RESEARCH ON THE HOMOGENEITY OF TEMPERATURES IN JOINT'S AREA BY VULCANIZING THE CONVEYOR BELTS

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Abstract: *The researches presented in this paper have followed the analysis of the heat transfer mode during joining through vulcanization of the conveyor belts and also the homogeneity of the temperatures in the joint area. The researches were made under laboratory conditions taking into account the process of joining of two conveyor belts of the type ST 2000 with an installation of the type DSLQ. Temperature measurement was conducted using an EX42570 pyrometer in four distinct points corresponding to each end of the two conveyor belts on the both sides of the band, namely the active and inactive side.*

Keywords: conveyor belts, homogeneity, temperature, vulcanizing

1. INTRODUCTION

The joining of the conveyor belts with metal and textile inserts is a particularly important operation in the construction and maintenance of the conveyor belt functioning.

The productivity of a conveyor belt is greatly influenced by the residence time needed to perform repairs and especially the rebuilding of the joints or replacement of sections of belt which requires new joints and in these circumstances it is desirable that this time be as short as possible. Knowledge and observance of the operations and the execution of the joint are absolute requirements for its success. Accumulating experience can continuously improve both organization of the operations and the materials and the workmanship of the joint.

Bonding process of the belts is made up of a succession of relatively simple operations, labor weight is due to heavy workloads, the weight of the vulcanization press, which mainly involves physical labor dependent on climatic conditions. On the joining of two belts it is necessary to obtain a structure as close to the original belt. Since the insert (metal or textile) is the basis of resistance of the section that is being formed, arrangement of the cables in the joint determines the merge system [1].

The method for joining the conveyor belts with inserts made of steel cables is not so well known and widespread as the method for joining the belts with textile inserts, due to the higher degree of complexity of operations that entail them. In the joining of these types of belts, the individual steel cables, corresponding to the two ends of the belt, are inserted one in each other (by a merge system) in a core of rubber and are vulcanized. Tensile forces are transmitted to the vulcanized rubber core, which ensures the adhesion of rubber-steel cable from one end to the other of the joint and the whole phenomenon is observed to the whole band. Cable's ends are not welded, not spliced, nor bind through other mechanically way.

When the corresponding cables are inappropriate placed, the tensile strength from the merged area decreases. Knowing this is particularly important for the vulcanizer and this demonstrates that only respecting the vulcanization technology in the joints there can be obtained an adequate reliability.

This system of placement of the wires is known as *the joint of conveyor belts in one stage* and is applicable to the following types of belts with steel cables: ST 800, ST 1000 and ST 1600, the length of the joint being respectively 650, 700 and 900 mm. Whatever the applied merge system, between the edges of two adjacent cables from the merged area must remain enough space where can be inserted between them strips of uncured rubber (plastic) with a thickness of 2 mm. Only this rubber layer ensures the required grip and the transmission of the traction forces. If the space between the cables does not allow a corresponding cable, then steel cables are placed in a shape of stairs, after a determined and calculated beforehand scheme [2].

This means that some cables are cut to different lengths and are placed facing each other and through the following of the vulcanization technology, transmit by the contact of the sidewalls to the adjacent longer cables the tensile forces required in the joint area. Thus, it can be concluded that the merge system is chosen depending on the class of resistant of the belt and the required distance between cables in the joint area (Table 1).

Table 1. The method for selecting the joint system depending on the class of resistant of the belt and the required distance between cables in the joint area

The class of resistant	Cable diameter [mm] × no. of cables	Joint methods	Distance between cables in the belt body [mm]	The effective distance between cables in the joint portion [mm]
ST 300	2,0 × 74	Joint in one stage	13,0	4,5
400	2,0 × 96	Idem	10,0	3,0
500	2,4 × 83	Idem	11,5	3,3
600	2,9 × 77	Idem	12,5	3,3
800	3,3 × 80	Idem	12,0	2,7
1000	3,9 × 74	Idem	13,0	2,6
1600	4,3 × 95	Joint in two stages	10,0	2,4
1250	4,6 × 96	Idem	10,0	2,1
2000	5,7 × 77	Idem	12,5	2,6
2500	8,3 × 51	Idem	19,0	3,5
3150	9,1 × 52	Idem	18,5	4,3
5000	10,0 × 58	Joint in three stages	16,5	4,9
4000	10,0 × 65	Idem	14,8	4,8
4500	11,3 × 59	Idem	16,3	5,0

2. MATERIALS AND METHODS

The experimental researches have been conducted in laboratory conditions taking into account hot vulcanization joining of two important conveyor belts, type ST 2000. The process of joining by vulcanization was conducted at hot and so the whole process is characterized by a heat transfer from the heating plate to the joint area.

Thus, in the bonding process by vulcanization of the conveyor belts, a special importance for the partner materials has thermal conductibility [3].
By definition, thermal conductibility λ results from the relation:

$$Q = -\lambda \frac{dT}{dx} dt \qquad (1)$$

where: Q is the heat flow or amount of energy that cross a unit of area; dx - the temperature gradient in the direction x, of the flux; T - temperature; t - time.
The minus sign indicates the fact that the flow of heat is directed from the high temperature area to the low temperature area. In the study of heat transfer there may be used analytical and numerical methods. The analytical methods include: Fourier method, the method of caloric sources and the operators method. For the determination of temperature in the case of thermal phenomena specific to the process of joining the conveyor belts by vulcanzation is applied with good results the sources method [4]. Thus, at time $t = 0$, in the elementary volume *dxdydz* belonging to a volume of material, at temperature $\theta_0 = 0$ is concentrated heat *Q*. There is chosen a cartesian landmark Oxyz, originated in the centre of caloric source. The heat transmission process $\theta(x,y,z,t)$ from the concentrated source *Q* is expressed by the equation:

$$\theta(x,y,z,t) = \frac{Q_t}{\rho c (4\pi a t)^{3/2}} e^{-\frac{x^2+y^2+z^2}{4at}} \qquad (1)$$

where: $a = \frac{\lambda}{}$; Q_t is the total quantity of heat.
As the heat Q_t is transmitted from the heating plate to the conveyor belt, the temperature at different points changes, but the amount of heat is the same equal to Q_t. For the flat source represented by the heating plate ($Q_2(J/m)$) disposed in the plane Oyz, the temperature variation $\theta(x,t)$, along the Ox axis can be expressed by the relation:

$$\theta(x,t) = \frac{Q_t}{\rho c (4\pi a t)^{1/2}} e^{-\frac{x^2}{4at}} \qquad (2)$$

For the joint made through vulcanization has been used an apparatus of vulcanization, type DSLQ, general scheme of which is illustrated in Figure 1.

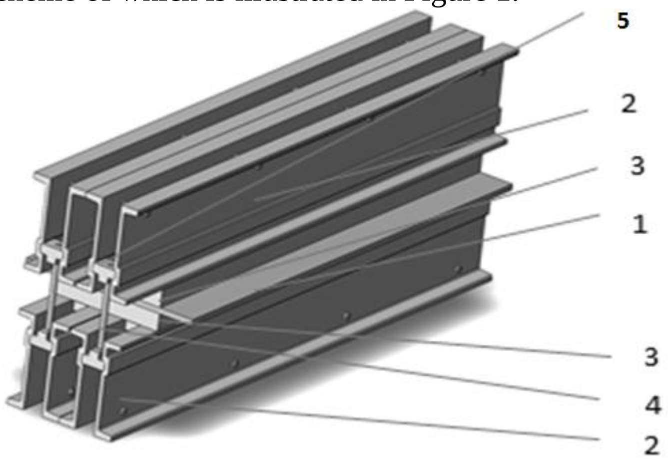

Fig. 1**.** General scheme of joint installation: 1 - conveyor belt; 2 - traverse; 3 - heating plate; 4 - system for fixation of traverse package; 5 - hydraulic pistons for maintaining the pressing pressure

3. EXPERIMENTAL RESULTS

The researches have sought to highlight the homogeneity of the temperatures from the merge area of the conveyor belts and in this way there was used an EX42570 pyrometer. At the same time due to the fact that the conveyor belt has two sides, namely one which is active where is transported the coal and one inactive there were monitored the temperatures on both sides.

The importance of monitoring the temperature is determined by the fact that the main technological parameter of the vulcanization process is the temperature of which values depends on the homogeneity of the material from the vulcanization area [5].

Temperature measurements were made on both sides of the conveyor belt in four points disposed at equal distances to each end of the conveyor belt, and the results are shown in Table 2 for the active part of the conveyor belt and in Table 3 for the inactive part of the conveyor belt.

Table 2. The values of the measured temperatures for the inactive part of the conveyor belt in each of the four points on the two ends of the conveyor belts

	Temperature measured / ^0C							
Measuring points / Time / min	1	2	3	4	1’	2’	3’	4’
10	112	117	116	110	110	111	112	115
20	113	120	120	111	110	117	124	118
30	117	123	121	113	110	119	127	121
40	113	120	118	114	107	114	123	118
50	112	119	117	112	110	114	122	117
60	112	118	117	111	109	121	122	117
70	116	123	121	117	112	118	126	119

Table 3. The values of the measured temperatures for the active part of the conveyor belt in each of the four points on the two ends of the conveyor belts

	Temperature measured / ^0C							
Measuring points / Time / min	1	2	3	4	1’	2’	3’	4’
10	133	128	132	133	128	137	134	136
20	125	121	122	126	124	129	125	129
30	134	129	130	134	130	139	133	138
40	136	130	131	136	131	140	135	139
50	129	123	125	131	128	135	131	133
60	133	128	132	133	128	137	134	136
70	134	129	130	134	130	139	133	138

4. CONCLUSIONS

As a result of the investigations it has been found that during the vulcanization process there is an inhomogeneity of the temperatures in the belt's material in the sense that the minimum recorded temperature was 110 ^{0}C, and the maximum temperature was 140 ^{0}C. This heterogeneity of temperature causes an inhomogeneity in the mechanical properties of the joining area of the conveyor belts. Thus, in practice it is appropriate to pay particular attention to how heat is transferred, so as to obtain a better homogeneity of temperatures in the joint area.

5. REFERENCES

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