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CHALLENGES OF MODERNIZING AND OPTIMIZING THE PROCESS OF IM-PLEMENTING CYCLICAL-FLOW TECHNOLOGY IN A COAL MINE

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Abstract. In connection with recent economic events in the world, the problems of providing countries with energy resources have become particularly relevant. A special role in solving these problems belongs to the mining enterprises of Uzbekistan, which today are characterized by the further development of the open-pit mining method, one of which is the Angren coal mine.

The main task, its relevance, is to present one of the ways to model the optimal options for the operation of cyclic flow technology in difficult conditions of stripping operations.

The methods used. In this work, finite element methods and mathematical modeling based on the computer program "Ansys" were used to model the structures of the Central Processing Plant in order to determine the optimal parameters of the unloading and loading bunkers of the central processing plant of the Angren site.

The main hypotheses and conclusions. The work carried out, the main factors affecting the integrity of the belt were identified: the tensile strength of the main belt when unloading rock by the unloading and loading hopper of the Central Processing Plant at various belt speed parameters.

Originality. The purpose of this study is computer simulation of the CPU operation process based on the program “Ansys”.

Practical significance. The calculation methods used in this study using the finite element method based on the Ansys program can be used to determine the causes of belt conveyor gusts during its operation in various production conditions, when choosing the optimal technical parameters of structures: the height of the production hopper, the speed of the conveyor belt, its angle of inclination and the material of the belt itself

Keywords: conveyor belt, main belt, quarry, modeling, Ansys, mining engineering.

© Ж. Тошов[1], К. Елемесов[2], У. Байназов[1], Т. Аннакулов[1], *Д. Басқанбаева[2], 2024.

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КӨМІР КЕНІН ИГЕРУ КЕНІШІНДЕГІ ЦИКЛДЫҚ АҒЫНДЫ ТЕХНОЛОГИЯНЫ ЕНГІЗУ ПРОЦЕСІН ЖАҢҒЫРТУ ЖӘНЕ ОҢТАЙЛАНДЫРУ МІНДЕТТЕРІ

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Аннотация. Әлемдегі соңғы экономикалық жағдайларға байланысты барлық елдерді энергетикалық ресурстармен қамтамасыз ету мәселелері ерекше өзекті бола бастады. Бұл дағдарысты шешуде ерекше рөл Өзбекстанның тау-кен өндіру кәсіпорындарына тиесілі, олар бүгінгі таңда карьерді ашық әдіспен өндірудің одан әрі дамуымен сипатталады және олардың бірі Ангрен көмір кеніші болып табылады.

Материалдар мен негізгі әдістері – көмір карьерлерінде аршу жұмыстарының күрделі жағдайында циклдік-ағынды технологияны пайдаланудың оңтайлы, әрі тиімді нұсқаларын модельдеу жолдарының бір түрі ұсынылды.

Негізгі қолданылатын әдістер, бұл жұмыста «Ангренский» кесіндісінің СРТ түсіру-тиеу бункерлерінің оңтайлы параметрлерін анықтау мақсатында, СРТ конструкцияларын модельдеу кезінде «Ansys» компьютерлік бағдарламасы негізге алынады. Соңғы элементтер мен математикалық модельдеу әдістері қолданылды және осы мақалада жазба түрінде келтірілді.

Негізгі гипотезалар мен қорытындылар. Жүргізілген жұмыс нәтижесінде таспаның тұтастығына әсер ететін негізгі факторлар анықталды: кенжар конвейерінің, магистральдық таспаның, конвейер желісінің көлбеу бұрышының, бункердің биіктігінің және пайдаланылатын таспаның материалының сапасының әртүрлі параметрлері жағдайында бункерге жынысты түсіру кезінде магистральдық таспаның деформациясының кернеу күші есепке алына отырып, қорытынды нәтижелері сараланды.

Өзіндік ерекшелігі. Бұл зерттеу «Ansys» бағдарламасы негізінде жүргізілгенін ескерсек, СРТ пайдалану процесін қолдана отырып, компьютерлік модельдеу этаптарын айқындағымыз келді.

Практикалық маңызы. Осы зерттеуде қолданылған «Ansys» бағдарламасы негізінде соңғы элемент әдісін қолдана отырып есептеу әдістері құрылымдардың оңтайлы техникалық параметрлерін есепке ала отырып: пайдалану бункерінің биіктігін, конвейер таспасының жылдамдығын, оның көлбеу бұрышын және де таспаның материалын таңдаған кезде, оны әртүрлі өндірістік жағдайларда пайдалану процесін ескере отырып, таспалы конвейердің импульстарының себептерін анықтауға қол жеткіздік.

Түйін сөздер: конвейер, негізгі таспа, карьер, модельдеу, Ansys, тау-кен инженериясы.

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ПРОБЛЕМЫ МОДЕРНИЗАЦИИ И ОПТИМИЗАЦИИ ПРОЦЕССА ИСПОЛЬЗОВАНИЯ ЦИКЛИЧНО-ПОТОЧНОЙ ТЕХНОЛОГИИ НА УГОЛЬНОМ РАЗРЕЗЕ

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Аннотация. В связи с последними экономическими событиями в мире особую актуальность приобретают проблемы по обеспечению стран энергетическими ресурсами. Особая роль в решении этих проблем принадлежит горнодобывающим предприятиям Узбекистана, характеризующихся на сегодняшний день дальнейшим развитием открытого способа разработки полезных ископаемых, одним из которых является Ангренский угольный разрез.

Базовая проблема, ее актуальность – представить один из путей моделирования оптимальных вариантов эксплуатации циклично-поточной технологии в сложных условиях вскрышных работ.

Применяемые методы. В данной работе при моделировании конструкций ЦПТ с целью определения оптимальных параметров разгрузочно-погрузочных бункеров ЦПТ разреза «Ангренский» использованы методы конечных элементов и математического моделирования на основе компьютерной программы «Ansys».

Ключевые гипотезы и выводы. В результате проведенной работы определены основные факторы, влияющие на цельность ленты: сила напряжения деформации магистральной ленты при разгрузке породы разгрузочно-погрузочным бункером ЦПТ в условиях различных параметров скорости забойного конвейера, магистральной ленты, угла наклона конвейерной линии, высоты бункера и качества материала эксплуатируемой ленты.

Оригинальность данного исследования заключается в компьютерном моделировании процесса эксплуатации ЦПТ на основе программы «Ansys».

Практическое значение. Применённые в данном исследовании методы расчётов при помощи метода конечного элемента на основе программы «Ansys» могут быть использованы при определении причин порывов ленточного конвейера в процессе её эксплуатации в различных производственных условиях, при выборе оптимальных технических параметров конструкций: высоты эксплуатационного бункера, скорости конвейерной ленты, угла её наклона и материала самой ленты.

Ключевые слова: конвейер магистральной ленты, карьер, моделирование, Ansys, горная инженерия.

Introduction. The challenges of modernizing and optimizing open-pit coal mining techniques in Uzbekistan are largely influenced by its geological characteristics (Akbarov, et al., 2021). Therefore, the accuracy of choosing the right technology, direction, and parameters for mining has a significant impact on the technical and economic performance of open-pit operations. The technology of stripping operations, which are complicated by the climatic and geological features of the quarry, necessitates the creation of ledges in order to prevent landslides (Gulomova, et al., 2023). This, in turn, leads to the need to handle large volumes of overburden during open-pit coal mining. Therefore, the process of transporting overburden becomes particularly important.

The Angren brown coal deposit is located in the Tashkent region of Uzbekistan. It occupies part of the intermountain valley of the Akhangaran River, between the village of Ablyk in the southwest and the Akhangaran dam in the northeast (Toshov, et al., 2024). The valley is surrounded by mountains on all sides. To the north, it is bounded by the Chatkal range, and to the south, by the Kuraminsky range. The height of these mountain ranges reaches up to 3,000 meters. The highest point near the valley is Mount Babaytaidar, also known as Bobo-tog, with an elevation of 3,654 meters. Within the Angren deposit, there are two main areas: the right-bank portion of the valley and the foothill areas. The right-bank area has an absolute height range of 930 to 1,100 meters, while the foothills are located in the northern and northeastern portions of the area and have a higher elevation. The main water source for the region is the Akhangaran river, which is 235 kilometers long (Toshov, et al.,2024). The geological structure of the deposit includes rocks from the Carboniferous, Permian, Jurassic, Mesozoic, Paleogene, Neogene, and Quaternary periods. The coal-bearing unit has a maximum thickness of 160 meters and contains a complex coal deposit with a thickness of 65 to 75 meters. Above this is a variegated kaolin formation with a thickness of 25 to 30 meters, consisting mainly of clays with siltstone, sand, and gravel impurities. Cretaceous deposits, which are 5 to 25 meters thick, are represented by red sandstone (Wang et al., 2022).

The belt conveyor is widely used in the coal industry and other industries, playing a crucial role in the transportation of raw coal (Huang, et al., 2023). It regulates the pace of production, maintains its rhythm, and contributes to increased labor productivity. This type of conveyor effectively addresses issues related to complex mechanization, automation of transportation, and technological processes (Kovrov, et al., 2024). However, the short lifespan (3-5 years) and high cost of conveyor belts, which account for 50-60% of the total cost of a conveyor system, make them a crucial component due to their load-bearing and traction role (Kassenov, et al., 2022). During operation, the strength and durability of the belts decrease due to various types of damage, such as transverse cracks in the rubber layers, abrasion, breakage and tearing of layers, longitudinal cuts and gouges, damage to the sides and end joints, and delamination of the traction frame (Srimitrungroj, et al., 2023). In many ways, the failure of the conveyor belt can be attributed to its design and operation. During use, the belt experiences not only longitudinal stress from the tensioning device, but also dynamic forces during start-up and shutdown (Mikušová et al., 2019). Additionally, there are issues with the hands on the drums and defects caused by devices, as well as support from stationary rollers due to inevitable sagging between them (Fedorko et al., 2021). These cyclic deformations lead to fatigue wear, which manifests itself in the form of cracks on the traction frame and plates (Marasova, et al., 2023). For example, in reference the authors demonstrate that their fault diagnosis model outperforms a single-method approach in terms of overall accuracy in diagnosis and recognition (Toshov, et al., 2024). The accuracy of fault classification reaches up to 97.22%, showing the potential for significant improvements in the reliability of the belt transportation system in coal mines. The paper discusses the classification of conveyor belt damage using machine learning techniques (Wang, et al., 2024). The authors developed four classification models and evaluated their accuracy and predictive capabilities (Zohra, et al., 2022). These models could be used in practice to identify and predict conveyor belt failures, which are often caused by damage to the belt. In a novel approach to detecting surface damage on conveyor belts is proposed (Gelman, et al., 2023). This method, referred to as AC-AGAIN, aims to address the challenges associated with long training and deployment times as well as the limitations of previous techniques due to their dependence on limited training data. In a new technology for the automated real-time diagnosis of conveyor belt systems was investigated and validated through extensive experimentation (Semrád, et al., 2024). In focused on developing a diagnostic system that uses magnetic markers embedded directly into the conveyor belt (Gładysiewicz, et al., 2024). This system allows for control of the conveyor speed based on the known distance between the magnetic markers. It can detect potential issues not only with the power supply or control system of the conveyor, but also with wear and tear on the belt itself.

Although there have been some studies on conveyor belts, there has been very little research conducted to determine the optimal settings for unloading and loading bins in the cyclic flow system at the Angrensk plant. By studying the mechanism of cyclic flow technology, we have identified several areas of concern regarding the operation of conveyor belts. One major issue that has been identified is the frequent breakage of the main conveyor belt due to pieces of overburden falling from a significant height. This issue is exacerbated by the high speed at which conveyor belts operate and has become a persistent problem that directly affects productivity. Disruptions to conveyor operations caused by repairs have a negative impact on the entire transportation system as they disrupt the flow of materials and lead to delays.

Materials and Methods

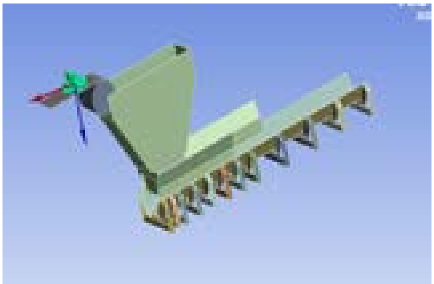
To accurately determine the stress-strain state of a multilayer rubber cable in a winding machine, it is essential to consider the longitudinal compression of the cable, which is unconstrained. Although the stiffness characteristics of each individual layer may vary depending on the number of layers, for simplicity, we will assume that they remain constant. Ignoring this factor could significantly underestimate the calculated power load and potentially lead to failure of the cable or other components in the winding system.

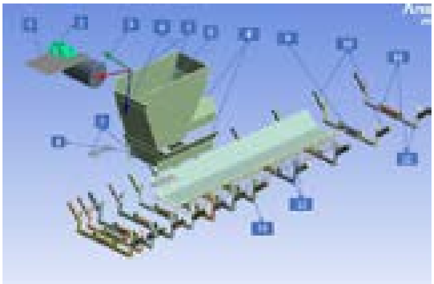
The process of calculating the forces in a multilayer cable involves several stages.

First, we need to determine the displacement of each layer within the bundle. Next, we must calculate the coefficients for transverse stiffness, expansion, and tension. Additionally, a mathematical model should take into account two significant factors: the longitudinal compression of the cable and the elastic properties of the rubber rings.The stiffness characteristics of these materials are determined by the total number of rings used in the winding process and their arrangement. This information can be calculated using programming languages such as Maple 12 and ANSYS Workbench 2022, which produce accurate and efficient results.

This information provides a high degree of accuracy in studying the stress-strain behavior of multi-layer ropes and identifies patterns that can inform engineering design decisions. It can also be used to create guidelines for load testing, ensuring the safety and reliability of these structures, as well as their durability and long-term performance.

In order to improve the efficiency of the cyclic flow technology used in coal mines for the extraction of solid overburden rocks, we conducted a thorough analysis of the main components of the system using computer-aided design. This analysis revealed that one of the main causes of conveyor stoppages was related to the unloading and loading mechanisms in the cyclic flow system. Based on this information, we carefully examined the operation of these mechanisms and created a detailed model of the unloading and loading points using ANSYS software (Figure 1).


a)


b)

1-tape; 2-rock; 3-dumping drum; 4-5- hopper walls; 6-shock absorber; 7-8 - iron aprons; 9-lower rollers; 10-side rollers; 11-roller holder; 12-roller support stop; 13-upper and lower layers of tape; 14-the ropes of the tape.

Fig. 1. General view of the belt direction model for calculation and the structural condition of the hopper model divided into parts

To determine the optimal height of the hopper and the stress-strain state of the belt, calculations were performed to simulate the unloading and loading of bunkers in the technological process of cyclic flow at the Angren coal mine. Overburden is removed from the bottom of the mine and transported to the main conveyor using various production parameters. The height of the bunker was varied between 3.5, 5.4, and 7.8 meters. The volume of rock falling on the belt, denoted as V, was 0.95 m^3. The belt moves at a speed of 5 m/s during the working process and enters the hopper, where it falls onto the lower main conveyor at a speed of 5.5 m/s with a resistance coefficient of 0.2. The properties of building iron (structural steel) bunker material are shown in Figure 2.

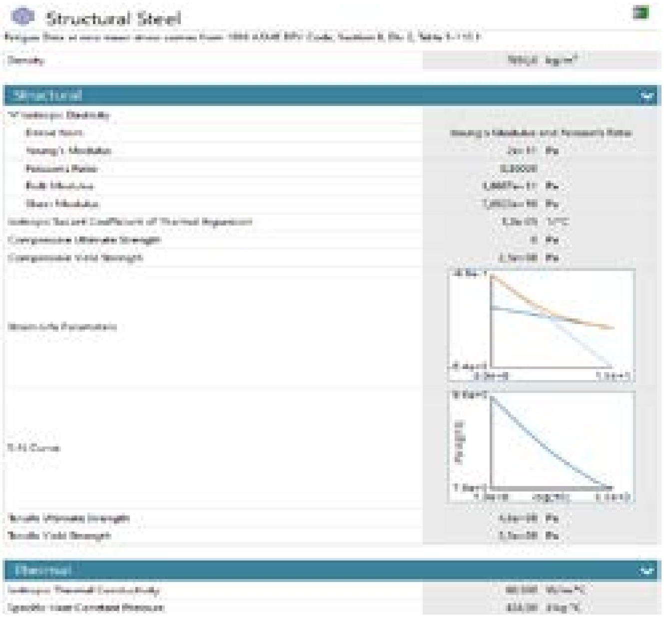


Fig. 2. Properties of building iron (steel) bunker material

The model of the impact of rock on the belt at a speed of 5.5 m/s when it moves with its own weight and an initial speed of 5 m/s is shown in Figure 3.

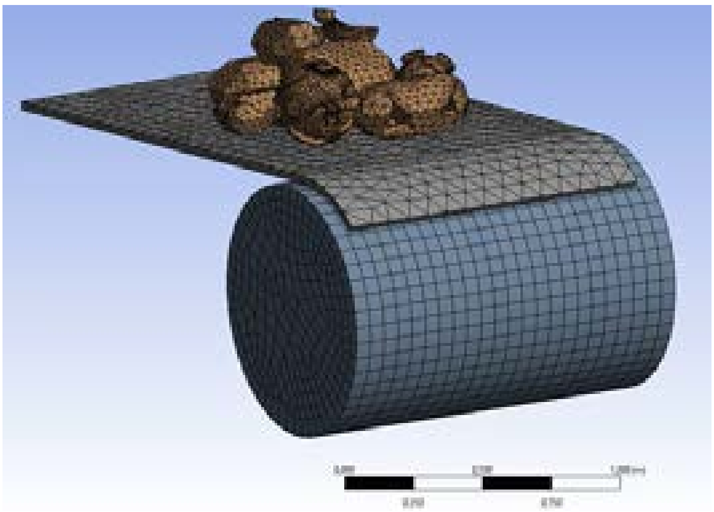


Fig. 3. General view of the tape with roller

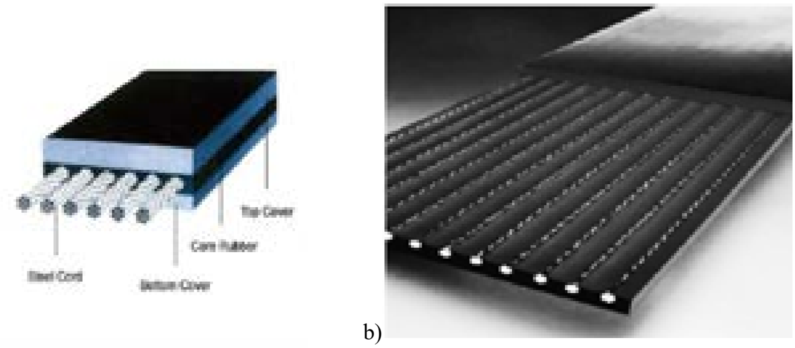
The main advantages of rubber conveyor belts are:

- High longitudinal flexibility, which allows for a smaller drive drum diameter compared to other types of belts. This makes them ideal for applications where space is limited, as they can be installed in tighter spaces.

- Good transverse flexibility, resulting in deeper grooves on narrower belts. These grooves help prevent materials from slipping off the belt, increasing transportation efficiency and reducing damage.

Rubber belts are also lighter than steel rope belts, making handling and installation easier. They are covered with a thicker layer to increase strength and durability, preventing wear and tear and ensuring a longer lifespan.

At the Angren coal mine, a STAHLCORD 1600 rubber belt is used to transport overburden rock over a distance of more than 5 kilometers. It is installed on the main conveyor line, which includes both vertical and horizontal curved sections. Figure 4 shows the typical design of a rubber-cord conveyor belt.



a) b)

Fig. 4. Rubber conveyor belt of standard design

Results and Discussion

The design of rubber belt conveyors in the mining industry is crucial for ensuring the efficient and safe operation of these systems. These belts play a vital role as load-bearing and traction components, carrying materials from one point to another. When designing these systems, it is essential to choose durable and reliable materials that can withstand the high dynamic loads placed on the drive drums, especially in cyclic-flow applications where the belt frequently starts and stops. High-quality materials should also have excellent abrasion resistance to ensure longevity and durability. Lightweight belts help minimize stress on the system, leading to optimal performance and reduced downtime. By selecting the right belt material for the job, miners and operators can maximize productivity and minimize maintenance costs, while ensuring safe and efficient operations. It is also important to choose a durable belt with a long lifespan, as this will help reduce operating costs, ensure optimal performance, and minimize downtime. A reliable belt that requires minimal maintenance will maximize uptime, ensuring uninterrupted production and minimizing the frequency of repairs. Selecting a high-quality belt allows miners and operators to have confidence in their conveyor systems, knowing that they will function smoothly and reliably over the long term. This leads to increased productivity, profitability, and reduced downtime, ultimately saving time and money.

In order to determine the optimal parameters and characteristics of the conveyor belt, we will use the finite element method to analyze the deformation and stress state of the belt under external forces. We will divide the entire area of the belt into smaller elements, as shown in Figure 3. For each individual element, we will calculate the total energy, considering the edges of the small parallelepipeds. Then, we will take the derivative of this total energy with respect to each variable, and set it equal to zero, in order to create a system of equations that corresponds to the number of nodes in the belt. This system of equations will help us in determining the optimal values for parameters such as the strength and flexibility of the belt.

Let us consider a finite element in the form of a parallelepiped (a,b,c). To determine the coordinates of this element, we need to know the displacement components (u, v, w), which can be found in Table 1.

Table 1. This is a table. Tables should be placed in the main text near to the first time they are cited.

Dot	Point coordinates (ζ, η, θ)	Move Component
1	(0,0,0)	(u_1, v_1, w_1),
2	(a,0,0)	(u_2, v_2, w_2),
3	(a,b,0)	(u_3, v_3, w_3),
4	(0,b,0)	(u_4, v_4, w_4),
5	(0,0,c)	(u_5, v_5, w_5),
6	(a,0,c)	(u_6, v_6, w_6),
7	(a,b,c)	(u_7, v_7, w_7),
8	(0,b,c)	(u_8, v_8, w_8),

We can describe this element by considering a small section of the parallelepiped, as shown in Figure 5.

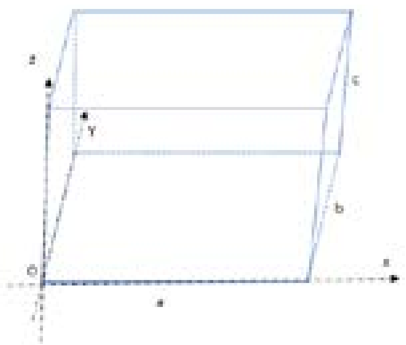


Fig.5. Elementary piecewise element of a parallelepiped

In this case, the total displacement of the field must also satisfy the edge points of the field u, v, w. Consider the displacement for its first component and obtain (1) a system of equations:

$$u = a_1\zeta + b_1\eta + c_1\theta + d_1\zeta\eta + f_1\zeta\theta + e_1\eta\theta + g_1 + h_1\zeta\eta\theta$$
$$v = a_2\zeta + b_2\eta + c_2 2\theta + d_2\zeta\eta + f_2\zeta\theta + e_2\eta\theta + g_2 + h_2\zeta\eta\theta$$
$$w = a_3\zeta + b_3\eta + c_3\theta + d_3\zeta\eta + f_3\zeta\theta + e_3\eta\theta + g_3 + h_3\zeta\eta\theta \quad (1)$$

here $a_i; b_i; c_i; d_i; f_i e_i; g_i; h_i$ constant, not yet known.

If we introduce the following definitions $\zeta = \frac{x}{a}; \eta = \frac{y}{b}; \theta = \frac{z}{c}$, and move on to dimensionless values, we will find the displacement of the total area for a three-dimensional region in the following form:

$$\begin{cases} u_1 = g_1 \\ u_2 = aa_1 + g_1 \\ u_3 = aa_1 + bb_1 + abd_1 + g_1 \\ u_4 = bb_1 + g_1 \\ u_5 = cc_1 + g_1 \\ u_6 = aa_1 + cc_1 + acf_1 + g_1 \\ u_7 = aa_1 + bb_1 + abd_1 + cc_1 + acf_1 + bce_1 + g_1 + abch_1 \\ u_8 = bb_1 + cc_1 + bce_1 + g_1 \end{cases} \quad (2)$$

From this

$$\begin{cases} g_1 = u_1 \\ a_1 = \frac{u_2 - u_1}{a} \\ b_1 = \frac{u_4 - u_1}{b} \\ c_1 = \frac{u_5 - u_1}{c} \\ u_5 = cc_1 + g_1 \\ u_6 = aa_1 + cc_1 + acf_1 + g_1 \\ u_7 = aa_1 + bb_1 + abd_1 + cc_1 + acf_1 + bce_1 + g_1 + abch_1 \\ u_8 = bb_1 + cc_1 + bce_1 + g_1 \end{cases} \quad (3)$$

Let's get all the constants depending on the movements

$$g_1 = u_1;$$
$$a_1 = \frac{u_2 - u_1}{a};$$
$$b_1 = \frac{u_4 - u_1}{b};$$
$$c_1 = \frac{u_5 - u_1}{c};$$
$$d_1 = \frac{u_3 - u_4 + u_1 - u_2}{ab};$$
$$f_1 = \frac{u_6 - u_5 + u_1 - u_2}{ac};$$
$$e_1 = \frac{u_8 - u_5 + u_1 - u_4}{ac};$$
$$h_1 = \frac{u_7 - u_8 - u_6 + u_5 + u_4 - u_3 + u_2 - u_1}{abc}$$

From here we can get a complete representation of the u,v,w function:

$$u= \frac{u_2-u_1}{a}\zeta+\frac{u_4-u_1}{b}\eta+\frac{u_5-u_1}{c}\theta+\frac{u_3-u_4+u_1-u_2}{ab}\zeta\eta+\frac{u_6-u_5+u_1-u_2}{ac}\zeta\theta +\frac{u_8-u_5+u_1-u_4}{ac}\eta\theta+u_1+\frac{u_7-u_8-u_6+u_5+u_4-u_3+u_2-u_1}{abc}\zeta\eta\theta$$

$$v= \frac{v_2-v_1}{a}\zeta+\frac{v_4-v_1}{b}\eta+\frac{v_5-v_1}{c}\theta+\frac{v_3-v_4+v_1-v_2}{ab}\zeta\eta+\frac{v_6-v_5+v_1-v_2}{ac}\zeta\theta +\frac{v_8-v_5+v_1-v_4}{ac}\eta\theta+v_1+\frac{v_7-v_8-v_6+v_5+v_4-v_3+v_2-v_1}{abc}\zeta\eta\theta$$

$$w= \frac{w_2-w_1}{a}\zeta+\frac{w_4-w_1}{b}\eta+\frac{w_5-w_1}{c}\theta+\frac{w_3-w_4+w_1-w_2}{ab}\zeta\eta+\frac{w_6-w_5+w_1-w_2}{ac}\zeta\theta +\frac{w_8-w_5+w_1-w_4}{ac}\eta\theta+w_1+\frac{w_7-w_8-w_6+w_5+w_4-w_3+w_2-w_1}{abc}\zeta\eta\theta$$

As is known, the kinetic energy of a deformable solid is equal to:

$$E_k=\frac{1}{2}\iiint \sigma_{ij}\varepsilon_{ij}dV \quad (4)$$

If we find the components σ_{ij} Hooke's law:

$$\sigma_{ij}=[A]\left[\varepsilon_{ij}\right] \quad (5)$$

$$[A]=\begin{pmatrix} \lambda+2\mu & \lambda & \lambda & 0 & 0 & 0\\ \lambda & \lambda+2\mu & \lambda & 0 & 0 & 0\\ \lambda & \lambda & \lambda+2\mu & 0 & 0 & 0\\ 0\ 0\ 0 & & & \mu & 0 & 0\\ 0\ 0\ 0 & & & 0 & \mu & 0\\ 0\ 0\ 0 & & & 0 & 0 & \mu \end{pmatrix} \quad (6)$$

here λ, μ - Lamé parameter, σ_{ij}-stress component, ε_{ij} - strain component.

Based on the fact that the total kinetic energy is equal to the following for our case:

$$E_k=\frac{1}{2}\iiint \sigma_{ij}\varepsilon_{ij}dV=\iiint [A]*[B]^T*\left[u_{ij}\right]^T*[B]*\left[u_{ij}\right]dV = =\int_0^1\int_0^1\int_0^1[A]*[B]^T*\left[u_{ij}\right]^T*[B]*\left[u_{ij}\right]d\zeta*d\eta*d\theta \quad (7)$$

In this case, the hardness matrix will be for one element:

$$k=\int_0^1\int_0^1\int_0^1[B]*[A]*[B]^T*\left[u_{ij}\right]d\zeta*d\eta*d\theta \quad (8)$$

here k-matrix coefficient of stiffness material.

Formula 7 represents the stiffness matrix of the unreinforced part of the tape. We use the hyperelastic Ogden model, assuming that the overall belt is hyperelastic, to represent the stiffness matrix of the entire belt (also suitable for large deformations).

Ansys uses existing large deformation models. To simplify the mathematical model, first of all, let's imagine the bottom band as solid, plastic (Figure 6).

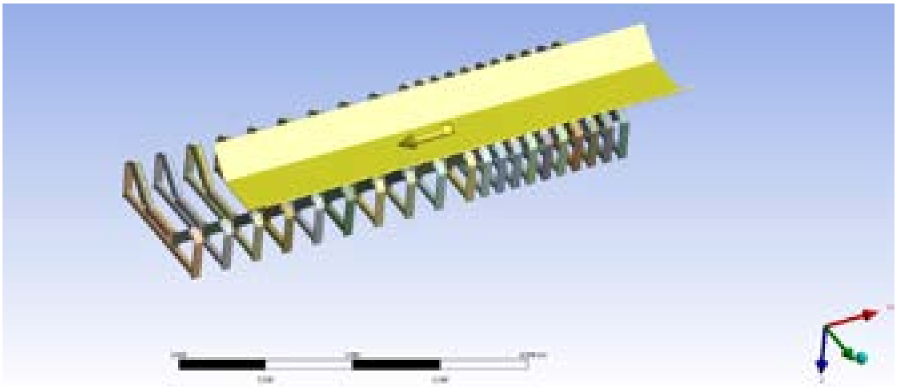


Fig.6. Conveyor belt model

To determine the maximum number of nodes in the parallelepiped, a stress-strain analysis of the tape was conducted using the Ansys software package and the finite element method. The results of this analysis are presented in Figures 7.

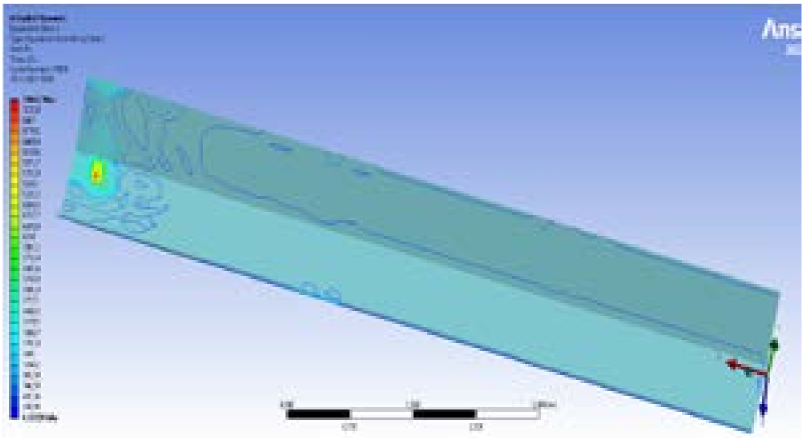


Fig.7. Strain distribution along a conveyor belt

As shown in Figure 7, when the top belt speed is 5 m/s and the hopper height is 5.4 m, the lower belt speed is also 5.5 m/s. The total belt deformation is 15 centimeters and the z-axis deformation is 2 centimeters. The force acting on the belt is 7464.7 Pascal. The graphical and mathematical calculations for analyzing the operation of the 5.4-meter-tall bunker are presented in the figure, showing the results of stress forces on the main conveyor belt. As illustrated in the diagram, rocks are thrown from the conveyor at a speed of 5 m/s when they reach a specified height and hit the hopper. The hopper then absorbs the speed of the falling rocks and their impact force, as they freely hit the receiving main conveyor belt at 5.5 m/s. In Figure 8, different colors are used to indicate different levels of stress. Red represents the highest level, while blue represents the lowest. The point at which the highest level occurs is called the "danger zone".

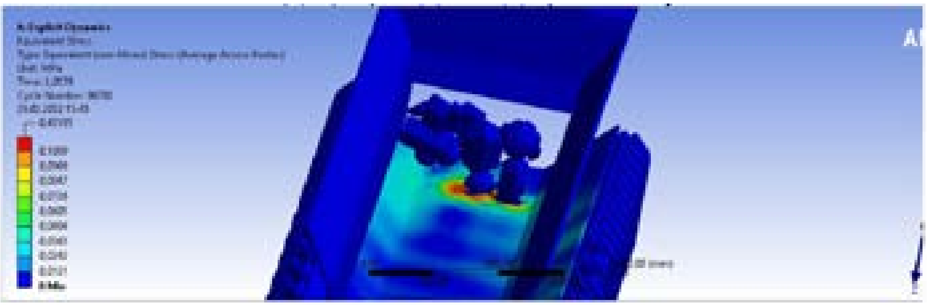


Fig.8. Strain distribution along a conveyor belt loaded with coal

The law of change in the tension of an elastic band over time is shown in Figure 9. The graph shows the voltage levels over time. The highest voltage is represented by green, the average by blue, and the lowest by red. This allows us to see that the peak voltage occurs around 2.125 seconds.

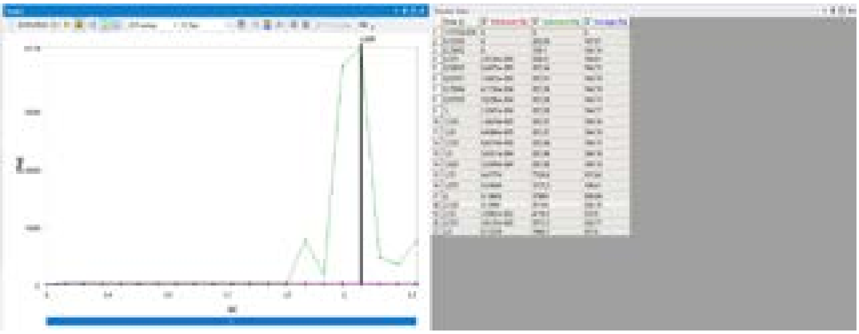


Fig. 9. Graph of stress in the bunker over time at a fall height of 5.4 m.

Thus, the "Ansys Workbench" software was used to create 3D models of the cyclical-flow unloading and loading system located between the conveyor belts of the structure. This software helped us to determine the exact geometric parameters of the system under study. Analysis of the 3D models allowed us to identify the causes of failure of the main conveyor belt in the cyclical-flow process, including the height of the unloading and loading bins, the forces applied by falling hard rocks, and the dynamic stress [19] on the rubber belt.

Conclusions

The results of the calculations, carried out using the finite element method and ANSYS software, have helped us to identify the causes of the frequent failures of the main conveyor belt during operation. These failures are caused by both structural and technical problems with the belt, as well as the impact forces from the falling rocks at the points of loading and unloading. Bunker-cyclic flow technology was also taken into account in the calculations. Based on this information, the optimal height of the bunker was determined to be 5.4 meters.

Thus, the use of mathematical modeling techniques, such as finite element analysis using the Ansys software, has allowed us to determine the optimal height of the loading and unloading chute. This has extended the lifespan of the conveyor belt by reducing the frequency of breakdowns and, consequently, reducing the need for repairs to the structure.

During the experiment, we also studied and determined other optimal parameters for technical units in the design of cyclic-flow technology. These include: the choice of optimal speed for the production line and main conveyor, as well as the correct setting of the optimal angle for the inclination of the conveyor in the cyclic-flow system.

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CONTENT

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