



INFLUENCE OF THE EXPLOITATION FACTORS ON DESIGN PARAMETERS OF MODERN CONVEYOR BELTS

UTICAJ EKSPLOATACIONIH FAKTORA NA KONSTRUKTIVNE PARAMETRE MODERNIH TRANSPORTNIH TRAKA

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Abstract: *The main factors influencing constructive parameters and term of live of conveyor belts which are exploited at coal mines of Russia are given in the paper. The main types of homemade belts are also examined.*

Key words: *belt, properties, injury, parameters*

Apstrakt: *U ovom radu su prikazani glavni faktori koji utiču na konstruktivne parametre i uslove rada transportnih traka koji se javljaju u rudnicima uglja Rusije. Takođe su istraživani i najvažniji tipovi traka domaće izrade.*

ključne reči: *traka, osobine, oštećenje, parametri*

1 INTRODUCTION

The conveyor belt is one of the most important elements of the belt conveyor which simultaneously carries out functions of tractive and carrying load body. It defines a number of properties, such as the longitudinal durability appropriate to a tension, working on a belt, necessary longitudinal flexibility in order to prevent substantial growth of diameters of drums, cross flexibility, sufficient for formation of the tray form on rollers bearing, but not excessive, at which levelling could occur in bay between rollers bearings, probably small elasticity and residual drawing out in order to prevent necessity of the large course of tight device or often joining of a belt for its shortening, probably high resistance to deterioration owing to bends on drums, rolling on rollers bearings, abrasive and shock influence of a cargo on loading items and linear rollers bearings.

1 UVOD

Transportna traka je jedan od najvažnijih elemenata trakastog transportera, koja istovremeno vrši funkciju vučnog i nosećeg organa. Ona je definisana nizom potrebnih osobina kao što su: potrebna uzdužna čvrstoća na zatezanje trake, neophodna uzdužna elastičnost u cilju izbegavanja većeg povećanja prečnika bubnjeva, poprečna elastičnost za obrazovanje koritaste forme na nosećim valjcima (ali ne preterana pri kojoj se mogu pojaviti ugibi među valjcima) što je moguće manja elastičnost i trajno izduženje u cilju sprečavanja potrebe za velikim hodom zateznih uređaja ili čestog skraćivanja i nastavljanja trake, moguća visoka otpornost na trošenje i propadanje usled savijanja na bubnjevima, utiskivanja nosećih valjaka, abrazivnog i udarnog dejstva tereta na utovarnim punktovima i linijskim valjcima.

2 STATEMENT OF A TASK

During exploitation conveyor belt was the most expensive and the least protected from abrasive and shock influence of transported pieces of a material by an element of the belt conveyor, accumulates in itself damages resulting to failures and very frequently to significant idle times of the belt conveyor. This negatively influences economic parameters of work of mining transport.

Generally when estimating serviceability of conveyor belts damages connected with abrasive and shock and fatigue destruction of the worker rubber facing, fatigue stratification of linings, exfoliation of facing; destruction of a string of a basis and duck of linings of rubber belts from variable loadings and sharp excesses, and also from influence of aggressive medium (moisture) penetrating into stratifications, cracks and damages of facing; destruction of boards because of lateral going down of the belt, clamps and cuts owing to impacts of large acute - angled pieces of transported cargo, longitudinal impulses, destruction of joints and etc.

Alongside with the above-stated subjective attributes of a working condition of a belt objective parametrical attributes are used. They are separate modular physico-mechanical characteristics, as of complex body: modular durability at stretching, modular module of elasticity, dynamic module of elasticity, factor of safety, speed of abrasive deterioration in terms of weight on a running meter of length, measure of accumulation fatigued damages etc.

From all mentioned above factors influencing a constructive condition of a belt while in service, the most significant are the damages connected with abrasive and shock destruction of the worker rubber facing and the core of a belt, and also deterioration and destruction of boards because of lateral going down.

A number of the authors theoretically and also experimentally have proved a measure of damage of elementary volume of a material of a conveyor belt at shock loading widely used in the theory of fatigued destruction of materials [1,2,5]. Increase of a measure of damage of loading at cycle j depends on an equivalent maximal voltage of this cycle [3]:

$$(\Delta\psi)_j = \frac{1}{N_j} = \left(\frac{\sigma_{eq,j}}{[\sigma_{eq}]} \right)^{m_1}, \quad (1)$$

2 POSTAVKA PROBLEMA

U procesu eksploatacije transportna traka je najskuplji i najmanje zaštićen element od udarnog dejstva komada tereta koji se transportuju, akumulira u sebi oštećenja i dovodi do otkaza i veoma često dolazi zbog toga do zastoja u radu trakastih transportera.

U opštem slučaju, kada se procenjuje radna sposobnost transportne trake razmatraju se oštećenja povezana sa uticajem abrazije, udara i zamora radne površine gumene obloge, raslojavanje uložaka usled zamora, ljuspanje obloge, propadanje niti osnove i potke uložaka tkanih gumenih traka usled promenljivog utovara i oštih pregiba, a takođe i od uticaja agresivne sredine (vlage), koja prodire u raslojenja, proboji i oštećenja obloga usled dejstva krupnih oštrouglih komada tereta koji se transportuje, uzdužnih impulsa, prekida spojeva itd.

Istovremeno, sa napred navedenim subjektivnim karakteristikama radnih uslova traka, korišćeni su objektivni parametarski pokazatelji. Oni predstavljaju zasebne modularne fizičko-mehaničke karakteristike, kao kompozitnog tela: agregatnu čvrstoću pri zatezanju, agregatni moduo elastičnosti, dinamički moduo elastičnosti, koeficijent sigurnosti, brzina propadanja pod uticajem abrazije po jedinici mase po metru dužine, mera akumuliranih oštećenja usled zamora itd.

Od svih navedenih faktora koji utiču na konstruktivne uslove pri eksploataciji trake, najznačajniji su oštećenja nastala pod uticajem abrazije i udara na gumenu oblogu trake i jezgro trake, a takođe pogoršanje i oštećenje njenih ivica usled bočnih kretanja.

Brojni autori su teorijski i eksperimentalno dokazali stepen oštećenja elementarnog oblika materijala, od koga je izrađena traka, pri udarnom oštećenju, koji su široko primenjeni u teoriji oštećenja materijala usled zamora [1,2,5]. Povećanje stepena oštećenja pri j -tom ciklusu opterećenja zavisi od maksimalnog ekvivalentnog naprezanja u tom ciklusu [3]:

$$(\Delta\psi)_j = \frac{1}{N_j} = \left(\frac{\sigma_{eq,j}}{[\sigma_{eq}]} \right)^{m_1}, \quad (1)$$

where:

N_j - number of cycles before destruction provided that in all cycles the maximal equivalent voltage is equal σ_{eq} ;

σ_{eq} - maximal equivalent voltage in the period loading of a cycle j ;

$[\sigma]_{eq,j}$ - maximal equivalent admitted voltage at which destruction of a framework of a belt occurs during the first cycle loading;

m_1 - parameter of a degree of curve of fatigue (curve of Veler).

Thus it is supposed that the connection between deformations and voltages looks like power function:

$$\sigma_{eq,j} = a \frac{m}{m_1} \quad (2)$$

It is experimentally proved [2,6] that the sizes $\left(\frac{a_j}{a_0}\right)^m$ or $\left(\frac{\sigma_{eq,j}}{[\sigma_{eq,j}]}\right)^{m_1}$ at different levels of deformations and voltages in cycles of loading can linearly be summarized.

The experimental researches allow to determine parameters a_0 m for this measure under condition of achievement dot, through clamp of a belt in the center of patches of loading by strikers of the various form and weight.

If on a belt there are several centers of shock damages located enough close from each other, the effects of decrease of durability of a belt from them are summarized. For definition of total effect of decrease of durability of a belt from n centers of shock damages the formula is received [3]:

$$\eta_\Sigma = \bigcup_{j=1}^n \eta_j \quad (3)$$

where:

\cup - operation of summation of the effective cross sizes of the centers of shock damages without the account of their overlapped sites;

η_j - integrated measure of damage in dangerous section from one impact j of a large piece of transported cargo under condition of non-failure operation of a belt.

The size of deterioration of top facing and boards of a belt is the result of summation of the large number of the normally distributed independent influences with average total size $v_{av} t$ and total dispersion $\sigma_v^2 t$.

gde su:

N_j - broj ciklusa pre izazvanog oštećenja, gde je u svim ciklusima maksimalne ekvivalentno naprezanje jednako σ_{eq} ,

σ_{eq} - maksimalno ekvivalentno naprezanje u periodu j -tog ciklusa opterećenja,

$[\sigma]_{eq,j}$ - maksimalno ekvivalentno dopušteno naprezanje, pri kojemprekid jezgra trake dolazi za vreme prvog ciklusa opterećenja i

m_1 - pokazatelj stepena krivine zamora (kriva Velera).

Pri tome je pretpostavljeno da veza između deformacija i naprezanja ima oblik eksponencijalne funkcije:

$$\sigma_{eq,j} = a \frac{m}{m_1} \quad (2)$$

Eksperimentalno je dokazano [2,6] da veličine $\left(\frac{a_j}{a_0}\right)^m$ ili $\left(\frac{\sigma_{eq,j}}{[\sigma_{eq,j}]}\right)^{m_1}$ pri različitim nivoima deformacija i naprezanja u ciklusu mogu da sesabiraju linearno.

Eksperimentalna istraživanja dozvoljavaju određivanje parametara a_0 m pod uslovima utvrđenog preseka kroz probaj trake u centru dejstva opterećenja usled udara komada različitog oblika i mase.

Ako na traci postoji nekoliko žarišta udarnih opterećenja, koji su dovoljno blizu jedno drugom, efekti smanjenja čvrstoće trake od njih se sabiraju. Za određivanje sumarnog efekta smanjenja čvrstoće trake od n žarišta udarnih oštećenja dobijena je formula [3]:

$$\eta_\Sigma = \bigcup_{j=1}^n \eta_j \quad (3)$$

gde su:

\cup - operacija sumiranja efektivnih poprečnih razmera žarišta udarnih povreda bez obzira na njihove položaje,

η_j - integralni stepen oštećenja u opasnom preseku od jednog udara j velikog komada transportovanog tereta pod uslovima bezotkaznog rada trake.

Veličina oštećenja obloge i platna trake je rezultat zbira velikog broja normalno raspodeljenih nezavisnih uticaja sa srednjom zbirnom veličinom $v_{av} t$ i sumarnom disperzijom $\sigma_v^2 t$.

As the settlement circuit it is accepted the model based on definition of time of achievement of casual size δ_c varied with casual speed v , limiting meaning δ_l , meaning failure. The most probable time of achievement of limiting meaning of deterioration δ_l is equal:

$$t_M = \frac{\delta_l}{v_{av}} \quad (4)$$

where:

v_{av} - average speed of wear and tear of top facing of a belt with the appropriate type of a cargo, or speed of wear and tear of a board of a belt.

As criterion of failure of a board of a belt the allowable deterioration of boards δ_b determined by specifications of operation of belt conveyors is accepted.

In view of the mentioned above operational factors of belts influencing design data, the domestic industry scientists mastered manufacture of modern multi laying rubber conveyor belts, and also woven as a whole of one and two laying belts.

We shall consider the most important design features of rubber belts produced by Russian plants.

The basic lack of multi laying belts is the large thickness and, consequently, their significant weight, and also discrepancy of durability of a belt and total durability of linings. The practice of operation shows that the real durability of a belt is less than settlement one because of impossibility of maintenance of an identical tension of all linings of a belt in process of its production.

As well as in world practice, the tendency of reduction of number of linings in a belt - their number does not exceed 6-8, but having higher durable parameters with $\sigma_p = 400$ and 800 N/mm of width of one lining was planned. The manufacturing of such linings from a fabric such as *TK-300*, *400* became possible due to development of workings of open stock research company in Yaroslavl and also allowed a factory of close stock company "Kurskresinotehnica" to make a belt such as *2SH-3200-4-TK-800 -4,5-3,5-G-RB*. It is necessary to note that all produced belts can have either rubber board (*RB*) or threaded (*THR*).

The designs of belts with smaller quantity of linings in the core are more durable, i.e. having smaller thickness they bend around drums without deformations of shift of top facing, This may result in a stratification of top facings.

Za postizanje kvaliteta računске šeme prihvaćen je model zasnovan na određivanju vremenu dostizanja slučajne veličine δ_c , koja se menja sa slučajnom brzinom v , graničnom vrednošću δ_l , koji označava otkaz. Vreme dostizanja granične vrednosti sa najvećom verovatnoćom biće:

$$t_M = \frac{\delta_l}{v_{av}} \quad (4)$$

gde je:

v_{av} - srednja brzina habanja gornje obloge trake sa odgovarajućim tipom tereta, ili brzina abanja ivice trake.

U svojstvu kriterijuma za otkaz ivice trake prihvaćena je pohabanost ivice δ_b koja je definisana tehničkim uslovima eksploatacije trakastih transporterata.

Pri razmatranju napred navedenih eksploatacionih faktora uticajnih na konstruktivne parametre trake, domaća industrija osvojila je proizvodnju savremenih gumenih tkanih traka sa više uložaka a takođe monolitnih tkanih traka sa jednim ili dva sloja.

Razmotrićemo nekoliko najvažnijih konstruktivnih svojstava gumenih tkanih traka koje se proizvode u ruskim fabrikama.

Osnovni nedostatak traka sa više uložaka je velika debljina i prema tome i značajna njihova masa, a takođe i neusklađenost čvrstoće trake i ukupne čvrstoće uložaka. Traka pri eksploataciji pokazuje da je stvarna izdržljivost trake manja od računске zbog nemogućnosti održavanja identičnog istezanja svih uložaka trake u procesu proizvodnje.

Isto kao i u svetskoj praksi, nametnuta je tendencija smanjenja broja uložaka u traci - njihov broj ne prelazi 6-8, ali imaju veće pokazatelje čvrstoće $\sigma_p = 400$ i 800 N/mm širine jednog uložaka. Izrada takvih uložaka od tkanine tipa *TK - 300*, *400* postala je moguća zahvaljujući radom OAO PIIT (istraživačka kompanija) u Jaroslavu, a takođe su se isplatile fabrici ZAO Kurskresinotehnica da izradi traku kao što je *2SH-3200-4-TK-800 -4,5-3,5-G-RB*. Neophodno je istaći da sve proizvedene trake mogu imati ili gumene ivice (*RB*) ili narezane (*NR*).

Konstrukcije traka sa manjim brojem uložaka u jezgru su dugoročnije, tj. imaju manju debljinu, savijaju se oko bubnjeva bez deformacija usled klizanja gornje odnosno donje površine obloge, što inače izaziva raslojavanje površinske obloge.

For improvement of elasticity of belts in a longitudinal direction, and also flexibility and the increases of durability of connections between elements of designs of the core belts are worked out with thick up to 1,5-2,0 mm rubber layers. This allows to increase term of their service up to 5-6 months in comparison with belts of a usual design.

Belts woven as a whole (with one or two linings) are received the greater application. They have framework impregnated by polyvinilchloride. So for example, open stock company "RTI-RUBBER" has developed and tested a belt woven as a whole with two linings such as 2SHTC with the increased thickness of layer of rubber from 2,5 up to 4,0 mm, which depends on durability of fabric plies. This took place in mine conditions. Thus special fabrics are used with breaking durability on a basis up to 1200 N/mm of width of a lining of a belt, and the durability till a duck makes about 25 % from a basis. Weight and thickness of such belt is less at 30 % than exploited ones at the present time, and wear and tear of top facing is increased at 25 %.

3 CONCLUSIONS

The submitted data concerning design data of domestic rubber conveyor belts show that factories- manufacturers take into account influence of the operational factors concerning the basic parameters of belts resulting in increase of their resource which can be determined in view of the given dependences; for exact definition of basic, design data of belts it is necessary to have the appropriate statistical material collected at mining enterprises. Its processing will allow more correctly to estimate influence of the various factors on a resource of belts.

Za poboljšanje elastičnosti u podužnom pravcu, a takođe i savitljivosti i povećanje čvrstoće veza između konstrukcije jezgra izgrađene su trake sa proslojcima debljine 1,5-2,0 mm, što omogućava produženje roka upotrebe i do 5-6 meseci u odnosu na trake obične konstrukcije.

Trake tkane kao jedna celina (sa jednim ili dva uloška) dobijaju sve veću primenu u rudarstvu. One imaju jezgra impregnirana polivinilhloridom. Tako j, na primer, kompanija OAO RTI - Kaučuk razvila i ispitala tkane trake sa dva uloška kao što je 2ŠTS sa povećanom debljinom gumenih proslojaka od 2,5 do 4,0 mm, koja zavisi od čvrstoće tekstilnih uložaka. Pri tome su korišćene specijalne tkanine sa osnovnom čvrstoćom na kidanje do 1200 N/mm širine uloška trake, a čvrstoća potke iznosi oko 25% od osnove. Masa i debljina takve trake je za 30% manja od onih koje su sada u eksploataciji, a izdržljivost gornje obloge je povećana za 25%.

3 ZAKLJUČCI

Prikazani podaci koji se odnose na konstruktivne parametre domaćih gumenih tkanih traka ukazuju na to da fabrike proizvođači uzimaju u obzir uticaj eksploatacionih faktora na osnovne parametre trake. To rezultira povećanjem njihovih resursa koje može biti definisano navedenim zavisnostima. Za tačno određivanje osnovnih konstruktivnih parametara trake neophodno je imati odgovarajući statistički materijal sakupljen u rudarskim preduzećima. Njihova obrada će dopustiti da se pravilnije proceni uticaj različitih faktora

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