

Simulation Model for a Waste Transportation System

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Abstract: - Continuous transport of waste on relative large distances, in different planes is a key problem of a sustainable waste management. A multi-section belt conveyor of cascade type is the best solution that enables a combined route, consisting of horizontal zones, sloped zones, connected by curve areas. Belt conveyors drive is usually performed through assemblies of type converter – three phase induction motors, designed to work under long term. The motor power depends on the transport productivity, as well as on its design, the lifting height, the distance to be transported the material and the type of material transported. Performance of such a continuous transport system can be pointed based on a numerical simulation model built by a software performance. MST numerical simulation model that we have conceived is based on MATLAB with its extensions SIMULINK and SimPowerSystems.

Key-Words: - belt conveyor, induction motor, MATLAB, solid waste, static converter

1 Introduction

Since the 1990s the induction motors have been included in most of electric drives. This became possible due to the spectacular performance of power electronics, as IGBT transistors and GTO thyristors. One could also note that cage rotor induction motor is highly used in electric drives since it is robust and reliable since it has few components. The transfer of energy between the stator and rotor is carried out without a mechanical contact, so that there are no limitations on power and speed, from this point of view. This type of induction motors can reach megawatts power of MW order, [4, 6, 8-9, 15-17].

Calculation of motor power that drives belt conveyors could be determined with the relation below:

$$P = \frac{Q \cdot H}{367} + \sqrt{Q} \cdot 0.13(1.3 + m) + 0.001 \cdot \sqrt[3]{Q \cdot L} \quad (1)$$

in which: Q is the conveyor productivity [t/h];

H is the lifting high [m];

m is the number of conveyor rollers;

L is the conveyor length [m].

Transportation speed v is another specific parameter. The belt speed must be chosen depending on the type of transported products, as well as on the productivity. In order to transport loads in pieces there must be adopted lower transportation speeds than in the case of the bulk loads [11-13].

Continuous transport of waste on relative large distances, in different angle planes is a key problem of a sustainable waste management. The optimum solution for c continuous transport on horizontal or on a direction at a 5-25° angle to the horizontal (for instance) is based on a belt conveyor consisting of several autonomous sections connected in cascade.

In the case of inclined conveyors the sloping angle of belt is considered depending on the transported load characteristics, as well as on the angle of friction of the transported material with the belt, the magnitude of the natural slope angle, the transportation speed and the transport supply characteristics.

The drive system of a performant belt conveyor is based on the assembly of type variable voltage variable frequency converters + three-phase induction motors. Nowadays the design of such systems is correlated to numerical simulation modeling in order to evaluate the performances of the drive system for the continuous transport with belt conveyor.

The software used for this simulation model is MATLAB with the extensions Simulink and SimPowerSystems.

2 Material and methods

A. General structure of electromechanical drive

The general structure of an electromechanical drive with induction (asynchronous) motors are encompassing the following components:

- electric drive motor **MA**;
- mechanical gear **RM**;
- voltage / frequency converter **CTF**.

In Fig. 1 it is depicted the general structure of a drive system with asynchronous motor and static converter, [4, 9, 11, 13].

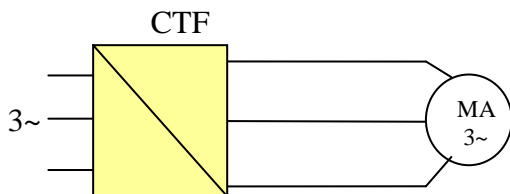


Fig. 1 General structure of an electric drive

The voltage and frequency static converter CTF is conceived in a complex electronic configuration and its role is to provide the electric energy with variable parameters to the electric asynchronous motor MA. Usually CTF is composed of a three-phase bridge rectifier followed by an intermediary circuit of type LC filter and a voltage or current inverter. The power static converter of type AC-AC encompasses power electronics of high power and voltage. The block structure of a voltage and frequency static converter is depicted in Fig. 2, [8, 15-16]. One can notice in Fig.2 the fundamental elements of the block electronics scheme as below:

- the three-phase rectifier **RT**;
- the intermediary circuit **CI**;

- the three-phase inverter **IT**;

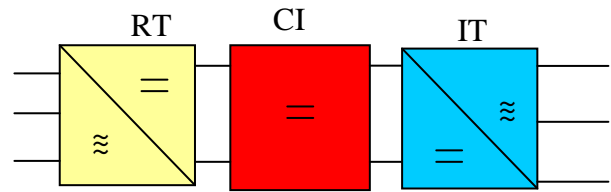


Fig. 2. Block electronic scheme of converter CTF

The technical parameters of the drive motor chosen for building the simulation model (AT 7.5) are presented in Table 1. the motor is manufactured by de SC BEGA ELECTROMOTOR Timișoara and can be used in driving the belt conveyors.

Table 1. Technical parameters of asynchronous motor

No.	Drive parameters	Motor 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	Rated frequency [Hz]	f_n	50
5	Rated speed [rpm]	n_n	1450

According to www.electromotor.ro/ro/produse

The manner of mechanical transmission of the rotating movement from the drive motor to the conveyor belt is depicted in Fig.3 [11-13].

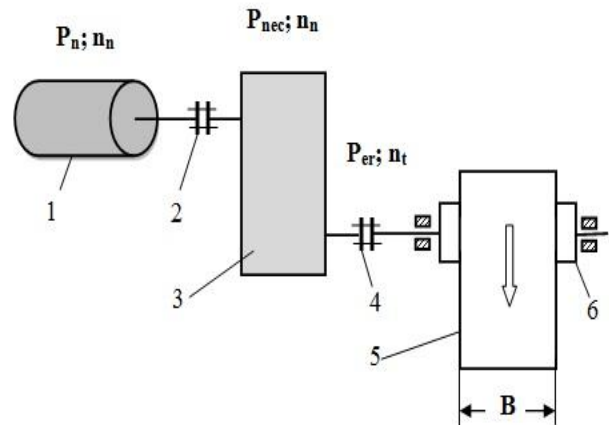


Fig. 3. Cinematic scheme of mechanical transmission: 1- motor; 2, 4- coupling; 3- reducer; 5- conveyor [11-13].

B. Command scheme of a conveyor consisting of three sections

When transportation is carried at large distances, transports with strips are achieved with 2-3 or more sections, each section being driven by a separate electric motor, [1-3, 10, 14]. The command to start of these machines can be made from a centralized point, or at various places. Whatever the mode of command of electric motors it is necessary that the command scheme to be achieved the control scheme

in such a way that the start of different sections to be made from the first to the last section. This way of working is chosen in order to avoid crowding of material transported in some points and hence its loss on tape.

It is obvious that if the start begins from the penultimate section to the last, there would be the possibility that if one of the sections would not start for any reason, the material from the previous section (which will fall to the anterior portion of the section which did not start) tends of agglomeration to falling on the tape.

To avoid this inconvenience has been designed and realized the corresponding command schemes of electric motors actuators.

Fig. 4 shows an electric power scheme of the conveyor consists of three sections, each section being driven by an electric motor.

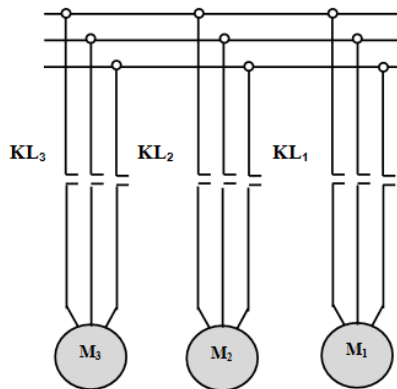


Fig.4. Electric power scheme of conveyor (3 sections)

Fig. 5 shows a command scheme of the conveyor.

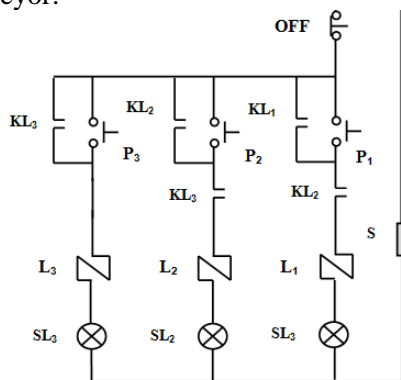


Fig.5. Command scheme of the conveyor (3 sections)

The command to start of the machines shall be carried out with the help of three buttons P1, P2, P3. Through the operation of these buttons are closed circuits of coils of electric contactors (L1, L2, L3), which ensuring the coupling of electric motors in the power grid. According to the scheme of the electrical principle, it can be seen that the starting of

electric motor M1 (by pressing the power button P1) it is not possible until the closing lock contact KL2 (from the circuit of coil of electric contactor L1). Also contact KL2 cannot be closed unless it is closed contact KL3 (from the circuit of electric contactor L2), [11-13].

In conclusion, the command scheme requires the following sequence of commands:

- pressing power button P3, for the entry into service of the contactor L3 (in preparation for the contactor L2);
- pressing power button P2, for the entry into service of the contactor L2 (in preparation for the contactor L1);
- pressing power button P1, for the entry into service of the contactor L1;

This way of working ensures starting machines in order of M3-2 -1, any other starting order can not be possible. Stopping actuation conveyors shall be carried out with the help of a stop button OFF [3, 8].

C. Model MST for an electric drive system

The numerical simulation model MST is presented in Fig. 6.

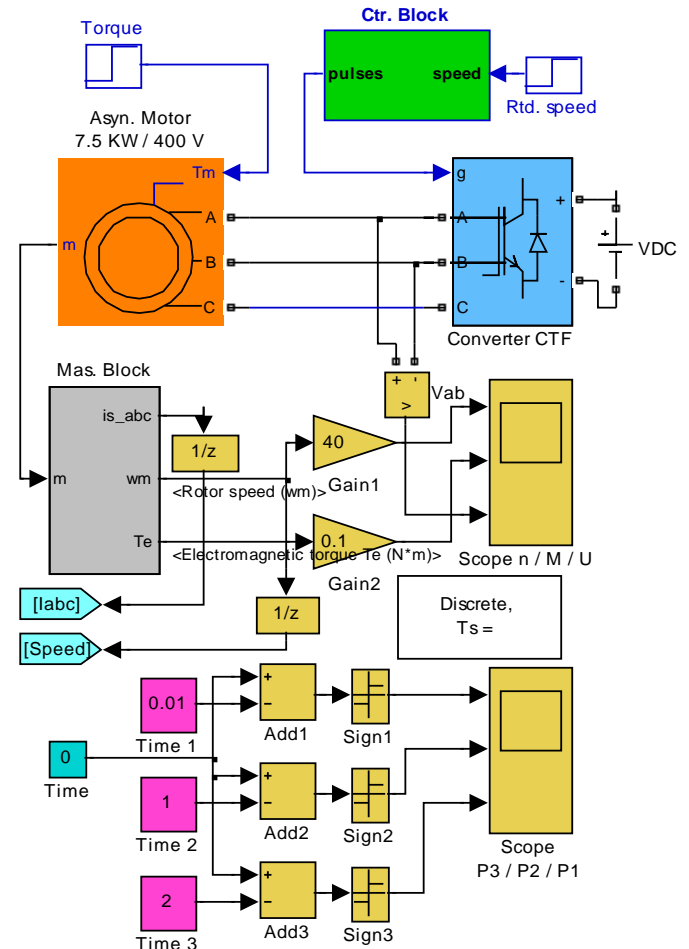


Fig. 6. Model MST in Matlab Simulink.

In this study the possibility to obtain distinct values of transport speed has been analyzed through the numerical simulation of the electromechanical drive system on a simulation model achieved with MATLAB and its extensions SIMULINK and SimPowerSystems. One could recall that the software MATLAB encompasses in the extension SimPowerSystems several libraries as: SimPowerSystems - *Power Electronics*; SimPowerSystems - *Machines*.

3 Results and discussions

A. Command scheme of conveyor with three sections

To verify the correct operation of the command scheme (to ensure the startup of electric motors in order of M3-M2-M1) there were mounted signal lamps SL1, SL2, SL3. These lamps were mounted on coils circuit of switching contactors from run-down (L1, L2 and L3), to flag closing of the circuit and the power supply to the electric motor controlled by this circuit.

The results of the tests concerning the operation of the control system are shown in Fig. 7 and Table 2. Also can be designed and achieved command schemes with three buttons, which ensure the stopping of the machines in reverse order of startup (M1-M2-M3). The advantage of stopping electric motors in reverse order of startup consists of the evacuation of all material that is on the tape.

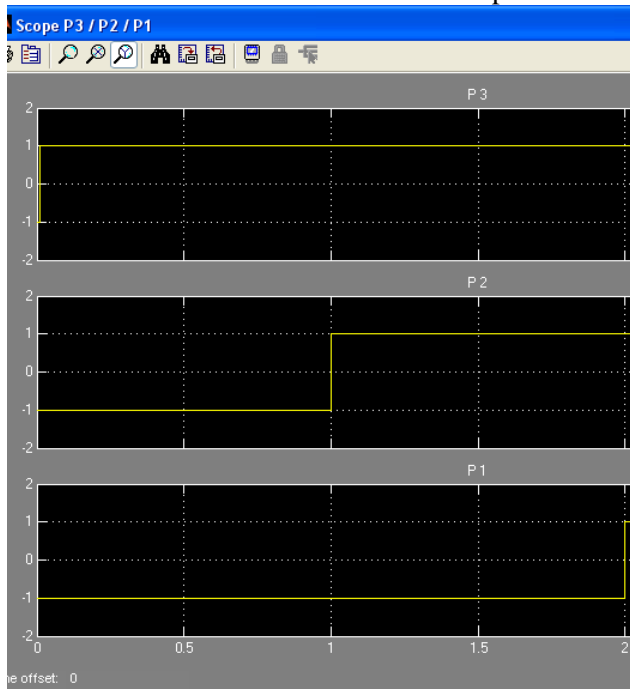


Fig. 7. Regimes of conveyor

Table 2. Results of the tests concerning the operation of the system

Stages	Start button		Signalling lamps status		Status of electric motor	
I	P1	off	SL1	OFF	M1	STOP
	P2	off	SL2	OFF	M2	STOP
	P3	on	SL3	ON	M3	START
II	P1	off	SL1	OFF	M1	STOP
	P2	on	SL2	ON	M2	START
	P3	on	SL3	ON	M3	START
III	P1	on	SL1	ON	M1	START
	P2	on	SL2	ON	M2	START
	P3	on	SL3	ON	M3	START
Startup order M3 –M2 – M1						

B. Records of transient regimes of drive systems

Subsequently there are presented the records achieved on the basis of the numerical simulation model MST for the main quantities in the study of belt conveyor driven with asynchronous motor. The simulation model MST has been built with MATLAB and its extensions SIMULINK and SimPowerSystems.

Record 1. It has been simulated a transient regime for the belt conveyor / section 3. The drive asynchronous motor is AT 7.5. The converter CTF permits the continuous regulation of the speed of drive motor AT (see Fig. 8). Hence, at t=0min has been prewritten the speed $n^* = 1100$ rpm. One could note that at the moment t=0.1 min the regime has been stabilized at the prewritten value $n^* = 1100$ rpm.

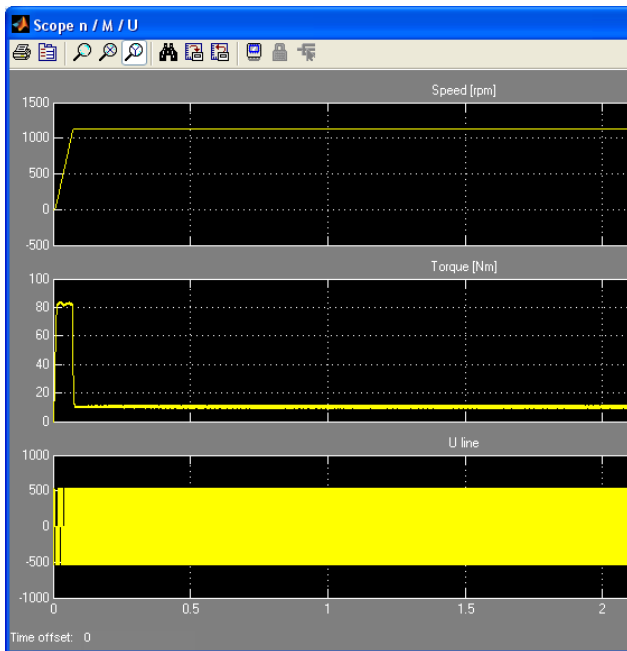


Fig. 8. Transient regime for conveyor/ Section 3

Record 2. It has been simulated a transient regime for the belt conveyor / section 2. The drive asynchronous motor is AT 7.5. The converter CTF permits the continuous regulation of the speed of drive motor AT (see Fig. 9). Hence, at $t=1$ min has been prewritten the speed $n^*=1000$ rpm. One could note that at the moment $t=1.08$ min the regime has been stabilized at the prewritten value $n^*=1000$ rpm.

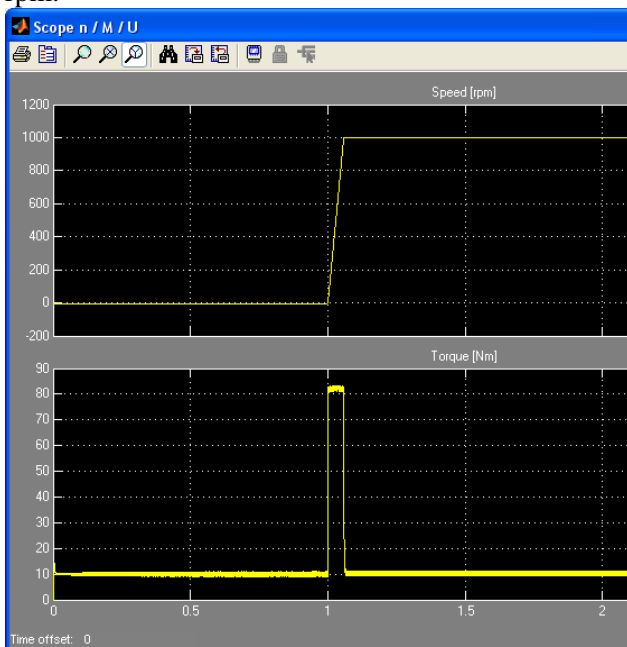


Fig. 9 Transient regime for conveyor/ Section 2

Record 3. It has been simulated a transient regime for the belt conveyor / section 1. The drive asynchronous motor is AT 7.5. The converter CTF permits the continuous regulation of the speed of drive motor AT (see Fig. 10). Hence, at $t=2$ min has been prewritten the speed $n^*=800$ rpm. One could note that at the moment $t=2.06$ min the regime has been stabilized at the prewritten value $n^*=800$ rpm.

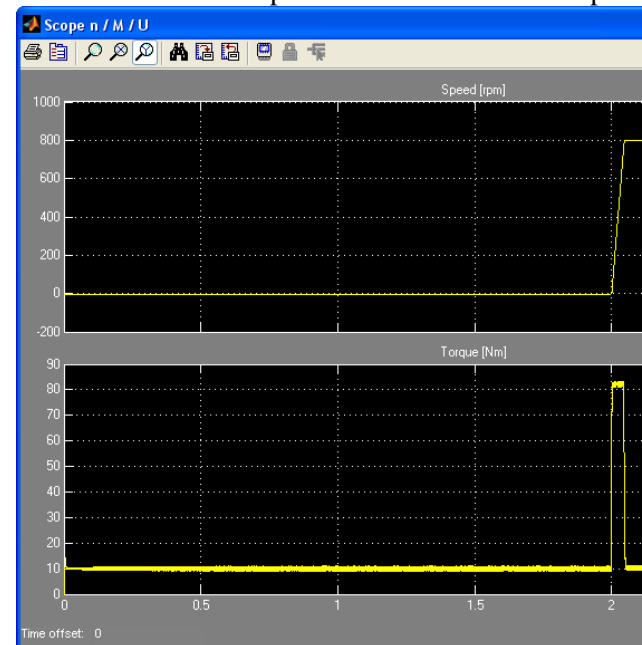


Fig. 10. Transient regime for conveyor/ Section 1

4 Conclusions

- Highlighting the fact that in many cases, transport of materials must be done on long distance transport and taking into account the resistance of the tape it is necessary that the transports with strips to be composed of 2-3 or more sections, each section being driven by a separate electric motor;

- In order to avoid crowding of transported material in some points and hence its loss on tape it is necessary that the start of different sections be made from the last to the first section;

- This requirement imposes to design and implementation of a control scheme, to ensure the startup of different sections from last to the first section;

- Checking the work process of the command scheme has indicated that it ensured the starting of electric machines according to established order (M3 –M2 – M1).

- A key aspect in driving a belt conveyor is that of the continuous regulation of the drive motor speed through a voltage frequency converter. This case emphasizes important aspects in the electric and

mechanical dynamics of the belt conveyor consisting of several sections connected in cascade. As a consequence, in the nowadays engineering it is important to build numerical simulation models based on appropriate software.

- For building the numerical simulation model MST has been used the software MATLAB and its extensions SIMULINK and SimPowerSystems. The simulation model MST for the drive system of a belt conveyor permits to emphasize the dynamic regime based on the main electromechanical quantities of the drive system.

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