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Design and manufacture of Fiberglass Pipe Cutting Machine with Adjustable Holder

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A B S T R A C T

Fiberglass is a material that is used for several products. This material was chosen because it has many advantages compared to other materials, namely it has better resistance, relatively affordable production costs and is easy to shape. PT.X is one of the manufacturing companies engaged in fiberglass, namely the manufacture of pipes and body from vehicles. In this case study the company still uses hand milling and manual processing. Fiberglass pipe in this company is molded indirectly to the size requested by the customer, therefore a cutting process is needed to get the required pipe length. The blade used specifically is a diamond-coated cutting blade because the fiber material is not heat-resistant. In this research, the researcher wants to design a fiberglass pipe cutting machine with an adjustable holder that can be adjusted so that it can cut various pipe sizes. Making the design of this machine is done using Fusion 360 software. The making of the machine includes the cutting process, grinding process, and welding process. The machine can cut a pipe with a diameter of 100 mm in 20 seconds and for a pipe with a diameter of 500 mm in 1 minute 20 seconds.

Keywords: Fiberglass, pipe cutting, machine

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I. INTRODUCTION

The manufacturing industry requires basic materials to create a product. Metal is the only basic material commonly used in the manufacturing industry, but there are several weaknesses of metals that can hinder the development of a technology, one of which is easily corroded metal. Therefore, many manufacturing industries are looking for other basic materials, one of which is composite materials. Composite materials were chosen because of their durability, relatively affordable production costs and easy to form. Composite is a material formed from a combination of two or more constituent materials through an inhomogeneous mixture, where the mechanical properties of each of the constituent materials are different.

In this modern era, humans are very effective in how to make a job efficient and efficient, so various kinds of tools and machines are made to simplify the work process and get consistent results, one of which is a cutting machine. The case study was carried out at PT.X which still uses Fiberglass pipes manually, because the work process is done manually, the results of the cuts cannot be perpendicular. When the Fiberglass pipe molding process is not directly in accordance with the design for the length of the pipe, then the process is cut so that the length of the pipe matches the design. Pipe cutters using special fiberglass pipe cutting machines can cause production costs.

Fiberglass pipe cutting machine here has a stand that can be adjusted so that the pipe that can be cut varies in diameter. The pipe holder can rotate the pipe automatically so that the results of the cut are perpendicular, for the grinding part the grinding wheel is used specifically because the Fiberglass material is flammable.

II. METHODOLOGY

1. Observation

Observation is the first step that forms the basis for determine the title of the study. The purpose of this stage is to find out problems that often occur in the process of cutting Fiberglass pipes.

2. Identification

In this process, the researcher explores the problems that occur in the compan especially during the pipe cutting process Fiberglass with a large diameter in order to obtain the formulation of the problem and the objectives to be achieved by this research. Likewise with the determination of the boundaries of the problem so that it can facilitate the process of conducting this research.

3. Study of literature

In the study of literature, it is necessary to collect various information and the right parameters to get the expected results. This stage aims to process the collection of several theories related to this research, which will be used as a reference in research and also as a comparison against the object being studied.

4. Design Concept

From the specifications of the pipe cutting machine, it is then applied to the following: design concept. At the design concept stage, it takes more than one or two design concepts. More and more design concepts are created too can help to increase the choice of design concepts that will used.

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5. Design and Calculation

This research is to make a Fiberglass pipe cutting machine with holder can be adjusted. Where planning and calculations come into play important in the success of this thesis. Selection of components for Assembling this machine is based on calculations. Where is the calculation will produce a quality product that is in accordance with what has been planned. Meanwhile, if there is an error in a calculation it will cause an error in selecting components for designing a machine. If an error occurs in the selection of components it can affect the results of the design of the machine itself. As a result the machine cannot run as designed. Machine not operating maximally, the machine is easily damaged and other consequences. Because of Therefore, the calculation and selection of components must be correct so that the machine can operate properly operate as expected.

The working mechanism of this cutting machine is to put Fiberglass pipe above the adjustable holder. After the pipe is laid on the holder then start the motor. After grinding cut rotates, the holder also rotates to rotate the pipe will be cut. The cutting grinder moves linearly perpendicular to pipe. The way to move the cutting grinder is by turning the lever as in a sitting vise. A meal hosted by grinding cutting that is gradually. After the pipe is cut successfully pull back the cutting grinder then lift the pipe that already cut it from the holder.

6. Material Preparation

At this stage, after the calculations have been done so that components can be determined, then the next step is to prepare components that have been determined based on calculations that have been conducted. If these components are available or sold in the market then can buy it, if not then have to make the components yourself. What must also be considered if you want to buy or make components must consider the material in terms of strength and also of in terms of safety.

7. Machine Assembly

At this stage the components have been determined. Next component which has been prepared is started to be assembled. Assembly is carried out according to designs that have been made earlier. If there is a discrepancy one component to another or another error occurs when assembly process, it is necessary to review the calculations and the design. But what if you don't experience problems during the process? assembly, and the machine can be assembled according to the plan, then it can be proceed to the next stage.

8. Machine Testing

In the next stage after machine assembly is testing finished machine. The finished machine will be tested for know whether the resulting output is in accordance with what is It has been planned that the test has also been carried out several times with the aim of to ascertain and determine whether the machine design is capable answer the problem formulation and research objectives. Tool Testing Success To find out the success of the Fiberglass pipe cutting machine with an adjustable holder for cutting various sizes pipe. The tool is declared successful if the tool is able to cut the pipe with perfect and no defects during the cutting process.

9. Conclusions and recommendations

After doing the analysis, a conclusion can be drawn From the research that has been done, from these conclusions it can be provide suggestions to support further research

III. Results and discussion

Motor Power Calculation

At this stage the calculation of the electric motor power will be carried out using the following formula:

a) Spindle speed

Spindle speed is the speed of the transmission shaft that drives the cutting blade used, namely the diamond cutting disc with the following data:

Table 1. Cutting data

Type	Size	Max
Wet and Dry	105x12x16	14.500

b) Cutting speed (Vc)

Cutting speed or cutting speed based on the diameter of the workpiece and the speed of the driven shaft

$$Vc = \frac{500\ x\ 3.14\ x\ 14500}{1000} = 22776{,}546\ mm/min$$

c) Penetration rate (Vf)

Penetration rate is ability holesaw or cutting edge to do penetration, using the equation

$$Vf = \frac{Dc}{t} = \frac{500}{2.5} = 200\ mm/min$$

d) Feed per revolution (fn)

Feed per revolution is food blade on the workpiece by rotation knife, using the equation:

$$fn = \frac{Vf}{n} = \frac{200}{14500} = 0.0137\ mm/rev$$

e) Torque

To calculate electric motor power first calculate the torque occurs while the machine is running, for calculate it using the formula

T = F x R

= 229 N x 0.01 m = 2.29 Nm

f) Motor Power

To determine the motor power needed for the motor to work properly with the desire to use the equation

$$P = \frac{T.2.\pi.n}{60}$$

$$P = \frac{2{,}29.2.3{,}14.30}{60} = 7{,}1906\ watt$$

Thus the 220V . gearbox AC motor with 25W power and has speed 30RPm gearbox ratio 1: 50 capable of used to rotate the working roller to rotate Fiberglass pipe during processing cutting.

Calculation of Frame Permit Stress

In analyzing the strength of the framework used Autodesk Fusion 360 software results from the analysis will get the value maximum stress in the frame. After getting the results of the stress calculation, Then a failure evaluation will be carried out material due to excessive loading. In order to evaluate these results, using the following equation:

$$\sigma\ maximum < \frac{\sigma y}{N}$$

Based on ASTM A36 material with factor the security used is 2, then calculation of maximum stress or stress The permits contained in the framework are:

$$\sigma\ maximum < \frac{250}{2} = 125\ MPa$$

Next determine the distribution of loading contained in the frame. Planning weight pipe cutting machine is 6.4 kg, unit weight adjustable holder is 10 kg and the weight of the motor along with gearbox reducer is 3.5 kg. for calculate the amount of loading that occurs can use the following equation:

P_{desain} (cutting tool) = M cutting tool x N
= 6,4 x 2 = 12,8 kg
P_{desain} (Adjustable Holder) = M Adjustable Holder x N
= 10 x 2 = 20 kg
P_{desain} (Motor gearbox) = M motor gearbox x N
= 3,5 x 2 = 7 kg

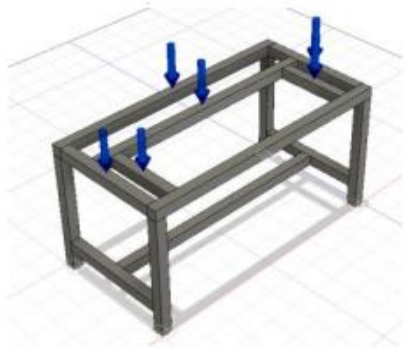

Figure 1. Distribution of the load on the frame

Figure 1 shows the distribution of the load what happens to the frame. Cutting machine load shown as the following figure.

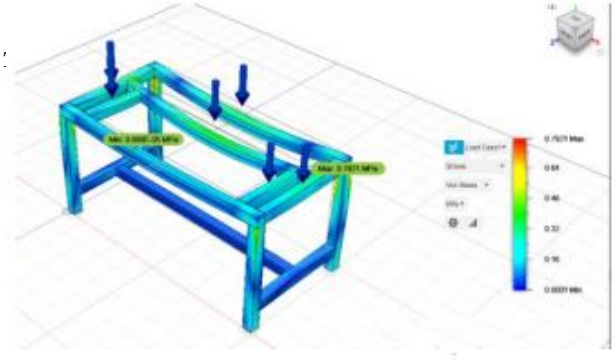

Figure 2. Results of frame analysis using Software

Maximum stress simulation results using Software is 0.7 MPa. If compared to the calculation of the voltage maximum then the result is still said safe because the maximum voltage is smaller of the allowable voltage.

Base roller strength analysis

Next determine the distribution of loading contained in the Base roller is 5 kg. for calculate the amount of loading that occurs can use the following equation:

P_{design}(Base Roller) = M base roller x N
= 5 x 2 = 10 kg

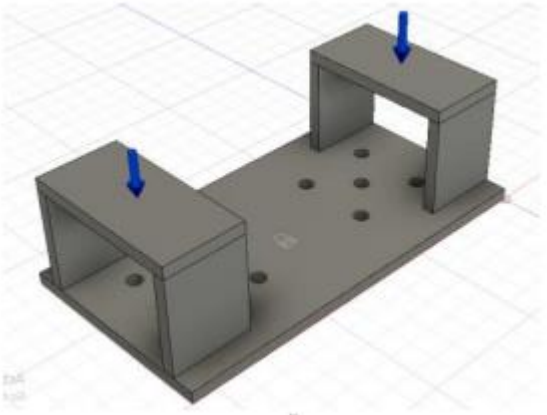

Figure 3. Roller bass load distribution

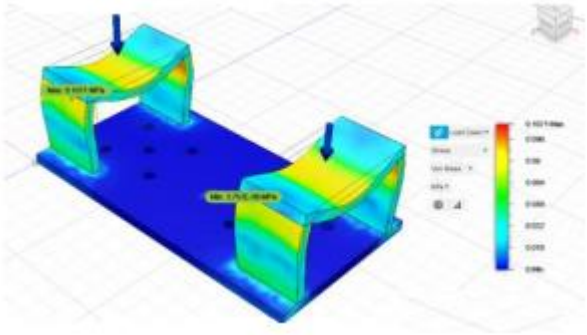

Figure 4. Base roller analysis results

Maximum stress simulation results using Software is 0.1 MPa. If compared to the calculation of the voltage maximum then the result is still said safe because the maximum voltage is smaller of the allowable voltage.

Fabrication Process

The following is an explanation of the process fiberglass pipe cutting machine adjustable holder.

1. Frame making
   The process of making the frame begins with 40 x . hollow profile cutting 40 x 1.2 mm as per design. Then continue with the welding process between profile connections.after the frame is finished then done frame assembly process.
2. Adjustable Roller Manufacture
   Roller designed using pipe ASTM a37 with a diameter of 2 dim. The roller is placed on the base made of 5mm thick ASTM A36 plate combined with SBR bearing Blocks. As a support for the roller given bearings sitting on both sides.
3. Cutting tools
   The Cut Tool is designed using jig mounted hand grinder and SBR guide railway as the base. Jig for hand grinding made of ASTM A36 Plate with 5mm thick and mounted with Hollow square 40 x 40 x 1.2 mm as the pole.
4. Machine painting and finishing stage

The finishing stage is carried out for improve and refine visuals of the assembled machine. Staged This is done to remove annoying part machine by grinding and caulked. The next step is the painting process which aims to not easy to rust and for beautify the appearance of the machine, so that increase the selling value of the machine.

Machine Trial

From the results of machine design and planning in the previous sub-chapter the results of the machine Fiberglass pipe cutter with holder adjustable as shown below

Figure 5. Machine Result

After the machine results are obtained, the next step is The next step is the testing process for know the speed of the cutting process for one pipe and also the operational feasibility of the machine. This test uses Fiberglass pipes with a diameter of 100mm.

Figure 6. Machine testing

This cutting process uses a grinder jigged and SBR-attached hands guide railway for the forward and backward system. For adjustable pipe support roller using the SBR guide railway which mounted under the base roller. The following is the time data for the cutting process after: machine test run:

Table 2. Test result

Pipe Size	cutting time without machine	cutting time by machine
D 100 mm	45 s	20s
D 500 mm	3m 10s	1m20s

From Table 2. it can be concluded that the process cutting using a cutting machine more fast compared to cutting process manually.

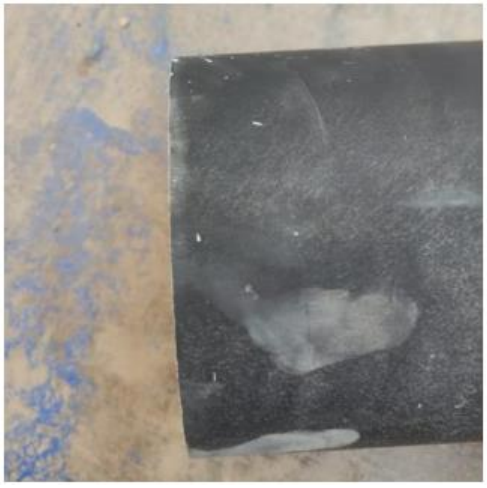

Figure 7. The results of the cutting process using a machine

IV. CONCLUSIONS

Based on research that has carried out by the author, the conclusion is obtained as follows :

1. The design of this machine is done using Fusion 360 software. The method used is the method Ulrich by creating 3 concepts different design with considering the criteria, of the three the design concept that has been made, obtained a concept design of 2 with a value of highest, so the concept is chosen design 2 as a concept design for Fiberglass pipe cutting machine with adjustable holder.
2. Machine manufacturing includes processes cutting, grinding process, and process welding. The machine is designed with dimensions 1000 x 500 x 500 mm with using 40 . hollow profile material 40 x 40 x 1.2 mm to form frame of the machine. After determine the next design determine the calculation of machine elements. And then testing machine that has been made.
3. The machine can cut diameter pipe 100 mm with a time of 20 seconds and for pipe diameter 500mm with time 1 minute 20 seconds.

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