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Microcontrolled Separating Machine

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Abstract - *The central idea of this work is to present the prototype of a machine that separates spheres by weight. This separation is performed by a device that takes the measurement of the weight of two types of spheres of same volume and dimension, in a dynamic and continuous way, and using a microcontroller, separates them into two different containers according to their weight. The spheres are initially mixed in a single container (silo) and the device transfers one sphere at a time, synchronously and in an organized manner. At the same time, the equipment analyzes and verifies the weight of each sphere through a system that monitors the electrical current of a traction motor, where the spheres are then directed into two types of containers according to their respective weight..*

Keywords - *microcontroller, timing system, detection system, separating system*

I. INTRODUCTION TO CONTROL SYSTEMS

This paper presents, in a very simple manner, a common industrial automation practice by using concepts that can be applied to a wide range of industries that require reliability, speed and precise control of variables. We intend to insert these concepts in the construction and programming of an automated machine that separates spheres of different weight into different containers.

1.1. Control System

A control system is basically composed of an input/output (I/O) [1]. The system to be controlled is generally called process or plant. The process is a dynamic system, in other words, its behavior is mathematically described by a set of differential equations. The process input is called either control variable or manipulated variable (MV); and the process output is called the controlled variable or process variable (PV). The basic philosophy of a control system consists in applying suitable signals at the process input in order to make the output signal meet certain specifications and/or provide a particular behavior. A control problem consists in determining the appropriate signal to be applied based on the desired output and knowledge of the process. There are various types of controllers currently available to help develop a control system, among which, the programmable logic controllers and microcontrollers stand out.

In a nutshell, we can define the microcontroller as a "small" electronic component, endowed with a programmable "intelligence" that is used in any logic process control. This process control must be understood as the control of peripheral devices such as LEDs, buttons, display segments, liquid crystal displays (LCD), resistors, relays, a variety of sensors (pressure, temperature, etc..) and many others. The system operation of logic controls is based on the logical sequence of actions that must take place depending on the state of input and/or output devices.

1.2. Microcontrollers

As previously discussed, Microcontrollers are programmable, since all the logical operation is structured in the form of a program and stored within the component. Thereafter, whenever the microcontroller is powered up, the internal program will run. As for the "intelligence" of the component, it can be associated to the Arithmetic Logic Unit (ALU), because it is within this unit that all mathematical and logical operations are performed. The more powerful the ALU component is, the greater its ability to process information will be [2].

Within this definition, the microcontroller even earns the adjective "small", because in a single encapsulated silicon wafer (popularly known as IC or chip) is found all the components necessary to control a process, that is, the microcontroller is provided internally with program memory, data memory, input and/or parallel outputs ports, timers, counters, serial communication, PWMs, analog-digital converters, etc. This is a fundamental feature that sets microcontrollers apart from microprocessors, for the latter, despite having a much more powerful ALU, do not have all these features in a single chip [3].

Today, many equipment of daily use, such as household appliances, videotape players, alarms, cell phones and toys, among others, use microcontrollers to perform their basic functions [4].

1.3. Sensors

A sensor is a device that measures a physical quantity and converts it into variations of some measurable electrical quantity, providing as a result an output signal that is proportional to the variation of this quantity. They can also directly transform one form of energy into another; in this case they are called transducers. The purpose of the output signal of a sensor is only to indicate a measurement or a condition, and hence is not a high power signal. Sensors can change any of their electrical characteristics such as resistance, capacitance or inductance, driven by changes in the quantity; this can happen proportionally, linearly or not linearly, and in the latter case its use may be restricted to a certain region of variation of the physical quantity, outside of which there will not be sufficient linearity. The sensor signal can be used to detect the presence of a material, measure a physical quantity and also to assist in this task [5].

1.4. Actuators

Actuators are devices that are activated to perform a given displacement force or other physical action that is defined by the controlled system through a control action (the way through which the controller produces the control signal). Actuators can be magnetic, hydraulic, pneumatic, electric or of mixed actuation. Examples are valves, pneumatic and hydraulic cylinders, electric motors, heaters, among others [6].

I. PURPOSE OF THIS WORK

The work presented here has as main objective the development of an automated system that performs the process of separating spheres of different weights. As for the specific purpose, the development of the project will use concepts that feature the application of knowledge acquired in the Mechatronics Engineering major, such as physics, electronics and computer science. In addition to applying general concepts of the course, this project serves as the basis for the development of other industrial automation projects.

II. PROJECT DEVELOPMENT

As mentioned above, what is interesting about the fact of separating spheres using a micro controlled machine is that this machine was mechanically designed and developed to work exclusively with 40 mm diameter spherical objects. During the simulations performed by the prototype presented, table tennis “balls”, better known as “Ping-Pong balls” were used as the default size of potential spheres to be inspected by the machine. To differentiate the weight between them, spheres with 2.7g of mass were used for the group of lower weight and to simulate the ones with higher weight, some were filled with liquid thus reaching a mass of 25 grams. Nevertheless, the concept used in this project can be applied to any type of product or article where separation by weight is required. The system itself is fairly simple, however is imbued with a complex synchronization control between motors and a logical sequence that is also found in many applications that use position control such as the control of a motor that drives an elevator, control of a winding machine, position control of synchronous belts, etc.

The process of the machine starts at a small container called silo where many spheres are stored. When the system is turned on, an element called loader tries to synchronously deliver the spheres one by one into the basket of the transfer wheel. When the sphere is transferred to the basket, the system detects whether there is an increment or not of electrical current in the motor of the transfer wheel that exceeds the value set in the microcontroller (set point). If there is an increase, the system detects a sphere of greater weight and this will be deposited in its own container. If no increase is detected, the system interprets it as a sphere of smaller weight and it will allocate it in a second container.

To carry out this type of work, the system has as a fundamental principle the control of the following variables, which are inherent in the timing between loader and transfer wheel: angular velocity of the transfer wheel, angular velocity of the loader, the angular position of the transfer wheel and angular position of the loader.Likewise, for the overweight detection of spheres that have less mass, 2.7 grams, in relation to the ones with larger mass, 25 grams, the variable to be monitored is the electrical current of the transfer wheel motor.Note that these are the key variables for the operation principle of the project. Some other variables must also be monitored and controlled such as time cadence between baskets, work speed and traction force momentum.

III. PROTOTYPE

For ideal operation, the project was divided into 3 parts: Synchronization system, detection system and deviation system:

4.1. Synchronization System

This is the control portion of the system that is responsible for the timing between loader and transfer wheel. It is given by encoders, referencing sensors and DC motors that synchronize the rotation signals (Figure 1).

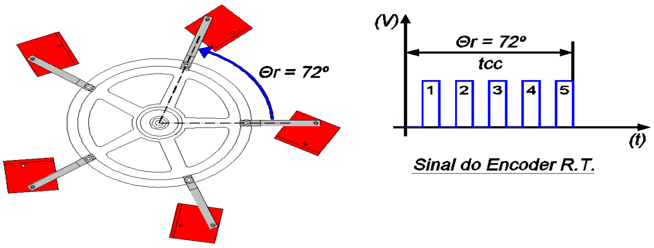

Figure 1 – Synchronization system

4.2. Detection System

Analyzes and checks the weight of each sphere. It is composed of a shunt circuit and a comparator circuit that emits an output signal when the shunt signal exceeds the set reference (Figure 2).

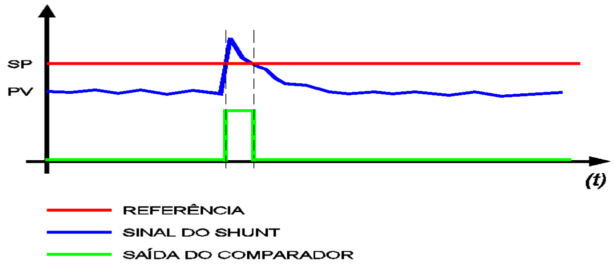

Figure 2 – Comparison of the output signals

4.3. Deviation System

Performs the logic of separation by counting the steps, then emitting a deviation signal (Figure 3).

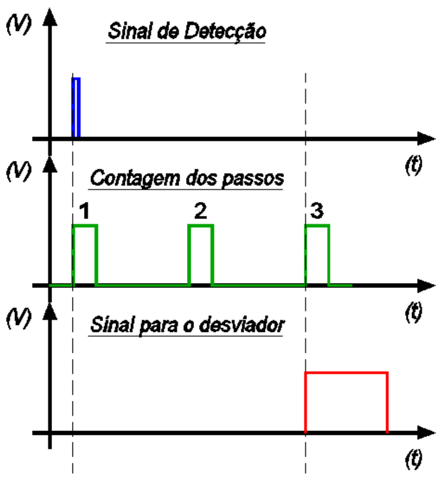

Figure 3 – Timing of deviation.

In order to achieve the objective of the proposed design, a series of evaluations was carried out to show the automation performance of the process of sphere separation by weight in the prototype shown in Figure 4.

Figure 4 – Prototype tested

IV. CONCLUSION

In developing this project we obtain results that were both practical and representative as to the purpose of achieving the separation of spheres by the recognition of their respective weight. However, despite the project not having any commercial purposes, except that of teaching, it can be technically proven that the use of monitored electrical current in electric motors, provided that there are proper calibration parameters and mechanical arrangements, can also be a viable alternative in automated industrial processes for the reading and sensorial analysis of physical quantities of not only mass and weight, but also force, torque, pressure, among others. Moreover, the gathering of electrical current information and the potential use of this signal has become extremely simple, since today, there are numerous equipment dedicated to this purpose in the automation industry.

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