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ANALYSIS OF DC MOTOR ROTATION SPEED ON THE BURNER STOVE FLAME USING OIL AS FUEL: A CASE STUDY IN TOMUANHOLLBUNG VILLAGE

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Abstract: Due to the successful conversion from LPG stoves to electric stoves, which are unsupported by the village's electricity supply—averaging 450 watts—while government-provided stoves have a power rating of 900 watts, making them unsuitable for use in Tomuanhollbung Village. To address this issue, the research team designed a stove that uses waste oil (35,000 kJ/kg) and incorporated embedded system technology, utilizing the French design research method. The research results indicated that by using a DC motor with specifications of 12VDC/3A, 3800 rpm, and a valve diameter of 9.7 x 9.5 x 3.3 cm, a power output of 36W was achieved, with a pressure of 288.7 Pa or 0.00289 bar and an angular velocity of 398.1 rad/s. When the burner stove was first ignited, the flame appeared yellow. With a voltage of 3.7VDC/3A, it produced a rotation of 3795 rpm, a yellow flame, a flame height of 8 cm from the stove, and a flame width diameter of approximately 18 cm. At a voltage of 3.7VDC, the pressure measured 0.000964 bar, with a flame temperature of 275°C (as measured by an infrared sensor). A voltage of 7.4VDC resulted in a pressure of 0.0192 bar and a flame temperature of 350°C, while a voltage of 11.8VDC produced a pressure of 0.0289 bar with a maximum flame temperature of 420°C. For fuel consumption over 10 minutes at 3.7VDC/3A, the flame height reached 7-10 cm, with a wind pressure of 0.000964 bar and a fuel consumption of 0.237 grams.

Keywords : embedded system burner stove; microcontroller; snail dc motor.

Abstrak: Dilatar belakangi masalah kelangkaan elpiji didesa tomuanhollbung, serta tidak berhasilnya konversi kompor elpiji menuju kompor listrik karena daya listrik rumah masyarakat berdaya 450wat, daya kompor pemerintah 900watt, sehingga tidak bisa digunakan. Dari masalah tersebut, tujuan utama penelitian ini merancang kompor berbahan bakar oli bekas, yang mampu mengatasi masalah kelangkaan gas elpiji dan tidak terpakainya kompor dari pemerintah psat. Metode penelitian ini menggnakan metode prototype sehingga menghasilkan satu produk kompor burner dengan mengatur kecepatan motor DC. Hasil penelitian mendapati data pengujian mendapati bahwa dengan menggunakan motor DC Keong spesifikasi tegangan 12VDC/3A, 3800 rpm, dengan diameter katup 9,7 x 9.5 x 3.3cm menghasilkan daya 36W, dengan tekanan 288.7Pa atau 0.00289bar kecepatan sudut 398.1 rad/s. Ketika kompor burner pertama kali dinyalakan, warna api berwarna kunig. Jika tegangan 3.7VDC/3A akan menghasilkan putaran 3795rpm nyala api kuning, tinggi api 8cm dari tunggku kompor, dan diameter lebar keluarnya api dari tungku berkisar 18cm. Tegangan 3,7VDC maka menghasilkan tekanan 0.000964bar, nyala api 275 ^{0}C (pembacaan sensor infrared). Tegangan 7.4VDC menghasilkan tekanan 0.0192 bar, nyala api 350 ^{0}C, dan Tegangan 11.8 VDC tekanan 0.0289 bar, nyala api maksimal 420 ^{0}C. Untuk konsumsi bahan bakar selama 10 menit, dengan tegangan 3.7VDC/3A mendapati nyala api setinggi 7-10 cm, tekanan angin senilai 000964 bar dan konsumsi bahan bakar 0.237 gram. Kesimpulan penelitian ini mendapati bahwa nyala api kompor burner bisa di atur seperti nyala api kompor elpiji pada umum nya.

Kata kunci: kompor burner embedded system; microcontroller; motor dc keong.

INTRODUCTION

PLN Director Darmawan Prasodjo revealed that the government plans to shift the 3 kg LPG subsidy to electric stoves, as it would ease the financial burden on the state. This change aims to accelerate the adoption of electric stoves domestically. Secretary-General of the Ministry of Energy and Mineral Resources (ESDM), Rida Mulyana, stated that electric stove packages would be provided to households registered in the Integrated Social Welfare Data (DTKS). "This year, the plan is for 300,000 recipients. Each household will receive one package, which includes the stove itself, cooking utensils, and an increase in their electricity capacity," said Rida, as quoted on Wednesday (September 21, 2022). The conversion of LPG stoves to electric stoves in major cities like Jakarta, or in regions like North Sumatra province such as Medan and Asahan Regency can be implemented. However, in remote or underdeveloped rural areas with poor road access, like Tomuan Holbung Village, it is seen as unlikely [1].

Tomuan Holbung Village is located in the Bandarpasir Mandoge sub-district, Asahan Regency. This village has existed since 1923 and was officially recognized by the Asahan government in 2013. It consists of 10 hamlets. In 2014, Tomuan Holbung was classified as an underdeveloped village, and by 2018, it was the only village in the area still categorized as underdeveloped. Currently, the village is home to 450 households, with a population of around 2,300 people. Electricity began flowing to the village in 2017, with an average power supply of 450 watts per household. [2]. Considering the electricity usage in Tomuan Holbung Village, where the average household power supply is 450 watts, and comparing it with the electric stove package the government plans to distribute, the electricity capacity in the village would not be sufficient to power the electric stoves. Therefore, the villagers would need to increase their electricity capacity to at least 1,300 watts, requiring a doubling of their current power supply. This upgrade would come at a connection cost of approximately Rp. 796,450 per household [3].

Based on this, the research team designed a stove powered by used oil or used cooking oil (a burner stove) using microcontroller technology and a 14.8V DC motor. The DC motor controls the blower speed, allowing the flame of the stove to be adjusted. The working system of the stove design involves placing the used oil inside the stove, which is then ignited with a match. Initially, the flame burns yellow, and the combustion is uneven. By utilizing microcontroller technology and adjusting the potentiometer (which controls the speed of the 14.8V DC motor), the DC motor blows air into the central shaft of the stove. This airflow causes the flame to burn evenly, turning blue and significantly hotter. The flame temperature is displayed on the LCD, and the stove is ready for use. [4] [5].

Several studies on burner stoves have also been conducted by Imam and colleagues. In their research, they found that the temperature control of the gas-fueled burner system was managed by a microcontroller using the fuzzy logic method to control the gas valve. A servo motor was used to automatically open and close the gas valve. For monitoring and controlling the burner system, they utilized Internet of Things (IoT) technology, employing a NodeMCU ESP8266 microcontroller to process data and wirelessly send it to an Android smartphone via the BLYNK application,

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which makes it easier for users to access information [6][7].

With the introduction of burner stoves, as a way to anticipate the shortage of LPG gas in Tomuan Holbung Village, and due to the failure of the government program in the area, the use of burner stoves is an alternative solution to reduce the residents' dependence on LPG, which is hard to obtain because transport trucks cannot reach the village. Additionally, residents would not need to bear the extra cost of increasing their electricity capacity from 450 watts to 1,300 watts by paying Rp. 796,450 to operate the government's 900-watt electric stove. Instead, residents can build their own burner stoves at a production cost of less than Rp. 500,000.

METHOD

In the design of the tool or the development of the product in this research, the research method used is the prototype method. s an approach to system or product development that prioritizes creating an initial version (prototype) of the product. The main goal is to test and review ideas, designs, and functionality before full development takes place. Thus, the research begins with the collection of information, including the technical specifications of the DC motor, the characteristics of oil as fuel, and the parameters of the flame (intensity, stability, temperature).

The next stage is determining the criteria or design of the tool, such as the optimal motor rotation speed, fuel consumption, and flame efficiency. Additionally, design constraints are set, such as motor power capacity and the availability of local fuel. This leads to the creation of a burner stove prototype based on the best-selected concept. The prototype is equipped with controls for the DC motor's rotation speed, flame adjustment, and a temperature display from the DS18B20 sensor.

The Image 1.1 shows the design of the burner stove created by the research team.

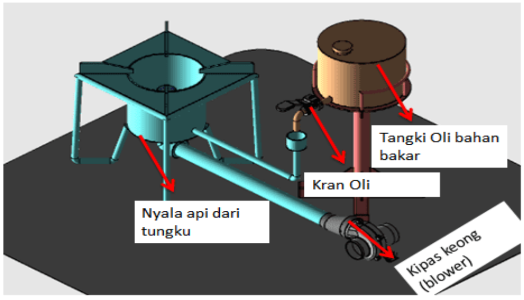

Image 1. Image of the burner stove powered by used oil [8].

The Image 1 above explains that the burner stoves available in the market do not utilize artificial intelligence concepts. Therefore, the research team aims to implement artificial intelligence, such as motor speed control, allowing the flame of the stove to be adjusted. Additionally, the temperature of the flame will be displayed either on the serial monitor or the LCD.

RESULT AND DISCUSSION

Some of the results discussed in this research include:

Block Diagram Design

The results of the comparison between LPG stoves and burner stoves, it was found that the highest emissions produced by oil-fueled stoves were 2.5 – 3.0 Kg2

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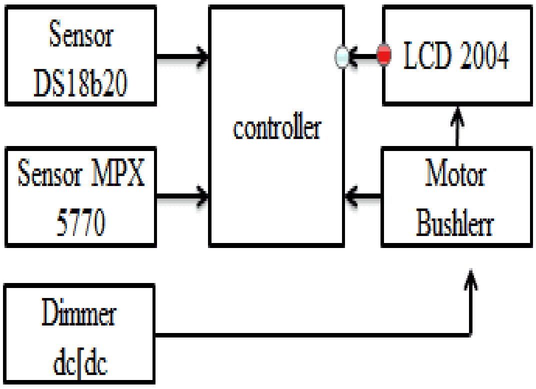

Image 2. Block diagram of the burner stove design

Changes in Voltage to Motor Rotation and Torque.

The keong motor or blower motor will generate air pressure, which will affect the flame of the stove. The results of the air pressure testing produced by the blower motor at 3,800 RPM are as follows.

Table 1. Changes in voltage to temperature form

Input voltage	Motor Power	Torsi	RPM
2.5V	3,75	0.009 nm	3978
3,7	5,55	0,014 nm	3787
7,4	11,1	0,027 nm	3926
11.1	16,65	0,041 nm	3877

The table explained that the highest torque is influenced by the highest voltage, while the highest RPM (rotation speed) occurs at a voltage of 7.4 VDC, reaching 3,926 RPM. At a voltage of 11.1 VDC, a decrease in speed is observed at 3,877 RPM, likely due to overheating, which can cause a reduction in motor rotation.

Changes in Flame Height with Air Pressure from the Blower Motor.

When air pressure increases, the density of oxygen in the air also increases. This provides more oxygen for the combustion reaction.

Under high-pressure conditions, the flame will become larger, brighter, and hotter. The flame may appear more yellow or orange, indicating more efficient combustion. However, if the air pressure is too high, the increased combustion rate can lead to dangerous conditions such as explosions or uncontrolled burning.

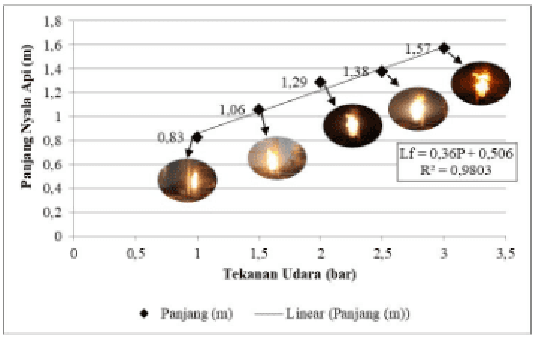

Image 3. The Effect of Flame on Air Pressure

The image explains that there is a linear equation represented as Lf = 0.36 (P) + 0.506. This equation shows a direct relationship, where the Lf equation (Flame Length) is influenced by the air pressure coefficient (P). The coefficient is 0.36, which means that for every unit increase in air pressure, the flame length increases by 0.36, plus a constant. The constant is 0.506, which represents an external factor, one of which is atmospheric pressure. Based on this equation, the R^2 value is 0.9803

R^2 represents the extent of the influence of air pressure (P) on flame length (Lf), which is 98.03%. The remaining 1.97% is attributed to external factors, one of which is atmospheric pressure, as demonstrated by the equation above. This equation is only valid at pressures between 1-3 Bar. The test results indicate that as the variation in air pressure increases, the resulting flame

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height also increases, and vice versa [9][10].

Comparison of The Use of Burner Stoves with LPG Stoves

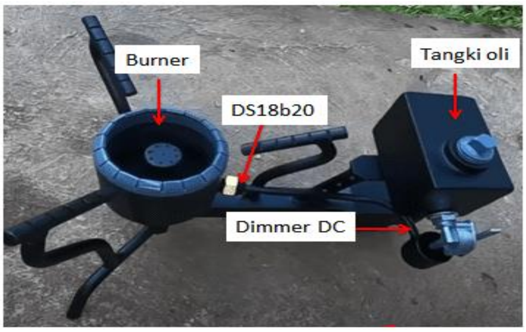

Image 4. View of a burner stove fueled by used oil

Based on its economic value, the original price of used oil is Rp. 2,500 per liter, while LPG is priced at Rp. 10,250. Therefore, the economic value of 8 liters of used oil is 8 liters x Rp. 2,500 = Rp. 20,000. In contrast, for LPG, the weight is 2.1 kg, so 2.1 kg x Rp. 11,583 = Rp. 24,324. In terms of economic value for aluminum smelting, used oil is cheaper than LPG. Based on the description above, if presented in a tabular form .

Table 2. Comparison of Fuels Between Used Oil and LPG

No	Used oil	Elpiji
1	The unit price per 3 kilograms or per 3 liters is cheaper	The fuel price is more expensive
2	It takes longer for the melting time	Fast melting time
3	The temperature is lower	Higher temperature
4	Combustion is incomplete	Complete combustion
5	Slow initial start.	Fast initial start.

Source: Fictitious data, for illustration purposes only

CONCLUSION

Analysis shows that variations in the rotation speed of the 14.8V DC motor significantly influence the intensity and quality of the flame in the oil-based burner stove. Higher rotation speeds tend to produce a more stable and efficient flame, thereby enhancing combustion effectiveness and energy efficiency. This research also. The process emphasizes that adjusting the rotation speed of the DC motor needs to be considered to achieve optimal combustion. In Tomuanhollbung Village, the correct motor rotation speed can help address issues of fuel efficiency and energy utilization, especially given the limitations of local resources.

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