# Semi-Automatic Machine with Programmable Logic Controller in the Mendong Woven industrial

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***Abstract*—The focus of this paper is to propose a design of semi-automatic saving mendong (Fimbristylis umbellaris) weaving machines using a programmable logic controller (PLC). The background of this paper is that mendong weaving machines are tools used in producing mendong mats, but until now, the machines used are still manual. The proposed method is to design a machine using a PLC as the central controller by using six ultrasonic sensors and a DC motor to drive the lever to mendong weaving. This paper concludes that the total electrical power consumed by three systems is 42.38 watts without load, and 104.59 watts with a load. The most significant sequential electricity consumption is the pressing system, then the roll-up system and the lowest in the embroider system. Based on the results of testing separately, the components used are Mechanical devices, PLC, power supply, ultrasonics sensors, DC motor drive that works well. The overall test is a weaving time of 42.5 minutes with a length of webbing of 1 meter, spending 37.27 WH.**

***Keywords—weaving, mendong, energy, PLC***

## I. Introduction

Currently creating mats is done by weaving techniques. The process of preparing this mat is relatively long. The production produced by a craftsman in one day is an average of 1 mat, which is 12 meters. Weaving using a *mendong* weaving machine takes ± 1 hour 10 minutes for 1 meter of the mat and manually requires ± 3 hours for 1 meter of webbing "[1]. While the results of woven from manual techniques have disadvantages, including the density of webbing from *mendong* mats that are not the same (not homogeneous), causing rejection by potential consumers and less durable products.

*Mendong* (Fimbristylis umbellaris) or is one type of grass that lives in the swamp [2], including tribal members Cyperaceae [3]. This plant produces woven material cultivated in some areas in Indonesia [4], especially in Ambarawa, Central Java, and There are a lot of these types of plants grow around swamps and commonly used by local people to be cultivated into a variety of crafts [4].

Automation technology using programmable controllers such as PLC has been widely used in large industries. PLC also allows providing ease of changing orders, system work procedures, good accuracy, excellent reliability, and fast responses that are readily accepted by the industry [5], [6] Nevertheless. When PLC is only used in advanced industries, even though PLC has the potential to be used in small industries, the use of PLCs in small industries will result in high productivity increases with good accuracy and reduced production costs. Especially in small industries that produce *mendong* weaving, it is necessary to implement advanced technologies such as PLC to increase the capacity and quality of *mendong* production. In this paper, we propose the design of *mendong* weaving machines using PLC as the central controller.

The control of the proposed *mendong* weaving machine requires several sensors and an electric motor as a driver. The sensors used are infrared sensors, proximity sensors, limit switches. The electric motor used is a DC motor. The application of automated systems to the *mendong* weaving machine produced will be of higher quality with a density that is homogeneous, energy-efficient, and is easy to use.

### *A. Programmable Logic Controller (PLC)*

according to the National Electrical Manufacturers Association (NEMA), Programmable Logic Controller (PLC) is a digital electronic device that uses memory that can be programmed to store instructions from certain functions such as logic, sequential, timing, enumeration, and arithmetic to control the engine from the process [7], [8]–[10].

### *B. Architecture of PLC*

Fig.1 shows the internal architecture of a PLC. This architecture consists of a central processing unit (CPU) that contains a microprocessor system, memory, and input/output circuit [11]. The CPU is in charge of controlling and running all operations in the PLC [12]. This device is connected to a timer device with a frequency between 1 s.d 8 MHz [7]. This frequency determines the PLC operating speed. Information in the PLC is transmitted through digital signals. The internal paths through which digital signals pass are called buses. Physically a bus is several conductors that electrical signals can pass. The CPU uses a data bus to send data to PLC elements, the address bus to send addresses to data storage locations, while the control bus for signals related to the internal control process. The system bus is used for communication between input/output ports and input/output units

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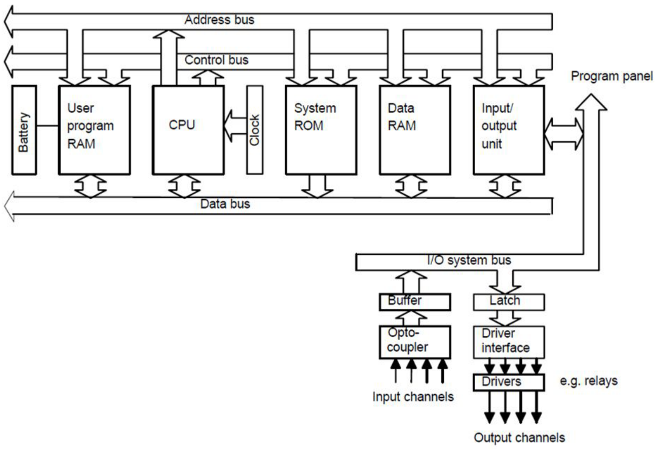


Fig. 1 Internal PLC architecture [13].

### C. Sensor Proximity

Fig.2 is the working principle of this type of proximity sensor uses an inductive and capacitive method based on an electromagnetic field (field) around the sensor surface caused by a high-frequency oscillator. The type of metal material that has inductive influence and other capacitive material will affect the amplitude of the oscillation around the sensor. So these objects are detected by the sensor.

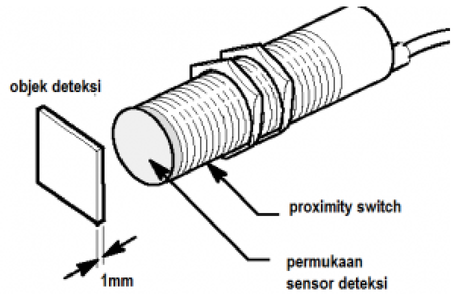


Fig. 2. Proximity sensor [14], [15].

## II. Material Method

### A. Machine Design

Fig.3 is the design of the weaving machine consists of the main parts installed on the steel frame, namely explanator units, pressing units, roll-up units. Explanator the unit functions to raise and lower the wicker arm so that the plait occurs on the mendong. Pressing the unit serves to press the *mendong* strands on the webbing. Pressing unit is responsible for density in *mendong* weaving. The roll-up unit serves to roll woven sheets of the mat. The dimensions of the engine frame are 1600 mm high, 1500 mm long and 930 mm of width. The frame is made of steel.

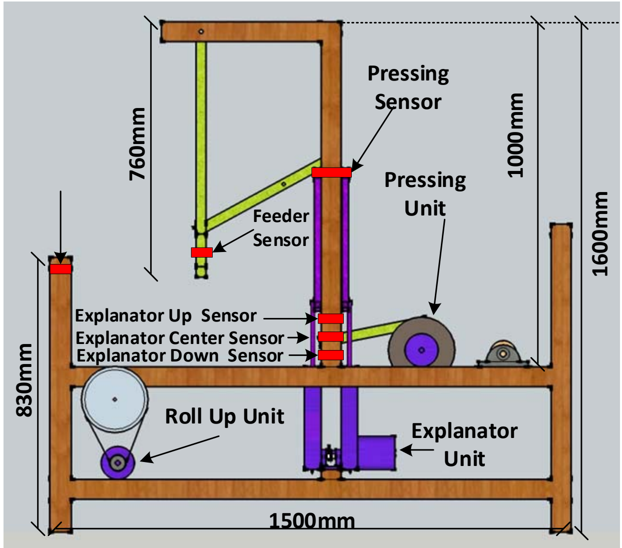


Fig. 3. Mendong weaving machine design using sensor and primary unit.

### B. Architecture design

Fig.4 is the architectural design of the proposed *mendong* loom. Weaving machine architecture consists of drive systems, mechanic systems, sensor units. A sensor drive is a drive unit in the form of a moor DC which functions as a driver of a mechanic system, namely a press system, a woven system, and a rolling system. The sensor unit is a sensor that detects the mechanical system movement of the machine which then becomes an input to the PLC which finally gives the system drive command to work.

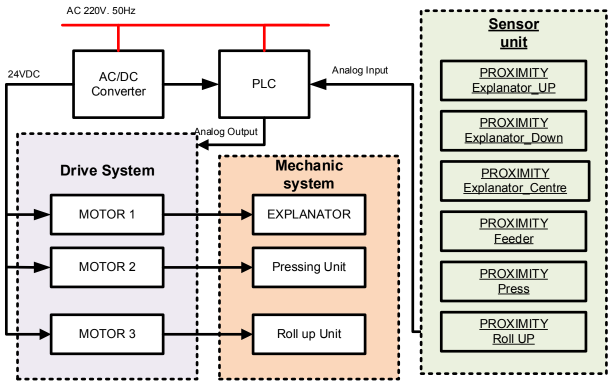


Fig. 4. System architecture

### C. Flowchart Design

Fig. 5 is a machine working system flowchart. Flowchart System starts from the ignition motor works and stops if the ignition sensor detects an object. Then the feeder system works by giving the *mendong* strands time to put on the thread. After the *mendong* strand is in place, the pressing system works, then the roll-up system rolls, so the *mendong* is weaved.

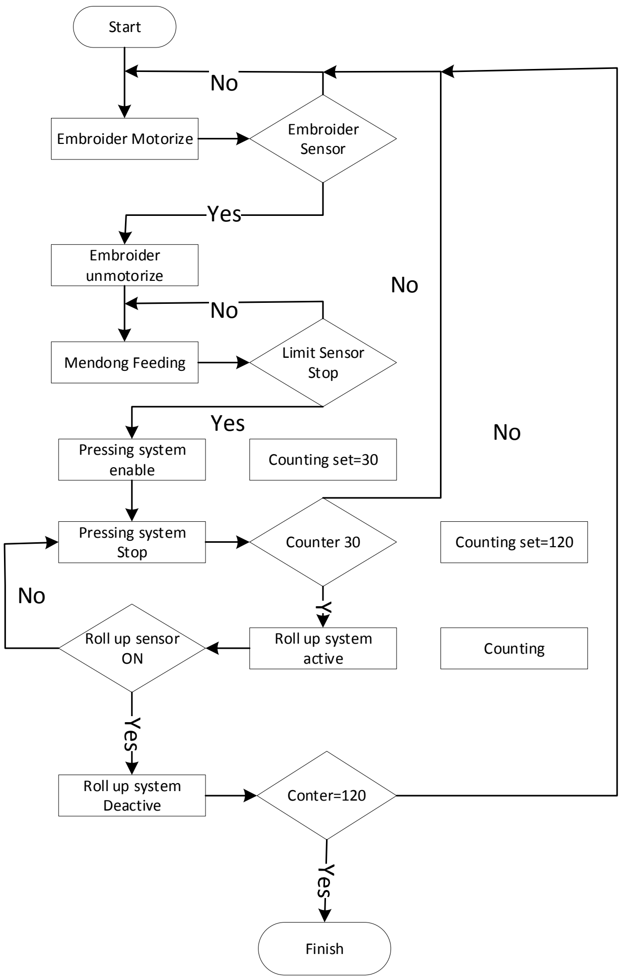


Fig. 5. System flowchart

### D. *Analysis of Procedure*

Engine performance analysis includes two main variables. The first variable is the consistency and accuracy of the machine in making *mendong* webbing, while the second is the energy consumption of the machine in making *mendong* webbing. Electric energy consumption is calculated from the electrical energy consumption of each drive unit, namely energy consumption from the ignition system, electrical energy consumption from the pressing system and electrical energy consumption from the roll-up system. Each system is tested under no conditions and with burdens. No-load testing means that the system works without *mendong* strands, while testing systems with loads is calculated when the system works with the given *mendong* strands. The examination is repeated ten times, and then the average electrical energy consumption is sought using the following equation:

$$\bar{x} = \frac{\sum f(x)}{n} \quad (1)$$

Electrical power parameters are calculated using the following equation;

$$P = E\ x\ I\ x\ \cos\theta\ (Watt) \quad (2)$$

$$Q = E\ x\ I\ x\ \sin\theta\ (VAR) \quad (3)$$

$$S = E\ x\ I\ (VA) \quad (4)$$

The calculation of electric power consumption is calculated using the following equation:

$$E = E\ x\ I\ x\ t\ (WH) \quad (5)$$

Woven density testing is observed from the results of plaiting then compared to the results of plaiting results from conventional machines. Comparison is then used as a density assessment.

## III. Results & Discussion

### A. *Electrical Energy Consumption within the System Embroider.*

Table I shows the test results on the embroider system for ten repetitions of the test. The test results show that the average power. It is known that the average electric power without load is 9.05 watt, while the average electric power of the embroider system with the load in the form of *mendong* is 9.84 watt.

TABLE I. Power Test Embroider System

| Repetition test | Power with load (W) | Power with No-load (W) |
|---|---|---|
| 1 | 10.17 | 9.08 |
| 2 | 10.19 | 9.07 |
| 3 | 9.06 | 9.07 |
| 4 | 9.04 | 9.00 |
| 5 | 9.05 | 9.07 |
| 6 | 12.44 | 9.06 |
| 7 | 11.29 | 9.06 |
| 8 | 9.04 | 8.99 |
| 9 | 9.04 | 9.08 |
| 10 | 9.01 | 9.00 |
| **Average** | **9.84** | **9.05** |

Fig. 6 is a graph of the electrical power consumed by the embroider system. The difference in electrical power consumed by the embroider system with a load and without load is only 0.79 watts.

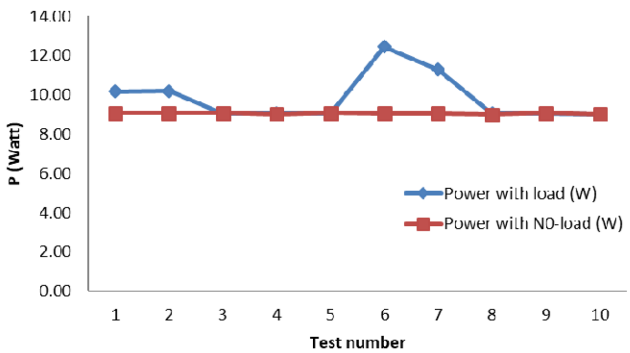


Fig. 6. Electric power in the embroidery system

Table II shows the test results on the pressing system for ten repetitions of testing. The test results show the average power. It is known that the average electric power without load is 17.82 watt, while the average electric power of the embroider system with the load in the form of mendong strands is 73.39 watts.

TABLE II. Power Test Pressing System

| Repetition test | Power with load (W) | Power with No-load (W) |
|---|---|---|
| 1 | 75.87 | 19.0344 |
| 2 | 74.58 | 17.6592 |
| 3 | 71.90 | 17.6748 |
| 4 | 67.83 | 17.6514 |

| | | |
|---|---|---|
| 5 | 67.86 | 17.6514 |
| 6 | 80.04 | 17.6904 |
| 7 | 73.32 | 17.7294 |
| 8 | 71.90 | 17.706 |
| 9 | 75.97 | 17.706 |
| 10 | 74.68 | 17.6904 |
| **Average** | **73.39** | **17.82** |

Fig. 7 is a graph of the electrical power consumed by the pressing system. The difference in electrical power is consumed by the pressing system where during working with load and without not load is only 55.58 watts. From these results, it can be concluded that on the pressing system, the burden of *mendong* webbing requires considerable electrical energy compared to the embroider system.

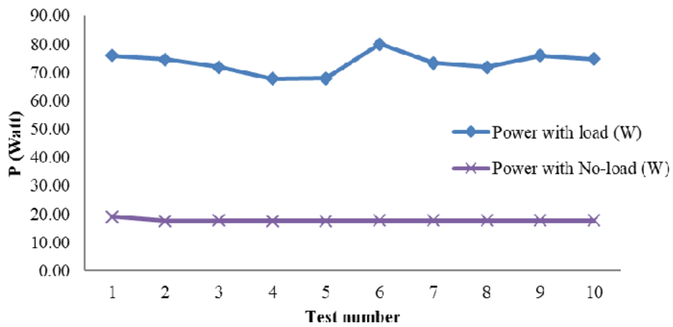


Fig.7. Electric power within the pressing system

Table III shows the test results data on the roll-up system with as many as ten repetitions of the test. The test results show that the average power of the roll-up system without load is 15.52 watts, while the average electric power of the roll-up system with a load of *mendong* strands is 21.36 watts.

TABLE III. POWER TEST ROLL-UP SYSTEM

| Repetition test | Power with load (W) | Power with No-load (W) |
|---|---|---|
| 1 | 22.61 | 16.3584 |
| 2 | 21.47 | 16.3368 |
| 3 | 20.32 | 16.344 |
| 4 | 24.81 | 16.308 |
| 5 | 19.20 | 14.949 |
| 6 | 21.50 | 14.9556 |
| 7 | 27.16 | 14.9688 |
| 8 | 19.21 | 14.9556 |
| 9 | 19.22 | 14.9886 |
| 10 | 18.09 | 14.9952 |
| **Average** | **21.36** | **15.52** |

Fig. 8 is a graph of the electrical power consumed by a roll-up system. The difference in electrical power consumed by the pressing system when working with a load and without load is only 5.84 watts.

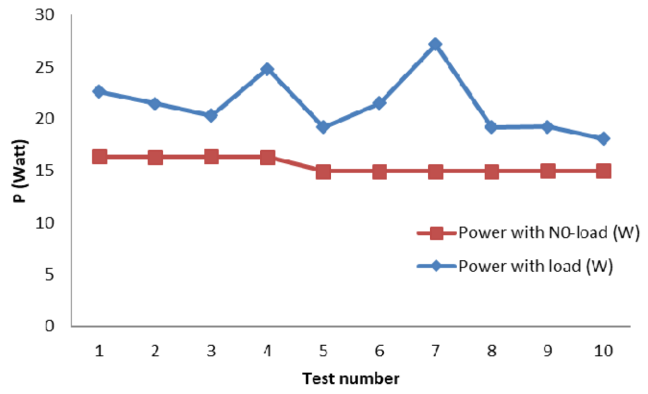


Fig. 8. Electric power within the roll-up system

From the test results presented in Table I, Table II, Table III, it was concluded that the sum of electric power consumed by three systems was 42.38 watts, while the load was 104.59 watts. The most significant sequential electricity consumption is the pressing system, then the roll-up system and the lowest in the embroider system.

Table IV is the result of testing a weaving machine processing the *mendong* weaving as long as 1 meter takes 2551.2 seconds or 42.5 minutes.

TABLE IV. POWER TEST PRESSING SYSTEM

| Test number | Duration for 1 meter of woven (second) |
|---|---|
| 1 | 2934 |
| 2 | 2226 |
| 3 | 2442 |
| 4 | 2490 |
| 5 | 3114 |
| 6 | 2610 |
| 7 | 2532 |
| 8 | 2772 |
| 9 | 2094 |
| 10 | 2298 |
| **Average** | **2551.2** |

Fig. 9 is a test chart of 10 repetitions. From this graph, it is found that the duration needed by the machine in weaving 1 meter long of *mendong* is 42.5 minutes.

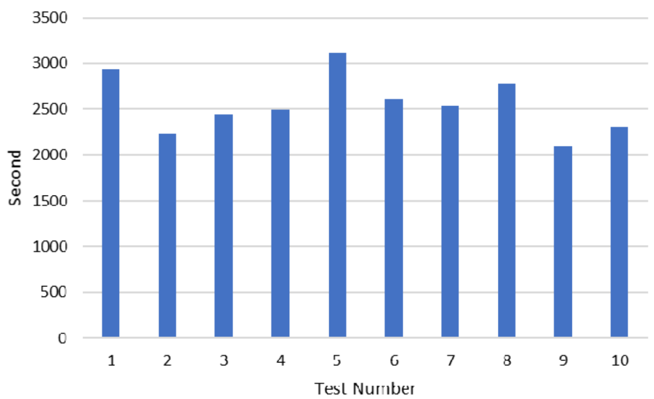


Fig. 9. The average duration for one meter of weaving

Fig. 10 shows the energy consumption (Wh) required by a weaving machine to work for 1 hour by the ten of test repetitions. From the measurement results, it was found that the machine required the energy of 37.27Wh to work making webbing for 1 hour. From these results, it was concluded that the *mendong* machine built was quite energy efficient.

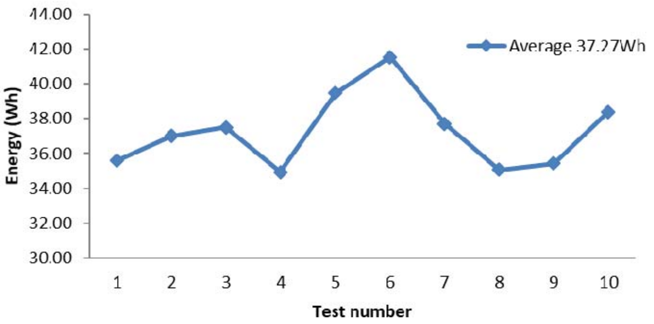


Fig. 10. Electrical energy consumption of the machine for one hour of weaving

From the comparison of the results of plaiting from conventional *mendong* weaving machines with the results of the proposed machine, it was obtained that the *mendong* woven from the proposed machine was quite beneficial. It is shown in Fig.11.

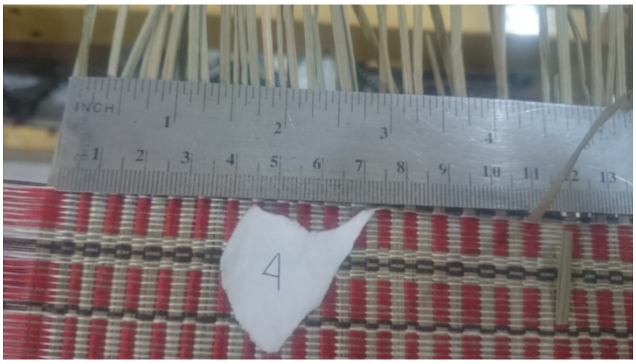

Fig. 11. The result of mendong density weaving experiment

## IV. CONCLUSIONS

The sensors used are inductive proximity sensors, using six sensors. The proximity sensor has three sensors, namely the upper sensor, center sensor, and bottom sensor, proximity pressing sensor, supplier proximity sensor, and proximity roller sensor. The sensors used can run well according to the program that has been made. It is necessary to add another sensor to protect every system error; for example, when it breaks, there must be a sensor that detects it.

From the data obtained from the drive system test, it was concluded that the sum of the electrical power consumed by three systems was 42.38 watts, while the load was 104.59 watts. The most significant sequential electricity consumption is the pressing system, then the roll-up system and the lowest in the embroider system

Based on the results of testing separately, the components used are Mechanical, PLC, Power Supply, Sensors, Drive Motors has been proven to work well. The overall test is a weaving time of 42.5 minutes with a length of 1 meter woven product, spending 37.27 Wh.


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