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Creation of the Project of a Logistic System for Transportation of Minerals - Case Study

Daniela Marasova [1], Miriam Andrejiova [2], Anna Grincova [3]

[1]*Technical University of Kosice, Faculty of Mining, Ecology, Process Control and Geotechnology, Letna 9, Kosice, Slovakia*
[2]*Technical University of Kosice, Faculty of Mechanical Engineering, Letna 9, Kosice, Slovakia*
[3]*Technical University of Kosice, Faculty of Electrical Engineering and Informatics, Letna 9, Kosice, Slovakia*

***Abstract* – One of the possibilities how to maintain the competitiveness of mining and processing undertakings on the minerals market is to increase the efficiency of the minerals recovery and processing process with the focus on the operating costs reduction. Intra-plant transportation plays an important role in this process. Optimization of minerals transportation and implementation of the logistic approach can result in significant saving of operating costs pertaining to the recovered number of valuable mineral. The article presents a logistic approach to the belt conveyor system designing, proposes possible modifications of selected parameters of belt conveyors in a particular processing plant, and monitors their impact on the improvement of operating, but mainly economic parameters of transportation of clay and limestone, while maintaining the required transportation capacity.**

***Keywords* – Belt conveyor, designing, innovations, logistics, minerals, transportation.**

1. Introduction

Belt conveyors represent an important part of the intra-plan transportation within the surface and underground mining of minerals. Belt conveyor technology represents a set of activities aimed at relocation of material in space and time using a belt conveyor [1]. Belt conveyors represent an important group of transportation devices providing continuous

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Corresponding author: Miriam Andrejiova,
Technical University of Kosice, Faculty of Mechanical Engineering, Kosice, Slovakia
Email: miriam.andrejiova@tuke.sk

material transportation [2]. The role of conveyors is to provide continuous transportation of materials between a loading site and an unloading site. In the past, they were used mainly in the extraction of minerals. At present, belt conveyors are used not only in the underground mining and surface quarries, mechanization and subsequent automation facilitated their use in various industries [3].

Minerals transportation systems can be evaluated from several points of view. Konakalla et al. [4] design the conveyor system on the basis of the standard calculation model, including the selection of belt speed, belt width, motor selection, belt specification, shaft diameter, pulley, and gear box. Nekoufar [5] describes how the filling of a belt can be influenced by the correct choice of the trough angle. In this article, the optimization of the trough angle by the mathematical calculation is explored and, after applying industrial standard practice to the result, the suitable trough angle will be suggested. Grujić and Ristović [6] point out some crucial criteria for the selection of optimal transportation methods in line with the given conditions in underground mine roadways. Transportation system assessment from the environmental point of view and suggestions regarding reduction of the negative impact of the number of conveyors in the transportation of coal by maximizing the conveyor length and using horizontal conveyors with the possibility of overcoming arcs is dealt with by [7]. Optimization of the belt conveyor system's technical parameters is discussed by [8]. Harisson [9] deals with the simulation of the material flow carried out by belt conveyors, while focusing on the chutes and the properties of the transported material, and he suggests a conveyor belt with the inclusion of inertial forces, an elasticity module. Author describes, using a mathematical model, the impact of the material onto the baffle plate within the belt conveyor chutes.

Definition of a logistic belt conveyor system is based on a general definition of a logistic system by Malindzak, who defines a logistic system as a system that controls, provides and performs „movement" of materials, information and finances [10]. The logistic belt conveyor system and the division thereof into three basic subsystems is defined in [11]. Belt conveyor system designing by modifying the logistic, constructional, or specific parameters of a belt conveyor is described in [12]. Increasing the efficiency of the belt conveyor system by optimization of the quantity of conveyor belts, with regard to their type and logistic parameters in a mining company, are presented in the publication by [13]. Another solution is offered by simulation experiments, which can be used to simulate the behaviour of a real system and thus obtain relevant, more detailed data, to increase the efficiency of the transportation system. Evaluation of conveyor belt parameters was carried out using multivariate statistical methods. One of the most frequently applied multi-criteria methods is the AHP. Analysis of the AHP method and its use in the logistics is dealt with by authors [14]. Authors dealing with issues of multi-criteria assessment include [15]; they apply the multiple criteria decision making to the mining method selection. Grujić et al. [16] describe possible applications of the multi-criteria analysis to the selection of conveyors in a lead and zinc mine. The selected parameters (variables) of conveyor belts are analysed through the method of principal components analysis (PCA) and the cluster analysis to group the monitored conveyor belts into clusters with similar characteristics in [17].

The main objective of the article is to suggest the innovation of the existing system of continuous transportation of minerals carried out by the belt conveyor system. The main input of the innovation suggestion is the analysis of a belt conveyor's technical parameters and operating conditions. The benefit of the article consists, in its theoretical part, in the suggestion of a procedure for the development of a logistic belt conveyor system; and in the practical part, it is the application of the logistic approach to the development of a transportation system in the real operation, focusing on clay and limestone processing.

2. Material and methods

Logistics as a branch of science applies generally applicable scientific methods [10]. Methodical apparatus of the article is based on the use of scientific methods preferred in the logistics and their application to the assessed belt conveyor transportation system. The research thereof was carried out using the *system analysis method,* which is the most complex one of the heuristic methods.

2.1. Logistic system

Logistic system is understood as a system consisting of subsystems and elements performing specific functions and these are interconnected through mutual relations. The belt conveyor system is a transportation system providing the transportation of materials using belt conveyors. According to [18], definition of a logistic system means *definition of its structure, functions, and purpose.* The structure of the logistic belt conveyor system consists of three basic subsystems: organizational, transportation, and economic subsystems. A more detailed description of subsystems and their components is presented in [11]. The function of a logistic belt conveyor system is to satisfy, upon request, the transportation needs using the transportation elements (belt conveyor), in the required quantity, required time, and with the minimum costs. The purpose of a logistic belt conveyor system is to ensure continuous transportation, especially of bulk materials, apply progressive transportation technologies, reduce overall consumption of energy, lubricants, and solve the environmental issues and issues regarding the working environment. Logistic systems are developed while applying a generally applicable procedure. Application of this procedure to the existing transportation system is used to verify the assessed system, particularly in terms of the requirements regarding its capacity, traction, and energy consumption required for the operation thereof. The procedure of the development of a logistic belt conveyor system is presented in Fig. 1.

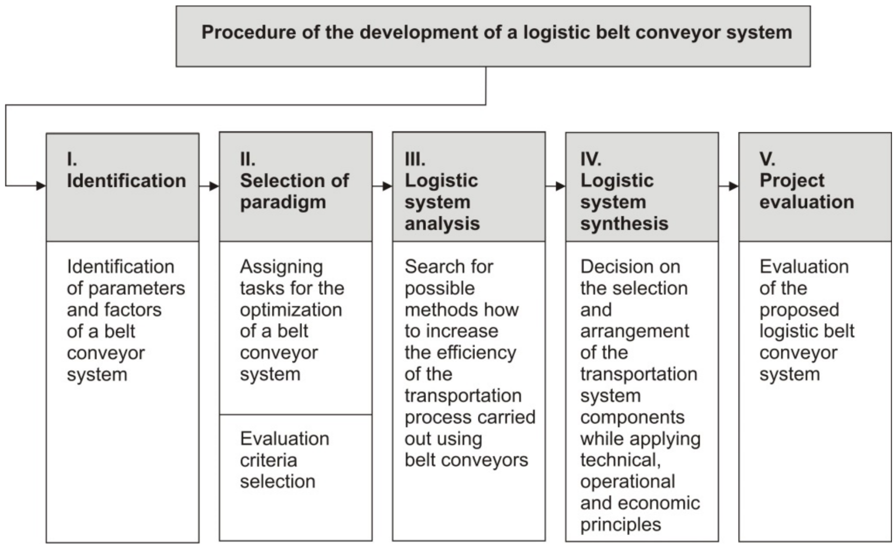

Figure 1. Basic steps within the development of a logistic belt conveyor system

2.2. Modification of belt conveyor parameters

The research is carried out using all the existing information and outputs obtained by calculations, based on the EN STN 26 3102 standard, facilitating the determination of the values of basic parameters of a belt conveyor, drives, brakes, conveyor belt, stretching device. Assessment of the existing belt conveyors was carried out in terms of determination of main, auxiliary, and additional resistance which is overcome by the belt conveyor‘s drive, while considering friction, route inclination, as well as acceleration of transported mass to the belt's speed at the loading site. The results of the analysis focused on the optimal use of belt conveyors indicated possible ways how to increase the efficiency of the transportation process, particularly by the modification of belt conveyor parameters, graphically presented in Figure 2.

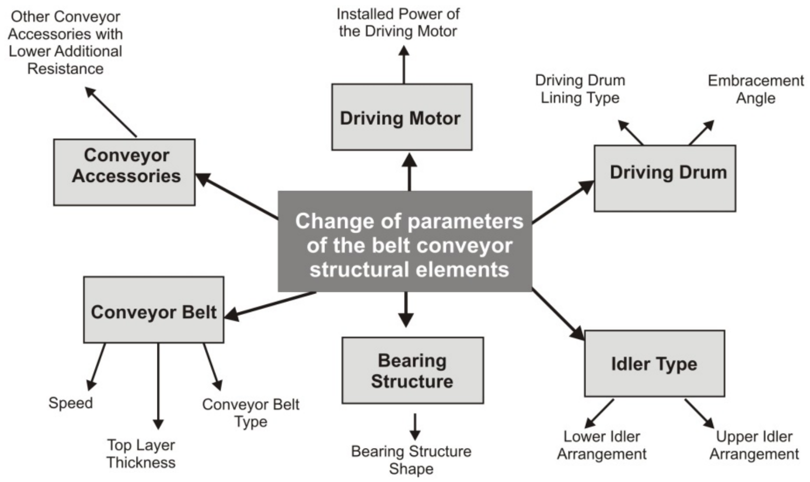

Figure 2. Representation of possible modifications of belt conveyor parameters

These fundamental structural elements (parameters) serve as the basis for deduction of the main criteria and the additional sub-criteria are deducted from their other components. Determination of weighs of assessed suggested general modifications of belt conveyors was carried out using the AHP method. The use of the AHP method at the determination of the optimal selection criteria for conveyor belts are described in details by authors [19].

3. Results and discussion

The objective of the creation of the project of the logistic system of minerals transportation is as follows:

- evaluation of importance of the suggested modifications of belt conveyors parameters, in general,
- suggestion of a logistic belt conveyor system in the processing plant.

3.1. *Multi-criteria evaluation of parameters of the proposed belt conveyors modifications*

The selection of the relevant criteria is a very important step of the decision-making. The main criteria are: *Conveyor Belt* (C1), *Bearing Structure* (C2), *Idler Type* (C3), *Driving Motor* (C4), *Conveyor Accessories* (C5) and *Driving Drum* (C6).

The significance of the criteria is determined by assigning weights to the estimates of the individual criteria. The preferred solution is the one that will reduce the total resistance to motion, necessary power input of drives of individual belt conveyors in connection with complexity of their application while implementing the changes of the existing transport system. Two experts from the Logistics Institute of Industry and Transport of the Faculty of Mining, Ecology, Process Control and Geotechnologies of the Technical University of Kosice participated in the evaluation of the criteria preferences.

Table 1. Resulting Average Values of Criteria Weights

Criteria	Weight	Subcriteria		Weights	Order
C1	0.127	**SC1**	Speed	0.040	5.
		SC2	Top Layers Thickness	0.008	9.
		SC3	Conveyor Belt Type	0.079	3.
C2	0.039	**SC4**	Bearing Structure Shape	0.039	6.
C3	0.040	**SC5**	Upper Idler Arrangement	0.035	7.
		SC6	Lower Idler Arrangement	0.005	10.
C4	0.437	**SC7**	Installed Power of the Driving Motor	0.437	1.
C5	0.258	**SC8**	Other Conveyor Accessories with Lower Additional Resistance	0.258	2.
C6	0.099	**SC9**	Driving Drum Lining Type	0.022	8.
		SC10	Embracement Angle	0.077	4.

In this work, the weights of individual criteria groups were identified using the normalized *geometric average of the Saaty matrix lines*. It followed from the order of average weighs of the main criteria with regard to the decision making on the used method of belt conveyors innovation that the *most important criterion* is the *Driving Motor* (C4). *The second most important criterion* is the Conveyor Accessories (C5) that also include resistance from overcoming the transport altitude (Table 1.). Its change will cause the remarkable change of the total resistance to motion. *The third place belongs* to the *Conveyor Belt* (C1) criterion, as its weight, depending on the type and strength, changes the value of total resistances and necessary power output of drives. *The fourth criterion* is the *Driving Drum* (C6) which is in the calculation, carried out in compliance with the standard, represented by the values of friction coefficient μ and the embracement angle α. *The next to the last* criterion is the *Idler Type* (C3) which changes the value of the transversal cross-section and subsequently the actual transported quantity. *The last criterion* is the *Bearing Structure of the Conveyor* (C2). The resulting values of weights for all criteria and subcriteria are given in Table 1.

On the basis of the resulting assessment of subcriteria weights (Table 1.) that specify in more details the fundamental criteria, importance of specific parameters of changes in belt conveyors structural elements were identified. In the first three places are the subcriteria that are related to the Installed Power of the Driving Motor (drive regulation, SC7), Other Conveyor Accessories with Lower Additional Resistance (SC8) and Conveyor Belt Type (SC3), which are identical to the fundamental criteria *Driving Motor*, *Filling Method and Other Additional Resistances* and *Conveyor Belt*. As for the order of fundamental criteria, the fourth criterion *Driving Drum* was preceded by subcriteria Embracement Angle (SC10). In the basic assessment of the subcriteria, the last place belonged to subcriterion Lower Idler Arrangement (SC6).

Generally determined order of priority of individual structural elements of the belt conveyor should be individually applied to innovation of each belt conveyor. The ratio of resistances affecting along the entire conveyor length, resistances affecting at certain location and in certain version is different.

3.2. *Suggested logistic belt conveyor system in the processing plant*

The case study is focused on the optimization of belt conveyor parameters in the transportation of clay and limestone obtained by quarry mining and transported to a particular processing plant. The development of a logistic belt conveyor system (hereinafter referred to as LBCS) in the processing plant was based on general principles of logistic systems designing [18]. Procedure of the LBCS development includes 5 basic steps (Fig. 1.).

Step 1: Identification of LBCS parameters and factors

The applied system of a transportation system suggestion begins with the *identification of parameters and factors* of the transportation system. In the first step we define primarily *active and passive components* of the transportation system. *A passive component* within the assessed transportation system represents the transported minerals (clay and limestone). They enter the transportation system with the dynamic angle of repose $\psi_{dyn}= 15^0$ and the powder density ρ= 1.3 $t.m^{-3}$ for limestone, and ρ =1.02 $t.m^{-3}$ for clay. Properties of passive components do not change by the passage through the transportation system, neither from the geometric, nor from the chemical point of view. For the purpose of maintaining the properties of the transported material and the protection thereof against degradation due to weather conditions, belt conveyors are equipped with protective covers. *An active component* of the assessed transportation system is the set of three belt conveyors (Fig. 3.).

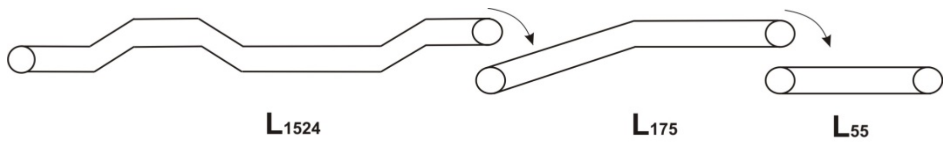

Figure 3. Layout of the belt conveyors system in the processing plant

Input technical parameters of the assessed belt conveyors arranged as a belt conveyor line are shown in Table 2. Each belt conveyor is filled through the hopper and by means of the chutes. The transportation *time factor* is not decisive for a real transportation system. The transportation capacity of the system significantly exceeds the volume of the minerals stock, being the destination of the minerals transportation.

Table 2. Selected technical parameters of the assessed belt conveyors

Parameters	**Conveyor type**		
	L_{1524}	L_{175}	L_{55}
Conveyor length L[m]	1524.00	176.159	55.00
Conveyor's inclination angle δ [^{0}]	5 and 7	13	0
Conveyor belt speed [$m.s^{-1}$]	1.56	1.80	2.65
Engine drive power P [kW]	250	100	22
Conveyor belt type	ST 2500 12/8Y65	P800/3 3+2 AA	P800/3 4+2 AA
Belt width [mm]	1000	1000	1200

Step 2: Selection of a paradigm

In the process of designing a logistic system, selection of a *strategy (paradigm)* represents an important step. The procedure of selecting a paradigm for the designing of a logistic belt conveyor system is analogical to the procedure of creating and designing logistic systems according to authors [18]. In the project creation, the simplest paradigm was chosen, particularly a *case study* of designing a logistic belt conveyor system in the processing plant. In the applied form, this step includes *formulation of tasks* and *selection of evaluation criteria*. In the development of a logistic belt conveyor system, we can *formulate the role of the research* as the optimization of the selected basic parameters of belt conveyors with the aim of their efficient use, while minimizing the operating costs. The *basic evaluation criterion* was determined as the costs of 1 ton of transported mineral. The costs of the operation of the transportation system represent an indispensable part of the total manufacture costs; therefore, the suggested modifications of the 3 assessed conveyors (L_{1524}, L_{175}, L_{55}) will be focused especially on the reduction of costs required for the transportation of 1 ton of material, while considering the operating conditions and specific parameters of each conveyor.

Step 3: Analysis of the operated transportation system

The objective of the following stage of the analytic processing of the obtained data is to verify appropriateness of belt conveyor parameters for the use in the assessed transportation system for the purpose of searching the possibilities how to increase the efficiency of the minerals transportation process based on calculations pursuant to the STN EN 26 3102 standard. The analysis of the transportation system requires the knowledge of:

- *material specifications:* material conveyed, tonnage, allowed cross sectional loading, bulk density, surcharge angle, maximum lump size, lump shape factor, chute drop distance, abrasive index, environmental condition, maintenance condition, hours in service per day, minimum and maximum temperature),
- *conveyor parameters:* motor specifications, belt specifications (width, speed, weight, thickness of top cover, thickness of bot cover), idler specifications (diameter, width, trough angle, carry series, return series), take-up specifications.

For each belt conveyor, calculations were made with regard to their capacities and rigidity, driving engines powers, relations between forces affecting the actuating drum, inspection of the conveyor belt rigidity, and the calculation of the anti-slip safety coefficient.

Step 4: Synthesis of the logistic system

Generally possible modifications, in terms of belt conveyor parameters and their structures, were determined by two experts from the processing plant. From the sequence of mean weighs of the main criteria for the decision making on the applied method of belt conveyors innovation, the most significant was the criterion of installed power capacity of driving engines. The second criterion is the method of filling and other additional resistances, including the resistance from overcoming the transportation height, which is closely related to the modification of the belt conveyor inclination angle, and thus also the modification of the conveyors' route profile. Such modification will result in a significant change of the overall dynamic resistance. The third criterion is the conveyor belt, the weight of which, depending on its type and rigidity, changes the value of total resistances and the required powers of driving engines. The analysis of a real belt conveyor system and the order of main evaluation criteria indicate the following possible innovations:

- modification of the conveyor's belt speed,
- modification of the bearing structure's route profile,
- modification of the conveyor belt type.

Conveyor belt speed modification

Conveyor belt speed modification can be used to achieve the change in the quantity of transported materials and reduce the required power of the driving engine. In order to balance the real transportation capacity to 1150 $t.h^{-1}$, the L_{55} conveyor's conveyor belt speed can be reduced from 2.6 $m.s^{-1}$ (Table 3.) to 1.226 $m.s^{-1}$. The nearest standardised speed of the conveyor belt is 1.25 $m.s^{-1}$. Conveyor belt speed modification results in the change of the original quantity of the transported material from the value of 2486.6 $t.h^{-1}$ to the value of 1172.9 $t.h^{-1}$. For the L_{175} conveyor, the current speed of 1.8 $m.s^{-1}$ (Table 3.) is satisfactory. Quantity of transported material is 1042.5 $t.h^{-1}$ and it does not change. Similarly, also for the L_{1524} conveyor, the current speed of 1.56 $m.s^{-1}$ (Table 3.) is satisfactory. Quantity of transported material is 1078.8 $t.h^{-1}$ and it does not change.

Bearing structure shape modification

One of the main elements of the technical base of the logistic transportation system is the *roadway***.** In case of belt conveyors, the synonym to "roadway" is the "conveyor's route" **-** a bearing structure with the conveyor belt consisting of upper and lower roller pulley. Depending on the inclination and shape of the transportation route, conveyors are divided into horizontal, inclined, and angular [1].

In case of the L_{55} conveyor, the modification of the bearing structure shape would be useless. Modification of the L_{175} belt conveyor's bearing structure shape into a direct conveyor, the conveyor's inclination angle will change from original 13º to 5º and, at the same time, the resistances for overcoming the transportation height will decrease as well. Modification of the L_{1524} belt conveyor's transportation route shape will reduce the dynamic resistances and increase the service life of a conveyor belt by elimination of its shape from an angular to a horizontal conveyor. Transportation height in the last section of the route profile remains unchanged, and so does the largest inclination angle. The suggested modification of L_{175} and L_{1524} belt conveyors' bearing structure shape is shown in Figure 4.

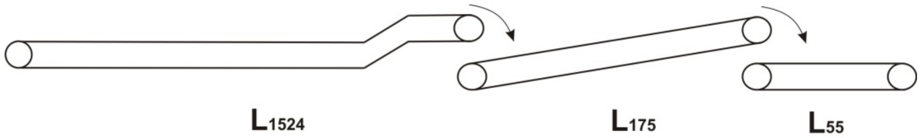

Figure 4. Proposed changes in the route profiles of L_{1524} and L_{175} conveyors

Modification of conveyor belt rigidity and skeleton

Analysis of the installed conveyor belts indicated possible saving of a conveyor belt's weight in all types of conveyors. For the L_{55} conveyor, modification of the existing rubber-textile polyamide conveyor belt with the rigidity of 800 $N.mm^{-1}$ (type P800/3 4+2 AA) to the same conveyor belt, in terms of the structure of skeleton and cover layers, but with lower rigidity of 630 $N.mm^{-1}$ (type P 630/3 4+2 AA) is suggested, which will result in the reduction of the original weight, calculated for 1 meter of the belt's length, from the value of 14.88 kg to the value of 10.8 kg, and the original price for 1 meter of the belt's length will change from the value of 71 € to 58 €. In case of L_{175} conveyor, modification of the existing rubber-textile conveyor belt (type P 800/3 3+2 AA) to the same conveyor belt, in terms of the structure of skeleton and cover layers, but with lower rigidity of 630 $N.mm^{-1}$ (type P 630/3 4+2 AA) is suggested, which will result in the reduction of the original weight, calculated for 1 meter of the belt's length, from the value of 11.20 kg to the value of 10.8 kg, and the original price for 1 meter of the belt's length will change from the value of 67 € to 58 €. Conveyor belt with lower rigidity is satisfactory at the inspection of rigidity, in terms of the maximum tension and the anti-slip safety coefficient pursuant to the EN STN 26 31 02 standard. For the L_{1524} conveyor, the suggestion includes modification of the existing steel-cord conveyor belt (type ST 2500) to the rubber-textile conveyor belt with the same rigidity of 2500 $N.mm^{-1}$, which will result in the reduction of the original weight, calculated for 1 meter of the belt's length, from the value of 68.80 kg to the value of 37.90 kg, and the original price for 1 meter of the belt's length will change from the value of 221 € to 151 €. The price of electricity is 0.0766 € for 1 kWh. The following relation applies to the price of 1 ton of the transported material

Price of 1 ton of transported material =

$$= \frac{P \times c_1}{Q}, \tag{1}$$

where P is the electric motor power [kW], c_1 is price for 1 kWh [€], and Q is the actually transported quantity [$t.h^{-1}$]. Table 3. shows the price of consumed electricity calculated for 1 ton of mineral and the total price of the conveyor belt. It also shows the saving of these prices following the suggested innovations. Price of conveyor belt replacement was determined according to the quotation provided by the manufacturer of conveyor belts.

Table 3. Costs of 1 ton of transported mineral

Conveyor belt (CB)	**Condition**	**Electric motor power P [kW]**	**Price of 1 ton of transported material [$€.t^{-1}$]**	**Saving of price of transported material [%]**	**Price of a conveyor belt [€]**	**Saving of price of a conveyor belt [%]**
L_{55}	current	12.64	0.0003893		3 834	
	after speed adjustment	5.96	0.0001835	52.86		
	after CB change	12.37	0.0003810	2.13	3 132	18.31
	after speed adjustment and CB change	5.83	0.0001795	53.89		
L_{175}	current	73.62	0.0054093		24 120	
	after structure's shape modification	66.78	0.0049068	9.29		
	after CB change	73.56	0.0054049	0.08	20 880	13.43
	after structure's shape modification and CB change	66.73	0.0049031	9.36		
L_{1524}	current	243.81	0.0173120		675 818	

Conveyor belt (CB)	Condition	Electric motor power P [kW]	Price of 1 ton of transported material [€.t^{-1}]	Saving of price of transported material [%]	Price of a conveyor belt [€]	Saving of price of a conveyor belt [%]
	after structure's shape modification	243.68	0,0173028	0.052		
	after CB change	209.87	0.0149020	13.92	461 758	31.67
	after structure's shape modification and CB change	209.77	0.0148950	13.96		

Step 5: Project evaluation

Execution of the proposed innovations for the assessed belt conveyors represents financial and time burden for the operator thereof. The most beneficial steps of the LBCS designing procedure are summarized in the suggestion evaluation.

For the L_{55} *belt conveyor,* the most beneficial change required is the change of the conveyor belt movement speed, which belongs to the primary innovations within the entire transporting belt conveyor system, while generating the saving of the price of the transported material in as much as 52.86% (Table 3.). Replacement of a currently used conveyor belt with a conveyor belt with lower rigidity is less important for the operator. Saving of the price of a conveyor belt is in this case 18.31%. The difference in the price of 1 ton of transported mineral, when comparing the current and the innovated layout of the belt conveyor, is theoretical. The filling belt conveyor for the L_{55} conveyor is the L_{1524} conveyor, which does not achieve the transporting capacity of the L_{55} conveyor.

For the L_{175} *belt conveyor,* replacement of the conveyor belt (13.43% price saving) is more beneficial than replacement of the bearing structure shape (9.29%).

For the L_{1524} *belt conveyor,* the most beneficial change is the change of the conveyor belt type (31.67% price saving). Change in the L_{1524} belt conveyor route profile in its entire length would require significant investment, while the price saving would represent only 0.052%.

4. Conclusions

The article was dealing with the process of the development of a logistic system for the transportation of minerals carried out by the set of belt conveyors. The described designing process includes designing of basic parameters and was applied in a real operation of the processing plant during the transportation of clay and limestone. The solution included the implementation of a generally applicable procedure of the designing of a logistic system, with the application to the designing of belt conveyor systems, and the multiple criteria decision making, whereas the results of the belt conveyor basic parameters analysis and assessment show that the most important modification is the modification of the Driving Motor. The following one is the Filling Method and Other Additional Resistances and Conveyor Belt. On the basis of sub-criteria assessment, three most important parameters of belt conveyor modification were determined: Installed Power of the Driving Motor, Conveyor Accessories with Lower Additional Resistance and the Conveyor Belt Type.

The use of the AHP method was followed by the evaluation of the selected belt conveyor parameters and the determination of generally applicable priorities with regard to the innovation. Evaluation criteria were derived from the principle of the belt conveyor function and the structural layout. The selected evaluation criteria included capacity calculation of the belt conveying, rigidity calculation and drive solution, inspection of a conveyor belt's rigidity, and the calculation of anti-slip safety coefficient, whereas the main decisive criterion was reduction of costs necessary to transport 1 ton of material. On the basis of the obtained results we carried out the economic evaluation of the belt conveyor innovations, with regard to the price of one tone of the transported material. In the conclusion, we also prepared the financial comparison of the existing and the suggested modifications of the belt conveyor parameters.

Calculations carried out for individual belt conveyors and the financial comparison have substantiated the suggested modifications of their selected parameters in compliance with the operating conditions and the principle of conveyors' functions, as well as the nature of the transported material. The method of the evaluation of clay and limestone transportation in form of a case study, while applying general principles of logistic systems designing, applying the multiple criteria decision making and the calculations of selected conveyor parameters, can serve as a suitable tool for the operator at the final decision making at the selection of innovations in the evaluated belt conveyors system.

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References

[1]. Marasova, D. (2013). *Mathematical and experimental support for belt conveyors*. VŠB-TU Ostrava.

[2]. Turnbull, D. (2013). A game changer in Mining. IPCC and continuous mining solution are set to gain more Ground. *Bulk Solids Handling, 33*(5), 16-18.

[3]. Marasova, D. et al. (2009*). Internal transport in the mining industry* (in Slovak). TU, Kosice.

[4]. Konakalla, N. S., & Vaitla, R., & Pothamsetty K. V. (2013). Design and Selecting the Proper Conveyor-belt. *International Journal of Advanced Engineering Technology, 1*, 43-49.

[5]. Nekoufar, S. (2009). Using Mathematical Optimalization Methods in Through Angle Selection. *Bulk Solids Handling, 29*, 210-213.

[6]. Grujić, M., & Ristović, I. (2004). Some questions of choice of transport System in the Coal Mines. *The International Journal of Transportation and Logistics, 7*, 7-15.

[7]. Grujic, M., & Malindžák, D., & Marasova, D. (2011). Possibilities for reducing the negative impact of the number of conveyors in a coal transportation system. *Technical Gazette, 18*(3), 453-458.

[8]. Harrison, A. (2009). Single-run dynamic simulation of conveyor belts. *Australian Bulk Handling Rewiew.*

[9]. Decmanova, J. (2010). Mathematical treatment of material impact on dampening shield flown out with the belt transport (in Slovak). *The International Journal of Transport and Logistics, 7*, 253-25.

[10]. Malindzak, D. (2010). Models and simulation in logistics (in Slovak). *Acta Montanistica Slovaca, 15*(1), 1-3.

[11]. Marasova, D., & Husakova, N., & Grendel, P. (2010). The proposal of the logistics transportation system and quarrying with conveyor belt (in Slovak). *The International Journal of Transport and Logistics, 7*, 467-471.

[12]. Bindzar, P. (2010). Designing conveyor systems according to its logistics parameters. *Metalurgija, 49*(3), 236.

[13]. Bindzar, P., & Malindzak, D. (2008). Number of conveyor belts optimization regarding to its type and logistical parameters in mining industry (in Slovak). *Acta Montanistica Slovaca, 14*(4), 524-531.

[14]. Rohacova, I., & Markova, Z. (2009). The Analysis of AHP method and its potential use in logistics (in Slovak). *Acta Montanistica Slovaca, 14*(1), 103-112.

[15]. Bitarafan, M. R., & Ataei, M. (2004). Mining method selection by multiple criteria decision making tools. *The Journal of The Southern African Institute of Mining and Metallurgy, 104*(9), 493-498.

[16]. Grujić, M., & Despodov, Z., & Ristović, I. (2007). Possibility of applying the multicriteria analysis method when selecting a conveyance system in lead and zinc mine. *Transport and Logistics, 13*, 7-14.

[17]. Grujić, M. et al. (2012). Using principal components analysis and clustering analysis to assess the similarity between conveyor belts. *TTEM Journal, 7*(1), 4-10.

[18]. Malindzak, D., & Takala, J. (2005). *Designing logistics systems: theory and practice* (in Slovak). Expres publicit.

[19]. Andrejiova, M., & Kimakova, Z., & Marasova, D. (2013). Using AHP method at the determination of the optimal selection criteria of conveyor belts. *Annals of Faculty Engineering Hunedoara-International Journal of Engineering, 11*(2), 155-160.