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COMPOSITIONS, CHARACTERIZATION AND REPARATION OF CONVEYER BELTS

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ABSTRACT

The information for the compositions, the characteristics and the reparation of the conveyer belts, during the last 25 years was classified. The types and the quantity of the different rubbers and ingredients for the production of the conveyer belts depend on their application. The characterization of the properties of the conveyer belts was made using several standard methods and a lot of conventional methods for investigation of polymer materials. The reparation of conveyer belts was made usually by three different technologies. The first one was the vulcanization of the rubber blend on the damaged place of the conveyer belt with portable or immobilized presses. This technology is too slowly, expensive, heavy and difficult. The second technology was based on the sticking of the rubber sheets on the damaged place with convenient adhesives. This technology for reparation by liquids polymeric materials is fast and easy, but it was difficult to produce the material, equal to the damage belt. Most of the literature sources are devoted to this technology.

Keywords: conveyer belts, compositions, reparation, characterization, polyurethanes.

COMPOSITION OF CONVEYER BELT

The technologies for the production of conveyer belts (CB) are heavy, expensive and difficult, because all their steps are connected with the application of a large amount of different materials, mashines and processes. This is the reason for the high prices of these articles. During their application in the different fields of the economics the CB could be damaged and their reparation is necessary. Because the reparation depends on the shape, the composition, and the characteristics of the top coat (the protector), an information concerning these topics is given in this paper.

The compositions of CB with general application consist of different types rubbers: mixture of natural rubber (NR) 10 – 70 parts, synthetic rubber (polyisoprene) 30 – 90 parts and a third component: one of the several synthetic rubber– usual or halogenated butyl rubber, copolymer of ethylene-propylene (EPDM) [1]. In the same patent the information for the polymerization of isoprene (IR) with new Ziegler – Natta type catalysts is given. The compounds of lantan or other unusual elements and the physical – mechanical properties of the resulting vulkanizates is also given. The composition, based on the EPDM for obtaining a porous layer on the surface of CB was described in [2]. The application of mixtures with epoxided NR leads to the increased adhesion between the layers of CB [3]. This author has published another article for the application of epoxided NR in the oil resistant rubber [4]. The composition for the belts with good characteristics was made from several layers [5] or from mixtures including silicon oligomers [6] or organosiloxanes [7]. The increasing of the thermostability and the decreasing of the flammability of the CB was achieved with suitable compositions and constructions. The construction with asbestos layer placed between the rubber and the textile layers was described in [8]. The including of halogen containing mixtures: 70 % chlorinated paraffin [9], its mixture with Sb_2O_3 [10] and with polyvinyl chloride [11] has decreased the flammability. In these compositions there are insoluble halogen containing compounds being dispersed in the rubber matrix like solid powders.

The surface coating of the CB for definite application must possess specific characteristics. Butyl oleat as antisticking component was described in [12] and polysiloxanes and amids of fatty acids in [13]. On the contrary the adhesive layers contained polyvinyl isobutyl ester. The surface with definite shape was obtained by modifying constructions of the matrix [14, 15] or by mechanical construction [16]. The increasing of the easy assembling of CB was achieved by specific construction of their ends [17-19] or by application of talk on the layers surfaces [20]. In [21] the composition for adhesion, based on polychloroprene and isocianates for connection of CB ends was described. This information is valid for the application of suitable adhesives or polymers for reparation of CB. The wear stability of CB was increased by a new construction of textile carcass [22] as well as by including of micro fibbers [23]. Laboratory simulation of wear process of CB was described in [24]. In [25] were tested three types of fabric CB and was shown that the permanent shear strength was diminished during precycling and can be modeled by power function of the number of cycles. The high temperature resistant CB were obtained from the blends of different amounts of brombuthyl rubber and EPDM rubber. The abrasion resistance as a function from the ageing temperature of the obtained CB was determined [26]. The heat resistant CB were made from the blends of chlorobuthyl rubber and styrene butadiene rubber (SBR) and the adhesion between the rubber matrix and the textile, based on nylon 66 and polyester-nylon 66 during the increasing of the temperature was determined [27]. In the literature there are data for different compositions from this type of CB and it is clear that for every type has to be developed a reparation technology. Relaxation and retardation processes during their application occur and some amount of the materials was lost because of abrasion and ageing and the resulting powders were contaminations [28, 29]. This is the reason for eco-design of CB [30]. The heat resistance of CB was increased not only by the application of different rubber, but also with suitable carcass, for example from aramides Kevlar [31]. In this article the influence of carcass made from Kevlar, Kevlar 49, polycaproamide, polyethylenefluoride or glass material on the thermal and physicochemical properties of CB was compared. The compositions for gasoline and oil resistant CB included not only suitable rubber, but also different polymers, for example polyvinylidenofluoride [32]. CB for application in food industries with antimicrobial additive and its substantially thinner in surface coating was given in [33]. To avoid bacterial attack in [34] were given the compositions with polyuretans, polyvinyl chloride or fluor containing polymers and with surface coat, containing suitable antiseptics. According [35] in CB for the production of pastry were applied not only the polymers, given in [34], but also polyolefins, polyesters, silicones. For contact with fish a special CB with height smoothness and thermostability was made [36]. The composition for CB described in [37] was based on polyketone Carilon one product of Shell Chemicals (USA). “Berndorf Band” and “Steel Belts” have prepared several compositions and constructions of CB for the heavy conditions of the chemical industry [38]. The information in [39] is interesting not only because the longest CB in Europe (25 km.) was described but also with the time for exploitation of this type construction -18 years. The increasing of the time for exploitation was obtained by the changes of the type of some ingredients [40], as well as with a new construction [41]. The first sentence of this article was for the technologies of production of CB. The machines used are very expensive [42]. This short review does not give all the information, available in the literature, but it is clear, that every CB has specific composition and it is impossible to use the same material for their reparation.

CHARACTERIZATION OF CONVEYER BELTS

Every producer uses to prepare his own compositions and technologies for the production of CB. During their application changes in all materials as a result of ageing processes occur. This is the reason to evaluate all characteristics of CB by standard or non- standard methods. In [43] are given all Bulgarian State Standards and Bulgarian State Standard EN or ISO. The investigation of CB was made also with non-standard methods to solve different problems. For example, in [44] was investigated the influence of several technological parameters in processing of CB on the adhesion between their sheets before and after ageing. The samples were heated at 22°C or at 100°C and the mechanical or adhesion behaviors were determined. The thermal ageing was made at 125°C for 168 and 360 h or at 150°C for 48, 96 and 168 h. As there are not any differences in the investigation of CB with IR, NMR, DSC and the other instrumental methods, in this review are given only several examples for the determination of the coefficient of thermal expansion. The influence of the type and the quantity of the fillers was described in [45-47]. The tensile creep apparatus, used to determine the transient length – temperature behaviors, was described in [48]. Previous constructions were given in [49, 50]. In [51] were compared the data for coefficient of thermal expansion, obtained with dilatometer and from calculations; it was evident, that the differences are negligible. In [52] were compared data for the electrical resistance and the coefficient of thermal expansion of several types of rubbers. Extremums in the dependence near the glass transition temperature were observed.

REPARATION OF CONVEYER BELTS

The high price of CB and technological difficulties for the changing of the damaged belts are the reason for their reparation. There are three different techniques for the reparation of CB:

- vulcanization of the rubber of the belts surface or on their ends;
- application of rubber shits and adhesives;
- filling of the damage place or the bell ends with suitable composition.

The first one is more difficult, expensive and slow, but gives high results. In UK patent [53] the construction of belt ends before and after reparation and the reparation method is given. The damage place of the belt was cut; the rubber surface was removed from the upper or lower faces and sides of the belt to produce a tongue of reduced thickness; a thin wrapping sheet of rubber was then affixed by an adhesion to the faces and edges of the tongue; the row of belt-hook was inserted through the wrapping sheet and tongue; the covering sheets were affixed and were vulcanised. In this way the longitude of the CB was reduced. In [54] a portable appliance for vulcanisation of CB with two heatable press plates, upper and lower girders and hydraulic pressure-producing equipment was given. Another less complicated portable appliances with pressing were described in [55, 56], a portable appliance with mechanical, obtaining of the pressure for joining of all components was given in [57]. Portable equipment for reparation of CB was given in [58], but with them is impossible to work in different sizes of the belts.The belt gripper [59] gives this possibility. Very complicated stationary equipment for cutting of the belts damage places and for their joining by vulcanisation was given in [60]. The belts were removed in workshop. A construction and a method for obtaining of reinforced elements for CB were described in [61], because in the damage places the carcass was damaged too. The intensification of the work of the vulcanization press was also made [62]. The non-Newtonian flow property of the rubber during the vulcanization was taken into account in the construction of equipment for reparation [63]. Very complicated installation was made for the reparation by sticking of the belts ends and the vulcanization on this place [64]. Actually, in all technologies for reparation with stationary equipment the belts must be transported to the workshop. The construction of suitable machine for removing and loading of these heavy articles was given [65]. During the vulcanization the atmosphere of workshop was seriously contaminated with number of chemicals. Jan P. Gromiec et al. investigated the type and the concentrations of these pollutants with several methods [66]. All disadvantages of the method of vulcanisation are the reason for the investigations of new technologies.

The second method for the reparation of CB (application of sticking processes and adhesives) was described [67-76]. In [67] the adhesives were divided in three groups: self-curing from adsorption of moisture or oxygen, thermo- or UV curing, two component systems (adhesive and hardeners or catalysts). Adhesives from the first type on the base of chlorinated and non-chlorinated ethylene – vinyl acetate – 2-alkenoil acid copolymers are suitable on tapes for processing of photograph materials [68]. The composition from the second type for water proof adhesive includes hexamethylenetetramine, hydrazinium hydrochloride, solvent, isoprene- and chloroprene rubbers, plastisizers, ZnO, altacs, SiO_2 and a component for the increasing of the adhesion [69]. It is interesting, that the quantity of this component is bigger than the quantity of chloroprene rubber. Compositions for ambient temperature cured polymers or prepolymers gelle only for 30 min, but the rubber surface must be cleaned with acetone and treated with 3 % trichloroisocyanuric acid in acetone [70]. Water-born composition on the base of butadiene – styrene latex and several ingredients was described in [71]. Sandwich material used as a shock-absorbing and flexible element, was described in [72]. Abrasion – resistant coating on surface of CB for coal and coke was obtained by spray-coated with polyurethane mixed with a hardener and hot-air dryed for 3 h [73]. The application of unvulcanized rubber sheet, placed between a vulcanized rubber sheets to form laminate with good interlaminar adhesion after heating at 150°C was described in [74]. Analogous idea was applied in [75]. Technology and compositions for reparation by welding of rubber sheets was given in [76]. It is evident that the reparation by adhesives has shorter application.

The third technology is most interesting, because the reparation is fastest. All processes are made without dismantle of CB and without special and heavy equipment. It is suitable where the damages are not so big and deep. Disadvanteges of this technology are the prices and the toxicity of several using materials (amines, isocianates, hardeners). Mostly the polyurethans or isocianates were applied. Thus, the composition [77] included modified toluene diisocianate; composition [78] – urethane forpolymer with isocianate end-groups. In JP [79] was applied with ultra-high speed curable polyurethane, sprayed to the adhesive coated region by a special construction. The application of liquid rubber was described in [80-82]. The rubber in [81] was with molecular mass 2200 and contained -SH groups. In [82] the liquid rubber contain -COOH groups. In this way the crosslinking was made by chemical reactions, like in polyurethanes, but sometime the increasing of temperature is suitable. The heating construction was described in [83]; to avoid thermal lost the heating device was in hermetic steel box. The application of the adhesives on the base of different kind chloroprenes: Bayprene 331 or 332 (“Bayer”, FRG), Neoprene AD (“Dupon”, USA), Denca A-90, TA-95, 85 and 105 (“Denca”, Japan), modified with alkilphenolform-aldehyde resin and some information for other ingredients was given in [84].

This short review gives only a part of all the publications, but is evident, that there are no enough investigations for the compatibility of different materials and for the changing of their characteristics during ageing. The classification of the methods for reparation of CB is given in Table 1.

Table 1. Classification of the methods for the reparation of CB.

Type of the process	Characterization	References
Vulcanisation of rubber composition on the working surface of CB	Stationary press	56, 57, 58, 64, 65
	Portable press	54, 55, 59, 60, 61, 62, 63
Sticking of vulcanized rubber on the damaged surface of CB	Self-curing	68, 71
	Thermo- or UV curing	69
	Two components	70, 72, 73, 76
	Sticking rubber without adhezives	74, 75
Filling of the damaged place or belt ends	Polyurethane compositions	77, 78, 79
	Liquid rubber	80, 81, 82, 83
	Chloroprenes	84
Joining of ends of conveyor belts	Vulcanization presses	53, 54, 55

The application of CB in Bulgaria is considerable, but still there is no a modern, fast and not so expensive technology for their reparation. The combination of several materials: polyurethanes, acrylates, epoxy-containing compounds, gives the possibility to make more effective composition.

REFERENCES

1. US Pat. 404750, 21.02.84.
2. JP Pat. 56-124579, 16.02.83.
3. I.R. Gelling, NR Technol.,16, **1**, 1985, 1-2.
4. Gelling I.R., Elastomers, 121, **6**, 1989, 18-21.
5. US Pat. 6436529, 20.08.2002.
6. US Pat. 6548599, 15.04.2003.
7. DE Pat.10210959, 09.10.2003.
8. Avt.sv. BG 20882, 20.01.76.
9. Poland Pat. 129227,20.12.84.
10. UK Pat. 45549, 15.04.2002.
11. UK Pat. 45548,15.04.2002.
12. Japan Pat. 60-212438, 24.10.85.
13. US Pat. 4500666, 12.05.1983.
14. FRG Pat. 3303834, 04.02.83.
15. Ru Pat. 2208516, 20.07.2003.
16. Ru Pat. 2208525, 20.07.2003.
17. Avt.sv.BG 10203,21.03.63.
18. Avt.sv.BG 499186, 22.03.76.
19 I. Djimiev, Trudi Severo-Kavkaskovo Gos. Teh. Universiteta, **7**, 2000, 274 – 275, (in Russian).
20. Avt.sv.SSSR SU 509503, 13.08.76.
21. Ji Yan-qiu, Dangdai huagong, Vol. **32**, 7, 2003, 92-93, (in Japan).
22. Avt.sv. USSR 514754, 04.06.76.
23. Avt.sv. USSR 522101, 14.09.76.
24. Avt.sv. USSR 543562, 25.03.77.
25. M. Fiset, D. Dussault, Wear, **2,** 1993, 1012-1015.
26. G.G. Kozbushko, V.A. Kopnov, Wear, 162-164, 1993, 1012-1015.
27. T.K. Bhaumik, T. Neogi, B.R.Gupta and K. A. Bhoumnik Materials & Design, 5, 1984, 43-45.
28. P.P. Sarkar, S.K. Ghosh,B.R.Gupta and K.A Bhowmick Wear, **128**, 1988, 167-178.
29. International Journal of Fatikue, 17, 1995, 539-544.
30. A.J.G. Nuttall, G. Lodewijks and A.J.K. Breteler Materials & Design, **24**, 2003, 111-120.
31. Du Pont de Nemours, Quarry and Constructions, 23, **4**, 1985, 39-45.
32. Eur pat. EP 194030, 10.09.86.
33. US Pat. 2004/0065529A1, 08. 04. 2004.
34. Wiss Hans-Ulrich, Heide Olaf, Ernahrungsindustrie, 7-8, 2000, 42-43.
35. Hener Roland, Zucker- und Susswaren Wirt., **6**, 2000, 53.
36. Company information, Ernahrungsindustrie, 1-2, 2001,41-44.
37. Company information, Kunstoffe, **10**, 1999, 104.
38. Company information, Chemikal Engineering, **3**, 2000, 100.
39. Company information, .Mining Engineering, **9**, 2000, 64.
40. A.F. Nosnicov, U.R. Ebich, Proizvodstvo i izpolzovanie elastomerov, **6**, 2000, 6-10, (in Russian).
41. U.N. Bochanov, G.V. Dodin , V.L. Kleiman, nauchno-tehnicheskaia konferencia, Materiali i izdelia iz nih pod vozdeistviem razlichnih vidov energii, Moskva, 1999, 31-32, (in Russian).
42. Company information, Produktion, **4**, 2000, 49.
43. N.Dishovski, Ingradienti, Sofia , UCTM, 2004, 201-203, (in Bulgarian).
44. F.A. Mahlis, L.B. Tomchin, G.A.Borinshtein, O.V. Vidova, Caochuk i Rezina, **1**, 1985, 25-27, (in Russian).
45. J.M. Caruthles, R.E. Kohen, Polymer Eng. Sci., **16**, 1976, 41.
46. J.M. Caruthles, C.J. Hooley, R.E. Kohen, Polymer Eng. Sci.,**18**, 1978, 667.
47. J.I.Tiele, R.E. Kohen, Rubber chemistry and technology, **53**, 1985, 313-320.
48. J.M. Caruthles, PhD, Thesis, Massachusetts Institute of Technology, 1977.
49. G.M. Bartenev, V.I.Garcman, Buletin izobretenii**,** **5**, 1960, 46, (in Russian).
50. G.M. Bartenev, V.I.Garcman, **28**, 2, 1962, 245 – 247, (in Russian).
51. G.M. Bartenev, MV. Voevodskaia, Cauchuk i Rezina**,** **2**, 1965, 25-27, (in Russian).
52. L Nikel, Kautschuk Gummi Kunststoffe, **57**, 2004, 538-540.
53. UK Pat. 728006, 13.04.55.
54. UK Pat. 2082966 A, 17.05.82.
55. US Pat. 4917741, 17.04.90.
56. RU Pat. 94037120 A1, 27.07.96.
57. Avt.sv. SSSR SU. 1565716 A1, 23.05.90.
58. US Pat. 4064775, 27.12.77.
59. DE Pat., 3517994 A1, 24.05.84.
60. Avt.sv. SSSR SU 1666346 A 1, 30.07.91.
61. US Pat. 4462626, 31.07.84.
62. Avt.sv. SSSR SU 1719238 A2, 20.11.92.

63. RU Pat. 2149757 C1, 27.05.2000.
64. DE Pat. 19619939 C2, 20.11.97.
65. US Pat. 6543126 B1, 09.04.03.
66. J.P. Gromiec, W. Wesolowski, S. Brezinicki, K. Jakubowska, M. Kucharska, J. Environ. Monit., **4**, 2002, 1054-1059.
67. S. Makoto, Setiaku Technol. Adhes. and Seal., **29**, 3, 1985, 116-119.
68. DDR Pat. 220152,24.10.83.
69. Avt.sv. USSR SU 1165701, 30.01.84.
70. US Pat. 4327138, 27.04.82.
71. S.Z. Polivoda., I.L. Krapivskaia, G.A. Heneman, Nov. klei technol. Ckleivania i obl. Primenenia, Mater. Semin., Moskva, 1989, 90-91, (in Russian).
72. Eur. Pat. EP 142716, 29.05.85.
73. JP Pat. 61 93,875, 12.05.86.
74. JP Pat. 82 51,443, 26.03.82.
75. Avt.sv. SSSR SU 1669752, 04.01.88.
76. DE Pat.3926946, 06.07.89.
77. ZA Pat.87 03,382, 15.05.86.
78. Avt.sv. SSSR, SU 1650471 A1, 23.05.91.
79. JP 3221170, 30.09.91.
80. DE 3926946 A1, 10. 1. 91.
81. DDR Pat. 203325, 19.10.83.
82. JP 61-295987, 23.04.88.
83. RU 14866, 10.09.2000.
84. L.P. Srebezova, N.I. Savaleva, T.A. Boiko Proizvodstvo i izpolzvanie elastomerov, **6**, 2000, 14-15, (in Russian).