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STUDIES AND EXPERIMENTAL MEASUREMENTS FOR AUTOMATED CONTROL OF CONVEYOR BELTS

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ABSTRACT

The transport of raw from bunkers to the work installations is a very important activity from the technological flow that takes place in a compound feed factory. So it is indicated to exist an automated control of the conveyor belts, to ensure the proper functioning of the work equipment. The experimental measurements were made using an own conception electronic assembly. Thus it was possible to analyze the operating parameters of rotation and proximity magnetic sensors, which can be used to implement devices that allow automated control of conveyor belts. Studies of measurements shown in this article offer the possibility of implementing automated control devices based on magnetic sensors, which allow the transmission of stop signals of motors that drive the conveyor belts at detection of disturbances in their normal operation, to maximize losses of materials.

INTRODUCTION

The accentuated technological boom of the last years and the increase of the population worldwide have determined the appearance of new priorities in the daily life and a radical change of the way of working in all fields of activity, with emphasis on the increase of work productivity correlated with a reduction of physical effort submitted by people. In this context the technical progress had a major impact on the degree of automation and computerization of most of the activities carried out, which determined an increase in the complexity of the command and control operations of the work installations from factories.[2, 6] All these aspects have determined that worldwide there to appear a permanent competition between companies in any field of activity, to ensure sales markets and to meet the growing and diversified needs of customers or consumers.

The evolution of society and population growth have led to an increasing and more diversified demand for alimentary products. A solution to satisfy these demands was offered by zootechnical farms, which have increased the number of animals or birds they raise and diversified their products sold in the profile markets. Automatically, given the need of food for these animals and birds from farms, the compound feed factories also had a rapid development.[8, 11]

The studies and experimental measurements presented in this article were made in a compound feed factory, given the complexity of the technological flow, with several successive activities: storage in bunkers, transport of raw materials, grinding, dosing, mixing, granulation, homogenization, cooling, packing.[4, 10]

For various reasons, unforeseen events can appear during these activities that may disturb the proper functioning. That is why numerous studies and analyzes have been made for the improvement of the work installations in the endowment of the compound feed factories.[1, 9] Thus, certain problems can appear during the transport of raw materials from the bunkers to the work equipment, or during the distribution and dosing of the components used to obtain the various recipes of compound feed. Conveyor belts are used for handling raw materials both inside bunkers and between work installations from compound feed factories (CFF).[10, 11]

Figure 1: Conveyor belts from a compound feed factory

The studies from this article showed the need to use automated devices for command and control of transport belts, to provide the correct quantities for the preparation of desired recipes of compound feed. For the automation of work installations it is proposed to use magnetic speed and proximity sensors, and the results obtained through the experimental measurements presented in this paper attest to the advantage of using automated and computerized command and control devices.

MATERIAL AND METHOD

Material and method. The raw materials and other ingredients needed in the production process are in bunkers, warehouses or deposits. From here they will reach at equipment and work installations with the help of horizontal or inclined conveyor belts.[5] They consist of a rollers succession that form a closed chain, driven in a motion by means of three-phase electric motors with start by type star-delta.[3, 7, 11]

The operation of the conveyor belts in a factory must be very safe, so as to avoid the blockage or loss of raw materials along the route. This safety can be achieved by the automated command and control of the conveyor belts, by using electronic command and control devices implemented with the help of magnetic rotation and distance sensors, as well as contactors or relays.

The studies from this article focused on performing experimental measurements on the operation of the two types of magnetic sensors that are used to implement automated devices for command and control of the operation of conveyor belts.

The principle of operation of magnetic sensors is as follows: it determines the transformation of a non-electrical input size into an electrical output size (voltage). For the two types of magnetic sensors analyzed in this paper, the non-electrical input sizes are represented by the speed of a metal object, respectively by the physical distance in relation to a metal body.[3, 7, 9]

To accomplish this transformation from non-electrical input to electrical output, the internal structure of magnetic sensors has the following components (figure 2): sensitive coils (1); high frequency oscillator (2); bistable circuit (3); electronic demodulation block (4); signal amplifier (5); metal body that changes the length of the magnetic field lines (6).

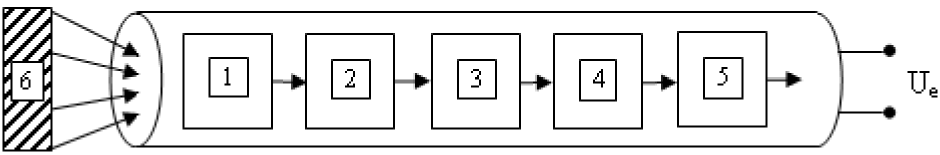

Figure 2: Components of a magnetic sensor

The magnetic sensors always are reported to a metal body according to the diagram in figure 2, their operation being based on the influence of this metal body (6) on the magnetic field generated by the sensing coils (1) fed by the high frequency oscillator (2). The approach of the metal body to the side with the sensitive coils of the sensor determines the change of the magnetic field emitted by these coils, which changes the magnetic impedance of the oscillating circuit. Automatically a damping of the oscillations takes place and automatically generates a change of the inductance of the magnetic circuit, noticed by the bistable circuit (3) initially found in inactive state “0”, which switches to the active state “1” of operation. The electronic demodulation block (4) takes the signals of the bistable circuit and converts them into electrical signals corresponding to states “0” (inactive) or “1” (active) of the output size (figure 3) that can thus be detected by the signal amplifier (5), this being the one that will provide the final value of the output size (Ue) through the built-in circuits (figure 4).

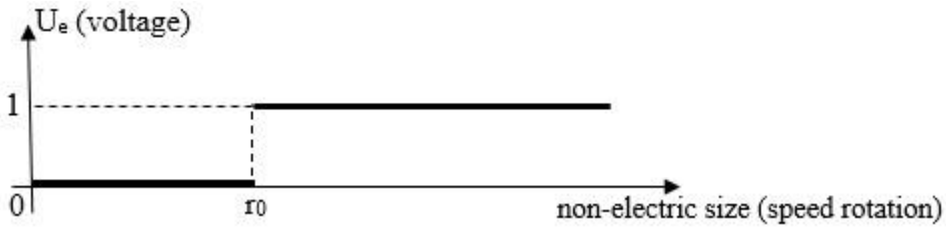

Figure 3: The electrical output size from the bistable circuit of the magnetic sensor

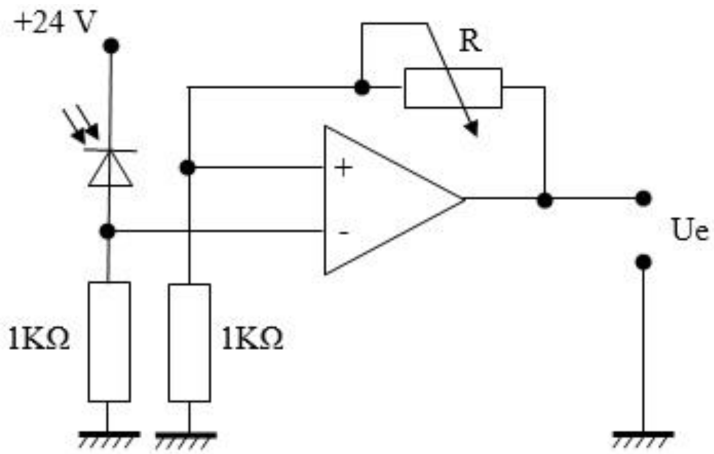

Figure 4: Electronic circuit of amplifier for electrical output size (Ue)

Because the electrical signal produced by the bistable circuit inside the magnetic sensor is very weak in intensity, it will be increased by the amplification module so as to obtain an output voltage which can activate the relays and contactors that drive the motors of the conveyor belts. The operation of these motors is stopped when the conveyor belts are overloaded or the support and guide drums are blocked with raw materials falling during the movement which can cause a deteriorating or even breaking of them. These unpleasant events cause losses by interrupting the production process, but also losses due to the high costs required to repair or replace the conveyor belts.

Studies performed have shown that the two types of magnetic sensors can be used to implement automated devices to control the operation of conveyor belts in factories precisely to avoid such unpleasant events during the technological flow. This article presents the working parameters of some rotation and proximity magnetic sensors, obtained through experimental tests with the help of an electronic assembly of own design. The values thus measured (figure 5) allowed the study of the reaction times to the two types of magnetic sensors used in the construction of the automated control devices of the conveyor belts from the factories.

Figure 5: Determination of the operating parameters for the magnetic sensors

RESULTS AND DISCUSSIONS

The studies presented in this paper started from the premise that in any factory, regardless of the field of activity, there is a movement of raw materials and other ingredients between bunkers and work installations. This activity is made with the help of conveyor belts, which can be critical points in the technological flow of production. Thus experimental research were performed which allowed the implementation of automated command and control devices through the use of magnetic sensors, which constantly monitor the optimal operation of motors that drive the movement of conveyor belts, with the aim of immediate stopping so as to avoid deteriorating or breaking of them.

The electronic assembly made especially for these studies allowed the making of experimental measurements of the characteristic parameters of operation for the rotation and proximity magnetic sensors, used in the construction of automated devices for command and control of transport belts.

The first experimental measurements were made for proximity magnetic sensors. The functional parameters followed were: the distances that allow the detection of the presence of a metal body and after how long is sent the detection signal of that metal body. The results of the experimental measurements are presented in table 1.

Table 1

Times and distances of reaction for proximity sensors

Sensor type	Experimental measurements															
XS112-BLPAL2	Distance [cm]	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2
	Sensor response	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
	Response time [s]	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1	1.1	1.3	1.5	1.8	2	-
X-4017	Distance [cm]	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2
	Sensor response	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
	Response time [s]	0.5	0.5	0.6	0.7	0.7	0.8	0.9	1	1	1.2	1.4	1.7	1.9	2.1	-
XMX-341	Distance [cm]	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2
	Sensor response	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	Response time [s]	0.6	0.6	0.7	0.8	0.9	1	1.1	1.3	1.4	1.6	1.9	2.1	2.2	-	-

The results of these experimental researches show that for the 3 types of proximity magnetic sensors analyzed the maximum value of the distance to which the metal object is detected is about 2.1 cm, and when exceeding this distance the pulses sent by these sensors are stopped. Thus, the disappearance of electrical impulses from the sensor will cause to stop the motor that moves the conveyor belts.

The values of response times depending on the distance between the analyzed proximity sensors and the metal body considered as a fixed landmark is represented graphically in figure 6.

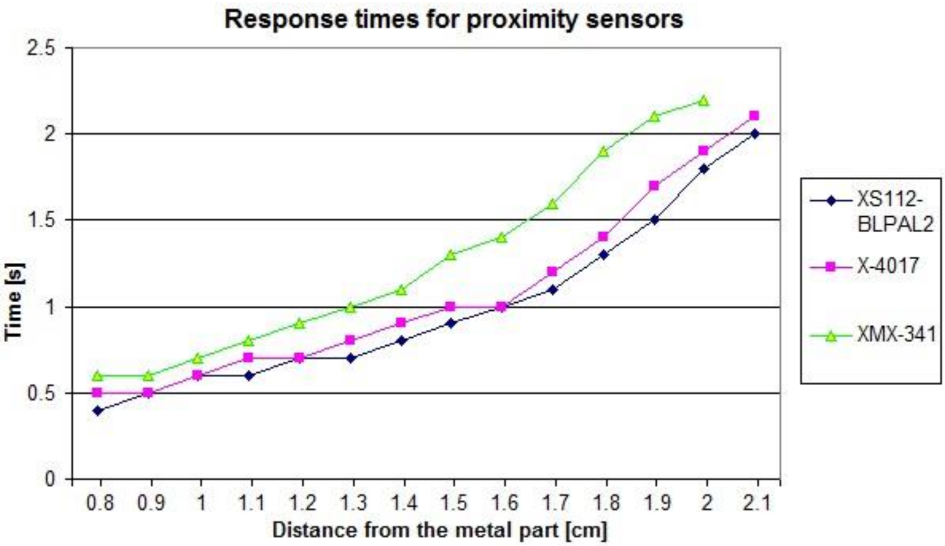

Figure 6: Response times depending on the distance from the metal object to the proximity sensors

During these researches the metal object remained as a fixed landmark and the sensor was moved horizontally using the grip nuts. It started from the initial distance of 0.8 cm between the sensor and the metal object, then the sensor was removed by 1 mm at each experimental measurement, to the final distance of 2.2 mm, when the magnetic sensor did not react. Measurements indicated an increase in reaction time from 0.5 s to over 2 s. For the first two sensors the response limit is 2.1 cm, but with an advantage in response time in favor of the first type of magnetic sensor, which led to its use in the implementation of automated devices for command and control of conveyor belts.

In the second stage of the experiments with this electronic assembly, three models of magnetic speed sensors were also analyzed in this case, to establish the reaction times and the distance until which the sensor detects a metal body in rotating motion (table 2).

Table 2

The functional parameters for rotation magnetic sensors

Sensor type	Experimental measurements																
SPH3A0	Distance [cm]	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4
	Rotational speed [rpm]	149	150	149	150	151	150	152	150	149	150	151	149	150	150	151	150
	Sensor response	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
	Reaction time [s]	1.5	1.9	2.4	2.7	3.1	3.6	4.1	4.3	4.5	4.7	5.1	5.3	5.6	5.9	6.1	-
ROS-P25	Distance [cm]	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4
	Rotational speed [rpm]	148	147	148	149	151	150	150	150	149	150	152	151	150	149	150	150
	Sensor response	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
	Reaction time [s]	1.4	1.7	2.2	2.5	2.9	3.3	3.8	3.9	4.1	4.3	4.8	5.1	5.3	5.5	5.8	-
ST420	Distance [cm]	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4
	Rotational speed [rpm]	149	149	149	148	149	149	150	151	149	150	151	149	151	150	149	150
	Sensor response	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
	Reaction time [s]	1.6	2.1	2.6	2.8	3.2	3.9	4.1	4.4	4.8	5.2	5.4	5.6	5.9	6.2	6.4	-

The sensors were mounted on a threaded support, which allows to adjust the distance between them and the metal object being in a rotating motion. The external threads of sensors allowed the made of experimental measurements in the range of 0.9-2.4 cm, for rotational speeds of the metal part between 148-152 rot/min, which were monitored using the EBRO DT-2236 tachometer. The results obtained by these experimental measurements indicated a reaction capacity of these sensors up to a distance of 2.3 cm, with a gradual increase in reaction times from 1.5 s to a maximum acceptable value of 6.3 s. Studies have confirmed a faster reaction time for the second type of sensor. That is why the ROS-P25 model was indicated for the implementation of an electronic device for command and control of the conveyor belts.

A graphical representation of the reaction times for the magnetic sensors analyzed as a function of the distance and rotational speed of the metal body attached to the drum of a motor is provided in figure 7.

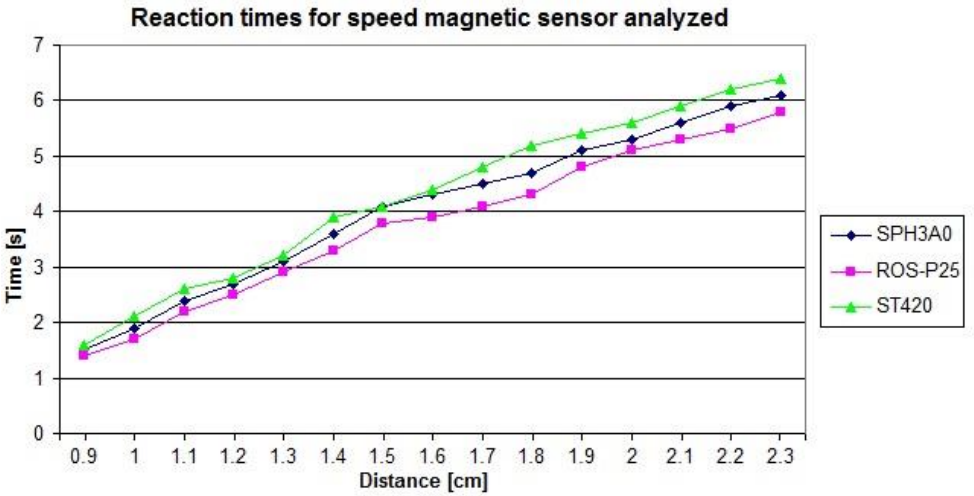

Figure 7: Sensor response times as function of distance and rotational speed

CONCLUSIONS

In any factory, regardless of the field of activity, the work performances are determined by the quality of the technical equipment used, by the possibility of an automated and computerized control and by the reliability and efficiency during the technological flow.

Given that most factories purchase modern installations, there is a growing trend towards rigorous control of each activity carried out by the equipment, so as to eliminate as much as possible any problems that may occur at the work installations. The studies presented in this article confirm that these trends are also followed in the case of activities carried out with the help of conveyor belts.

The objective of this article is to study the possibilities of automated and computerized command and control of conveyor belts in a factory, by designing and implementing electronic devices based on rotation and proximity magnetic sensors and by developing computer programs to follow these activities of transport.

Due to the complexity of the production process, which involves travel from warehouses and bunkers to work equipment, all the studies and analyzes presented in this article were carried out in a compound feed factory. The results of experimental measurements obtained confirmed that installations with automated and computerized control minimize the risks of interruptions of activities in the technological flow and avoid losses of raw materials or other ingredients, allowing to obtain the desired compound feed recipe.

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