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Programmable Logic Controller for Cassava Centrifugal Machine

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***Abstract*—**Chaiyaphum Starch Co. Ltd. is one of many starch manufacturers that has introduced machinery to aid in manufacturing. Even though machinery has replaced many elements and is now a significant part in manufacturing processes, problems that must be solved with respect to current process flow to increase efficiency still exist. The paper's aim is to increase productivity while maintaining desired quality of starch, by redesigning the flipping machine's mechanical control system which has grossly low functional lifetime. Such problems stem from the mechanical control system's bearings, as fluids and humidity can access into said bearing directly, in tandem with vibrations from the machine's function itself. The wheel which is used to sense starch thickness occasionally falls from its shaft, due to high speed rotation during operation, while the shaft may bend from impact when processing dried bread. Redesigning its mechanical control system has increased its efficiency, allowing quality thickness measurement while increasing functional lifetime an additional 62 days.

***Keywords*—**Control system, Machinery, Measurement, Potato starch

I. Introduction

CHAIYAPHUM Starch Co. Ltd., 50 Moo 11 Chaiyaphum-Sikhio Rd., Thambol Lahan, Amphoe Muang, Chaiyaphum 36130, is a starch manufacturer that distributes Advantages of cassava starch are as follow; high level of purity, excellent thickening characteristics, A neutral (bland) taste, desirable textural characteristics, sweet potato, and rice.

A relatively cheap source of raw material containing a high concentration of starch (dry-matter basis) that can equal or surpass the properties offered by other starches (maize, wheat,

Cassava starch is easy to extract using a simple process (when compared to other starches) that can be carried out on a small-scale with limited capital is often preferred in adhesive production as the adhesives are more viscous, work more smoothly, and provide stable glues of neutral pH has clear paste.

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The development of both the food and non food uses of cassava starch has made much progress and continues to have a bright future. Both old and important new products, such as modified starches, starch sugars, starch-based plastics and fuel alcohol, are reviewed briefly both locally and internationally.

Potato starch manufacturing is an important industry to Thai economy, as the potato is resilient against extreme low humidity and barren lands where other crops are incapable of growth. Potatoes can be stored up to 24 month, some species ranging up to 36 months, allowing farmers to select a profitable harvest time depending on marketing or production advantages.

Starch is one of the most abundant substances in nature, a renewable and almost unlimited resource. Starch is produced from grain or root crops. It is mainly used as food, but is also readily converted chemically, physically, and biologically into many useful products to date, starch is used to produce such diverse products as food, paper, textiles, adhesives, beverages, confectionery, pharmaceuticals, and building materials.

Cassava starch has many remarkable characteristics, including high paste viscosity, high paste clarity, and high freeze-thaw stability, which are advantageous to many industries

Cassava starch is produced primarily by the wet milling of fresh cassava roots but in some countries such as Thailand it is produced from dry cassava chips. Starch is the main constituent of cassava. About 25% starch may be obtained from mature, good quality tubers. About 60 % starch may be obtained from dry cassava chips and about 10 % dry pulp may be obtained per 100 kg of cassava roots.

Fresh tubers are processed during season and dry chips during the off-season in some countries. Extraction of starch from fresh cassava roots (Fig. 1) can be divided into five main stages: preparation (peeling and washing), rasping/pulping/grating, purification (starch washing), dewatering and drying, and finishing (milling and packaging).

For cassava, the process of starch extraction is relatively simple as there are only small amounts of secondary substances, such as protein, in the roots. When cassava roots are harvested or selected for starch extraction, age and root quality are critical factors.

Cassava roots need to be processed almost immediately after harvest, as the roots are highly perishable and enzymatic processes accelerate deterioration within 1-2 days. A first-rate quality starch can be obtained from cassava using only water, and this makes the processing of cassava starch and flour particularly suitable for developing countries and rural industries.

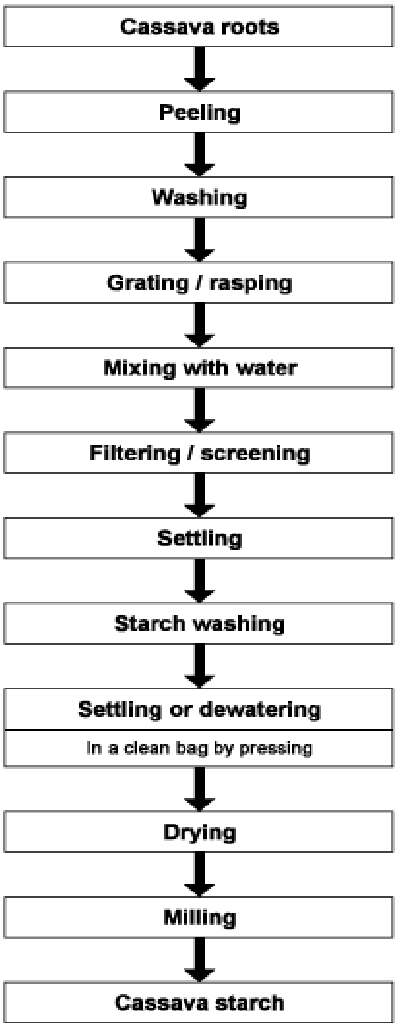

Fig. 1 Simple process for cassava starch production [1]

Modern starch manufacturing now utilizes massive amounts of machinery into every step of production to increase quality and production itself, but certain problems optimizing efficiency in respect to production line still exist. The flipping machine is a vital in starch manufacturing; it flings potato starch to wring excess water while leaving about 33-45% moisture. Quality of starch depends on this very process. The capability of being able to control moisture percentage to a constant degree will provide constant and high, if percentage is kept low, quality of starch.

In the present, personnel are used to monitor this machine, which, unless manned by highly experienced personnel, gives us varied quality from human error. Multiple machines are employed in the manufacturing line, meaning multiple personnel are required to man these machines, unavoidably introducing personnel that lack experience.

Therefore, this project redesigns the mechanism used to measure starch thickness to increase functional lifetime, by addressing the following; bearings that break down due to exposure to liquids, vibrations from the act of measuring thickness itself, measuring wheel falling loose from its shaft due to high speed rotation and shaft disfigurement from impacting dried starch.

A. Programmable logic controller (PLC)

A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a *hard* real time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

A programmable logic controller (PLC) or programmable controller is used in many industries and machines. PLC is an example of a hard real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result. This work reports the PLC controller design for controlling cassava centrifugal machine.

II. Materials and Methods

We began redesigning the thickness measurement system by reviewing automatic control systems from machine manufacturer; Bang Na Steel Works Co. Ltd., who has no information on this particular area. Korat SW Group Co. Ltd., has tried monitoring the inlet valve and has gotten inefficient results, from starch flow inconsistency. Another method tested was motor current control, but was met with varying bearing loads that age with time. Lastly, a Scree was tried by skimming the starch surface, but was met with complications from uneven starch surface leading to high vibration feedback forces.

The method we have employed monitors rotational speed of the control mechanism which touches the starch. Considering friction, high rotation speed indicates that starch layer has reached high enough to support wheel mechanism in an ideal wheel setup, while low rotational speed would signify that starch layer has not reached said level yet, bad fitting would give us low passing of speed between these two surfaces. Only after starch layer has reached our desired thickness would we pass it to the flinging mechanism.

From this idea, we have our first design, shown in Fig. 2.

After installation, found that that functional lifetime has not improved. Design does not foolproof problems that arise from bearing exposure to liquids, neither vibrations from measurement causing the wheel mechanism to fall from its shaft, nor shaft distortion from impact. Therefore, we improved the design by reducing its shaft size from 330 millimeters to 290 millimeters to discourage shaft deformation, installing a waterproof shield onto its bearings and increasing wheel size to make it more force absorbent to impact caused when met with dried starch. We installed the improved design, shown in figure 2, to test for functional lifetime.

Fig. 2 Original redesigned control mechanism

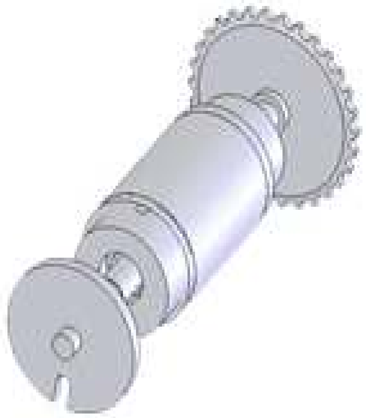

Fig. 3 Improved redesigned control mechanism

The controller for cassava centrifugal machine was installed and tested for controller efficiency. Additionally, the Programmable Logic Controller (PLC) was designed and tested for controlling the centrifugal machine.

Automatic control system was designed using Programmable Logic Controller (PLC) within these parameters; machine was started and run until reaching 900 rpm to be ready to work properly. Then the starch solution would be transfer into the machine until its full.

The on off switch of machine were design to be connect to limited switch (LM3) which send signal to time counting (T1)which would count the time until starch came dried. When time is up, the circuit will order raising the hydraulic arm and the knife would get rid starch from machine.

As the knife hit the limited switch (LM1), this switch would relay time with second counted time (T2). T2 Arm of knife would back off, hydraulic arm reduce the level down, and the starch solution would get in to machine again to start the new drying round. In this part, the automatic controller was installed with the drying machine by applying Programmable Logic Controller (PLC), the machine works according to design.

In addition, the proximity switch was changed and the function of PLC would be adjusted to suit high speed counter of the drying machine.

III. Results and Discussion

Operation of machinery begins with operating personnel fixing a fabric filter to the machine with a flexible rubber band. The machine is driven with a 50 horsepower motor, moving a C slotted 11 inch speed pulley connected to an 18 inch pulley through 6 C127 industrial belts. Machinery operates at 880 rpm. Operator will then open starch water into flinging machine, which, as named, would fling starch from a hole layering starch onto the fabric.

We tested installing the initial design and tested from 1st May to 8th June 2008, total of 59 days. Found that design had functional lifetime issues from bearing water exposure, operational vibrations, high rotational speed causing wheel-shaft disconnection and shaft deformation from dried starch.

We tested the improved design after installation during 2nd August to 22nd December 2008; functionality totaling 121 days. This design still has problems of failures from operation vibrations.

Comparing the original redesign (fig. 1) and improved redesign (fig. 2), we see that the improved design has much better efficiency, incurring lesser problems and extended functional lifetime up to 62 days.

The cassava centrifugal machine was controlled by PLC designed controller and showed efficiency in machine work.

IV. Conclusion

Redesigning thickness measurement control mechanism of starch flinging machine in potato starch manufacturing line has increased the efficiency and effectiveness of said machine; extending usage lifetime an additional 62 days. The design still has problems involving its bearings, specifically damage from machine measuring operation.

The designed PLC controller could be used in cassava centrifugal machine and helping in reducing labor cost and production time in cassava flour manufacturer.

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