Manufacture of mold of polymeric composite water pipe reinforced charcoal

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Abstract. In general, household wastewater pipelines currently use thermoplastic pipes of Polyvinyl Chloride (PVC). This material is known to be not high heat resistant, contains hazardous chemicals (toxins), relatively inhospitable, and relatively more expensive. Therefore, researchers make innovations utilizing natural materials in the form of wood charcoal as the basic material of making the water pipe. Making this pipe requires a simple mold design that can be worked in the scale of household and intermediate industries. This research aims to produce water pipe mold with simple design, easy to do, and making time relatively short. Some considerations for molding materials are weight of mold, ease of raw material, strong, sturdy, and able to cast. Pipe molds are grouped into 4 (four) main parts, including: outer diameter pipe molding, pipe inside diameter, pipe holder, and pipe alignment control. Some materials have been tested as raw materials for outer diameter of pipes, such as wood, iron / steel, cement, and thermoset. The best results are obtained on thermoset material, where the process of disassembling is easier and the resulting mold weight is relatively lighter. For the inside diameter of the pipe is used stainless steel, because in addition to be resistant to chemical processes that occur, in this part of the mold must hold the press load due to shrinkage of raw materials of the pipe during the process of hardening (polymerization). Therefore, it needs high pressure resistant material and does not blend with the raw material of the pipe. The base of the mold is made of stainless steel material because it must be resistant to corrosion due to chemical processes. As for the adjustment of the pipe is made of ST 37 carbon steel, because its function is only as a regulator of the alignment of the pipe structure.

1. Introduction

Wood charcoal is a black residue containing impurities of carbon produced by removing the water content and volatile components of the plant [1]. Wood charcoal is generally used as cooking fuel, water purifier, poison absorber, etc. The wood material used for making wood charcoal is good wood, in this case the wood that has not decomposed [2].

The rambutan tree (Nephelium sp.) is a tropical plant originating from Indonesia. This plant belongs to the Sapindaceae family and thrives in tropical regions. In English, this plant is known as Hairy Fruit [3].

In general, in North Sumatera, rambutan wood is used as raw material for making wood charcoal. Selection of this type of wood due to the availability of raw materials are abundant, easy to grow, and the selling price is relatively cheaper.

This research is a technological innovation activity in the field of engineering materials in an effort to utilize natural materials that are more environmentally friendly. In this study, wood charcoal
will be processed into a polymer composite material and molded into a water pipe of diameter of 2". The form of charcoal used in this study is shown in Figure 1.

![Figure 1. Rambutan tree charcoal.](image)

So far, the type of water pipe used for households is made of thermoplastic polyvinyl chloride (PVC), as shown in Figure 2. The chemical structure of PVC is a material that is not readily biodegradable in nature, is not sufficiently resistant to weather changes, and its selling price relatively more expensive. In addition, the chemical compounds in PVC can leak and mix with the wrapped material when heating up to 80 °C. The effects of liver cancer, kidney failure, weight loss, etc. [4].

![Figure 2. Water Pipe ∅ 2" from PVC material.](image)

The preliminary research on the design of this water pipe is done and published in The 3rd National Engineering Technology Seminar (SNTR 3) in December 2016. The size of the water pipe to be made is 300 mm in length and 2" in diameter [5]. In this research, the researcher has produced an engineering drawing of water pipe mold design as shown in figure 3.

![Figure 3. Engineering drawings of pipe mold design: (1) mold stand, (2) outer diameter mold wall, (3) inner diameter mold, (4) molding guide, and (5) fasten bolt of mold.](image)
Part of the mold is composed by a molding holder, an outer diameter molding wall, an inner diameter mold, a guide, and a mold fastening bolt. The outer wall material of the mold is made of thermoset polymer material. Selection of this material because of the ease in the process of disassembly and have a light weight. The inner diameter pipe mold is made of AISI 304 stainless steel material. The material selection is intended to be able to withstand pressure during the hardening of the composite material. The pipe wall uniform control section aims to ensure that the pipe wall is produced in a straight and uniform state [5].

The objection of this research was to make a water pipe mold of the aforementioned materials. The resulting mold is box-shaped with a cylindrical cavity inside which is three pieces. This cylindrical cavity will then be filled by a liquid composite material and harden to form a pipe. Therefore, the manufacture of this pipe mold also considers the good pipe disassembly technique, without damaging the shape of the resulting pipe.

2. Method
This research activity is carried out in Mechanical Engineering Laboratory, Institute Technology of Medan. This activity includes the work of preparing pipe mold parts, including: 1) molding holder, 2) outer diameter molding wall, 3) inner diameter mold, 4) molding guide, and 5) fasten bolt of molding (figure 3).

The mold holder serves to maintain the stability of the mold structure during the pipe-making process. This section will retain the entire weight of the mold parts. In addition, this section also serves to close the bottom of the mold so as not to leak during the pipe-making process. The mold holder is made of AISI 304 stainless steel with the size of this section is 300 x 150 x 40 mm. The shape of this section is shown in figure 4.

![Figure 4. The mold holder](image)

The outer diameter pipe mold is made of thermoset material. The manufacturing technique of this part is to pour the thermoset material which has been mixed with the surface softener (powder) into a special mold, as shown in figure 5a. The results are shown in figure 5b.

![Figure 5. Making of the outer diameter of the pipe: (a) the casting of the material in the mold, and (b) the shape of the mold.](image)
The inner diameter mold is made of AISI 304. The size of this part is as follows: outer diameter 36 mm, length 400 mm, and at both ends are given threaded rods. The function of this equipment is to control the thickness of pipe wall. This equipment will be connected directly to the mold guide part. To close the molded walls used bolts and nuts placed on the outer diameter molding wall. The overall shape of the mold is shown in figure 6.

![Figure 6. Water pipe mold.](image)

3. Results and Discussions

The time required during the molding process of the outer diameter of the pipe, starting from casting to mold to disassembly ranges from 45 minutes to 1 hour. Prolonged demolition time will cause cracks on the mold surface. In addition, the mold is easily broken during the demolition process. The cause is the occurrence of high stresses between polymer molecules during the polymerization process. This stress causes high pressure and friction between the polymer material and the mold surface. Therefore, disassembly is done when the condition of the polymer material has begun to harden.

The process of incorporation of the mold parts is preceded by applying a Wax coating on the outer diameter mold surface, inner diameter, and molding holder. This material serves as a separation layer between the raw materials of the pipe and the mold, thus giving ease in the process of dismantling the mold. The next process is the installation of an inner diameter mold on the mold holder and followed by the installation of the outer diameter of the pipe mold. The thickness of the pipe wall arrangement is done by placing the adjusting device on top of the outer diameter of the pipe. To measure the thickness of the pipe is used calipers. Tightening of outer diameter mold using bolts and nuts. This tightening process should not be too strong, as it will cause damage to the mold wall.

Testing of water pipe making from polymer composite material reinforced wood charcoal powder has been worked out and produces a pipe product as shown in Fig. 7. The thickness of the resulting pipe wall is between 2.0 sd. 2.3 mm. The surface of the outer wall of the pipe is less smooth and there are small indentations. This is due to surface cracking during the polymerization process. While the inner wall surface is very smooth and shiny.

![Figure 7. Water pipe made of polymer composite material reinforced wood charcoal powder.](image)
4. Conclusions
Pipe molds have been successfully constructed using tools and materials that are simple enough and easy to obtain (figure 6). The technique of making these water pipe molds is also done by using simple and easy-to-obtain work tools, so they can be made easily in small and medium-sized industries. The technique of assembly mold parts is also very easy and practical, does not require a long time. Accuracy is required when adjusting the mold part of inner diameter pipe. It aims to get a more uniform pipe wall thickness.

The use of thermoset material as an outer diameter molding material provides the following advantages: easy in the process of disassembling the mold, the elastic characteristic of the material produces a tight gap and is not easily leaking during casting process of polymer, and relatively light weight of the mold. Conversely, tightening of bolts and nuts should not be too strong at the time of the molding process. Tightening is too strong will cause damage to the mold surface.

The result of the water pipe making experiment using this equipment has resulted a water pipe of composite material reinforced by wood charcoal powder (figure 7). Visually, the resulting pipe has the following characteristics: the raw material is uniformly distributed in the mold, the outer wall surface of the pipe is still rough, the inner wall surface of the pipe is smooth, and requires a relatively short disassembly time. Raw material pipe has filled the entire space contained in the mold and no visible cavities in the resulting pipe. But the surface of the outer wall of the resulting pipe is still rough and not good. This case will be investigated further to get better results. The time of dissembling the mold should not be too long, which is between 45-60 minutes. Based on the results of research that has been done, the dissembling time more than 60 minutes will cause the raw material hard to be released on the inner diameter mold. This is due to the drying process which is accompanied by shrinkage on the raw material. This shrinking process will produce strong pressure on the inner diameter mold. Provision of wax coating also does not provide a solution to this case. Therefore a better technique is needed in handling this case and will be further investigated.

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