COMPUTERIZED MODEL SUPPORTING OPTIMIZATION OF DRIVE FOR THE BELT CONVEYOR SYSTEM IN OPENCAST MINING

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Introduction

Electric energy utilized in driving conveyor tracks operating in the opencast mining sites and belt conveyors operating at different special mining machinery is a significant cost item for the operating companies. For this reason, every saving achieved in this area results in a major and remarkable reduction of fixed costs for the company.

Transport parameters and operational conditions of belt conveyors operating in opencast minings vary in a wide range. One of the main reasons comes from the special feature of the mining transport that the sites of charging the conveyors and even the material discharge is varying, within a relatively narrow time interval. In addition, the change is often of a cyclic nature. The essential and relatively short-term change in the operational conditions is most often caused by the change in the weather conditions. For example, warming due to sunshine or wetting due to rain or mist can have significant influence on the operating conditions of a belt conveyor. Significant changes occurring in a longer period are generally caused by wear-out of the units in the conveyor machinery.

Sizing of the drive system should provide for a power necessary to the material flow demand and input the required hauling power even under extreme conditions. We describe only two of the extreme cases, both are well-known among the conveyor experts.

- Starting the track loaded along its full length
- Operation at greater-than-average effective coeficient of friction:, e.g. in winter cold

At reduced transport demands or under improved conditions of motion, installation of a moving power able of operation in extreme conditions is superfluous. By partial switch-off energy saving can be achieved in the drive system and the excess energy can be switched back in due time, whenever the circumstances make it necessary. The decision of switch-off and return should, however, be preceded by a preliminary assessment. With considering the results of this assessment incorrect decisions may be avoided. The assessment is effective only if its time requirement is able to follow changes in the operational conditions.

The computerized modeling system to be demonstrated in the following paragraphs runs in an EXCEL environment and - with its computing capacity - is able to determine, as well as visually represent the conveyor forces adapted to the modified conditions in a short time frame. In addition, as a result of the completed calculations, the model provides supplemental information for the user that helps operate the belt conveyor track with a greater safety and better efficiency.

Beyond the above items, the model can also be well utilized in training. It can help improve efficiencies of both the demonstrating and the inspection stage of training, thus improving degree of utilization of the available training time.

Description of the operator environment

The modeling program communicates with the operator by the use of eight EXCEL sheets. The first sheet is for displaying the input data. (See Figure 1)

Explanatory diagram below the text fields help unterstanding the geometrical dimensions of the belt conveyor track. This is shown on Figure 2, demonstrating that the model can handle

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three receiving points. This is sufficient for most transport systems operating in the mining practice. The first receiving point is coupled with the front part of the track. Positions of the other two charging points can be custom defined within reasonable distance limits.

	A	B	C	D	E	F	G	H	I
1	**Belt conveyor model**								
2	Basic data								
3									
4									
5	Row data:			Matetial flows:			Piece of drives:		
6	distance, L1:	500	m	mass flow Q1:	1500	t/h	discharge end:	1	db
7	distance, L2:	50	m	mass flow Q2:	0	t/h	receiving end:	0	db
8	distance, L3:	50	m	mass flow Q3:	0	t/h			
9	elevation, H1:	-50	m				Wrapping angle:		
10	idler distance, upper:	1,0	m				1. discharge end pulley:	240	fok
11	idler distance, lower:	3	m	accelerating time:	1000	s	2. discharge end pulley:	240	fok
12	mass of idler, upper:	50	kg/db				3. receiving end pulley:	220	fok
13	mass of idler, lower:	25	kg/db	material cross section:	0,116	m2			
14	belt speed:	3	m/s	anyag keresztm igény.:	0,139	m2			
15	belt width:	1	m	keresztm. kitölt. tény.:	1		Friction coefficient:		
16	troughing angle:	35	fok				1. discharge end pulley:	0,4	
17	specific mass of belt:	60	kg/m				2. discharge end pulley:	0,4	
18	effective coeficient of friction:	0,050					3. receiving end pulley:	0,4	
19	slope angle of material:	15	fok						
20	density (loose):	1000	kg/m3				efficiency:	0,9	
21									
22							Place of tension:		
23							at discharge end		
24									
25									

Figure 1

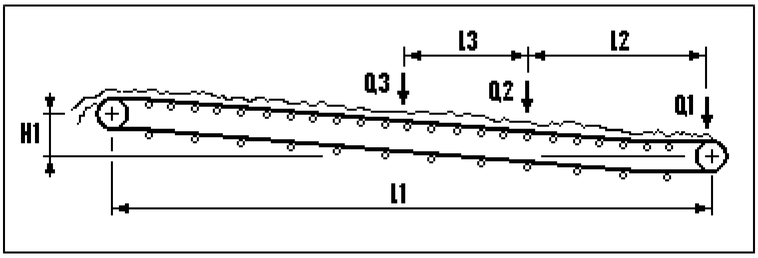

Figure 2

It is not practical, however, to input data of the conveyor track to be modeled by directly entering cell data on the input sheet. A special Windows panel serves for this purpose, to be called by running an EXCELmacro. After starting the macro, the *Alapadatok (Basic data)* window appears, as shown in Figure 3. In addition to the parameters of the input sheet, the window also contains the already mentioned explanation scheme and the drawing demonstrating layout of the drive units. The latter always shows the picture corresponding to the actual selected drive layout. Hauling power distribution along the track is essentially (but not exclusively) determined by layout of the belt conveyor's drive units. Input site and method of hauling power input, or - if there are more than one input sites - their distribution ratio, etc., have significant effects on parameters, such as, including maximum force generated in the belt, average force, the required tensioning force. But it has effect also on the ability of the system to tolerate parameter changes influenced e.g. by the weather. This is why the model manages the drive arrangement solutions usually applied in belt conveyor systems driven at the track end. Selectable layouts: 0;1;2;3 drive units in front and 0;1 drive unit at the back. The model does not support the intermediate drive.

Loaded quantities (Q1;Q2;Q3) have to be given in the *Input basic data* window as mass flows. Loaded mass flows can have, of course, also a zero value, which corresponds to the idle operating state. All the material charged onto the belt leaves the track at the end drum.

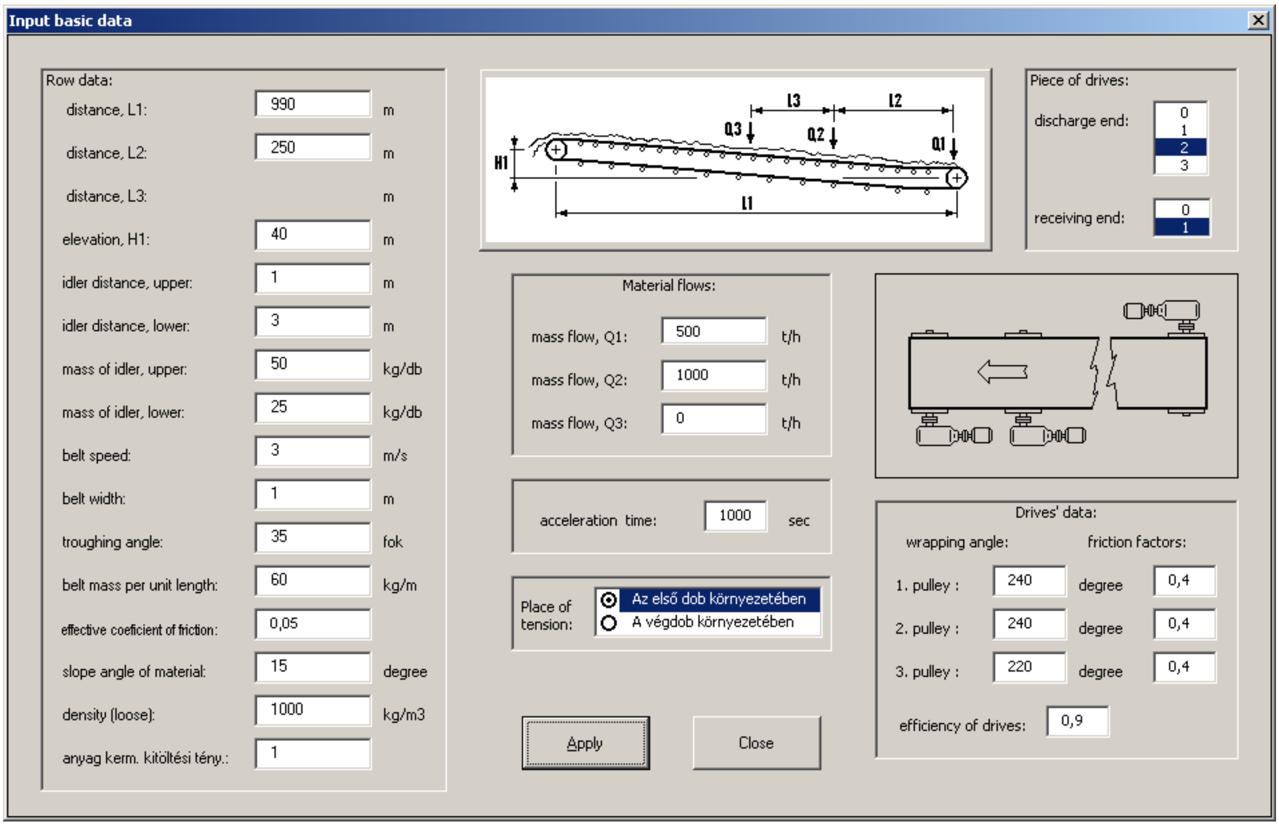

Figure 3

The user can move freely amongst the fields for parameter entry, e.g. the data field to be actually entered can be selected with the mouse. Leaving a particular field one can obtain an error message. This is because the program checks, whether value of the data to be entered is within the range acceptable for a belt conveyor. After leaving the field a pop-up window will notify in case the user is about to validate an out-of-the-range figure, at the same time giving the valid range of the particular parameter. Exactly this is the main function of data entry via the *Input basic data* window. If data entry takes place in a validated manner, we can avoid lots of annoyance. The model, however, does not verify compatibilities of all parameters to be entered. User of the model must provide for this. For example, width of the belt to some extent limits mass of the roller set to be used with. But compatibility of the two data in this example is not validated by the model.

On the other hand, it is able to handle dynamic effect of the acceleration phenomenon occurring at starting the belt and it considers not only the static forces but also the power requirement of the system acceleration. To do this, time period of the starting process can be entered in the *Input basic data* window. Accepted range in the *Acceleration time* field: 20sec< t_{acc} <1000sec. By entering the highest value – this is also the default value – the user can select the constant-speed-run case. Note that the model does not manage the transient phenomena taking place along the track and originating from the energy storing capability due to flexibility of the belt and other features of the system. Thus, calculated forces and powers are values produced after cease of transients that occur at starting.

For validation of already entered data, there is the *Apply* button in the *Input basic data* window. Clicking on it, the model performs some cross-checks of the entered parameters – this is why appearance of a warning window can also be expected –, then all data of the window are written to the input sheet shown in Figure 1, however, the *Input basic data* window is not left. Clicking on the *Close* button, one can leave this window, and after the necessary cross-checks all data of the window are rewritten to the input sheet and the window closes at the same time. After closing, our modeling system immediately performs the necessary calculations.

Displaying the results

The remaining seven sheets of the workbook feature displaying the calculated results. These sheets show trends of the hauling force distribution along the track. Each sheet contains diagrams of the possible hauling force distributions belonging to the possible drive layouts. By clicking on the sheet tab the diagram appears, the address of which and the scheme below it uniquely identifies the respective drive layout. For ease of reading, the forces arising in characteristic points of the track are also displayed with their value numbers on the diagram. Field at the bottom right corner contains the most important quantities of the track and results of the calculations. These are the following:

- power demand of the drive by drive units
- drive reliability factor valid for each drive unit
- tensioning force to be applied at the tension site
- the transported mass flow
- track length
- average force calculated from the forces along the track
- elevation of the track

The same field also contains the acceleration time applied at starting. These data clearly show the operating state that particular diagram belongs, even at later study of the diagram. Figures 4, 5 and 6 show three out of the seven result sheets belonging to the basic data obtained from Figure 3. The layout modes can be read from the Figures themselves.

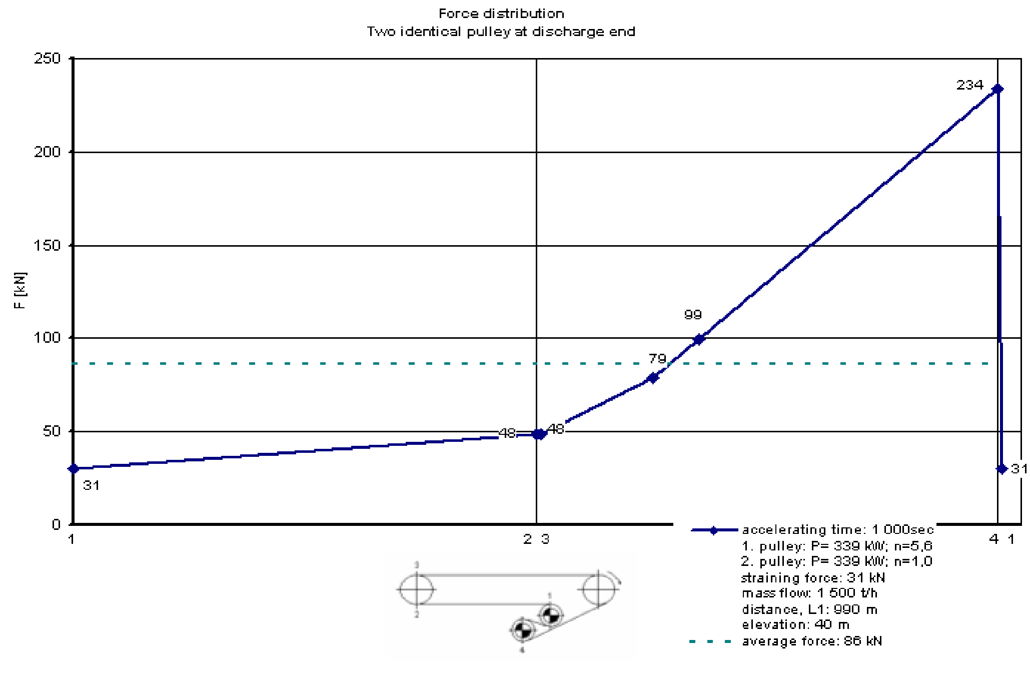

Figure 4

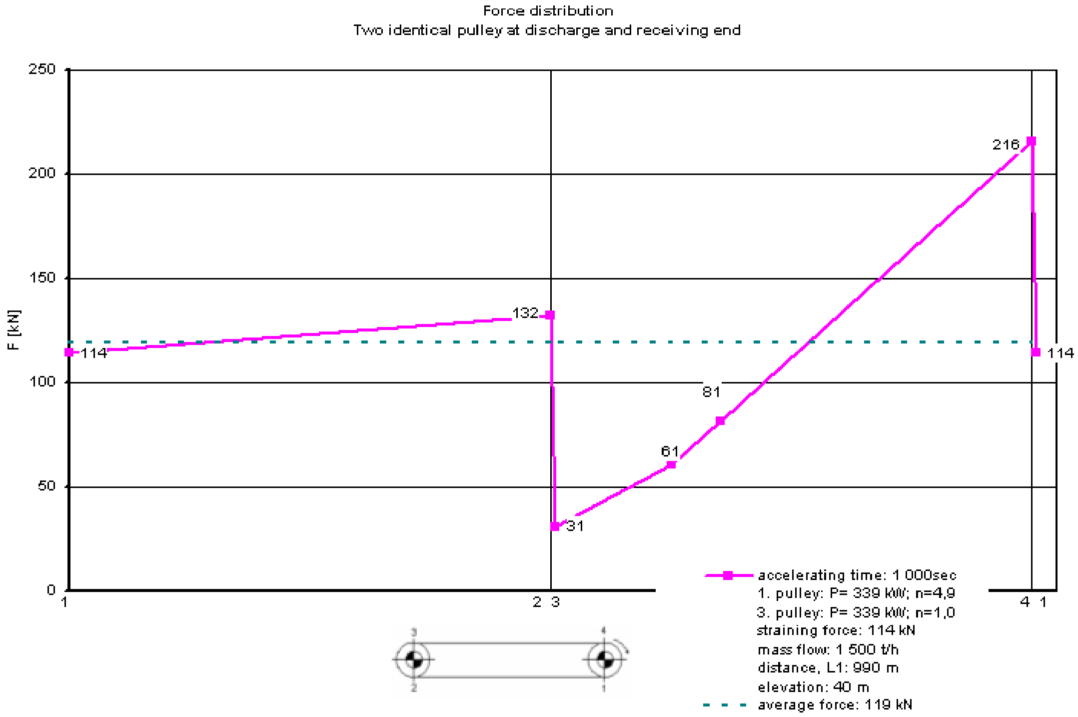

Figure 5

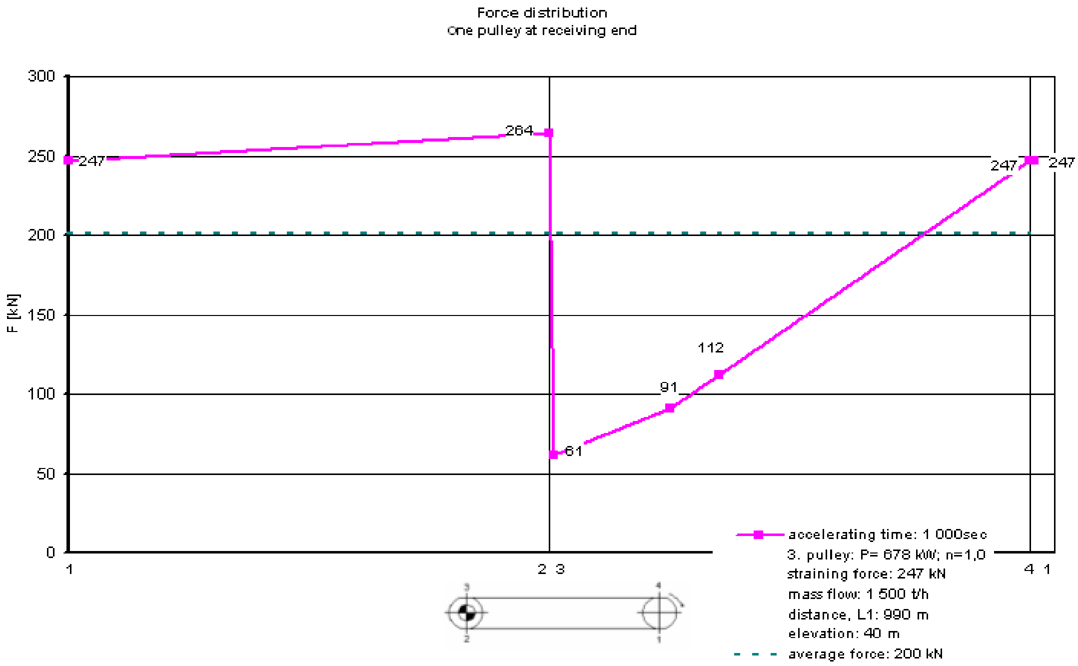

Figure 6

Note that the negative sign before the power values indicate that the track is not required to drive but rather even braking have to be applied, by a power corresponding to the respective figure. For parameter H1 giving the ascent of the track, the negative sign is interpreted similarly as before. This represents the slope of the track, as well as the level difference between the starting and ending points of the track in case of a downward transport.

Input sheet shown on Figure 1 is not locked from the user, it is editable. Advantage of this feature is that in case of changing a single input parameter – e.g. the acceleration time – reentering all data fields of the *Input basic data* window is not necessary. However, after any modification of the input sheet the model does not evaluate the changes.

For documentation purposes the integrated print function of EXCEL can be used, with all options offered thereby. All other EXCEL functions are, of course, available for the user, except for those protected by a password. Thus, any stage of the modeling can be saved and then reloaded.

Finally, we would like to call the attention of every professional having ever faced with some modeling. Please let us highlight again for obvious reasons. Results of a modeling and the conclusions drawn do not support the user in making the right decision in case the user enters invalid and unrealistic information. This is why it is so essential that the basic data entered through the input fields correspond to the condition to be modeled. Otherwise, it is possible that conclusions drawn from the results steer away the user from the right decision, but generally not because of applying a modeling process. That is, to recall an old saying: “Don’t blame the mirror if the reflection is distorted.”

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