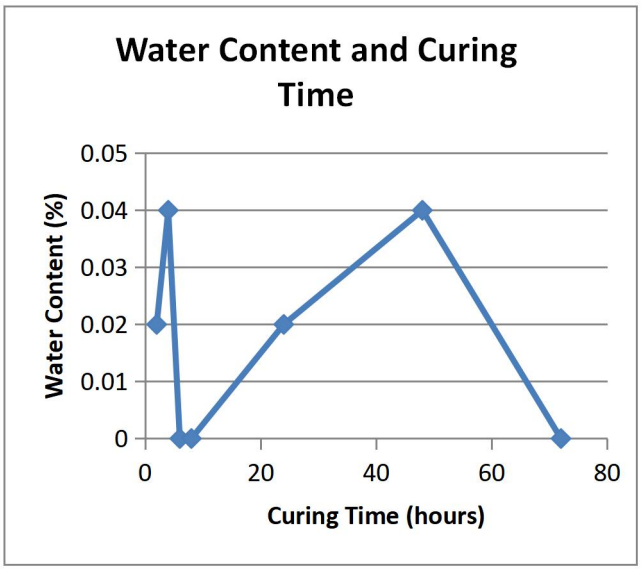

Fig. 5. Water Content and Curing Time

From the data obtained in testing the water content, some variations of curing time show different results. Water content testing conducted on a sample variation of curing time of 2 hours; 4 hours; 6 hours; 8 hours; 24 hours; 48 hours; 72 hours shows that the water content of the 4 hours and 48 hours curing time samples is greater than other variations of the curing time.

The value of the water content of the 2 hour curing time variation is 0.02%, the 4 hour curing time variation is 0.04%, the 6 hour curing time variation is 0.00%, the 8 hour curing time variation is 0.00%, the curing time variation 24 hours at 0.02%, 48 hours curing time variation at 0.04%, 72 hours curing time variation at 0.00%.

The water content of the 4 hour curing time variation is 0.04%, and the 48 hour curing time variation is 0.04% higher compared to other water content contents. This is due to the remaining binding material in the grains of sand and because the temperature room of the sample when curing time is not stable.

In the test results above, the good samples used for alphaset molding are samples that have a curing time of 6 hours, 8 hours and 72 hours. The best water content is the lowest water content value, because during the mixing process the alphaset resin sand mold and catalyst will adhere optimally so that no water can stick to the sand bond.

Here is the formula for finding the value of water content contained in sand:

$$Water\ Content = \frac{w1 - w2}{w1} \text{ x } 100\%$$

1. Curing Time 6 Hour

$$Water\ Content = \frac{49{,}29 - 49{,}29}{49{,}29} \text{ x } 100\%$$
$$= 0{,}00\%$$

2. Curing Time 8 Hour

$$Water\ Content = \frac{49{,}28 - 49{,}28}{49{,}28} \text{ x } 100\%$$
$$= 0{,}00\%$$

3. Curing Time 72 Hour

$$Water\ Content = \frac{49{,}10 - 49{,}10}{49{,}10} \text{ x } 100\%$$
$$= 0{,}00\%$$

IV. CONCLUSION

- Test samples that can be used are samples with curing time of 6 hours, 8 hours and 72 hours.
- Research data shows the longer the curing time, the water content remains varied. This is due to the lack of one research parameter, the temperature of the sample test room.

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