RESEARCH OF METHODS OF OBTAINING A VARIED SPEED RANGE OF CONVEYORS USED IN THE FOOD INDUSTRY, BY ADJUSTING THE SPEED OF THE DRIVE ENGINE

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ABSTRACT

The choice of the type of installation depends on the physical-mechanical properties of the load, the direction and length of the route, the nature of the working environment, the technical-economic parameters of the process. The characteristic feature of the transport of materials in the food industry is their large volume and relatively short distance to be transported. This involves a large volume of loading and unloading works, which usually, together with the actual transport operation, takes approx. 20-30% of the total volume of operations performed. The speed of the conveyor is chosen according to the type of products transported, as well as according to productivity. For this reason, it is necessary to design and build modern systems for driving and automating the transport facilities used in the food industry, which ensure a wide range of working speeds.

INTRODUCTION

Since the 1990s, asynchronous motors have been introduced in most electric drives. This was possible due to the exceptional performance of some electronic power devices, IGBT transistors, GTO thyristors. Also the asynchronous motor with short-circuited rotor is very good in electric drives because it is robust, easy to maintain and consists of few components. The energy exchange between the stator and the rotor is done without mechanical parts in contact, so that there are no limitations from this point of view, regarding the power and speed.

The drive of the conveyors is done with three-phase asynchronous motors, calculated to operate in continuous mode. The power of the drive motor depends on the productivity of the conveyor, its construction, the lifting height at which the material is to be transported, as well as the type of material transported.

Transport speed is a characteristic parameter of conveyors. The speed of the belt is chosen according to the type of products transported, as well as according to productivity.

For transporting loads in pieces, lower transport speeds will be selected than for bulk loads, as follows (Hapenciuc M., 2004):

Table 1

Recommendations for choosing the speed of the belt

Task to be transported	Speed (m/s)	Task to be transported	Speed (m/s)
Wheat, rye, barley, oats, corn	**2,5 – 4,5**	Soybeans	**2,5 – 3,5**
Sunflower seeds	**2 – 2,5**	Corn cobs	**1,5 – 1,75**
Semințe bumbac	**1,5 - 2**	Grain waste	**0,8 – 1,2**

after (Hapenciuc M., 2004)

MATERIAL AND METHOD

The experimental research was carried out with the aim of designing, realizing and implementing in the structure of some often used transport systems in the food industry, control schemes meant to considerably improve the working parameters. The objective of the experimental research was to study efficient methods for obtaining a wide range of conveyor speeds by adjusting the speed of the drive motor.

During the experiments, the following variants were studied (which present particularly important aspects, in electrical and mechanical dynamics) regarding the possibilities of obtaining a varied range of conveyor speeds, by adjusting the speed of the drive motor:

- the method of adjusting the speed of an asynchronous motor with coiled rotor, by means of a rheostat inserted in the rotor circuit;
- the method of adjusting the speed of an asynchronous motor with short-circuited rotor, by means of a static frequency converter.

1. The method of adjusting the speed of an asynchronous motor with coiled rotor, by means of a rheostat inserted in the rotor circuit

For asynchronous motors with a coiled rotor, the speed can be adjusted when operating in load by means of a three-phase rheostat inserted in series in the rotor circuit. With the variation of the resistance of the rotor circuit, the maximum torque remains practically unchanged, and the sliding corresponding to this torque changes.To study this method, the scheme of figure 1 was made (the asynchronous motor being coupled to the shaft with a direct current generator, with separate excitation).

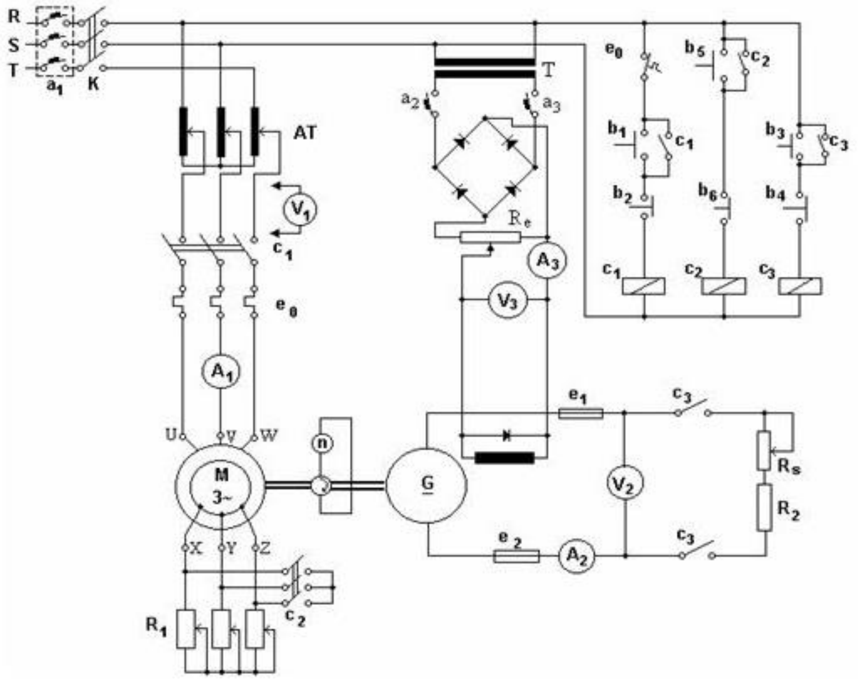


Fig. 1. Scheme for adjusting the speed of an asynchronous motor by means of a rheostat mounted in the rotor circuit.

The asynchronous motor is started by the progressive increase of the supply voltage with the help of the autotransformer AT, the rheostat R_1 being short-circuited (C_1 closed) and the d.c. generator with the unwinding excitation non-powered. Asynchronous motor being supplied at nominal voltage, the decoupling of C_2 is ordered (R_1 in the position correspond to zero resistance). It will gradually increase the resistance value of the rheostat R_1 and measure the speed of the asynchronous motor at different values of the resistance introduced in the rotor circuit. The cursor of R_1 will be returned to “zero” position.

The rheostat slider R_e will be moved to the position corresponding to the minimum excitation voltage, then close the circuit breakers a_2 and a_3. By pressing button b_3, it is ordered to engage the contactor C_3, which connects the load to the generator terminals. There are two charging regimes for the generator and implicitly for the asynchronous motor, from low to high: Mr1 <Mr2.

For each of the two values of the resistive torque, the speed of the asynchronous motor is adjusted (by means of the rheostat R_1) and the speeds for different values of its resistance are measured.

The technical characteristics of the drive motor subjected to experiments are presented in table 2. The motor can be used to drive belt conveyors.

Table 2

Technical characteristics of the asynchronous motor with the coiled rotor

N_o	**Engine Type; operation**	**Symbol**	**ASI 2.0**
1	Rated power [kW]	$\mathbf{P_n}$	2,0
2	Rated voltage [V]	$\mathbf{U_n}$	380
3	Rated current [A]	$\mathbf{I_n}$	6
4	Nominal frequency [Hz]	$\mathbf{f_n}$	50
5	Nominal speed [rot/min]	$\mathbf{n_n}$	1275

2. The method of adjusting the speed of an asynchronous motor with short-circuited rotor, by means of a static frequency converter.

In frame of this method, for speed regulation it is necessary to interpose between the primary electrical network and the motor a static converter, which converts the energy at constant parameters U_1=ct, f_1=ct, into energy with variable parameters: f_2=variable, U_1/f_1 = ct. (fig. 2).

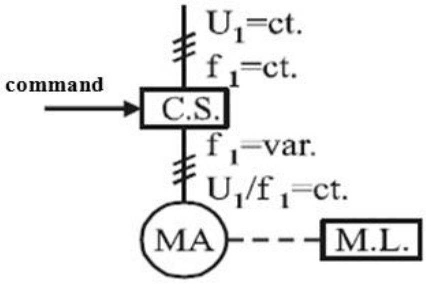


Fig. 2. Schematic diagram of the open circuit system.

Static frequency converters (CFS) transform energy from three-phase fixed voltage and frequency network into an alternating current energy with variable voltage and frequency. The electrical scheme of the CFS is shown in figure 3.

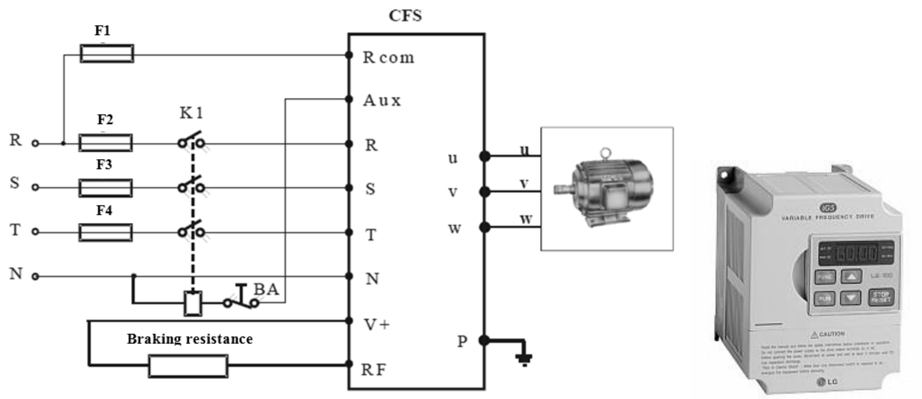


Fig. 3. The electrical connection scheme of the CFS. braking resistance fuses

In conclusion, a general structure of such an electric drive with asynchronous electric motor (which ensures the adjustment of the asynchronous motor speed) must include the following basic equipment (Rădulescu C., Nicolescu E., 1981; Saal C., Szabo W., 1981):

- electric drive motor of asynchronous type (with short-circuited rotor), MA;
- the mechanical reducer, which is interposed between the asynchronous motor and the transporter, RM;
- static voltage and frequency converter, CFS.

The technical characteristics of the drive motor subjected to experiments are presented in table 3. The motor also can be used to drive belt conveyors.

Table 3

Technical characteristics of the asynchronous motor with short-circuited rotor

N_o	**Engine Type; operation**	**Symbol**	**AT 7.5**
1	Rated power [kW]	P_n	7,5
2	Rated voltage [V]	U_n	380
3	Rated current [A]	I_n	11
4	Nominal frequency [Hz]	f_n	50
5	Nominal speed [rot/min]	n_n	1450

In order to determine the values of the transmission speeds, obtained by modifying the speed of the electric drive motor by the two studied methods, the following will be taken into account:

- the diameter of the actuating drums for rubber bands is established based on the relation:

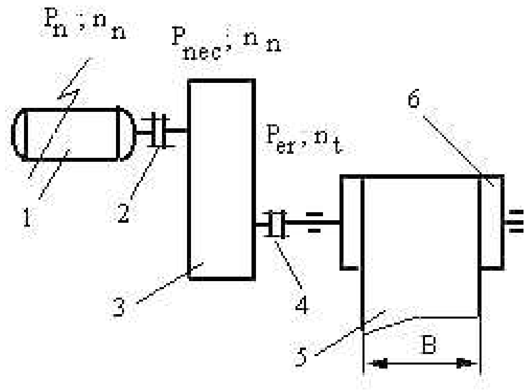
$$D>(125 – 150)\cdot i \qquad (1)$$

where i - the number of layers of the strip. In the studied example D = 375 mm.

- the transmission ratio of the movement from the motor to the conveyor belt (by means of the reducer) is calculated with the relation (fig. 4) (Palade V., Constantin V., Hapenciuc M, 2003):

$$i=n_n/n_t \qquad (2)$$

where: n_n - speed of the electric motor, n_t - speed of the drum shaft. In the studied example i=6,3.



after (Hapenciuc M., 2004)

Fig. 4. Kinematic scheme of the mechanical transmission: 1-electric motor; 2-coupling I; 3-speed reducer; 4-coupling II; 5-conveyor belt.

RESULTS AND DISCUSSIONS

Based on the speed values of the drum shaft and taking into account its diameter, the values of the speed of the belt conveyor (obtained by changing the speed of the electric drive motor) shall be calculated.

Table 4 shows the speed values of the electric drive motor, obtained with the help of the rheostat inserted in the rotor circuit (for different values R_1 of its resistance).

Table 4

The values of the speed of the electric drive motor, obtained with the help of the rheostat inserted in the rotor circuit

R1 values of the resistance of the adjustment rheostat					
R_1=0	R_1=0,2 R_{1max}	R_1=0,4 R_{1max}	R_1=0,6 R_{1max}	R_1=0,8 R_{1max}	R_1= R_{1max}
The speed values of the drive motor n_n (rot/min)					
n_n=1275	n_n=940	n_n=720	n_n=460	n_n=240	n_n= 120

Table 5 shows the values of the conveyor speed obtained by changing the speed of the electric drive motor, with the help of the rheostat inserted in the rotor circuit.

Table 5

The values of the conveyor speed obtained by changing the speed of the electric drive motor, with the help of the rheostat inserted in the rotor circuit

Prescribed sizes: - motion transmission ratio (from engine to reducer) **i=6,3** - the diameter of the drive drum **D=375 mm**				
Drive motor speed n_t (rot/min)	**Drum drive speed n_t (rot/min)**	**Drive drum frequency υ (s^{-1})**	**Angular speed of the drive drum ω (rad/s)**	**Transport speed V (m/s)**
1275	202,3	3,37	21,1	**3,94**
940	149,2	24,8	15,6	**2,92**
720	114,2	1,90	11,90	**2,23**
460	73,0	1,21	0,63	**0,31**
240	38,0	0,63	3,98	**0,74**
120	19,0	0,31	1,00	**0,37**

The analysis of the results obtained shows that the values of the speed of the conveyor obtained by changing the speed of the electric drive motor fit perfectly in the range of permissible values (0,4 ... 4,5 m / s, taking into account the type of load transported). Table 6 shows the values of the conveyor speed obtained by changing the speed of the electric drive motor, using a static frequency converter.

Table 6

The values of the conveyor speed obtained by changing the speed of the electric drive motor, using a static frequency converter

Prescribed sizes: - motion transmission ratio (from engine to reducer) **i=6,3** - the diameter of the drive drum **D=375 mm**				
Drive motor speed n_t (rot/min)	**Drum drive speed n_t (rot/min)**	**Drive drum frequency υ (s^{-1})**	**Angular speed of the drive drum ω (rad/s)**	**Transport speed V (m/s)**
210	33,3	0,55	3,45	**0,64**
450	71,4	1,19	7,47	**1,40**
690	109,5	1,82	11,46	**2,14**
920	146,0	2,43	15,28	**2,86**
1380	219,0	3,65	22,92	**4,29**

The analysis of the obtained results highlights also in this case the fact that the values of the conveyor speed obtained by changing the speed of the electric drive motor (by means of a static frequency converter) fall perfectly within the range of permissible values 0,4 ... 4,5 m/s, taking into account the type of load transported).

CONCLUSIONS

The widespread use of different types of transport systems in the food industry, involves the large-scale automation of the work process provided by them, in order to maximize the efficiency, safety and control of this process, which involves approx. 20% of the total volume of works (operations) performed.

The analysis of the results obtained in the case of research carried out in order to obtain a wide range of speeds of belt conveyors by adjusting the speed of the electric drive motor reveals the following:

- the values of the conveyor speed obtained by adjusting the speed of an asynchronous motor with coiled rotor by means of a rheostat introduced in the rotor circuit fit perfectly in the range of permissible values (0,4 ... 4,5 m/s, taking into account the type of load transported);
- the values of the conveyor speed obtained by adjusting the speed of an asynchronous motor with short-circuited rotor, by means of a static frequency converter are also within the range of permissible values specific to the transported load.

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