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# Design Build a Hot Plate Magnetic Stirer

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***Abstract*** *. A hot plate magnetic stirrer is laboratory equipment used to heat and mix one solution with another solution to create a homogeneous solution with the help of a Stir Bar stirrer. The plate contained in the equipment can be heated so as to speed up the homogenization process. The measuring cup containing the solution will be stirred using a stir bar as a stirrer. An Arduino Uno as a heater controller and a dimmer as a motor controller. Based on data from tool testing results that have been carried out, the temperature measurement results were 39-220 °C while the motor speed was 500-1200 rad/m.*

***Keywords*** *: Magnetic Stirer , Arduino Uno Microcontroller , Thermocouple*

## BACKGROUND

A magnetic stirrer is a laboratory tool that is used to mix or stir one solution with another solution so that the solution becomes homogeneous (Guidote et al., 2015; Mayer-Scholl et al., 2017; Salisu et al., 2020; Subratti et al., 2020). In operation, the stirrer speed is regulated with a control knob and the user uses a stopwatch to determine the time for stirring the solution. This process can be simplified by adding a timer and buzzer to the magnetic stirrer tool.

In the mixing process, the temperature of the solution also affects the speed of homogeneity of a solution. The higher the temperature of the solution, the faster the process of the solution becoming homogeneous (Agung et al., 2019; Harahap et al., 2017; Indri Astuti et al., 2022). In this research, a magnetic stirrer hot plate prototype was designed and built. Heating elements, timmer, buzzer, speed selection mode, and display are added to the magnetic stirrer tool so that the magnetic stirrer tool becomes more complex and can support the solution mixing process more quickly and practically.

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## THEORETICAL STUDY

Magnetic Stirrer is tool the stirrer that uses magnetic field for move the steering bar that is placed in fluid solution so that will help mix solution in a way homogeneous . The steering bar rotates in a way constant and stable . Principle magnetic stirrer work, namely with utilise A magnetic field or A electromagnetic coupled statistics with motor rotation, the magnet move a steering bar is placed in glass breaker for stir A solution. Speed round from the steering bar you can arranged with arrange speed turn the motor (Asha et al., 2017; Made Agus Mahardiananta et al., 2022). Meanwhile hotplate or heating is tool laboratory used For heat solution sample will researched . The hotplate consists on the top plate that works as a heating pad . During the heating process , the glass breaker contains solution will placed above the top plate. Aluminum chosen as material main top plate because its nature as sender good heat . Hotplate is also equipped with regulator temperature , so in its use temperature can customized with need .


**Figure 1. Magnetic Stirer**

**Figure 2. Hot plate**

Component The important thing in a magnetic stirrer is a DC motor. DC motors are changing device energy DC electricity becomes power motion . In its application , a DC motor is connected with DC source and generate speed defined play with rotary units per minute (Rpm). Voltage rating , speed rotation , large torque, requirements powerful and big nominal current is a parameter that is taken into account in DC motor selection . Whereas component The main thing on the hot plate is element heater / heater. Heater is A changing elements current

electricity become hot with dissipate current electricity passing through element become hot . There are 2 types of heaters , namely wet heaters and dry heaters .

Arrangement speed rotate the DC motor greatly simple , that is with arrange the input voltage the motor uses potentio (Rukmana et al., 2023). If applied voltage get off the motorbike below 50%, then the motor does not will turn . Getting higher the voltage at the motor input, increases The rpm is fast too . If voltage raised up to 20% of its voltage rating , the motor will become hot and finally damaged . Besides with arrangement voltage , speed You can also rotate the motor controlled with pulse width modulation (PWM) technique . For arrange speed You can rotate the DC motor on the magnetic stirrer in real time use control . DC motor setup with PWM using change wide credit Where increasingly wide credit so will the more fast speed rotate the DC motor. Control This assessed more effective compared control in a way conventional (Asha et al., 2017; Petru & Mazen, 2015) . (Junaidi et al., 2020)in his research state that with built in stirrer hotplate use control speed and temperature with PWM based technique arduino mega has tolerance ±5rpm and tolerance temperature of ±5 $^{o}$ C. Other research by(Fiqhi Ibadillah et al., 2018) use ATMega16 based PID control for arrangement temperature on the magnetic stirrer hotplate, with temperature settings between 30 $^{o}$ C to with 60 $^{o}$ C.

The magnetic stirrer rotates with speed turn ranges from 100 rpm to 3000 rpm (Irsyad et al., 2016). A timer program is added to the Arduino microprocessor for control when does the motorbike stop? (Made Agus Mahardiananta et al., 2022). Speed turn tool will scanned by a non-contact tachometer and displayed on the LCD display. Principle non-contact tachometer work is a reading sensor ray reflection from light infrared shot at the field spinning that has been given sign (marker). This marker can do it reflect light infrared shot by the tachometer. (Tunggal et al., 2020). Besides motor speed , microcontroller program magnetic stirrer hot plate tool added For arrange temperature of the element heater .(Asha et al., 2017; Jiwatami, 2022) in his research succeed build system arrangement temperature , which is temperature be read in a way realtime and guarded in accordance temperature settings with thermocouple and Arduino. Arduino is programmed for can read the voltage level on the sensor then processing the analog data into digital data for sent to LCD and Relay (Mulyatno et al., 2021). If it happens increase temperature above the set point ( temperature overshoot ), then relay become active and turning on fan as device cooler (E Harshavardhan Gout et al., 2017; Ramdani et al., 2020; Tampubolon et al., 2020).

## RESEARCH METHODS

### Planning System

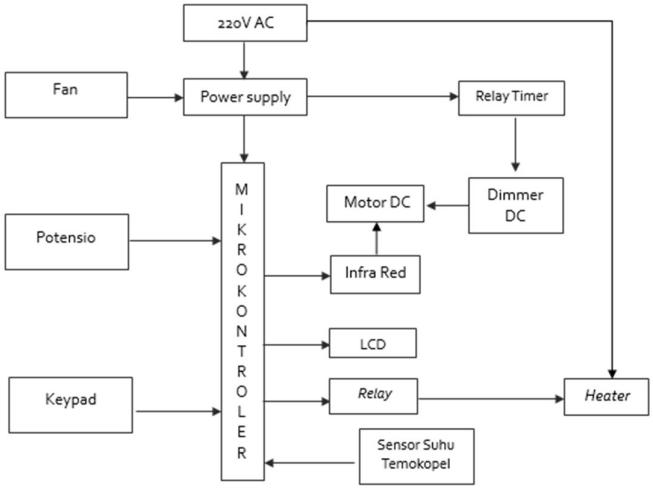


Figure 3. Block Diagram

Figure 3 is block diagram of system whole . Arduino Uno as connected microcontroller to various component such as keypad, LCD, sensors, motors, heaters, timers and buzzers. Arduino Uno is on duty as center control temperature (heater and fan), timer and buzzer, meanwhile control speed done with control voltage use potentio . Meanwhile, LCD and Keypad are used as displays and devices input . Measurement speed Using infrared as a non- contact tachometer, measurements temperature using a k-type thermocouple sensor .

### Wiring Diagram

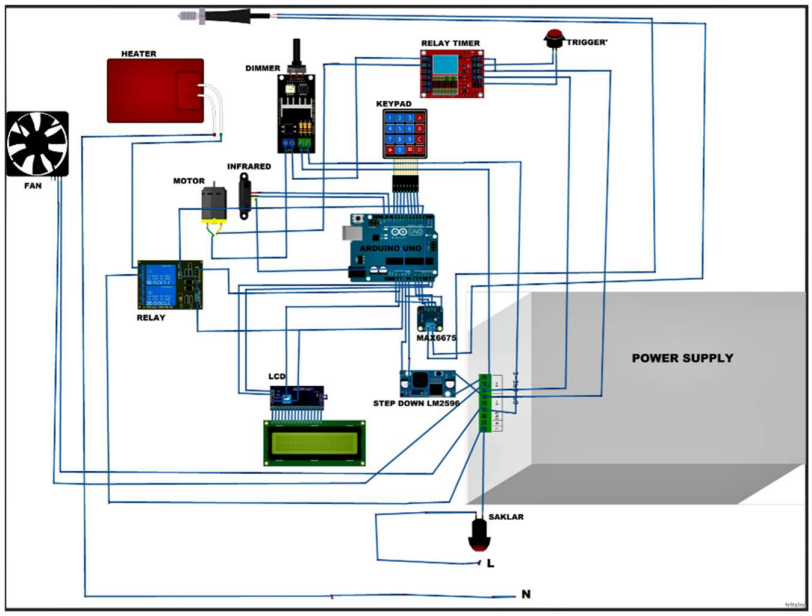


**Figure 4. wiring diagram**

In Figure 4 you can Look at the wiring diagram in detail whole , composed from the components used is on the magnetic stirrer hot plate . The Arduino Uno microcontroller gets power from the LM2596 which is connected to the power supply. The LM2596 module enters the power supply via the On/Off switch as the main power source (220V). The LM2596 module in this series functions as a voltage reducer with an output of 7V 3A which is connected as a source to the Arduino Uno.

sensor has 5 cables connected to the Arduino Uno, the SO cable is connected to A0, the CS cable is connected to A1, the SCK cable is connected to A2, the VCC cable is connected to 5 V, and the GND cable is connected to ground on the Arduino Uno. Meanwhile, the infrared sensor has 3 cables connected to the Arduino Uno, the VCC cable is connected to 3.3V, the GND cable is connected to ground and the out cable is connected to pin 2 on the Arduino Uno.

The LCD in this tool is useful for displaying setting values, temperature and motor rpm values which have been read by the infrared sensor. Timer function to find out how long the mixing duration is. The 20x4 LCD uses an I2C module as an interface that connects to the Arduino Uno microcontroller pin. The I2C module has 4 pins, namely VCC, GND, SDA, and SCL. VCC is connected to the 5V pin, GND is connected to the GND pin, SDA to pin A4 and SCL to pin A5 on the Arduino Uno. Meanwhile, the fan has 2 cables connected to the power supply, namely DC+ and DC-, the DC+ cable is connected to V+, the DC- cable is connected to V-.

The motor driver in this tool functions to move the magnet on the steering bar to stir the solution in the glass. This driver has 2 cables, namely DC+ and DC-. DC+ is connected to NO on the timer relay while DC- is connected to the input on the dimmer. The cables on the dimmer and timer relay are connected to the 12V power supply, the dimmer input is connected to COM on the timer relay.

A heater is a heating energy element that converts electrical energy into heat. In this circuit the heater is regulated by a relay via keypad, by inputting numbers on the keypad in Celsius units, the heater used is 300 watts, the heater cable is connected to the PLN and the relay. The output cable on the relay is connected to the power supply and heater as AC current, while the input on the DC current relay is connected to the Arduino Uno, INT 1 is connected to PIN 3, VCC is connected to 5V, and GND is connected to ground.

## RESULTS AND DISCUSSION

### Design Results

Made magnetic stirrer hotplate tool dimensions from tool This is 50cm x 40cm x23cm. Control speed turn and temperature made separated so that tool This can functioned just the stirrer For stir solution , or hotplate only For heat solution , or functioned in a way simultaneously that is heating and stirring solution at a time . When the power button is pressed, all circuits receive voltage, so that the sensor is ready and ready to operate. Then select the temperature, speed and timer settings by pressing the keypad button for the heater temperature, the timer button on the relay for the motor, while setting the motor speed using potentiometer rotation. Once finished, press enter, the heater indicator lights up and indicates that the AC heater is working. When the heater is working, the incoming heat will be detected via the MAX6675 temperature sensor . The results of this processing are processed via a microcontroller, then the LCD displays the plate temperature and rpm. After the temperature is reached, the motor is regulated manually by the timer relay and the speed is regulated by the dimmer .


**Figure 5. Magnetic Stirrer Hotplate Design Results**

### Function Test Results

Indicators tested in functional test activities is accuracy motor speed , stability temperature and time warmup . Following is table results testing speed turn the motor.

Table 1 Results of measuring the rotational speed of the magnetic stirrer hotplate

| Settings | Speed Spin (Rpm) | | Voltage (Volts) |
|---|---|---|---|
| | Shown on the LCD | Tachometer comparison | |
| Low (516-773) | 507 | 506.8 | 1.10 V |
| Medium (773-978) | 770 | 773.1 | 1.42 V |
| Medium (773-978) | 970 | 973.2 | 1.86 V |
| High (978-1179) | 1160 | 1164.1 | 2.83 V |

testing on the designed tool is carried out with 4 speed tests, namely when setting low, lower medium, upper medium and high. Then the speed reading results displayed on the LCD will be compared with the reading results using a comparison tachometer. From the magnetic stirr test results, the error rate in reading the motor rotational speed is ±5 Rpm.

Furthermore, in testing the temperature attainment of the set temperature, the results of the thermocouple sensor readings displayed on the LCD are compared with the results of temperature measurements using a comparison tool. Apart from that, it is also monitored how long it takes for the temperature of the tool to match the set temperature. The initial temperature before heating is set at 31 ° C -33 ° C.


**Figure 6. Measurement results Magnetic Stirrer Hotplate temperature**

Table 1 Results of magnetic stirrer hotplate temperature measurements

| No | Before Heated | Settings | Displayed on the LCD | Comparison tool | % error | Time |
|---|---|---|---|---|---|---|
| 1 | 33° C | 80°C | 79° C | 80.9°C | 1.25% | 24 s |
| 2 | 33° C | 85°C | 88° C | 85.5°C | 3.53% | 27 s |
| 3 | 33° C | 90°C | 88°C | 90.6°C | 2.22% | 30 s |
| 4 | 31° C | 95°C | 95°C | 95.2°C | 0% | 33 s |
| 5 | 33° C | 107°C | 109°C | 107.7°C | 1.87% | 1m 49s |
| 6 | 33° C | 220°C | 221°C | 220°C | 0.45% | 2m 58s |

From the hot plate test results, the temperature before heating was 31°C & 33°C. The percentage error of the largest hotplate temperature reading is 3.53%. When the setting point is reached, the heater will stop. Overshoot may occur, therefore there is a fan that works to remove heat from the heater and keep the temperature not far from the setting.

## CONCLUSIONS AND RECOMMENDATIONS

The magnetic stirrer hotplate is designed by combining electronic components and Arduino as a microcontroller. In setting the temperature, a thermocouple sensor is used as a temperature detector and a heating element as a heat conductor which is connected to a relay and regulated via a keypad. To regulate the stirring speed, it is made by combining a timer relay and a potentiometer as speed input. The speed is monitored with a non-contact tachometer and the results are displayed on the LCD. To set the time using the keypad as input, the buzzer will light up as an alarm when the time runs out. The speed, time and temperature control system on the *Hot Plate Magnetic Stirer tool* can be used as intended. The largest percentage error in hotplate temperature readings is 3.53% and the error rate in motor rotational speed readings is ±5 Rpm.

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