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Retrofit Design Control System of Bladder Turn Up Tire Assembly Machine Based on Programmable Logic Controller to Improve Machine Performance

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***Abstract*—The manufacturing production process is constantly being developed along with industrial automation and the industrial revolution 4.0. This paper discusses research conducted at a manufacturing company that makes tires for motorbikes. The process of making a tire includes the following processes, including mixing, topping, extruding, bead wire, tire assembly, spraying, gimlet, and tire curing. In the tire assembly process, there is a machine used in the assembling process for the manufacture of the outer tires. There are 2 types of machines used, namely STU (Spring Turn Up) and BTU (Bladder Turn Up). To improve the machine performance, a BTU (Bladder Turn Up) tire assembly machine was retrofit on the shaft former drive control system using a servo motor. After retrofit the control system based on Programmable Logic Controller (PLC) on the BTU (Bladder Turn Up) tire assembly machine, the green tire production capacity increases. Furthermore, the cycle time has decreased by making a one-loop system during the ply cord setting process. Also, there is no variation in spare parts on the shaft former drive motor to extend the machine lifetime.**

Keywords—tire assembly machine, retrofit, bladder turn up, programmable logic controller

I. INTRODUCTION

In the old tire assembly machine, the driving motor used in the shaft former is a 3-phase AC motor, so that in the shaft former rotation, the ply cord setting process only uses inching. While on the new tire assembly machine, the shaft former driving motor uses a servo motor, and there is already a one-turn program on the tire assembly machine during the ply cord setting process. On the old BTU (Bladder Turn Up) tire assembly machine, a one-turn program was made using a timer and break, but problems often occur, so it is no longer functional.

With this one-round program, it affects the cycle time of the tire assembly machine, especially during the ply cord setting process. Besides that, it also affects the spare parts of the tire assembly machine, so the company must provide spare parts for the different shaft former driving motors for the old tire assembly machine and the new tire assembly machine. Therefore, a retrofit was carried out on the old tire assembly BTU (Bladder Turn Up) machine which is still operating in the company to improve machine performance. So, it did a retrofit on the tire assembly machine. Based on the existing background, this paper discusses how to increase the production capacity of green tires, how to reduce cycle time in the ply cord setting process in tire assembly machines, and how to reduce variations in spare parts of the shaft former driving motor on tire assembly machines.

II. METHODOLOGY

A. Product Introduction

This company produces outer and inner tires. Tires are devices that cover the wheels of a wheel. Tires are also an important part of the vehicle because they are in direct contact with the road surface. Fig. 1. shows the process of making outer tires.

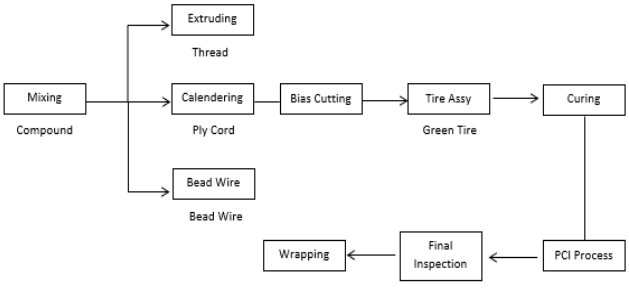

Fig. 1. The process of making outer tires.

The flow of the outer tire manufacturing process from start to finish, which includes:

- mixing (the process of mixing raw materials, namely rubber, filler, chemical, and final batch into one),

- extruding (the stage of producing a compound that has been adjusted to a certain width and thickness using an extruder and producing a thread),
- Bead wire (a supporting component for the manufacture of outer tires, consisting of wire coated by a WADC compound),
- Calendaring (making ply & steel belt material, JLB & cap ply), Bias cutting (the process of cutting nylon cord from the calendaring process diagonally with certain widths, lengths, and angles into sheets called ply cords according to the desired specifications),
- Building or tire assembly (assembling all materials resulting from previous processes),
- curing (the process of cooking while printing green tires into tires or finished tires),
- Final inspection (the process of inspecting tires, visually inspecting tires for defects or not).

B. A Tire Assembly Machine

A Tire assembly machine is a machine used in the assembly process in the manufacture of a tire. In this process, all the materials resulting from the previous processes are put together in the tire assembly machine so that they become green tires. The materials resulting from the previous process are ply cord, bead wire, and thread. The tire assembly machine that the author discusses is a machine used to manufacture tube-type tires. So, it only uses 2 layers of ply cord. Fig. 2. Show tire assembly BTU machine.

Fig. 2. Tire assembly BTU machine.

C. Problem Analysis

Based on the analysis of the fishbone diagram that has been made, the root of the problem is the lack of time effectiveness in the ply cord setting process. This is because the tire assembly machine still uses a 3 phase AC motor on the shaft former driving motor. So that in the process of setting the ply cord, it still uses inching or jog because there is no one-turn program on the tire assembly machine. In the condition of the machine before the retrofit, some components are no longer used, namely the 3 phase AC motor, because the system is an open loop. In addition, there will be the addition of a footswitch component, to support the performance of the new control system.

D. Machine Working System

The first step that must be taken by the operator to start the process on the machine is to activate the MCCB and MCB. Then press the push-button start on the machine panel. After that check whether the ply cord material is still there or not. Then check whether the emergency button is in a state of release or not, if not then the button must be turned so that the position is in a state of release. Next, select the mode on the panel by turning the selector switch. The working system of this machine is divided into 2 modes, namely manual mode, and auto mode.

E. Problem-Solving

Based on the analysis of the problems that the author has conveyed; it can be concluded that the main problem is in the process of setting the ply cord which is still using inching or jog during the process. It is because the motor driving the shaft former is still using a 3 phase AC motor, with this problem we decided to do retrofit on the tire assembly machine control system, namely on the shaft former driving motor to make it easier to use. After retrofitting the control system on the motor driving the shaft former, the author hopes that the operator no longer needs to use inching or jog in the ply cord setting process but uses one rotation and makes the operator's work easier.

F. Design Concept

Based on the existing problems, the control system used on the old BTU (Bladder Turn Up) tire assembly machine still uses a 3-phase AC motor as the driver of the shaft former. The control system will be converted into a servo motor. Besides being used during the process of setting the ply cord, the motor driving the shaft former is also used in the turn-up stitcher and thread stitcher processes. Fig. 3. shows the concept of a tire assembly machine control system that is made.

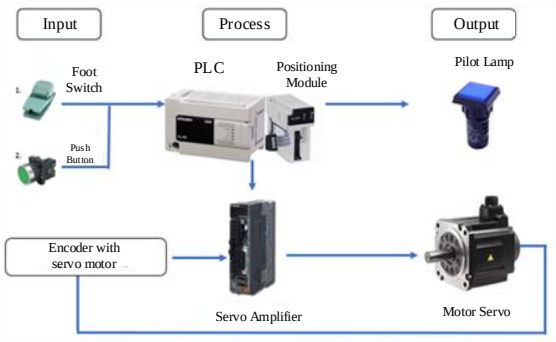

Fig. 3. Motor servo control system.

This new control system uses a servo motor to drive the shaft former. Where it will use footswitches and push buttons as input devices. Then, the PLC, positioning module, and servo

amplifier will process data from the input device, which will later control the output. As for the output device, using a servo motor [1,2].

III. Design and Analysis

A. Control System Design

The design of the control system includes the design of the processing device, the design of the input device, the design of the output, the electrical design, and the specifications of the device to be used. Fig. 4. shows the design of the control system.

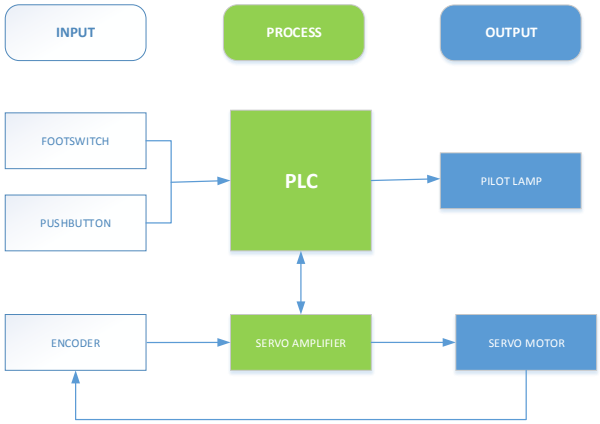

Fig. 4. The design of the control system.

- Configure PLC and Servo Drive. The application used during the configuration between PLC and servo drive is MR Configurator2.
- Flow chart. In operating the BTU (Bladder Turn Up) tire assembly machine, it is done by programming from the PLC as a controlling device. There are two modes when running the tire assembly process on the BTU (Bladder Turn Up) machine, namely auto mode and manual mode. Fig. 5. shows an example of a Forward and Reverse Jogging Program.

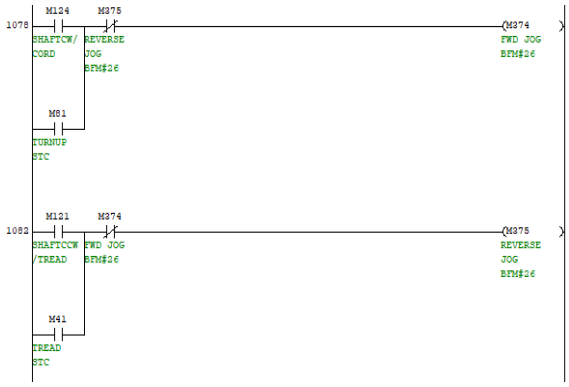

Fig. 5. An example of a forward and reverse jogging program.

The first mode is manual mode. Manual mode is used to check whether the input or output components are working or not in case of damage. The second method is auto mode, this auto mode works by utilizing input devices (sensors, footswitches, pushbuttons, selector switches) that are connected to the PLC to support the running of the program sequences that have been made.

B. Testing

1) Work process testing: Testing on the process is carried out to find out whether the BTU tire assembly machine is working according to the desired process. This test can be monitored through the output movement or the status of the LED on the PLC, and the light indicator from the control panel.

2) Normal condition test:

- When the MCB is activated, the electricity in the machine is active.
- When the emergency button is pressed, the power will cut off.
- When the start button is pressed, the PLC is active, and the sensor is on.
- When the mode is not selected, but the controls and sensors are active, the process will not run.
- When the auto mode is selected, the auto indicator will be active and the process will run if the switch is working, the push button is working, or the sensor detects it.
- When manual mode is selected, the manual indicator will be active, and the process will not run if the switch is not pressed.

3) Auto mode operation:

- When the auto man selector switch is on auto, the auto mode is selected, and the auto indicator will be active.
- When the auto mode is active and the step run button is pressed, the tail stock advances.
- When auto mode is active, place ply 1 on the drum and step on the foot switch one turn, then the building stand by indicator lights up, the servo motor will rotate one full rotation and roll up ply 1 on the surface of the drum.
- When auto mode is active, place ply 2 on the drum and step on the foot switch one turn, then the servo motor will rotate one full rotation and roll up ply 2 on the surface of the drum.
- When the auto mode is active, ply 2 has been set and the step run button is pressed, the building stand by indicator turns off while the beadset indicator lights up, the drum expands, and the beadset advances to place the bead wire on top of the ply layer that has been set.

- When the auto mode is on, the bead wire is above the ply cord layer and the beadset is backwards, then the left and right bladder will expand and the beadset will move forward so that it folds the side of the ply cord into the middle.
- When the auto mode is active, the beadset process is complete, the beadset indicator turns off while the cord turn up indicator lights up, the center roller works, the under stitcher roller moves from the outside to the center while pressing the green case and the servo motor driving the shaft former rotates forward.
- When the auto mode is active, the turn up process is complete, then put the thread on the ply cord layer and step on the reverse foot switch, then the servo motor driving the shaft former rotates reverse.
- When the auto mode is active, the turn up process is complete, and the thread has been installed on the ply cord layer and then the step run button is pressed, then the thread stitching indicator lights up, the center roller works, the under-stitcher roller moves from the middle to the outside while pressing the green case and motor servo drive shaft former rotates reverse.
- When the auto mode is active and the ply 1 sensor works, the ply 1 motor will rotate forward.
- When the auto mode is active and the ply 2 sensor works, the ply 2 motor will rotate forward.

4) Cycle time test: Cycle time testing was done by simulating the program. This test was carried out to find out how much time it takes the machine to complete one work process using a stopwatch and see the results of the simulation that has been done. The average cycle time result is 58 seconds.

5) Design test: Design testing is done in two ways. That is by looking at the light indicators on the PLC module, or through the online monitoring mode on the Gx Developer Software.

6) Evaluation of design results: After retrofitting the BTU (Bladder Turn Up) tire assembly machine with the design of a new control system, the machine can run again. Machines that previously used a 3 phase AC motor as a drive for the shaft former now use a servo motor. In addition, there is a footswitch to support the performance of the new control system [3-10].

IV. CONCLUSION

In this paper, we have designed a retrofit design for a BTU (Bladder Turn Up) tire assembly machine. After retrofitting, the BTU (Bladder Turn Up) tire assembly machine experienced an increase in green tire production capacity. Cycle time has decreased, to 58 seconds, this is due to the development of a one-turn system in the process of setting the ply cord. Next, the shaft former driving motor has been replaced using a servo motor, so there is no spare part variation in the shaft former driving motor. This can extend the lifetime of the machine.

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