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MIXER DESIGN EQUIPPED WITH HEATING CONTROL ELEMENTS FOR MANUFACTURING COMPOSITE MATERIALS

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Abstract

Composite is a composite material consisting of two or more materials with different mechanical properties. Composite materials are mixed to obtain new materials that have better micro-mechanical properties. To facilitate the mixing of composite materials and obtain materials that have good quality, in this study, a mixer machine design with heating elements was carried out so that the temperature could be adjusted as needed. Experiments from the results of a mixer machine with a heating element that have been made are comparing the mixing of resin and iron sand using a mixer machine without a heating element and using a heating element. The result of mixing composite materials using a mixer machine without heating elements is that the composite material is homogeneously mixed but when viewed from the micro-photos there are still many white spots so that the quality of the composite material is still not good. then the composite material is mixed and mixed using a mixer machine with a heating element, the composite material is homogeneously mixed and after seeing from the micro-photos there are a few wite spots on the composite.

Keywords: *Mixer, mixing, stirring, temperature, heating element, white spot*

Abstrak

Komposit adalah material komposit yang terdiri dari dua atau lebih material dengan sifat mekanik yang berbeda. Material komposit dicampur untuk mendapatkan material baru yang memiliki sifat mekanik mikro yang lebih baik. Untuk memudahkan pencampuran material komposit dan mendapatkan material yang memiliki kualitas yang baik, pada penelitian ini dilakukan perancangan mesin mixer dengan elemen pemanas sehingga temperatur dapat diatur sesuai kebutuhan. Percobaan dari hasil mesin mixer dengan elemen pemanas yang telah dibuat adalah membandingkan pencampuran resin dan pasir besi menggunakan mesin mixer tanpa elemen pemanas dan menggunakan elemen pemanas. Hasil pencampuran material komposit menggunakan mesin mixer tanpa elemen pemanas adalah material komposit tercampur secara homogen namun jika dilihat dari foto mikro masih banyak terdapat bercak putih sehingga kualitas material komposit masih kurang baik. kemudian material komposit dicampur dan diaduk menggunakan mesin mixer dengan elemen pemanas, material komposit dicampur secara homogen dan setelah dilihat dari foto mikro terdapat beberapa bercak putih pada komposit.

Kata kunci: Mixer, pencampuran, pengadukan, temperatur, elemen pemanas, white spot

1. Introduction

Before the technology was developed, the process of mixing materials in the manufacture of nano composites was still done manually, namely mixed by hand. By using a manual mixing procedure, it is certain that the nano-composite manufacturing process takes a long time. Not only because of that, but the results of the mixing are not thorough or not homogeneous. On the other hand, in the manufacture of nanocomposites, a good homogeneity of the combination is required which will affect the quality of the nanocomposite. With the various problems that have been discussed, the authors are interested in solving these problems by producing a nano-composite mixer that is useful for improving the creation and quality of nano-composites.

The heating element is a device that converts electrical energy into heat energy through a process. Composite materials generally produce good materials when stirred or mixed using a stable temperature.
This mixer is designed for even distribution of composite mixing, it is beneficial for the community this tool can be used as a basis for developing work in the composite field. In the manufacture of flow control composite resins and the prevention of white spots (white dots on the composite) the presence of an unstable ratio of fiber and resin, this is still an important problem for the quality of the resulting composite material. These factors affect the quality of the resulting composite material, therefore a mixer is designed to mix fiber and resin evenly.

2. Literature Review

According to Sabuin, Boimau, and Adoe [1] in his research entitled The Effect of Oven Temperature on Mechanical Properties of Hybrid Composites Fiber Glass Reinforced Polyester and Leaf Gewang Fiber concluded that there is an effect of temperature on the mechanical properties of hybrid composites.

2.1 Mixer

Mixing is the activity of mixing two or more substances to obtain a homogeneous mixture. In liquid media, stirring is intended to obtain a turbulent state (turbulent). Mixing can occur by causing motion in a material that causes the parts of the material to move with each other, so that the stirring operation is only one way for the mixing operation. On the mixer machine there is a stirrer that has a function as a pump that will produce a velumetric rate at each rotation speed and power input. The power input itself is influenced by the geometry of the equipment and the fluid used. The design of the stirrer is greatly influenced by the type of flow, laminar and turbulent. Mixing in the mixer machine occurs because of the rotational motion of the stirrer in the material. [2]

2.2 Electric Motor

An electric motor is a machine that converts electrical energy into mechanical energy. It can be either a direct current or an alternating current motor. This tool is also called a generator or dynamo because it can convert mechanical energy into electrical energy. A direct current electric motor in the form of a rotary electric motor that will be used as a production tool player. The electric motor serves as the prime mover for the nano-composite mixing mixer machine. [2]

2.3 Mixer Tube

The mixer tube for mixing composite materials is needed to calculate the volume of the tube to determine the maximum volume of the composite material mixture and to calculate the surface area of the mixer tube used to determine the weight of the mixer tube. [3]

The following is the formula for calculating the volume of the tube and the surface area of the tube:

Tube volume: $\pi \times r^2 \times t$

Tube surface area: $2 \times \pi \times r \times t$

2.4 Motor Shaft

The shaft is one part of the rotating machine element, which has a function to transmit power from one place to another. In its application, the shaft is varied with pulleys, bearings, gears and other elements. [3]

Table 1 Shaft Group

Shaft Group	Rate C (%)
Mild Steel	-0,15
Clay Steel	0,2-0,3
Slightly Hard Steel	0,3-0,5
Hard Steel	0,5-0,8
Verry Hard Steel	0,8-1,2

2.5 Mixer Machine Frame

The mixer machine frame is made of angle iron. The standard length of the elbow iron is 6 meters with different dimensions and thicknesses. The frame serves to stack the components of the mixer machine into a single unit and the frame serves to strengthen the engine and also dampen vibrations due to the mixing process. [4]

2.6 Bearing

Pillow Block or bearing is a machine element that supports a shaft that has a load, so that rotation can take place smoothly, safely, and for a long time. Bearings must be sturdy to ensure the shaft and other elements work properly. If the bearings are not functioning properly then the usability of the whole system will be reduced and will not function properly. [3]

2.7 Paddle Stirrer

According to Perangin-angin [5], mixing can be said to be good if the shape and dimensions of the stirrer used are considered, this is because it will affect the effectiveness of the mixing process and the power required.

The stirrer that will be used in this mixer is a propeller type. Mixer with this type of vane is usually used for stirring processes that have high speed with axial flow direction. The resulting circulation capacity is large and sensitive to the head. In propeller design, the angular area is expressed in the ratio of the formed area to the outside area.

2.8 Thermocouple

According to Lubis, Fathir, and Abas [6], a heating element is a tool that works to convert electrical energy into heat energy through a process, namely Joule

Heating. The working principle of the heat element is that the electric current flowing in the element will experience resistance, it will generate heat in the element.

The heating element itself has requirements that must be known, namely:

1. must be durable to the desired temperature.
2. have strong mechanical properties at the desired temperature.
3. has a small coefficient of expansion, so that the deformation at the desired temperature is not too large.
4. The resistivity must be high.
5. has a small temperature coefficient, so that the working current is as constant as possible.

In choosing a heating element there are things that must be considered as follows.

1. Maximum Element Surface Temperature (MET)
2. Maximum Power / Surface Loading

The area exposed to radiation on the surface of the element will be expressed in (Watt/cm2) MET, which is the temperature at which the material of the element begins to deform causing the element to break. The higher the MET, the higher the Maximum Power Loading.

Basic Principles of Heat Transfer

1. Conduction

   Conduction is a heat transfer process that occurs in a solid, impermeable medium. Heat conduction can only occur if there is a temperature difference phenomenon. Objects have a certain thermal conductivity (ability to conduct heat) which will affect the transfer of heat from the hot side to the cold side. The high value of the thermal conductivity of an object will affect the speed of heat received from one side to the other. The rate of heat transfer can be expressed by Fourier's law as follows:

$$Q = -kA\left(\frac{T_2 - T_2}{L}\right)$$

$$R = \frac{L}{kA}$$

   Information:

   Q : The rate of heat transfer (W)
   k : Thermal Conductivity (W/ (m.k))
   A : The cross-sectional area that lies in the heat flow (m2)
   T : Temperature (0 C)
   L : Plate thickness (m)
   R : Thermal resistance (0 C/m)

2. Convection

   The transfer of heat based on fluid motion is called convection. Convection heat transfer is a combination of conduction heat transfer with fluid flow. There are three types of flow, namely forced convection, internal flow, external flow, and natural flow. Heat transfer by convection is forced if the fluid flow is caused by a blower / fan, whereas if it is caused by a density gradient it is called natural. The rate of heat transfer is expressed by Newton's cold law equation as follows.

$$Q = hA(T_s - T_f)$$

   Information:

   Q : The rate of heat transfer (W)
   h : Convection coefficient (W/m2 K)
   A : Surface area of solar collector (m^2)
   Ts : Plate temperature (K)
   Tf : Fluid temperature (K)

3. Radiation

   Radiation is the process of transferring heat from a high-temperature object to a lower-temperature object if the objects are separated in a space and there is an analogy for the phenomenon of light and electromagnetic waves. The Stefan-Boltzmann law (for black bodies) is the basic law for the transfer of radiation, which is defined as follow:

$$Q = \sigma AT^4$$

   Information

   σ : Stefan-Boltzmann. Constant (5,56 x 10-8 W/m2K4)

2.9 Speed Control

The speed of an induction motor is determined by the frequency of the voltage and the number of poles of the motor, as described in Speed control This router works with Universal brush-type AC/DC motors rated at 15 amperes or below. [5]

2.10 Research Methods

Product design is an alternative development in the form of a scheme or sketch into a product or item formed, the material and size of the element are determined. The mixer machine design phase begins with adjusting needs, the next initial sketch/ image is carried out, ending with a detailed product element design, which is then determined in the details for the manufacturing process. For detailed images made using SolidWorks software.

Product Design Product design phase is an alternative development in the form of a scheme or sketch into a

product or technical object that forms, materials and dimensions of the element is determined. The mixer machine design phase begins with adjusting needs, then the initial sketch/ sketch, ends with the design of detailed product elements, which are then poured in detailed images for the manufacturing process.

Documents for Documents or Product Making Products Product Design Results can be described in the form of traditional images on paper (two dimensions) or images in modern form, namely digital information that is stored in the form of computer memory. Information in digital can be in the form of molds to produce traditional images or can be read by computer software.

Product design results consist of:

1. Images of all product elements complete with geometry, dimensions, roughness/smoothness of the surface and material.
3. Image component (assembly).
4. Product settings.
5. Specifications that make information that cannot be loaded in the picture

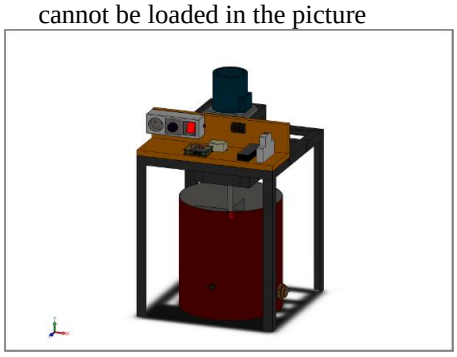


Figure 1 3D Design

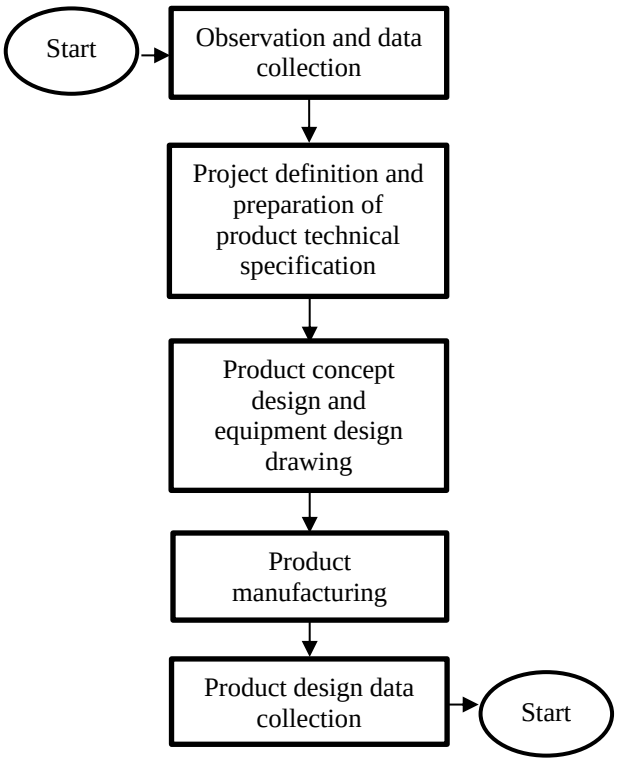
2.11 Design Material

1. Grinder
2. Meters
3. Welding equipment
4. Hand drill
6. Power supply
7. Lathe
8. Vise (Vise)
9. Safety glasses
10. Solder
11. Tin
12. Combination pliers
13. Pliers
14. Screwdriver (+/-)
15. Cutter
16. Sandpaper
17. Caliper
18. Lock L
19. File a semicircle
20. Pegs/pins
21. Avometer
22. Tachometer

2.12 Design Tools

1. Electric Motor
2. Flexible Coupling
3. Pillow Block
4. Axis Diameter 12mm
5. Iron Elbow 30 x 30 x 2,5
6. Strip Plate Iron 3 x 2,5
7. Control Speed
8. Cable 2 x 2,5 (1m)
9. Cable 2 x 2,5 (6m)
10. MCb
11. Capacitor
12. Terminal Block 6 Pin
13. Cable Skun 1,5 (20)
14. Cable Skun 2,5 (20)
15. Cable Insulation
16. Screw 6 x 5/8 (20)
17. Screw 6 x 1 ¼ (20)
18. Bolt 10mm 3cm (4)
19. Electrical terminal (10mm)
20. Board 30 x 12 x 1,5 (2)

2.13 Flowcharts



2.14 Design stage

1. Library research
2. 2D and 3D drawing design
3. Prepare tools and materials
4. Cut the angle iron and plate iron according to the planned size
5. Doing frame welding

6. Making the mixer tube followed by the installation of the heating element at the bottom of the tube
7. Make shaft and blade
8. The shaft is mounted on the pillow block then the coupling and connected to the frame
9. Followed by the electric motor then install the bolts on the motor and pillow block then tighten all the bolts on the components
10. Install the paddle stirrer on the shaft that is already connected to the electric motor
11. After all the components were installed, cut the board into two parts and then install it to form an L on the top of the frame
12. Perform electrical installation
13. Install the speed control and capacitor on the board
14. Connect the motor to the capacitor and speed control via the terminal socket
15. Install temperature control and AC/DC adapter
16. Connect the heater on the tube to the temperature control and terminal block
17. Install terminal block then connect speed control and temperature control to terminal block and then connect to MCB
18. Perform mixer operational test
19. If the mixer is not working as it should do a re-calibration
20. Did the test again and it worked. looking for mixer data

2.15 Place and Time of Design

As for where this research was carried out in the materials laboratory at the College of Aerospace Technology and the time was 10 January 2022 until it was finished.

2.16 Data Collection and Data Analysis Techniques

1. Requirements determination aims to make accurate specifications necessary for the design / design. The method used in this step is the performance specification model
2. Project definition, project planning, and preparation of project technical specifications. The project definition and other activities in this phase result in, among other things:
3. Product Concept Design
   The technical specifications of the product from the first phase of the design process become the basis for the next phase, namely the product concept design phase. The purpose of this phase is to generate as many alternative product concepts as possible. The product concept produced in this phase is still in the form of a schematic or in the form of a sketch. In principle, all alternatives of all product concepts meet the technical specifications of the product. At the end of the product concept design phase, an evaluation of the product concept design results is carried out to select one or several best product concepts to be developed in the third phase of the product design phase.
4. Product Design Phase
   Product design is the development of alternatives in the form of schemes or sketches into products or technical objects whose shapes, materials and dimensions are determined. The design phase of the mixer machine begins with adjusting the requirements, then initial sketches / drawings are carried out, ending with the detailed design of product elements, which are then poured into detailed drawings for the manufacturing process. For detailed drawings and analysis of the mixer machine frame, it is done using Solidworks software.
5. Documents for Product Manufacturing
   Documents or images resulting from product design can be expressed in the form of traditional images on paper (two dimensions) or images in modern forms, namely digital information stored in the form of computer memory. The information in the digital can be in the form of a printout to produce a traditional image or it can be read by a computer software.

3. Results and Discussions

The design of a mixer machine using a heating system aims to make the resulting composite material into a good material, so that during mixing and stirring it avoids or minimizes the white spots (white spots on the composite) produced. This is because if there are many white spots on the composite material, the quality of the composite cannot be said to be good. The heating system is installed on the mixer with the aim that the resulting temperature can be regulated both by thermocontrol and the temperature at the time of stirring and mixing remains stable.

3.1 Resin Mixer With Heater

The results that have been achieved in the manufacture of a heating mixer machine for mixing resins can be seen in the following figure.

Figure 2 Mixer Resin with Heater

3.2. Design Mixer Using Solidworks

Before realizing the design of the mixer machine, a mixer machine design with heating elements has been made using the solidworks application. The design is in accordance with the needs in designing a mixer machine. It aims to already have an idea about the results and objectives of the mixer machine using a heating system. The following is a picture of a mixer machine that has been made using the Solidoworks application.

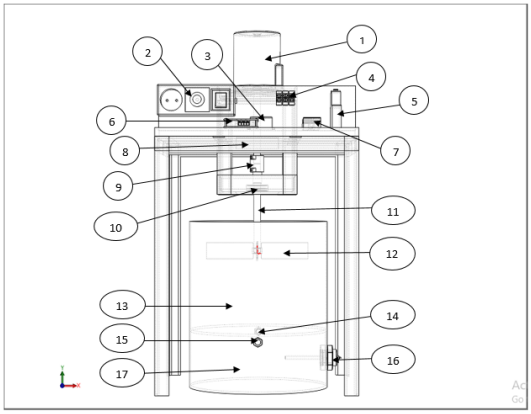


Figure 3 Design Part Mixer

As for the component parts in the picture above, namely:

1. Electric Motor
2. Speed Control
3. AC to DC converter adapter
4. Terminal Block
5. MCB
6. Thermo Control
7. Terminal Block 6 pin
8. Capacitor
9. Clutch
10. Pillow Block
11. Shaft
12. Blade
13. Mixing Section Tube
14. Oil drain valve
15. Oil filling valve
16. Thermocouple
17. Oil Tube

3.3. Spesification

Table 2 Mixer Specifications

No	Name	Mixer Specifications
1	Electric Motor	motor (AC) 220/230 V 25 Watt 1400/1650 RPM
2	Flexible Coupling	shaft 12 mm x 12 mm outside diameter 25 mm length/height 30 mm
3	Axis	axis diameter 12 mm axis length 17 cm
4	Pillow Block	inside diameter 12 mm outside diameter 25 mm
5	Paddle Stirrer	length 7 cm height 3 cm
6	Tube	height 20 cm diameter 10 in thick 3 mm
7	Speed Control	input (AC) 110/220 V output Adjustable 15~99% current Output 12 A
8	MCB C10	10 A/ 230 V/ 2200 Watt
9	Thermo Control	temperature control range: -50 ~110 measurement accuracy: 0,1 control accuracy: 0,1 refresh rate: 0,5 input power (DC): 12 V measuring Inputs: NTC (10K 0,5%) waterproof cable sensors: 1 m range: 0 ~ 400ºC output 1 channel relay, 10 A power consumtion : Static Current: <35mA current: <65mA environmental ecuipments temperature: -10 ~ 60, humidity: 20 ~ 80%
10	Heater	1750 watt input (AC) 220 V
11	Capasitor	capacity (uF/mfd) : 8.0 tolerance: +/- 10% 400 V (per hour): 30,000 450/500 (per hour): 10,000/1,000 diameter: 35 mm, length: 71 mm
12	Adapter AC-DC	input range: AC/DC 100-240 V output voltage: DC12V 300mA appearance size: 40*28*23mm

In accordance with the specifications of the tool in the table above, which is used to design the machine has a function, namely the motor used to work as a driver so that the mixer machine can work properly, then a flexible coupling is used to transmit the force and motion generated by the engine motor to the axle or axle. Sir. AS itself is used so that the blade on the mixer machine can rotate properly, while the pillow block is used for the AS stand or shaft.

The blade works as a stirrer and mixing composite material to be produced, and the tube as a container for the material to be mixed or stirred. In the design of the mixer machine made in this study using speed control which has a function to regulate the speed produced by the motor as the driving force.

Design a mixer with a heating element using MCB C10. MCB works as a protection system in electrical installations in case of overload and short circuit or short circuit. The heat generated from the electric current through the MCB is then directed to the terminal block. There are several sizes of current in the MCB, namely 2A, 4A, 6A, and 10A. In this study the authors use MCB 10A because it has a power of 2200 watts. If the electricity usage from the mixer exceeds the Watt capacity limit on the MCB, of course the MCB will experience automatic disconnection.

Terminal block has a function to make electrical panels because all the electric current in the terminal block can examine other components, so that in this electric current can work well together as a speed regulator and element heater.

The temperature controller is an electrical component that has the function of being able to disconnect and connect electric currents automatically by detecting the temperature of a medium to keep it at the set

temperature. The heating element used to generate the desired heat so that it can be adjusted using a temperature controller, is used to make the motor rotation more stable and can increase the power factor and its effect so as to save electricity. Capacitors are also designed to work non-stop as long as the motor in the machine generates force and motion. The AC/DC adapter is used to convert AC electric current (alternating current) into DC electric current (direct current) so that it can control the temperature so that it has power and works well.

The selection of materials and specifications in this study is in accordance with the design requirements in order to facilitate the design of the mixer machine to be studied.

3.4. Component Manufacturing

1. frame making

   In making the frame of the mixer machine used angle iron with a size of 30 mm x 30 mm. The total angle iron used for the manufacture of the frame is ± 4.5 m, in addition to the use of angle iron in the manufacture of the mixer machine frame, an iron plate with a length of 1 m is also used. The elbow iron and plate that have been selected are then cut using a cutting grinder and a saw as shown in Figure 4. On the machine frame, a drilling process is carried out for the placement of the motor. In the process of connecting the frame, welding is carried out using electric welding.

Figure 4 Frame

2. Mixer Tube Making

   The tube mixer machine is made of pipe with a diameter of 10 inches with a thickness of 3 mm. The base of the tube is made of plate iron according to the pipe diameter of 10 inches. The pipe base and tube are welded with electric welding for the connection between the pipe and the tube base that has been made.

Figure 5 Tube

3. Making Paddle Stirrer

   The manufacture of the paddle stirrer uses a material consisting of plate iron and uses bolts with a size of 15 mm. The iron plate used has a length of 7 cm, the middle of which is cut to adjust the top and bottom of the bolt so that when welding it can be easier and make the connection between the iron plate and the bolt stronger. The paddle stirrer that has been made is used as a stirring eye for composite materials to be mixed and stirred

Figure 6 Paddle Stirrer

4. Shaft Making

   The shaft is made of axle iron which has an initial diameter of 20 mm which is then turned to reduce the diameter to 12 mm. the shaft diameter is reduced using a lathe to 12 mm to match the shaft on the motor. This shaft will later be used as a drive shaft for the paddle stirrer which is connected to an electric motor.

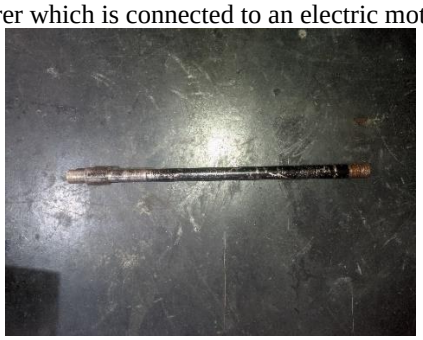


Figure 7 Shaft (axle)

5. Heating Element Plan

   In planning the heating element there are several factors that must be considered, namely the maximum power that will be produced, the temperature of the heating element according to the needs or specifications of the machine to be made. The electrical factor must be considered because electricity is a source of energy and if it is used incorrectly or in the wrong circuit, it will cause losses.

Figure 8 Heater

6. Wooden Board Installation
   The wooden planks are cut according to the length of the frame, which is 30 cm long and 1.5 cm thick. The wooden boards used are 2 pieces of the same size, then the two boards are formed into an L where one board is placed horizontally and the other board is placed vertically. The wooden board that has been formed will be placed on top of the mixer machine frame. The wooden board is used as a medium for the electrical components that support the mixer machine with a heating element.

Figure 9 Wooden Board

7. Electrical installation
   In the preparation of electrical components for the design of machines using heating elements, the first is the manufacture of media for the MCB and the installation of other components such as terminal blocks, speed control, adapters, and temperature controllers. The arrangement of these electrical components is placed on a board that has been made previously so that it is neatly arranged later it will be placed on the mixer machine frame. The results of the preparation of electrical components can be seen as shown in the following figure

Figure 10 Electrical Installation

3.5. Mixer Machine Working Principle Using Heating System

The following are the working principles of the components of a mixer machine using a heating element for mixing and stirring composite materials.

1. The mixer machine uses an electric motor with a maximum rotation of 1400/1650 rpm which can be adjusted using a variable speed control with 9 variations of rotation speed.

Table 3 Rotation Speed

Speed Control Indicator	Rotation Speed (RPM)
0	0
1	42
2	156
3	302
4	458
5	614
6	770
7	926
8	1082
9	1238

2. Mixer using blade type paddle stirrer (basic)
3. The mixer in this study uses an electric heating system, namely a spiral heating element.
4. 4. The power used in the heating element is 1750 watts. The heating element is placed under the oil-filled mixer tube.
5. 5. The heating process carried out by the heating element will conduct heat to the top of the tube so that the mixing process occurs by stabilizing the temperature.
6. 6. The mixing function is carried out so that homogeneous mixing of the resin occurs.

From the working principle of the mixer machine above, the following is the flow of how the mixer machine works with a heating element in order to mix and stir composite materials.

1. The power mixer cable is connected to the power supply to produce electricity which is delivered to the motor and to the heating element.

2. From the electricity the motor can move and generate rotation on the blade whose speed can be regulated by speed control.
3. Then the electricity in the heating element produces power which can increase the temperature in the mixer tube. Useless at all
4. The temperature can be regulated by a temperature controller that has been installed on the mixer machine so that the temperature remains stable as desired during the process of mixing and stirring composite materials.

3.6. Wiring Diagram

Wiring diagram is a network structure or electrical path expressed in the form of a picture. The wiring diagram of the results of the electrical installation can be seen in the following figure:

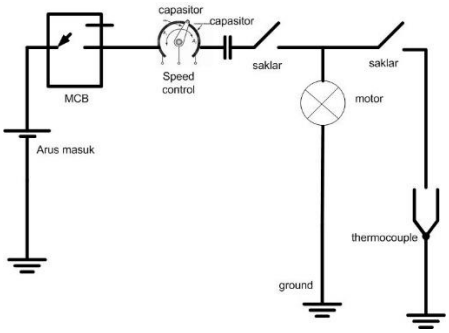


Figure 11 Wiring Diagram

3.7. Comparison of Composite Material Results

1. Composite Material Using Mixer Machine with Heating.
   In this study, testing was carried out on mixing and stirring composite materials using a mixer with a heating element and a mixer machine without a heating element. In this test, materials in the form of resin and iron sand are used to produce composite materials that you want to study the differences. In the first experiment using a heating element on a mixer machine with a speed of 42 RPM on 1 speed control indicator, with a temperature of 500 C. This test resulted in an even mixing of the specimens and had few white spots. The test results can be seen in the macro photo image below.

Figure 12 Specimen with Heating Element (Macro Photo)

In the picture above, this specimen uses a mixture of 1: 10, namely 2 kg of resin, 200 g of iron sand. Stirred using a mixer with a heater at a temperature of 50□C for a maximum of 8 minutes then poured into the mold before finally becoming jelly at 10 minutes.

2. Composite Material Using Unheated Mixer Machine.
   In this experiment, a mixer machine without a heating element was used to produce specimens with a speed of 42 RPM at 1 speed control indicator. The specimens produced from the second experiment can be said to be evenly distributed and have few white spots on the specimens, but the resin mixing time is faster. The test results can be seen in the macro photo image below.

Figure 13 Specimen Without Heating Element (Macro Photo)

In the picture above, this composite uses a mixture of 1: 10, namely 2 kg of resin, 200 g of iron sand. Stirred using an unheated mixer for a maximum of 6 minutes then poured into the mold before finally turning into jelly at 8 minutes.

3. Composite Material Using Manual Stirring.
   In this experiment the resin mixing was done manually (stirring by hand). From what I know, manual mixing is still uneven. The test results can be seen in the macro photo image below

Figure 14 Specimen Using Manual Stirring (Macro Photo)

In the picture above, this specimen uses a ratio of 1: 10, namely 200 g of resin and 20 g of iron sand. Stirred manually up to a maximum of 5 minutes then poured into the mold. The weakness of this specimen is that it does not harden well, iron sand tends to fall to the bottom and visible fragments in the specimen.

In the results of trials 1, 2, and 3, it can be seen the difference in the specimens produced from the three experiments that have been carried out. The results of

trial 1 showed that the specimens were evenly mixed and there were few visible white spots, with a maximum stirring time of up to 8 minutes (the best time). In the test results of 2 specimens by mixing using a mixer without heating, the results of the mixing are evenly distributed and a little white spot with the results of trial 1, this means that the specimen material produced is still quite good but the mixing time is only up to 6 minutes maximum (time best). The results of the trial of 3 specimens with the hand lay-up method can be said to be poor due to uneven mixing, not hardening well, and visible fragments in the specimen. Can be seen in Figure 14 above.

4. Conclusion

After testing using a mixer machine with a heating element that has been made, the following conclusions have been drawn from the experiment.

1. In this research, the first step in designing a heating element mixing machine is to design a solidworks application first so that it can easily make its components. After the design is obtained, the components are made, the selection of materials and tools are then put together according to the design, resulting in a mixer machine with a heating element accompanied by a speed controller and a temperature controller. Composite material that will be mixed with a mixer machine that has been designed will produce a material viscosity (resin) that is evenly mixed because it is stirred at a stable speed and temperature.
2. From the mixer machine that has been made, an experiment was carried out to stir and mix composite materials in the form of resin and iron sand. In this study, a comparison of the results of mixing composite materials using a mixer machine without a heating element and using a heating element was carried out. The results of mixing and mixing composite materials using a mixer machine without heating elements are composite materials that are homogeneously mixed, but when viewed from the micro photo there are still many white spots so that the quality of the composite material is still not good. then the composite material is mixed and stirred using a mixer machine with a heating element, the composite material is mixed homogeneously and after seeing from the macro photos there are some white spots on the composite. The results of the two experiments of stirring and mixing composite materials using the same speed, volume and time.

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