Annual Academic Sessions 2011
ISSN 2012-9912; ©2011 Open University of Sri Lanka

REDUCTION OF TIRE SCRAP AND REWORK LEVEL BY AUTOMATION OF THE GREEN TIRE RESIN SPRAYING MACHINE

A. A. Gayan Aravinda Abeygunawardane*

Department of Mechanical Engineering, Open University of Sri Lanka

INTRODUCTION

Green tire preparation is one of the important functions in the tire manufacturing plant in order to ensure high quality of the vulcanized tires. This includes an application of two different resins, to exterior and interior surfaces of the green tire, for selected surface areas, prior to vulcanizing. Several types of tires are available which differs by their dimensions; which are to be used in different vehicles.

These resins are used when the green tire is to be vulcanized by the bag – o – matic type press. Exterior resin is a mould releasing agent and interior resin is a bladder releasing agent. Improper application of these resins, due to the use of manual paint brush and due to human related reasons, have created many problems related to the quality of vulcanized tire. The following were identified as the main reasons which lead to the inferior quality of vulcanized tires. The paint is not applied evenly throughout the area of the green tire, because of the inherent quality of paint brushes. Insufficient time allowed for drying the paint, before it is sent to press, is another fact. Manual painting and use of paint brushes lead to mixing both inside and outside paint, which completely deteriorates the chemical properties of the concerned area. Further negligence of the workers is a vital factor. Additionally, most of the paint brushes are defective; this leads to non uniform paint thicknesses for a particular type of green tire. These factors prompted the design of an automated machine

The whole research includes the design of a new machine to apply both paints efficiently, and automation of the machine. However this article is mainly focused on the automation side of the newly designed green tire resin spraying machine.

However automation is generally defined as the process of having machines which follows predetermined sequence of operations with little or no human labor, using specialized equipment and devices that perform and control manufacturing processes. This is achieved through the use of sensors, actuators and techniques which are capable of observing and making decisions based on the operation and the condition of the processes.

The main objectives to be accomplish by automating this newly designed machine can be shown as follows.

- Improve the quality of the product.
- Reduce human involvement, boredom, and the possibility of human error.
- Ensure uniformity of paint thickness for a particular green tire size.
- Reduce tire scrap level, rework, and other tire repairs.
- Improve the efficiency and effectiveness of that work station, which ultimately serve to increase the total plant efficiency.

* All correspondence should be addressed to A. A. Gayan Aravinda Abeygunawardane , Department of Mechanical Engineering , Open University of Sri Lanka (email: aravindaousl@gmail.com)

METHODOLOGY

Types of Actuators and their Locations

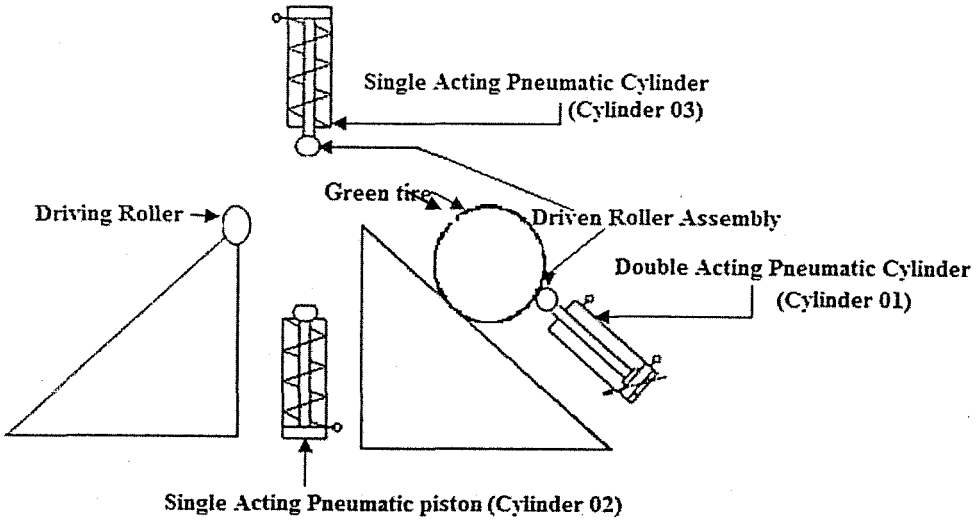

Figure 1: Basic components arrangement of the machine

As mentioned, the whole process has been done manually. So initially there should be a proper mechanism and a structure to handle the green tire. It should be able to carry and sustain dynamic and static stresses induced by the weight and the inertial forces of the green tire. The system comprises of rollers, machine structure, actuators and sensors. The rollers and machine structure are designed by a suitable type of mild steel. The pneumatic pistons and DC motor were selected as the actuators. The distance between the spraying nozzle and green tire surface, and green tire rotation speed should be controlled for each type, for accurate paint spraying. Figure 1 is the diagrammatic view of the arrangement of components.

Each of the above shown components is expected to perform the following activities. Pneumatic cylinder 01 is a double acting cylinder, used to lift the green tire along the inclined plane; to the fixture arrangement. Pneumatic cylinder 02 is a single acting cylinder (spring return type), used in the bottom of the fixture to support the tire until the top piston touches on the tire. Pneumatic cylinder 03 is a single acting cylinder (spring return type) used in the fixture to support the tire from top position. Pneumatic cylinder 04 is a double acting cylinder, used to take the internal spraying nozzle to the centre position of the green tire (moves along its horizontal axis) (Joji,P., 2008) It is located and moves along a perpendicular direction to the paper. Finally, the driving roller is use to rotate the green tire while both paints are being applied and driving roller is rotated by a DC motor. Additionally to change the distance between the spraying nozzle and spraying surface; a complete unit of SLTE mini slide with motor controller was used.

Types of Sensors and their Locations

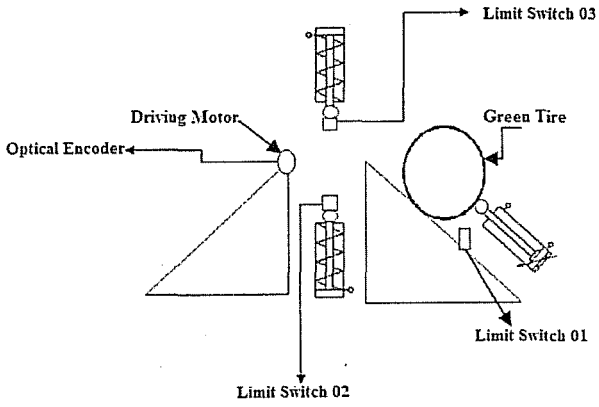

Figure 2: Sensors location

Sensors are used to inform the control unit about the real time status of the system. Several types of sensors are used and are located suitably in the above shown system as shown in Figure 2. Each sensor is expected to do the following duties. Limit Switch 01 is to inform the availability of the green tire at the initial stage of the sequence. Limit Switch 02 and 03 informs the control system about the availability of the green tire at its rotation point. An optical Encoder is placed parallel to the axis of the driving roller; while keeping the contact between the driving roller and optical encoder. Optical encoder is used to signal to the control system when green tire rotates one complete revolution; as the system is designed to apply both paints while the green tire is being rotated within one revolution.

A key pad was used to input the type of tire which is available at the work station. Key pad can be located at a convenient place for the operator of the machine. Different numbers are allocated for each type of green tire and hence all the spraying details can be sent to the control unit simultaneously by the operator.

The controlling mechanism of this project is automated using program logic controller (PLC). PLC is a user friendly, microprocessor based specialized computer that carries out control functions of many types and levels of complexity. It can be programmed, controlled, and operated by a person unskilled in operating computers. A PLC's operator draws the lines and devices of ladder diagram with a keyboard on to a display screen (John,W *et al.*, 2003). Among the several commercial PLCs available; Siemens s7 – 200 PLC was selected, Because of its cost, flexibility, serviceability and training. PLC was programmed according to the required process sequence. The input signals are received from limit switches and optical encoder while output signals are sent to DC solenoid valves, to DC motor controller and SLTE mini slide.

Green tire rotational speed should be changed for each type, considering the width of the paint thickness considered. Tire rotational speed is regulated by the pulse width modulation techniques (PWM) associated with s7 – 200. This PWM signal then is sent to the DC motor via a suitable motor controller.

To get the required thickness green tire rotational speed is a critical factor. Maximum and minimum paint requirements are mentioned by the manufacturer for a quality vulcanizing. This data were taken for the calculations; so that the green tire rotational speed can vary between those maximum and minimum values to get the thickness within that approved region.

For the selected spraying nozzle, it was given in the data that at a distance of about 254 mm from the paint surface, 685.8 mm spraying width can be achieved. If the tire spraying width required is 580 mm; the spraying nozzle height was calculated as shown below.

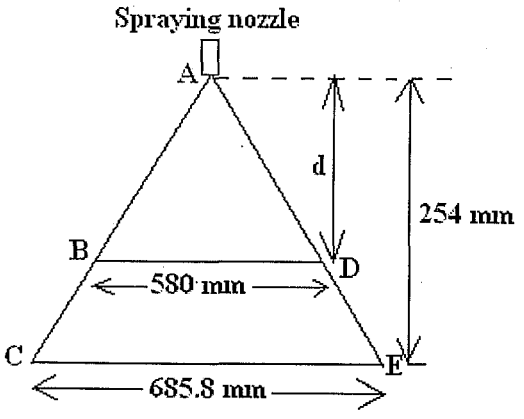

Figure 3: Variation of distance and spraying width (Internal)

RESULTS AND DISCUSSION

According to the calculations, the required internal and external paint thickness can be achieved if the green tire is rotated within the maximum and minimum speed range. Spraying width can be achieved with the use of SLTE mini slide. The calculation was done to all types of tires and those results indicate that paint thickness can be successfully achieved The time can be saved and productivity can be increased. Achieving the paint thickness without human involvement is also another important achievement here.

CONCLUSIONS AND RECOMMENDATIONS

By automation; many advantages can be achieved. First, the negligence of the worker is completely eliminated and total operation of the machine can be done by one operator. He is only responsible to initiate the process and not be involved in application of paint. Human element is significantly reduced from the system. The other advantage is the protection of uniformity and accepted quality of the vulcanized tire. This will reduce the tire scrap level and rework and hence reduce unnecessary related costs. Elimination of the human element will make the total cycle time to be reduced and hence low level of work in progress inventory.

Further it can be recommended that image processing system can be used to identify the type of tire that arrives at the station, by a certain color code dedicated for each type of green tire. With this; green tire type selection which is done manually, can also be eliminated.

Process simulation techniques can be used to monitor the condition of the machine. These process simulation techniques consisted of color visual displays and various controls. With this engineers and management can read the condition of the machine status and its operational details, without going to the machine premises. This simulation system can be established within a main control unit of the factory and hence it is very easy for engineering and management operations.

ACKNOWLEDGEMENT

Special thanks go to Mr. Asitha Jayaweera, (Head of Engineering), and Mr. Ravi Palihakkara, (Technical Manager) and Eng. Dhammika Jagodage (Engineer) of CEAT International Tires (Pvt) Ltd, for granting the permission to access some technical details regarding chemicals and engineering and for the excellent support given.

REFERENCES

John W. Webb, Ronald A. Reis, *Programmable logic controller principles and applications* Fifth edition, (2003) by Prentice Hall Inc.

Joji,P. (2008) *Pneumatic controls,* Wiley India Pvt. Ltd,