Effect grain size of sand to mould’s permeability & compressive strength, and casting products

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Abstract. Sand for mould must comply with requirements for casting moulding, this sand mould must have enough permeability and strength. Permeability is the capability to remove air from the mould cavity. Sand from volcanoes is very easy to get and costs less than silica sand. One of the sands that can be used is Mount Semeru, which has only been used as a building material. The use of volcanic sand has been using clay as a binder. In order to improve the quality of the mould, in this research, we was carried out using phenolic resins as a binder. The sand used in this research is sand from Semeru Mountain which is obtained from the Pasirian area of Lumajang Regency. The sand sizes for the mould are 20, 40 and 60 mesh. The sand binder used is phenolic resin mixed with water with a ratio of 2 resins to 1 water. Permeability testing uses a sand mould specimen in the form of a tube in accordance with SNI 15-0312-1989 standards. The highest permeability occurs in sand moulds with a mesh grain sand 20 (321.67 cm³/minute), The highest compressive strength is found in moulds with 60 mesh (4.13 MPa).

1. Introduction
Sand for mould must comply with requirements for casting moulding, this sand mould must have enough permeability and strength. Permeability is the capability to remove air from the mould cavity [1][2]. Permeability is determined by the cavity in the mould, high mould cavities will have higher the permeability[3][4]. Mould have high permeability are very suitable for casting processes, high permeability will prevent air trapping in the mould cavity and thus prevent defects in casting products[5][6].

The disadvantages of high permeability moulds are having low strength and rough surface [7][8]. Low strength in sand moulds will cause the eroded easily when molten metal is poured into the mould. this sand mould loss causes defects in the casting products [9][10]. In addition to defects due to falling out of the mould, the rough surface of the mould results in a rough surface product[11].

Most of the sand that is used as a mould-making material is silica sand [10][12], while the binder used is clay [8]. Silica sand is a material that is easily available and cheap, besides that, silica sand can be used several times as a mould material. Although it is easy and cheap, silica sand can only be found in certain areas, other materialsthat make it possible to use it as a moulding material that is easier to obtain and cheaper.

Another material that can be used is sand from volcanoes. Sand from volcanoes is very easy to get and costs less than silica sand. One of the sands that can be used is Mount Semeru, which has only been used as a building material. The use of volcanic sand has been using clay as a binder. In order to
improve the quality of the mould, in this research, we was carried out using phenolic resins as a binder [13][14].

2. Material and methods
The sand used in this research is sand from Semeru Mountain which is obtained from the Pasirian area of Lumajang Regency. The sand sizes for the mould are 20, 40 and 60 mesh, the sand sizes for the mould are 20, 40 and 60 mesh. Selection of grain size is done using a ro-tap machine (figure 1).

The sand binder used is phenolics resin mixed with water with a ratio of 2 resins to 1 water. The resin was crushed using a desktop ball-mill for 4 hours to make it easier to process. The resin was crushed using a desktop ball-mill for 4 hours to make it easier to process. After being held for 10 minutes the resin was mixed with sand and formed for compression and permeability tests. Permeability testing uses a sand mould specimen in the form of a tube in accordance with SNI 15-0312-1989 standards.

The sand mould testing process is carried out using aluminum. The aluminum is melted using a furnace with LPG fuel. Liquid aluminum is poured into the mould at a temperature of 750 °C.
3. Results and discussion

The results of the permeability test of sand mould can be seen in figure 4. The highest permeability occurs in sand moulds with a mesh grain sand 20 (321.67 cm$^3$/minute), while the lowest permeability is found in sand moulds with 60 mesh sand (118 cm$^3$/minute). This shows that increasing grain size will increasing the permeability.

The compressive strength test results can be seen in Figure 5. The highest compressive strength is found in moulds with 60 mesh (4.13 MPa) and the lowest is 3.70 MPa for sand mould with mesh 20.
The Selection of sand size for mould must be considered to both its characteristics, compression strength and permeability. Moulds that have a high permeability flow very quickly from the inside of the mould cavity but have a higher risk of defects due to damage to the mould walls. Products resulting from the casting process using various sizes of sand can be seen in Figure 6.

Defects are occurring on the surface of casting products. The defect is a pinhole, these defects can be analysed with macrophotography. The macro photo for each sample can be seen in figure 7.
The defects on the surface casting products are pinhole, air cavity, and mould erosion. The defects at casting sample from mould with mesh 20 sand are pinhole and air cavity. The defects at casting sample from mould with mesh 40 sand are pinhole and air cavity. Pinhole and air cavity defect occur on casting products because there are gases trapped in mould. These gas not only air but gas that comes from the evaporation of water contained in the mould, this water evaporates because of the heat from the liquid metal [11][14]. In moulds with 60 mesh sand, pinhole, and air cavity occur.

In moulds with mesh 20, 40 and 60 all occur pinhole and air cavity defects. These defects can occur caused by water on sand so it can be prevented by drying the sand before it is used as a mould [15][16]. The defects can be tolerated because the size of these defects small. The erosion of the mould with 60 mesh sand shows that the strength of this mould is less strong so it is better not to use it as a mould. The defects that occur in the three moulds, it is recommended to use sand with mesh 20 and 40.

4. Conclusion
The highest permeability occurs in sand moulds with a mesh grain sand 20 (321.67 cm$^3$/minute). The highest compressive strength is found in moulds with 60 mesh (4.13 MPa). The erosion of the mould with 60 mesh sand shows that the strength of this mould is less strong so it is better not to use it as a mould. The defects that occur in the three moulds, it is recommended to use sand with mesh 20 and 40.

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