AUTOMATIC SYSTEM FOR CONTROLLING A BELT CONVEYOR OF A PVC BAKING MACHINE

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ABSTRACT: Present paper describes a solution of automation for a belt conveyor type used in material baking. Conveyors are used in many industry fields, where material handling in time expensive or involves various risks for human factor, and are of different types, according to the nature of their use. Main concern in designing belt conveyors is speed adjustment. The proposed solution is implementing an automated system which involves a PLC and a variable speed driver. Most significant steps in designing and implementing the entire conveyor system are depicted. The solution is specific to applications that imply material baking, PVC in this case, but it can be adjusted to other similar uses.

KEY WORDS: conveyor belt, automation, PLC, variable speed, drive.

1. BELT CONVEYERS

Belt conveyers are reliable tools used in a large variety of industrial processes in terms of time and human factor safety. Often are used as part of a production system which involve processing and transportation of heavy, risky bulk material between two different areas of production system. These are usually driven by electrical motors with variable speed or other drives, parts of a complex system [1,6].

Belt conveyers functioning is based on the principle of variable speed controlling. If a conveyor belt moves too slow one can expect losses in terms of number of finished goods. As well, if a conveyor belt moves too fast, the risk of harming involved human factor increases or parts of conveyor system can be damaged [2,8-12].

A great deal of time is often consumed with adjusting belt conveyers speed, according to production needs and process particularity.

Thus, conveyor speed has a great influence upon a certain production system in which synchronizing two or more process stages is required.

For a general case scenario, main parts of belt conveyers are: conveyor belt, carrier idlers, conveyor drive end drum, return idlers, drum bend pulleys. The conveyor belt moves along carrier idlers which are driven by an electric motor by means of a variable speed drive and of a gearbox.

There are particular types of conveyers, depending of industrial application, types which have a more complex architecture, according to process nature.

Present paper presents a solution of automatic system for controlling a belt conveyor speed of a PVC baking machine. Conveyor functioning is influenced by processing parameters such as baking machine temperature and baking time of PVC material. For designed belt conveyor it will be designed automatic system for speed controlling by means of PLC. The conveyor is used as part of process of production for domestic anti-slip door mats[12-19].

2. SYSTEM HARDWARE DESIGN

As mentioned, belt conveyor designed for this application, shown in figure 1, is used for the

process of baking PVC material. Belt conveyor is structured in two main parts [4]:
- baking part which has a length of 15 meters, formed of five sections of 3 meters each, provided with two burners of 540 W, mounted on the two sides of the belt.

- cooling part which is 15 meters long, formed of four sections of 3 meters each provided with 4 groups of 6 coolers/group, each cooler having 380 W.
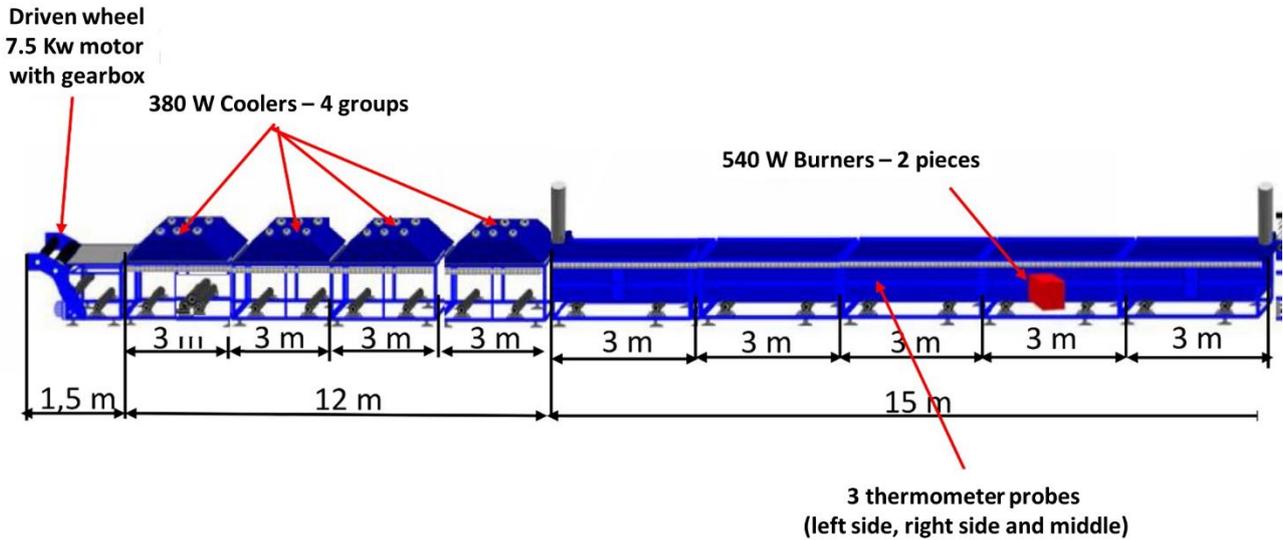

Figure 1. Belt conveyor design

The automatic controlling system of conveyor belt is provided with a 7.5 Kw three-phase motor drive having a maximum speed of 750 rpm, a slotted wheel fixed on motor drive, a gearbox having a transmission ratio of 64.7,

allowing speed controlling. For automation a M221 Schneider Electric PLC and a Altivar ATV930 variable speed drive are used. The automation process is depicted in figure 2.
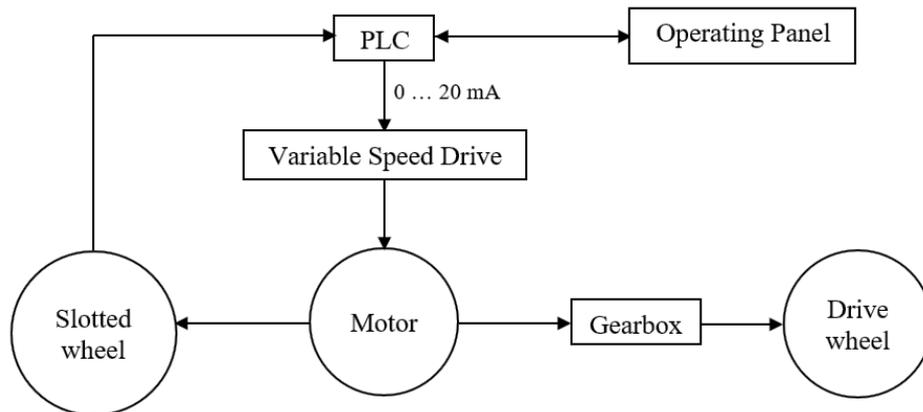

Figure 2. Functioning block diagram of automatic system

In order to determine the operating parameters of the system, we consider as input data the maximum motor speed, n_{1max}=750 rpm, the speed transmission ratio, i=64.7, the diameter of the drive-end drum, D=0.3 m.
The maximum output speed of the gearbox, n_{2max}, is determined with relation (1):

$$i = \frac{n_{1max}}{n_{2max}} \qquad (1)$$

For considered gearbox maximum output speed is n_{2max}=11.59 rpm.
Using drive-end drum diameter value we can calculate maximum speed of conveyor belt, with following relations [3]:

$$l = \pi \cdot D = 3.14 \cdot 0.3 \, m = 0.942 \, m \qquad (2)$$

$$v_{max} = \frac{n_{2max} \cdot l}{t} = 10.91 \frac{m}{min} \qquad (3)$$

where:

l=unfolded diameter of drive-end drum

n_{2max}=maximum speed of gearbox

t=time unit considered for conveyor belt movement.

The speed of the conveyor belt is influenced by the parameters of the system used. In the case of the current application, as we established earlier, the parameters that influence the speed of the conveyor belt are the oven temperature, the baking time of the transported material.

Using as input data the values of the previously calculated operating parameters and correlating these values with the operating range of the PLC we used, we can vary the speed of the conveyor belt, depending on the need of the application (parameters that influence the system).

In order to be able to adjust the speed of the conveyor belt, the automatic system needs to know the input speed n_1 of the motor. The motor speed calculation formula is:

$$n_1 = \frac{60 \cdot f}{p} \qquad (4)$$

where:

f is the output frequency of the variable speed drive

p is the number of pole pairs of the stator winding.

For this application, standard grid frequency is 50 Hz and, for this value, number of pole pairs is p=4.

For automatic control, it is necessary to enter a parameter that corresponds to the speed of the conveyor belt motor and the control measure. This is implemented using a 16-tooth slotted wheel that attaches to the motor shaft and a wheel-mounted pulse transducer that transmits pulses to the input of the PLC counter.

The operator can adjust the speed of the belt movement from the operator panel (figure 2). The M221 Schneider Electric PLC, shown in figure 3, processes the data in the reverse order of the previous calculations. Thus, having a desired value for the speed of the belt, the speed of the gearbox is calculated. With this value the speed at which the motor has to work is obtained. This speed value determines the output frequency of the variable speed drive.
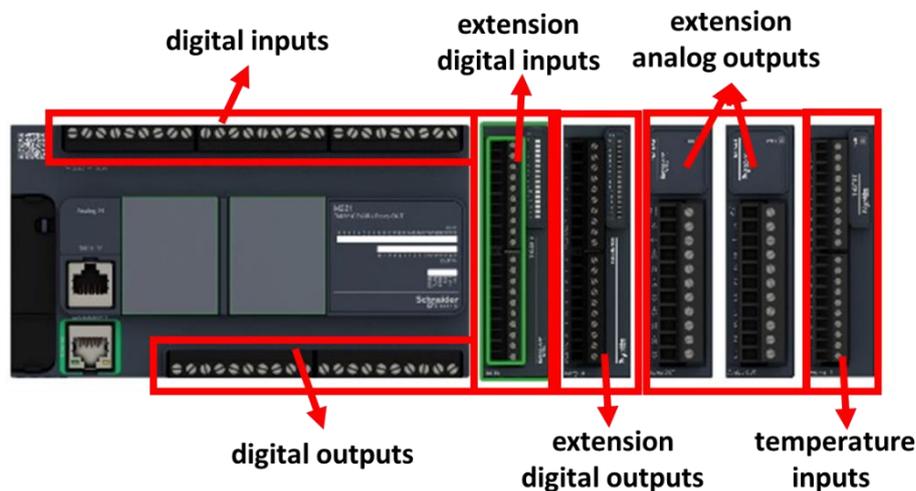

Figure 3. M221 Schneider Electric PLC

Using the operating range of the PLC, the correlation is made between the speed value and the counter value that the PLC transmits as a command to the variable speed drive that translates the data and transmits the signal to the motor.

The PLC reads the signals from the operator panel, where the operating parameters of the conveyor belt are set by the operator. The signals are processed in the PLC and commands are transmitted to the variable speed drive by a unified signal 0...20 mA [5].

The Altivar ATV930 variable speed drive, shown in figure 4, receives the command from the PCL on the analog inputs and processes it internally according to the parameters set at start-up (motor power, motor operating speed, starting ramp, stop ramp, grid frequency). The output of the variable speed drive results in a motor supply voltage with a frequency adapted to the input signal to determine the motor speed.
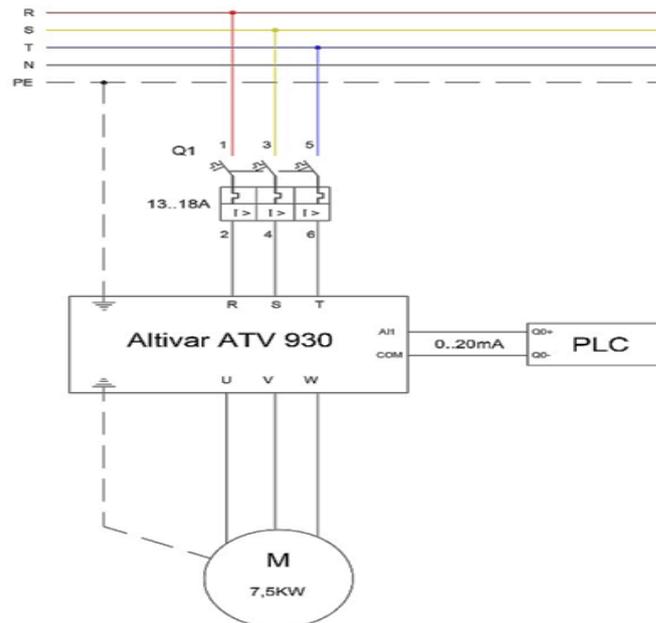

Figure 4. Electric scheme of variable speed drive connections

To verify if the actual speed of the conveyor belt corresponds to the value set from the operating panel, it is use the slotted wheel connected to the motor shaft and the pulse transducer that measures this speed and compares it with the speed set in the operator panel. If the difference between the speed value set from the panel and the read speed of the conveyor belt is greater than an imposed prescribed limit then it must be checked whether the drive wheel diameter or the gear ratio is correctly set in the PLC. All parameters involved in the automatic adjustment stage of the conveyor belt are set from the operator panel.

The motor drives the gearbox to reduce the speed and transmits it to the conveyor belt by means of the drive wheel (see figure 2).

3. IMPLEMENTING SOLUTION

The belt conveyor was implemented according the design, consisting of two main parts, baking part and cooling part, as it can be noticed in figure 5.

Figure 5. Belt conveyor for PVC baking

Operating panel (figure 6.a) is set at the start of belt conveyor. Here, the conveyor operating parameters are set, as well as conveyor speed is adjusted. After the new speed value is given, it is transmitted as digital data to PLC (figure 6.b) which processes received data, converts it into analog and sends the results as command to variable speed drive (figure 7.a).
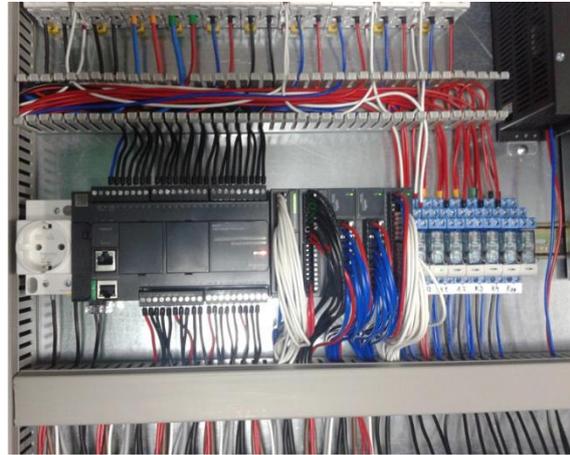
Figure 6. a) Operating panel; b) PLC wiring

Variable speed drive sends to asynchronous motor drive (figure 7.b) a supply voltage with the frequency adjusted to input signal from the operating panel. The motor drive is mounted at the end of the cooling part of belt conveyor. The slotted wheel is fixed on motor shaft. The motor engages the gearbox in order to reduce the speed, which is transmitted to conveyor belt by means of drive wheel.

Figure 7. a) Variable speed drive; b) motor drive

4. CONCLUSION

The belt conveyor controlled with automatic system presented in this paper is designed for production of anti-slip door mats which are mainly used at inside door, decorative purpose, etc. Conveyor design can be adjusted according to other production processes from a similar industry field. Main advantage brought by conveyor system designed and implemented is the high precision in speed adjustment assured by automation, mainly by the PLC and variable drive speed.

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