Performance Comparison Of Semi-Automatic Machine For Mendong Woven Industrial

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***Abstract*—In this study, a comparative analysis of the performance of a weaving machine for energy-efficient semi-automatic mendong between the laboratory and the performance in an industrial environment has been investigated. Tests are carried out in laboratories and in production houses on a home scale industry. The analysis includes the Energy Performance Index (EPI) of the performance of the semi-automatic weaving machine. The measured variable is the electricity consumption (Wh) per 1 meter of the mat that is woven by the semi-automatic weaving machine. The test was carried out in 10 repetitions. The test results in the industrial house are compared with the test results in the laboratory. The target of the test is said to be good if the ratio is below 10%. The results of the test show that energy consumption in industrial homes is 7% higher than in the laboratory. These results can be considered reasonable and acceptable. The conclusion of this examination is that the Mendong weaving machine is suitable for use in the Mendong weaving industry.**

Keywords—woven, mendong, energy, EPI

I. INTRODUCTION

The high competition in home-scale businesses and also the high demands for the speed of the production process, accuracy, and energy efficiency are issues that are always raised as the main topics for both researchers and entrepreneurs of large and small scale home industries [1], [2]. The same condition also occurs in small industries that produce mats made of mendong, located in the Tasikmalaya area. Even though mendong material [3] is easy to obtain in Tasikmalaya, there are still many entrepreneurs in the area who have gone bankrupt due to a low desire to use advanced technology, increasing operational costs which results in a high reduction in labour. But for entrepreneurs who have made quick adaptations to small industrial technology, their businesses can survive, even though initially they have to be pursued with large capital. However, this large expenditure was replaced by increased production efficiency and sustained business

The results of several studies indicate that an increase in product quality is directly proportional to electricity consumption and production processing time [4]. some researchers believe that the higher the quality of the product the higher the energy consumption [5]. Based on the definition of the efficiency of a process, that the efficiency of the manufacturing process is measured from the level of good quality to low energy and processing time [6], but achieving these goals is not easy. Generally, a machine with a high level of efficiency requires an intelligent system, the right algorithm, a high-precision machine to produce a short process duration with a high-quality manufacturing process, and therefore, many researchers are trying to solve the problem.

Weaving machine for mendong is a semi-automatic based machine working system and is programmed using a PLC-based microcontroller. This semi-automatic mendong weaving machine is engineering which working principle is based on a conventional mendong weaving machine. By adding several sensors, including proximity sensors [7], [8], electric motors, and some digital engineering on PLCs, the weaving machine has better performance than manual machines, high accuracy, and energy efficiency. Overall testing in the laboratory, that the Mendong weaving machine consumes energy every 1 meter of Mendong weaving requires electrical energy of 37.27Wh in 42.5 minutes [4]. While the conventional way, 1 meter takes 1 hour 10 minutes [9].

In this study, an Energy Performance Index (EPI) analysis was carried out as in [10], [11], which is an indicator of energy consumption by machines in producing products. The smaller the EPI value, the higher the engine work efficiency. Performance testing of machines from two different locations with different operators. One test is carried out in a laboratory and the other is carried out in an industrial house or a mendong weaving factory. The test sample is dry mendong woven along 1 meter, then the energy consumption is measured. The test was repeated 10 times. Each test analysed the energy consumption index of Mendong weaving production.

The semi-automatic mendong weaving machine has a block diagram consisting of four main blocks, namely the unit sensor block, the mechanical system block, the control system block, and the PLC which is the control and coordination center. The unit sensor block consists of six proximity sensors which have the role of providing input to the PLC. PLC is used to run logic algorithms. The PLC then gives commands to the three DC motors on the drive system block. Each drive system block operates an explanator, pressing unit, and roll-up unit integrated into the mechanical system block as shown in Fig.1. With the block diagram design as shown in Fig.1, where it only uses three DC motors with a small capacity and six sensor units, and does not

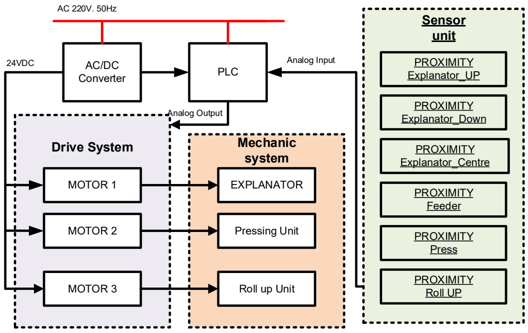

Fig. 1. Block diagram of a semi-automatic weaving machine.

involve any mechanical parts, the semi-automatic mendong weaving can work efficiently, quickly without reducing the accuracy required.

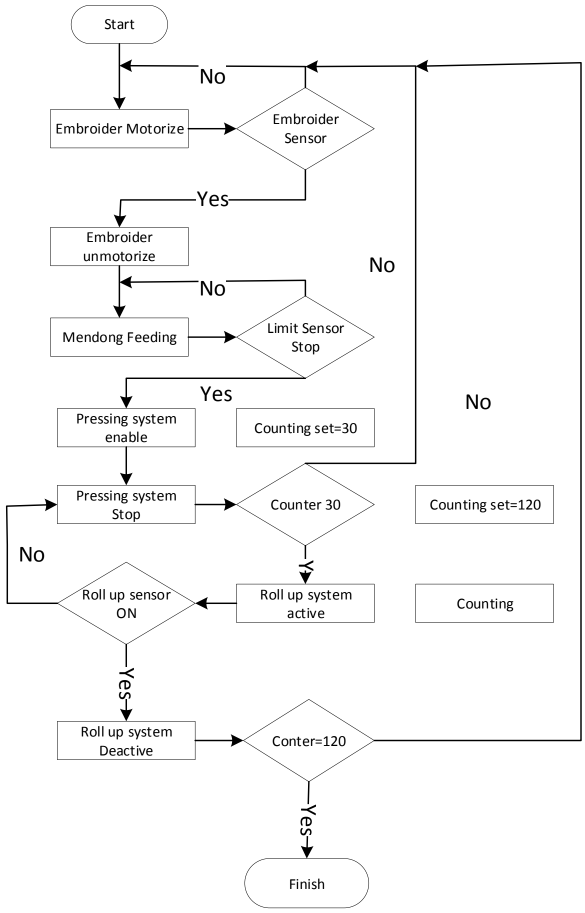

Fig.2. Mendong weaving working procedure

Fig.2 is the process stage of the semi-automatic mendong weaving machine. The machine work process consists of seven processes with four levels of process validation. Implementation of PLC programmed to control DC motors and process input signals from six proximity sensors, causes a shorter working process, so that one process cycle only requires relatively small electrical energy, is more accurate, and has a good response.

II. Material and Method

A. *Work concept of moven machine*

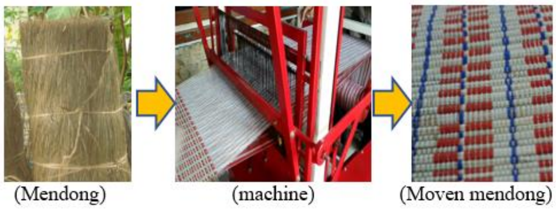

Fig. 3. The concept of the process of making mendong weaving.

Fig.3 is the working concept of the weaving machine doing the dry mendong weaving process. The process of mendong weaving is to create a cross-stitch arrangement between the mendong strands and the thread so that it becomes a mutually reinforcing unit. The final result is a woven mat made of mendong material with a good density value.

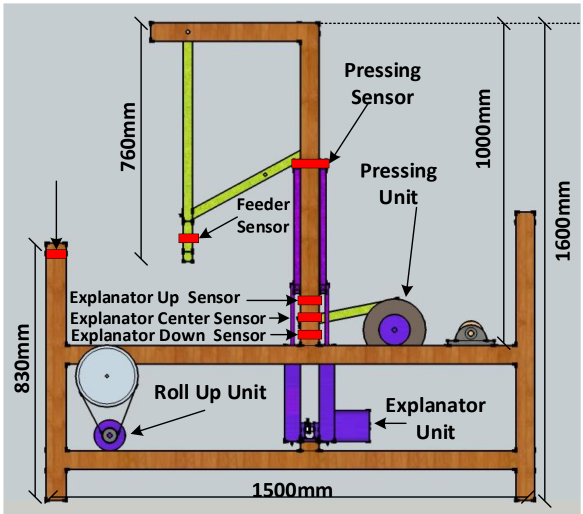

Fig.3. Mendong weaving machine design with sensor and main unit.

In this test, the machine operator in the laboratory test is not the same as the operator in the industrial house. In laboratory testing, an operator is a person who has no experience in sewing mendong but can use a semi-automatic mendong weaving machine, while the operator used in testing in an industrial house is a machine operator who is very experienced in using manual mendong weaving machines.

Fig.4, showing the main parts of the semi-automatic mendong weaving machine. The dimensions and working principles of the machine are made to resemble those of a manual machine, this is so that users quickly adapt to operating this machine. There are two DC motors, each of which functions as a pressure unit and the other as a roll-up unit.

B. *Stages of Testing*

The test is carried out in two different places, the first is carried out in the laboratory, then the next test is carried out at the production house. Fig. 5 is a test procedure carried out for ten repetitions with the same sample. The analysis process begins with sample preparation in the form of dry mendong weaving, then weaving it by machine. During the mendong weaving process, the machine's electricity consumption is measured using a Kyoritsu power quality analyser.

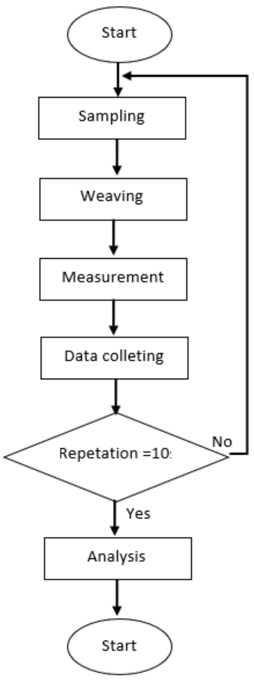

Fig. 5. Machine testing procedure.

Measurements are made while the machine carries out the mendong weaving process for every one meter of webbing. The turnaround time for one meter and the electricity consumption for each meter of mendong webbing were collected for analysis.

C. *Energy Performance Index (EPI) Analysis*

Energy Performance Index (EPI) analysis of electrical energy on the production process by machines uses an approach that is also carried out in [10], [11], using equation (1), where E is the electrical energy consumed by the machine in units of time (Wh) divided by X is the length of the resulting mat (meters). The energy consumption value is obtained using equation (2).

$$EPI = \frac{\sum E}{\sum X} \left(\frac{Wh}{m}\right) \quad (1)$$

$$E = V \; x \; I \; x \; t \; (Wh) \quad (2)$$

The repetition of the test is carried out 10 times. Measurement of current and voltage is carried out every one meter of woven mendong.

III. Results & Discussion

Table I shows the comparison of the average electricity consumption of the data from the test results in the laboratory to the tests in industrial houses. From 10 repetitions of the same sample, the electricity consumption during testing in the laboratory the average per meter of mendong weaving was 18.30 Wh, while in the industrial house test it was 19.69 Wh (Fig.6). From these results, it is concluded that the difference in electricity consumption is 7%. This difference can be said to be quite good because the target achievement is below 10%.

TABLE I. Test of Electricity Consumption

No. test	Laboratory Test (Wh)	Home Industrial Test (Wh)
1.	19.46	23.35
2.	15.47	22.58
3.	16.32	15.34
4.	18.48	16.63
5.	21.55	23.92
6.	19.72	18.54
7.	19.09	20.62
8.	20.44	24.74
9.	15.90	15.11
10.	16.58	16.09
Average	18.30	19.69

Fig. 6, is Energy Performance Index (EPI) of each experiment carried out (Wh/m). The average of the test shows the machine electricity consumption when used in industrial homes is 7% greater than when tested in the laboratory. From the experimental data collected, it can be concluded that mathematically, there is a trend of decreasing electricity consumption linearly, so it can be expressed in mathematical form as a linear equation as in equation (3), where y is the duration of electrical energy (Wh), x is the value trial. However, the test is not repeated until a constant trend line is obtained regarding electricity consumption (Wh).

$$y = -0.3887x + 21.829 \quad (3)$$

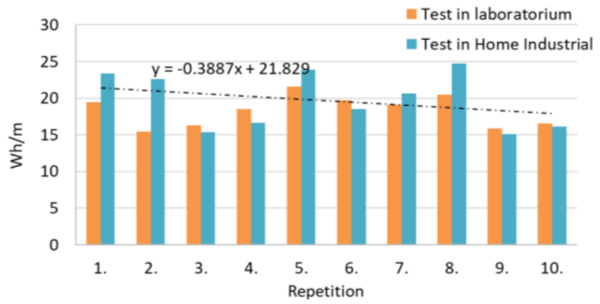

Fig. 6. Electricity consumption for each meter of mendong woven production.

Fig. 7, shows that there is a significant difference from each iteration. There are three significant differences, namely in the experiments on samples 1, 2, and 8. While the other seven experiments had values that were identical to the results of tests carried out in the laboratory. It can be understood that in the test with the first and second samples, the operator is still in the adaptation stage to the machine working system, while in the eighth sample, the operator starts to make improvements or changes in operator behavior so that electricity consumption increases.

From the results of the electricity consumption test, it can be concluded that the semi-automatic mendong weaving machine is very sensitive to changes in the working mode of the operator. Experienced operators, work behavior, or work modes do not change much, while operators who are not experienced in using mendong weaving machines may cause changes during operation and these changes cause an increase in electricity consumption and the duration of the production process.

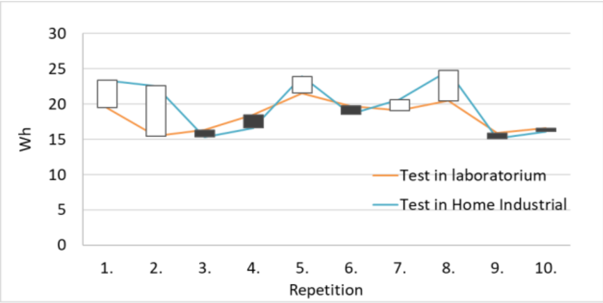

Fig. 7. Energy performance index (EPI) machine graph.

Table II shows the duration of the process in a tabulated form. Manufacturing test for each meter of mendong weaving. From the repetition of the tests carried out, there was a significant difference between testing in the laboratory and testing in the production house. These changes occurred in the first, second, and eighth phase of testing. The average duration of the weaving process per meter in laboratory testing was 42.52 minutes, while in the industrial house test it was 45.87 minutes. This means that there is a difference of 7%, and this ratio is acceptable from the target, which is a max of 10%, provided that operators are already accustomed to using manual weaving machines.

TABLE II. TEST OF DURASI PROCESS PER METER MENDONG MOVEN

No. test	Test of Process duration per meter (minute)	
	Laboratory	Home Industrial
1.	48.9	58.68
2.	37.1	54.166
3.	40.7	38.258
4.	41.5	37.35
5.	51.9	57.609
6.	43.5	40.89
7.	42.2	45.576
8.	46.2	55.902
9.	34.9	33.155
10.	38.3	37.151
Average	42.52	45.87

Fig. 8 is a graph of the comparison test results which shows the difference in each test from the duration of the process in tabulated form. The manufacturing test for each meter of mendong weaving has changed, although on average it is not significant, it can be concluded that the semi-automatic mendong weaving machine where the drive uses a DC electric motor has a high response. This can be seen from the response of the machine to each piece of mendong that is woven which has an impact on electricity consumption and the accumulative duration of the production process.

From the aspect of process duration, there is a change in the speed of the process from 10 repetitions of the experiment, especially in the ninth and tenth stage of the experiment, the change is that there is a linear decrease in the duration of the process. If observed from the overall test results of the duration of the weaving process with a mendong machine, it can be concluded that there is a linear decrease in duration, or if expressed in mathematical form as a linear equation (3), where y is the duration of the process (minutes), x is the experimental value. However, the test is not repeated until a constant duration of the production process is obtained.

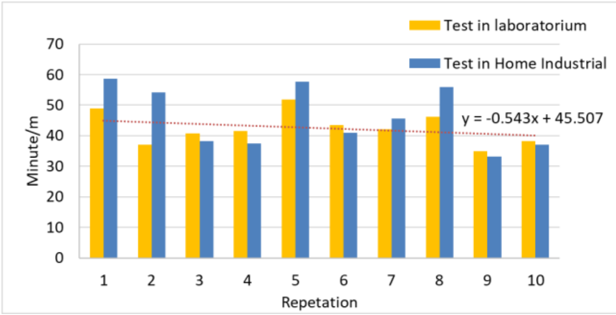

Fig.8. The processing time duration for each meter of Mendong weaving production.

$$y = -0.543x + 45.507 \quad (4)$$

CONCLUSIONS

Comparative testing of semi-automatic mendong engine performance has been investigated. From the tests carried out in laboratories and industrial homes, it appears that there is a trend of reducing energy consumption and a trend of reducing the duration of the machine working process in making each meter of woven stretch.

From 10 repetitions of the same sample, the average electricity consumption in laboratory testing per meter of mendong matting was 18.30 Wh, while in the industrial house test it was 19.69 Wh (Fig.6). From these results, it is concluded that the difference in electricity consumption is 7%. This difference can be said to be quite good because the target achievement is below 10%. The average duration of the weaving process per meter in laboratory testing was 42.52 minutes, while in the industrial house test it was 45.87 minutes.

The test for making mendong webbing has changed, although on average it is not significant, it can be concluded that the semi-automatic mendong weaving machine, which uses a DC electric motor, has a high sensitivity. This can be seen from the response of the machine to each piece of mendong that is woven which has an impact on accumulative electricity consumption.

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