Modeling of Control System on Sorting Palm Fruit Machine by Using Arduino Microcontroller

Dodi Sofyan Arief [a,*] Edy Fitra [a,*], Minarni [b], Herman [c] and Roni Salambue [d]

a) *Department of Mechanical Engineering, Faculty of Engineering, Universitas Riau, Indonesia*
b) *Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Riau, Indonesia*
c) *Department of Biology s, Faculty of Mathematics and Natural Sciences, Universitas Riau, Indonesia*
d) *Department of Information Systems, Faculty of Mathematics and Natural Sciences, Universitas Riau, Indonesia*

*Corresponding author: dodidarul@yahoo.com, fitra_edy@yahoo.co.id

ABSTRACT

One of the reasons for the poor quality of palm oil in Indonesia is because of the separation system of processing method is processed manually. In this research, the proposed solution to overcome the problem is by applying the automatic separation system by using microcontroller. The maturity of the fruit will be determined from the image that taken by a camera. The reading of the camera image will be processed in a microcontroller which will move the separator arms so that the fruit will be separated based on the level of maturity. This system is designed to work continuously by placing the palm fruit over a conveyor belt mechanism. With this automation method, the separation process of fruit is no longer depends on the ability of humans manually and more importantly it can take place continuously.

KEY WORDS: *Process, Automation, Fruit, Separation.*

1.0 INTRODUCTION

The world's palm oil production is dominated by Indonesia and Malaysia, both country produce 85% to 90% of the total of world's palm oil and 53% of the world's palm oil production is contributed by Indonesia.

Although Indonesia is the world's largest palm oil producer, yet Indonesia's palm oil exports to the United States as the world's major markets are second place after Malaysia where 63.2% of Malaysia and 35.4% of Indonesia.

The low imports of palm oil by the United States for Indonesian products, due to the poor quality standards of Indonesian palm oil. This condition is caused by the applied grading system is not maximal yet.

In order to maximize the grading system effectively, it is required a machine that has the ability to detect the maturity of the palm fruit and at the same time can separate it based on the maturity level of the palm fruit. This separator machine will be valuable when it operates automatically and without involving the operator. Therefore, this final project is planned to design and produce palm oil separator machine which based on the above described performance.

Automation tools either for home industry or modern industries also experienced developments due to the impact of technological advances in the current era of modernization. The process of machine automation is known by technical term as control system. Control in mechatronic technical term is "an equipment or group of equipment used to set the function of machine as desired [2]. The system that has the ability to control a process in accordance with the desired is called "Control System." If the control system works automatically (without using the operator) then the system is called the automatic control system.

Researchers who have developed an automatic sorting machine like reference [3] in "Study on an automatic sorting system for Date fruits", developing a fruit separator using four separators driven by a driving force. While [4] in "Model design and simulation of automatic sorting machine using proximity sensor", by doing with conveyor concept and three of double acting cylinder as separator. Other researchers [5] in "Automatic

Conveyor System with In-Process Sorting Mechanism using PLC and HMI System" by trying to apply with conveyor concept using pneumatic system as its separator. Even one of researcher like Makky and Soni [6] "Development of an automatic grading machine for oil palm fresh fruits bunches (FFBs) based on machine vision", they apply a microcontroller control system and use one separator to sort the palm fruit. While other research that the authors will develop is concerning the design of grading machine automatic control system using a microcontroller with two separators.

2.0 LITERATURE REVIEW

2.1 Sorting of Palm Oil Fruit Process
The palm oil that goes into the Palm Oil Factory, the quality & maturity should be checked properly. The process of palm fruit inspection is often called fruit sorting, where the process of sorting is done manually. According to [1] the type of fruit that goes into the Palm Factory is generally the type of Tenera or type of Dura. Criteria of mature harvest is a very important factor in examining the quality of palm fruit in the fruit receiving station, the following maturity criteria of palm fruit based on fruit color:
1) Unripe Fruit
   Unripe fruit is a FFB (Fresh Fruit Bunch) the criteria which no fraction that free out of bunch and its color will be black.
2) Under Ripe Fruit
   Under ripe fruits are FFB with criteria only 25% of loose fruit from the total fresh fruit bunches by fraction loose fruit <10 loose fruit and usually the fruit will be reddish colored.
3) Ripe Fruit
   Ripe fruit is FFB where the criteria have loosed 2 pieces / kg FFB or > 10 loose fruit / 50% already loosed and usually the fruit will be shiny red color.
4) Over Ripe Fruit
   Over-ripe fruit is FFB where the fruit criteria already loosed more than 75%, this can occur because of the transport delay of FFB from the garden to the factory.

2.2 Control System
According to [7] the system is the arrangement of physical components connected or related in such a way that it forms or acts as a whole unit in a single unity. While the word of control is usually defined set, direct, or command. From both meaning of word system and control, the control system is a composition of physical components that are connected or related in such a way that it can govern, direct, or organize itself or the system.
According to [2] the control system consists of sub-systems and processes which arranged to obtain the desired outputs and performance of the given inputs and the control system consists of:
1) Open loop control system is a control system in which the output does not give effect to the input quantity, so that the controlled variable can't be compared against the desired price.
2) A closed loop control system is a control system whose output signals that has a direct effect on the control action. The closed loop control system is also a feedback control system. The drive error signal, which is the difference between the input signal and the feedback signal, is fed to the

controller to minimize the error and to make the system output close to the desired value. In other words, the term of closed loop means using a feedback action to minimize system errors.

2.3 Microcontroller
According to [8] a microcontroller is a device that integrates a number of components from a microprocessor system into a single microchip. There are three main components of microcontroller, namely: CPU processor, memory and input / output (I/O). In addition, most microcontrollers are also equipped by other features in general, such as:
1. Timer module functions to perform the process that function which associated with "time period or time range".
2. A "Serial Port" that serves to perform data communication with other microcontroller or PC computer.
3. ADC module functions to receive analog data input.

3.0 RESEARCH METHOD
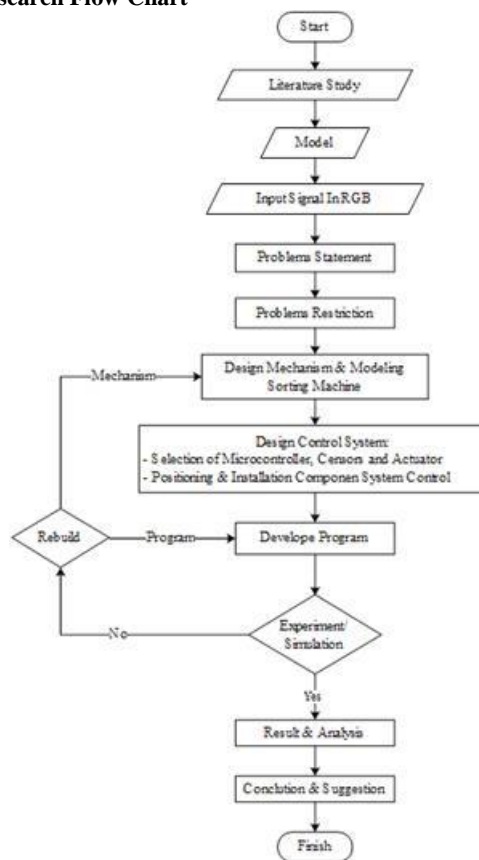
3.1 Research Flow Chart

Figure 1: Flowchart of Research

3.2 Materials Application of Palm Oil Sorting System
The material which used for the implementation of the palm fruit sorting control system is a model of a conveyor belt as shown in figure 2.
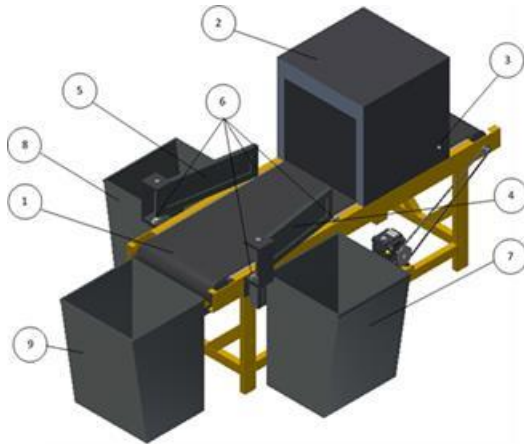
Figure 2: Palm Oil Sorting Machine Model

1. Belt Conveyor
2. Box Camera
3. Infrared Censor
4. Unripe Palm Fruits Separator
5. Over Ripe Palm Fruits Separator
6. Limit Switch
7. Unripe Palm Fruits Shelters
8. Over Ripe Palm Fruits Shelters
9. Ripe Palm Fruit Shelter

3.3 Block Diagram of Control System

The block diagram functions to feed the information to the overall palm oil sorting modeling control system, as can be seen in figure 3.
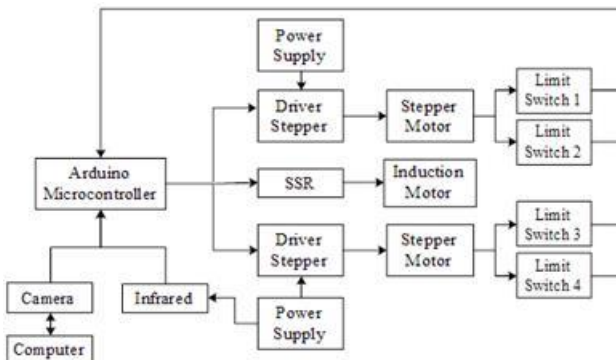

Figure 3: Block Diagram of Control System

In the figure 3.3 displayed that Arduino microcontroller receives input signal / input of 6 pieces of sensor including camera, infrared and 4 limit limits switch. When the power supply in the ON position, the infrared sensor lights up then the microcontroller will control the SSR (Solid State Relay) to connect the current to the AC motor (conveyor drive) until the conveyor moves. The palm fruits over on the conveyor belt will be brought into the room where infrared and camera is installed, when the palm fruits cut off the infrared signal, the microcontroller will receive input from the infrared to control the SSR to switch off the conveyor motor current for 3 seconds, afterwards, SSR will automatically reconnect the current to the electric motor so the conveyor belt moves back.

Delay time of 3 seconds is used by camera sensors that linked to the computer to take photos of palm fruits and accumulate the grading through the maturity of the palm fruit and provide input signal in the form of RGB (Red, Green, Blue) for microcontroller. Furthermore, the microcontroller will give the command / output to one of stepper motor to move the separator / separator according to the palm fruit grading that received from the camera input, until it touches the first limit switch that mounted on the separator pedestal.

After the separator touches the limit switch and accumulated, the limit switch will give the input signal to the microcontroller to stop the stepper motor for 4 seconds, and after 4 seconds the stepper motor will automatically rotate backward until it touches the second switch limit and stops. This 4 second of time is required to move the palm fruit conveyor through the camera room until it falls into the reservoir, and so on.

4.0 RESULT AND DISCUSSION

After designing and determining of hardwares are used for the control system modeling of palm fruit sorting machine, then the ladder diagram program is designed with LDmicro release 4.2.3 software. When the programming has been completed, the next step is to test to confirm whether the program made is working as expected or not. Where the test consists of two tests: firstly, the test of ladder diagram by using software LDmicro releases 4.2.3. Secondly, the test of control system modeling of palm fruit sorting machine by using Arduino microcontroller that has been programmed with LDmicro release 4.2.3.

4.1 Simulation program of ladder diagram

Testing / simulation program of ladder diagram by using software LDmicro release 4.2.3 is done which aims to find out whether the program ladder diagram works properly as expected before uploaded to arduino microcontroller. The simulation steps of ladder diagram by using LDmicro release 4.2.3 software will be explained as follow:

1. Select Simulate menu on the toolbar, then check the Simulation Mode so that the ladder diagram program will change color as shown in Figure 4.
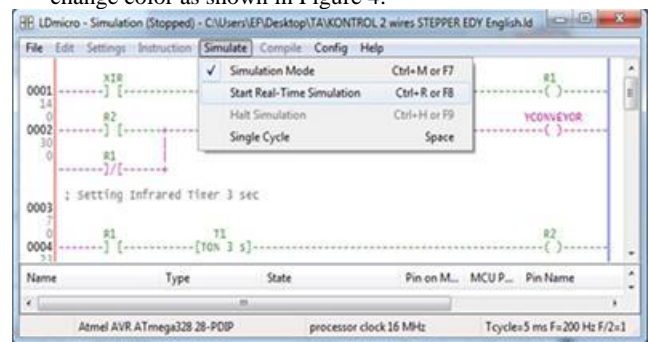

Figure 4: Running for Simulation Mode of Ladder Diagram.

2. After Simulation Mode is active, to run the simulation then, click Start Real-Time Simulation so that the red ladder diagram shows that the conveyor is operating as shown in Figure 5.
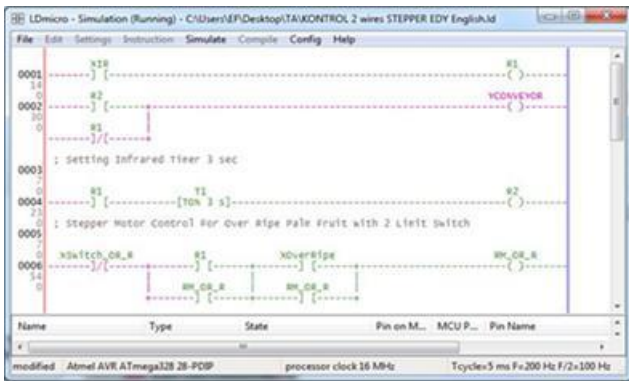
Figure 5: Ladder Diagram Displayed of Simulation Mode.

4.1.1 Simulation of Ripe Palm Fruit

Perform steps 1 up to 2 to start the simulation as above, double click XIR so that the ladder diagram on infrared works which marked by the color change of ladder diagram (R1) into red as shown in Figure 6.a while the conveyor stops for 3 seconds, where it is the time required by the camera to take images and calculate the maturity of the palm fruit then the camera will send RGB data to the microcontroller in the form of ripe palm fruit (ripe) then after 3 seconds ends, the conveyor belt will move back, (ladder diagram Conveyor change color to red) as shown in figure 6.b and bring the ripe palm fruit to the palm fruit shelter which is positioned in front of the conveyor belt.

Figure 6.a: Infrared mode simulation is in active condition

Figure 6.b: Conveyor Mode Simulation moves after Infrared is inactive for 3 seconds.

4.1.2 Simulation of Palm Fruit Over Ripe

1. Do the above steps until the camera produces the photo and if the photo declares the palm fruit is too mature and during 3 seconds of time, the camera will send the RGB data to the microcontroller to move the separator arm (Pul_OverRipe and Dir_OverRipe stepper motor turns red) to the limit switch (RM_OR_R) as shown in Figure 7 which will direct the entry of palm fruits into the reservoir that too much mature of palm fruit.
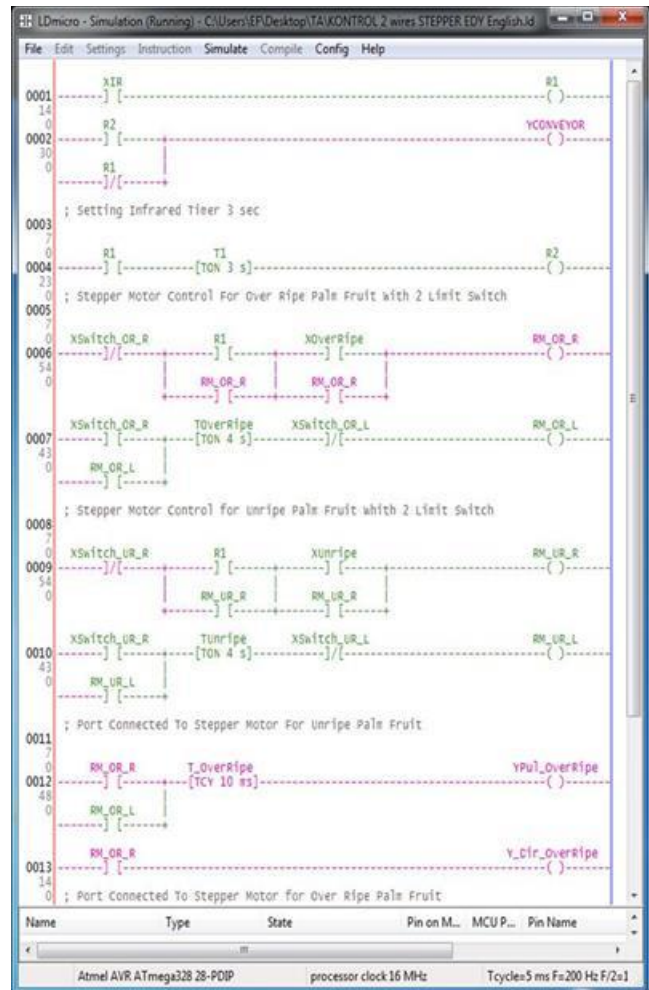

Figure 7: Simulation mode of separation arm which moves up to touching the limit switch to the right hand side.

2. After 4 seconds, the separating arm moves back to its original position, where the stepper motor rotates (Pul_OverRipe turns red) until it touches the limit switch (RM_OR_R active) as shown in Figure 8.
3. The simulation either for unripe or overripe of palm fruit are same steps but the stepper motor which moves arm fruit separator is less mature.
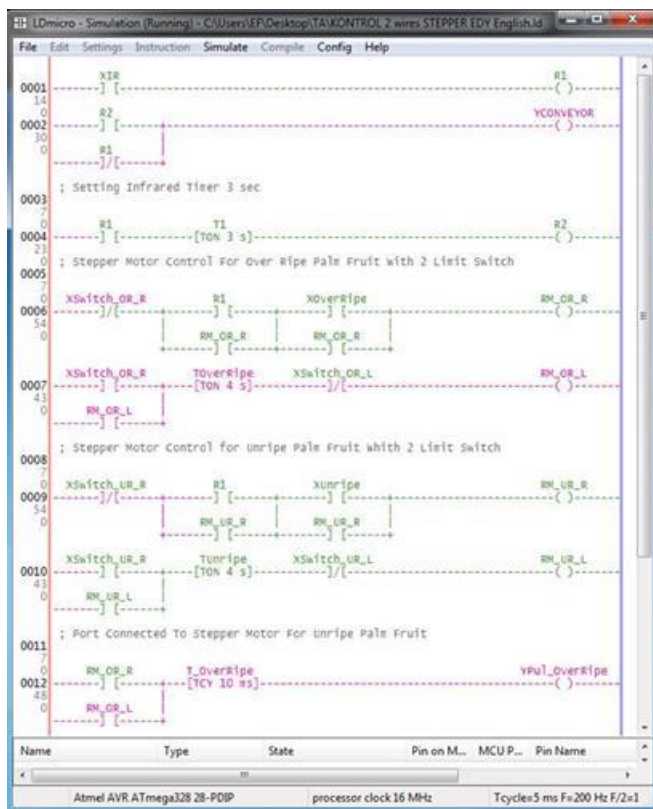
Figure 8: Simulation mode of separator arm returns to original position until it touches the left switch limit after the palm fruits drop off.

5.0 COCLUSION

The design of the palm oil sorting model control system by using the arduino microcontroller can be concluded as follows:

1. The palm fruit sorting which has been done in the palm oil factory is still manual in open eyes. Meanwhile in this equipment, the sorting process is based on the color difference and time required only 10 seconds for each bunch.

2. The use of Arduino microcontroller on the scale of this model scale machine provides satisfactory result to control a mechanism of sensor and actuator like stepper motor, infrared, limit switch and solid state relay.

3. Arduino microcontroller can be programmed with several programming languages. In this study, the used programming language is LDmicro or ladder diagram that commonly used for PLC programming.

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