

# CONVEYOR ENERGY EFFICIENCY PARAMETERS DETERMINATION USING MATLAB – SIMULINK

POPESCU N.\*, DINU R.C.\*, MIRCEA I.\*

\*University of Craiova, Faculty of Electrical Engineering, Decebal no.105, Craiova  
npopescu@elth.ucv, [rcdinu@elth.ucv.ro](mailto:rcdinu@elth.ucv.ro), imircea@elth.ucv.ro

**Abstract:** Energy efficiency should, in general, to determine, based on actual measured input parameters that define the operation of the main indicators and plant equipment with energy. Based on the general concept of modeling and simulation of different processes, based on dimensions of a conveyor belt large capacity and knowledge of nominal parameters that train engines, in this paper the authors realize a simulation of the behavior of a high capacity conveyor to transport coal varying speeds within acceptable limits using Matlab – Simulink.

**Keywords:** energy efficiency, modeling, simulation, transport parameters.

## 1. INTRODUCTION

The system is a physical entity within which a process is carried out in accordance with the nature laws (physics).

The model is a simplified representation of the significant elements of a given system and is built for driving a system so that the actual results to be united.

Models, regardless of the nature or type of system described depend on the structure:

- Shoulder to modeling;
- The information we have about the system;
- Mode which is modeled system.

Modeling is real abstraction process by reducing it to an equation or a system of mathematical equations. Modeling is difficult because the evolution of systems is generally governed by many laws, and it is impossible to take all into consideration.

Simulation is the process of using a model of a physical system we have to obtain certain data referring to the behavior of the analyzed system.

MATLAB is a high-performance computing language used in technical calculations performing. This program integrates computing modules, modules and modular programming view. Modules allow easy use of the program and the problems and solutions can be expressed using familiar mathematical notation.

Typical areas of use MATLAB program are:

- Mathematical calculation;
- Algorithms development;
- Prototypes modeling, simulation and development;
- Data analysis and exploitation and their view;
- Applications development, including the design of graphical user interfaces.

## 2. DESCRIPTION OF THE MAIN TECHNOLOGICAL EQUIPMENT WITHIN A CAREERS AREA

Basin coal mining fields of Oltenia characterizes itself as the location in the meadow and hill areas. Stripping ratios, dispersal, thickness and inclination of layers of coal and modern technology continuous handling equipment and large capacity, favored by career gaining ground at the expense of groundwater.

Mining technique used in our country for the extraction and use of coal is characterized by the following synthetic defining:

- Mining technologies are used at the global and European level;
- Machinery and equipment used in the extraction, processing and transport are mostly old and outdated;
- Technical and economic performance of the technologies applied are reduced due to the difficult geological-mineral deposit and the low reliability of the equipment supplied;
- Insufficient financial resources did not allow continuous and consistent a program of modernization and refurbishment.

Lignite operation to date in our country is growing as worldwide, such as output per unit of service and the number of such enterprises.

Coal requirements imposed assimilation of high productivity equipment such as: bucket wheel excavators (ERC), high capacity transport (TMC), special dump (MH) etc.. Technology used in streaming is practiced all over the world where like conditions prevail, since external dump, dump continuing with indoor and lately, when were attacked last few pit coal strata was switched to direct Haldar.

All equipments are using: mechanisms driving career track, providing specific ground pressure dipping below required so as live rock and the loose (if dump) [5], [6].

The quarries extracting lignite coal basin of Oltenia includes rotor excavators (four types), abzetere MH (10 types), high capacity transport TMC (5 types), other career tools: tape trolleys, special stored and recharged coal, special material made etc. (BRS's, KSS's, GSA's, HSS's).

Next the article presents a description of high capacity conveyor belt (TMC), and trolleys band (BRS).

High capacity conveyor belt is the infrastructure of a career, the second principal component, they function conditional expected economic effects relating to improving the construction and operation of bucket wheel excavators.

These in turn have their own system of conveyors and material elements transshipment bucket wheel to TMC. Lately we are

witnessing a continuous extension of conveyor belts transport the cast mining of lignite, due to the advantages it presents: transporting large volumes and very large angles that can reach 18 ... 35 degrees, reliability increased and, not least, low shipping price.

When transporting pit lignite, conveyor belt is made with two schemes containing differ transportation: one for coal and one for waste. Regardless of the type of material transport, power installed such equipment can reach 4000 kW.

A tape transport scheme in a career consists of the following types of transport: stationary conveyor are mounted on concrete pillars and serving a long career, conveyor belts are so buses, semi-stationary conveyors, which are prolonged or relatively shorter intervals of time when deploy mobile carriers, mobile carriers (ripabile) are those that after a relatively short period of operation changes its working position, being ripped from the working face.

In a lignite career are three types of conveyor indicated, as well as for good or for sterile.

Regarding tape carts, they are designed to work with dump cars and wheel excavators and link between them and high capacity belt conveyors pit in order to increase their distance and reduce riparia times stationary. Currently two versions of the carriages known band: the uninterrupted transport, two separate swivel arm equipped with one belt conveyor.

Tape carts, as intermediate transported conveyors are mounted especially in places where there are differences of level, serving and discharge of materials transported.

Main technical characteristics of band trolleys are hourly productivity, length of the two bands pickup and delivery, and their speed width, height teaching, etc installed capacity.

### 3. DETERMINATION OF FUNCTIONAL PARAMETERS OF A BELT CONVEYOR

#### a. Determine the idling consume of conveyor belt:

Determination of parameters effectiveness of conveyor belts involves the algorithm by which we can calculate the electrical power required to drive the engine of a belt conveyor [1]:

$$P_1 = 0,01 \cdot K_0 \cdot L_0 \cdot w \cdot r_{sp} \text{ [kW]} \quad (1)$$

where:

$K_0$  -Coefficient depending on conveyor length determined depending on conveyor length  $L_0$ ;

$L_0$  -Horizontal projection of bandwidth, [m];

$w$  - The speed of the tape, [m/s];

$r_{sp}$  - Specific strength [daN/m], determined by wheel diameter expressed in mm and the width of the chart chosen.

#### b. Calculate the power consumption of material transported horizontally neglect:

$$P_2 = 0,003 \cdot K_0 \cdot L_0 \cdot f \cdot D_{car} \text{ [kW]} \quad (2)$$

Where:

$f$  - Friction coefficient values between 0.025 to 0.05 for roller bearings and roller bearings;

$D_{car}$  - Tape transport capacity [kg / s], determined by the relation 3:

$$D_{car} = \frac{1}{3600} \cdot K_{\alpha} \cdot k \cdot w \cdot \rho \cdot (0,009 \cdot B - 0,5)^2 \text{ [kg/s]} \quad (3)$$

Where:

$K_{\alpha}$  - Coefficient depending on the angle  $\square$  band;

$k$  - Coefficient determined by cross-sectional shape of the branch bearing the band. For three roller conveyor chute  $k = 4$ ;

$\rho$  - Transported coal density [kg/m<sup>3</sup>];

$B$  - Width of conveyor belt [mm].

#### c. It is determine the electrical power required to move the material to be consumed vertical:

$$P_3 = 0,003 \cdot D_{car} \cdot H \text{ [kW]} \quad (4)$$

Where:

$H$  - Vertical projection of wavelength [m].

#### d. Is determining the power consumed to overcome friction between the belt conveyor and the discharge chute guides:

$$P_4 = K_4 \cdot w \cdot L_g \text{ [kW]} \quad (5)$$

Where:

$K_4$  - coefficient depending on bandwidth, with values of 0.05 for the  $B \leq$  conveyor 1000 mm and 0.1 for  $B > 1000$  mm;

$L_g$  - guide trough length [m].

#### e. Calculate the electrical power needed to overcome resistance wiper strip:

$$P_5 = 0,002 \cdot w \cdot B \text{ [kW]} \quad (6)$$

#### f. Calculate the electrical power needed to overcome resistance band arresters type two drums:

$$P_6 = K_5 \cdot w + 0,001 \cdot K_6 \cdot D_{car} \text{ [kW]} \quad (7)$$

Where:

$K_5$  and  $K_6$  - coefficients that depend on bandwidth.

#### g. Determine the total electrical power drive belt:

$$P_a = \sum_{i=1}^6 P_i \text{ [kW]} \quad (8)$$

#### h .Calculate the power consumption of the drive motor:

$$P_m = (1,0 - 1,2) \cdot \frac{P_a}{\eta_R} \text{ [kW]} \quad (9)$$

Where:

$\eta_R$  -Return gear.

### 4. MODELING AND SIMULATION OF A CONVEYOR BELT WITH MATLAB – SIMULINK

High capacity belt conveyors are continuous flow transport equipment with high transportation capacity of 4400 m<sup>3</sup>/h up to 12500 m<sup>3</sup>/h.

Are designed to operate under continuous flow transport of coal mining to date (career) but can also be used in other operations where physical and mechanical characteristics of

materials transport correspond to a steady stream of excavation, transport and dump-storage.

In terms of operation are generally operated medium voltage motors (6 kV). Drive power and flow depending on the length of conveyors, electric motors with power between 400 kW and 630 kW (each carrier there up to 4 actuators).

Given that the composition of production lines, process flow organization of careers prefer to take tension controlled transport schemes (with adjustable tension force), the tension roller.

The main data base is determined in accordance with technological requirements and provisions literature on transported material whose physical and chemical properties should be considered when choosing and designing conveyor belt. This is the type of material waterway (coal, sterile), volumetric density, angle of natural slope, chart size, maximum slope transport.

**Dynamic slope angle** is generally smaller than the natural material transported and depends on the type and speed of transported material, pattern and gradient power point system.

**Transported material flow** is expressed as mass flow or volume flow. Waterway capacity of belt conveyor will be determined and chosen based on these values.

**Conveyor path** is determined by the geometry and Infrastructure careers. Tilting band may change randomly and thus will be offered the best solution for long distance transport sisteul, minimum radii concave or convex curves will have associated with it.

**Slope conveyor** with band in that material transport form of lumps on smooth bands is limited by tilting it starts to slide or roll. For most materials transported tilt limit is 15-20 degrees.

**Required bandwidth** is chosen as possible of the standardized values according to the size of rollers and other construction elements.

**Transport speed** is the speed of transport material and the conveyor belt is driven by implications in the design and choice of carrier tape.

The most important is choosing the maximum transport speed to adapt to specific operating conditions. Limits depend on the type and nature of the feed material and in some cases additional measures to meet the power requirements.

High speed transport results in increasing the capacity transport for a constant width band.

Low speed of transport can ensure optimal operation of conveyor to reduce the power flow.

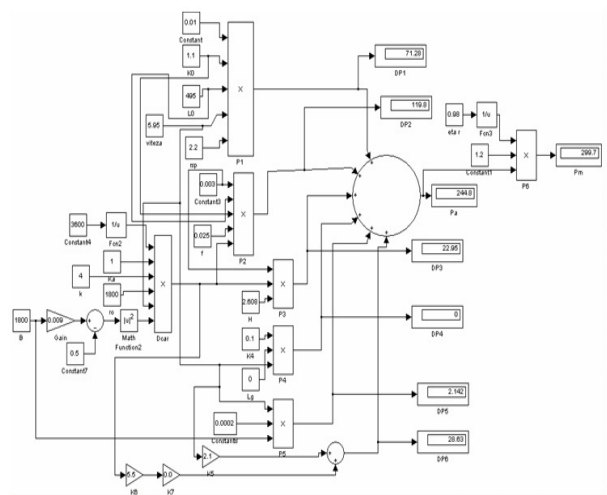
The main parameters characterizing the T234I conveyor belt, used for setting model in Matlab - Simulink are presented in Table 1.

**Table 1. Geometrical parameters used as input for conveyor Model in Matlab – Simulink**

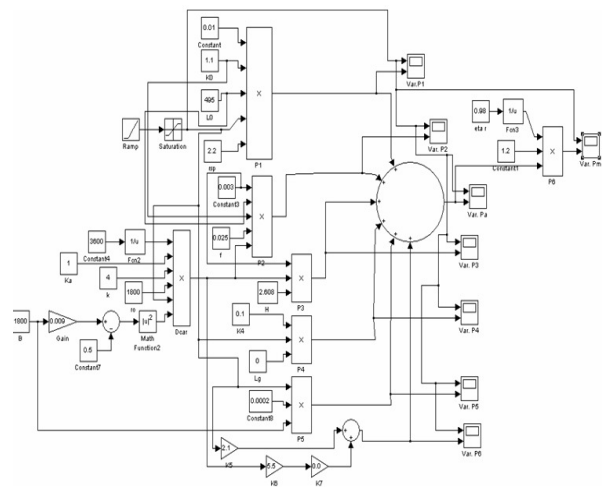
Nr. crt.	Measured	Analyzed belt	Symbol	U.M.	Value
1.	Flow of material transported (coal, sterile)	T234 I	$D_{transp}$	[t/h]	1530
2.	Density of coal transported	T234 I	$\rho$	[kg/m <sup>3</sup> ]	1800
3.	Horizontal projection of the strip	T234 I	$L_0$	[m]	495
4.	Vertical projection of the strip	T234 I	H	[m]	238; 243

Nr. crt.	Measured	Analyzed belt	Symbol	U.M.	Value
5.	Transport bandwidth	T234 I	B	[mm]	1800
6.	Angle of the tape	T234 I	$\alpha$	[grd]	0,64
7.	Type lane cross section	T234 I	-	-	three roller chute
8.	The thickness of the conveyor belt	T234 I	s	[mm]	24
9.	Diameter rollers	T234 I	$d_{role}$	[mm]	159
10.	Length gutters training guides	T234 I	$L_g$	[m]	0
11.	Yield reducer	T234 I	$\eta_R$	-	0,98
12.	Speed in normal values, the tape drive	T234 I	w	[m/s]	5,95

Modeling schemes functional parameters achieved in Matlab - Simulink (Figure 1 and 2) based on the algorithm described above, the results based on the input data in Table 1, are presented in Table 2 [2].

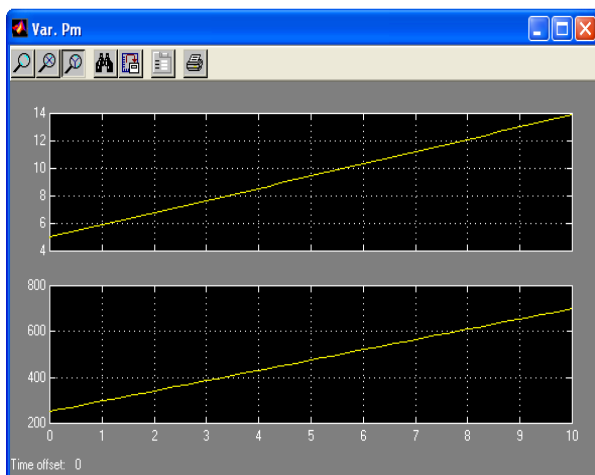


**Figure1. Matlab - Simulink modeling scheme of functional parameters of the high capacity conveyor**



**Figure2. Matlab - Simulink modeling scheme of the functional parameters variation depending on the their speed conveyor drive**

Given that coal conveyor speed usually varies between 5 m/s and 15 m/s, for consideration conveyor belt it can be draw a chart for the driving motor power variation (Figure 3), using simulation scheme.



**Figure3. Variation of electrical power consumed by the drive motor of the conveyor belt, depending on the speed of the tape**

**Table 2. Electrical power required conveyor drive motors of the modeled**

Nr. crt.	Measured	Symbol	U.M.	Function value
1.	Total power drive belt	$P_a$	[kW]	244,78
2.	Consumption idle conveyor	$P_1$	[kW]	71,28
3.	Coefficient depending on the length of the strip	$K_0$	[-]	1,1
4.	Specific resistance band	rsp	[daN/m]	2,2
5.	Power for horizontal displacement of material transported	$P_2$	[kW]	119,79
6.	Power for vertical movement of the transported material	$P_3$	[kW]	22,95
7.	Power to overcome friction between the belt conveyor discharge chutes and guides	$P_4$	[kW]	0,0
8.	Power to overcome friction between the belt conveyor discharge chutes and guides	$P_5$	[kW]	2,14
9.	Power to overcome resistance band arresters	$P_6$	[kW]	28,63
10.	Engine power drive	$P_m$	[kW]	299,73

#### 4. CONCLUDE

Conveyor operation is discontinuous, being a high number of stops and starts conveyor system. Since starting the conveyor is done both idle and load (tape material is transported) inrush currents bands have high values. For this reason, the installed engines drive conveyor belts are great bands motors are oversized.

Load coefficients of electric motors driving conveyor system studied are low values.

Drive motor power depends on the speed of the conveyor belt transport of coal, ranging from about 244 kW at a speed de5m/s to about 700kW for a speed of 14 m/s

The simulation was performed assuming a linear variation of speed for the same type of coal transported (density and flow).

#### Acknowledgment

“This work was partially supported by the strategic grant POSDRU/CPP107/DMI1.5/S/78421, Project ID 78421 (2010), co-financed by the European Social Fund – Investing in People, within the Sectoral Operational Programme Human Resources Development 2007-2013.”

#### 5. REFERENCES

- [1]. Carabogdan, I. Gh., ș.a., Bilanțuri energetice. Probleme și aplicații pentru ingineri, Editura Tehnică, București, 1986.
- [2]. Ionescu, C. D., ș.a., Monitorizarea și evaluarea continuă a eficienței energetice, Editura Agir, București, 2001.
- [3]. Răducanu, C., ș.a., Audit energetic, Editura Agir, București, 2000.
- [4]. \*\*\*, Normativ privind metodică de întocmire și analiza bilanțurilor energetice în întreprinderile industriale, ICEMENERG, București, 2000.
- [5]. \*\*\*, Normativul pentru întocmirea și analiza bilanțurilor energetice. PE 902/1996, București, CIDE.
- [6] \*\*\* Contract de cercetare, nr.17C/2011, “Elaborare bilanț energetic la cariera Jilț Sud și cariera Jilț Nord”, Responsabil contract, Ș.l.dr.ing. Paul – Mihai Mircea, Craiova, 2011.