Repair of conveyer belts and expansion bellows of bell-less tops of blast furnaces by elastomers of cold vulcanization

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Abstract
The article covers the results of performed tasks concerning repair of metallurgical equipment including conveyer belts of by-product coke plant and sintering plant and also compensators of bell-less tops of blast furnaces with the help of modern polymer materials, allowing to fulfill hermetization of various assemblies without removal of equipment on-site of exploitation.
Keywords: COMPOSITE, CONVEYER BELT, REPAIR, RECOVERY, COMPENSATORS, BELL-LESS TOP, BLAST FURNACE.

In recent years there increased an interest to new technologies of repair and renewal operations with application of polymeric materials. This is connected with the fact that such technologies allow effectively to place the equipment into service as soon as possible and

avoid the necessity for permanent repair and stoppage of productive process for a long time. It refers considerably to metallurgical equipment and reconstruction first of all conveyer belts.

Two types of polymeric materials refer to two-component elastomers, which allow to solve the problem of conveyer belts. The first one is two-pack glue (for example, of German company «Tip-Top»), which is applied with a thin layer and allows both to join the belts and repair of certain failures with application of prepared patches.

The second one is multifunctional shape-generating two-component elastomer, which allows to grow worn out and damaged areas by material itself without application of patches. At the same time they may fulfill a function of glue, considering their increased adhesive properties (elastomer “diagum” of DIAMANT Metallplastic GmbH Company may be referred to such materials). Priazovskyi State Technical University accumulated unique experience of application of such elastomers in coke chemistry and metallurgy.

Let us consider first the recovery process of conveyer belt. Their damage in the process of exploitation may be of various characters. Figure 1 shows the main and possible types of conveyer belts damages, taking place on one of the coke and by-product processes. Among these are:

- Long cuttings of any length (both interface and blind);
- Reach-through breakdowns of conveyer belts;
- Damages of belt borders;
- Crossed cuttings of rubber-fabric belts up to 20% of the belt.

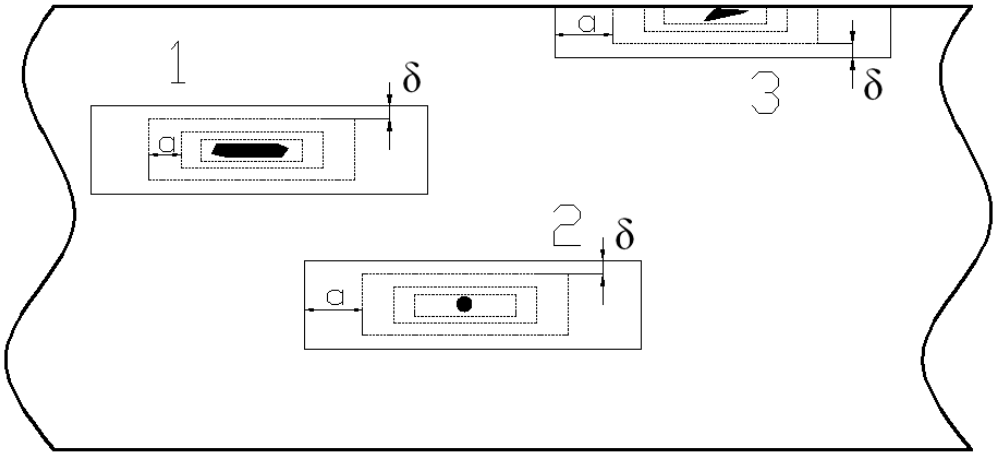


Figure 1. Possible types of conveyer belts damages: 1- long cutting; 2 - reach-through breakdown; 3 – damage of belt border.

Traditional technology of reclamation work lies in the following. Repair of reach-through breakdowns and cuttings of cloth belt 20 – 25 mm in size are fulfilled on the conveyer in the area of minimum tension of the belt.

Primary sectoring of stages of fault locations with the help of samples is fulfilled. The samples feature the set of rectangles. The smallest sample should recover the damaged piece not less than δ=10 mm across-track of the belt and a=60 – 100 mm – lengthwise (fig.1).

Splicing of damaged piece is then fulfilled, rubber lining by a pattern is sliced with the help of special gripper layer by layer and forms stages for patches of squared shape. Then the surfaces of prepared patches are skinned, defatted and greased twice with special glue with further drying, first time- till complete drying, the second time – till formation of adhered layer. After this the patches one by one are applied and rolled down. Before cut by steps gash is filled in layers in the wake of size rising of patches. Then according to traditional technology, it is necessary to fulfill the vulcanization process at $t=145^0(\pm 5^0 C)$ and pressure 1.0 MPa with further press cooling up to $t = 70^0 C$. Such process certainly requires conveyer break not less than for a shift and that is why in certain cases, it is necessary to install check clamps, which strap the gust. Within nearest stop the clamp should be removed and the above described operational flow should be fulfilled.

However such technology relates more to the steel-reinforced belts, and rubber-fabric in conditions of continuous coke-chemical or agglomerative production, where scheduled outage under repair may occur once per month, such U-shaped rough mountings destroy the tape base

gradually, passing through the areas of bending, which leads to its breakdown.

Two-pack glues, for example «Tip- Top», allow to solve the problem of performance restoration of conveyer much more quickly, as their application excludes glue drying and patch curing with further cooling. But herein the described methodology of patch preparation and stepped layer-by-layer preparation of the belt remains and requires rather long time. One more fact, which restricts application of two-pack glues, is their low thermal endurance (up to 80 ^{0} C), while transporting of hot coke the temperature of mass may exceed 100 ^{0} C.

In connection with this, in Priazovskyi State Technical University there was developed technology of further time cutting for repair of belts and increase of thermal endurance of lining patch by means of application of two-component shape-generating elastomers , which posses unique glue properties and may fill the gashes on defective areas of the belt. Among these are such materials as “diagum” of of DIAMANT Metallplastic GmbH Company with following technical characteristics (Table1).

Table 1. Technical characteristics of “diagum”

Material	Diagum – P	Diagum - Fl
Weight flow ratio	100 : 30	100 : 30
Цвет смеси	black	black
Density (ready mix) g/cm^3	1.1	1.1
Initial viscosity25 ^{0} C	thixotropic	fluid
Output time At + 20^0 C, min	10	10
+23^0 C, min	5 - 10	5 - 10
Final hardness at 10 -15^0 C, days.	8	8
Room temperature, days	6	6
+40^{0}C, hour	12	12
+60 ^{0}C, hour	8	8
Hardness 80 % at room temperature, hour	24	24
+ 40 ^{0}C, hour	10	10
+ 60 ^{0}C, hour	6	6
Shore hardness (at room temperature)		
1day	80	75
2 day	85	78
7 day	90	85
longitudinal strength DIN 53455, MPa	38	40
Elongation at failure according to DIN 53455, %	400 – 500	500 -600
E - DIN 53455 module, MPa	200 – 350	300 – 350
Range of operating temperatures, ^{0}C	- 40/ +120	- 40/ +120
Chemical resistance		
Chemically stable to:	natural oils, diesel fuel, petroleum, salt, water, sea water	
Relatively stable to:	inorganic acids and alkalis (concentration 10 %), benzine	
Unstable to:	ketones, ethers, alkohole.	

Application of this material during repair of defective belt areas at one of the by-product coke plants allowed to reduce repair time and also the delay of conveyer up to 1-2 hours. Reclaimed by such material areas of the belt with various damages are shown in the figure 2.

1)

2)

a) b)

Figure 2. Damaged areas of conveyer belt before (a) and after (b) reclamation:
1 – long cutting;
2 – damage of belt border.

Exploitation results of reclaimed areas of conveyer belts proved economic efficiency and effectiveness of technologies application.

Wide range of possibilities of elastomers of cold vulcanization allowed to solve one more problem connected with reclamation of hermiticity of expansion bellows of bell-less top of blast furnace “Azovmash”.

Expansion bellows are knurled cylinder courses made of multilayer stainless steel, which allow axial and angular displacements. In construction of bell-less top there used expansion bellows of three typical sizes:

- expansion bellows DU 400 mm placed on the transmission shaft of shuttle and serving for compensating of angular displacements within the limits of 5 mm.
- expansion bellows DU 400 mm, placed between fixed block body of burden valves, bearing on the columns of bell-less top and between moveable loading hoppers. This compensator allows moving within the limit of 5 mm.
- expansion bellows DU 400 mm provides assembling and replacement of equipment parts and also movement of isolation gate. Reactivity worth of the block from two expansion bellows makes 30 mm .

Defects arising during exploitation of compensators may be divided into three types:

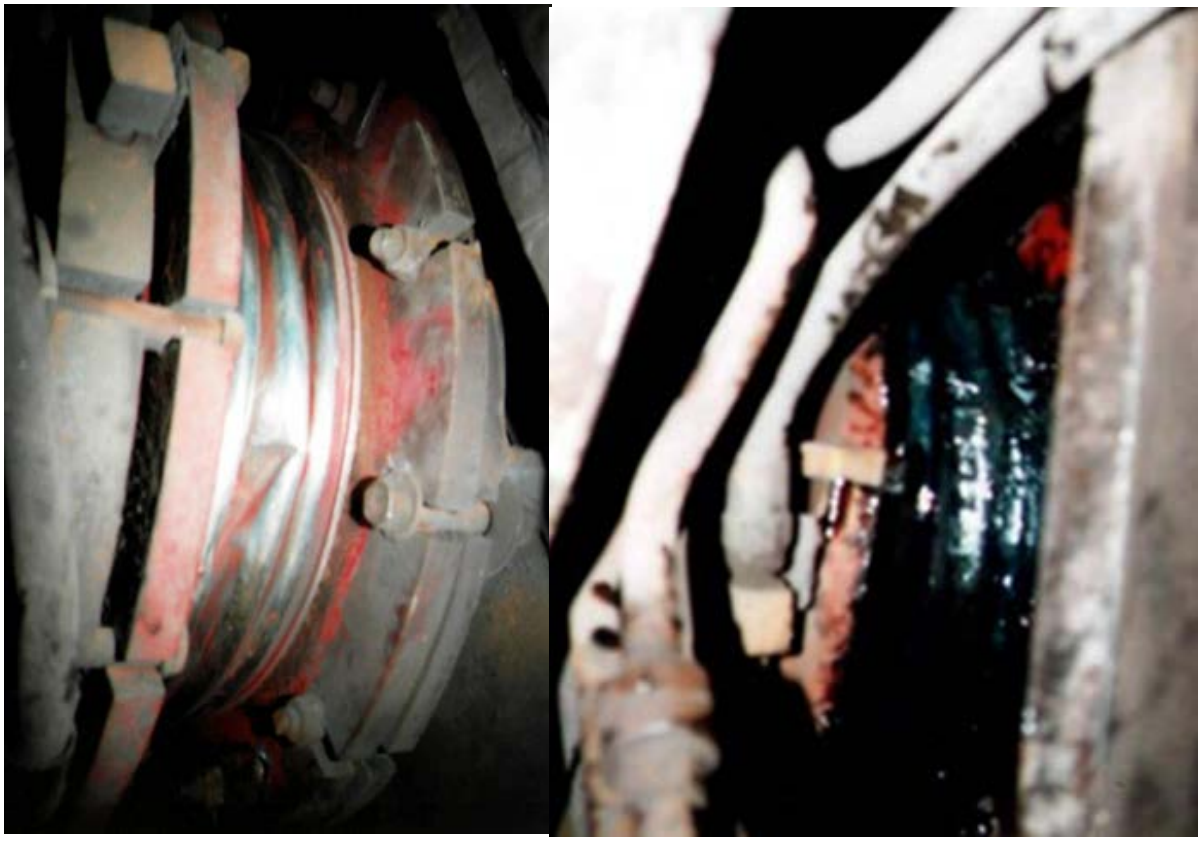
- bends, caused by shear forces and holes, formed at this bending.
- holes, formed in result of casual touching by welding electrodes or blow during installation;
- leakage (faulty fusion) across the welding seam.

Any of these defects in case of untimely elimination because of extreme pressure of blast-furnace gas and content of flour particles in it, lead to rapid expansion of the hole and occurrence of

emergency situation, which requires compensator replacement.

In the cases when it is necessary to eliminate numerous holes, formed as a result of jam on the compensator axis of a shuttle DU 400 mm, there was used a technique of creation of “diagum” polymer solid bed on a top of stainless surface of compensator with application of glass fabric, which is also sodden with this polymer. This technique was repeated twice.

It was rather complicated to secure airtight packing, considering the fact that this work was performed on the acting blast furnace and space-limited environment for repair (the distance between support bearing of underslung gearing of shuttle and between block body of burden gaps was not more than 600 mm). However in 8 hours the repaired unit was operated and provided hermiticity of compensator within 1.5 hours till turn around maintenance(fig.3).

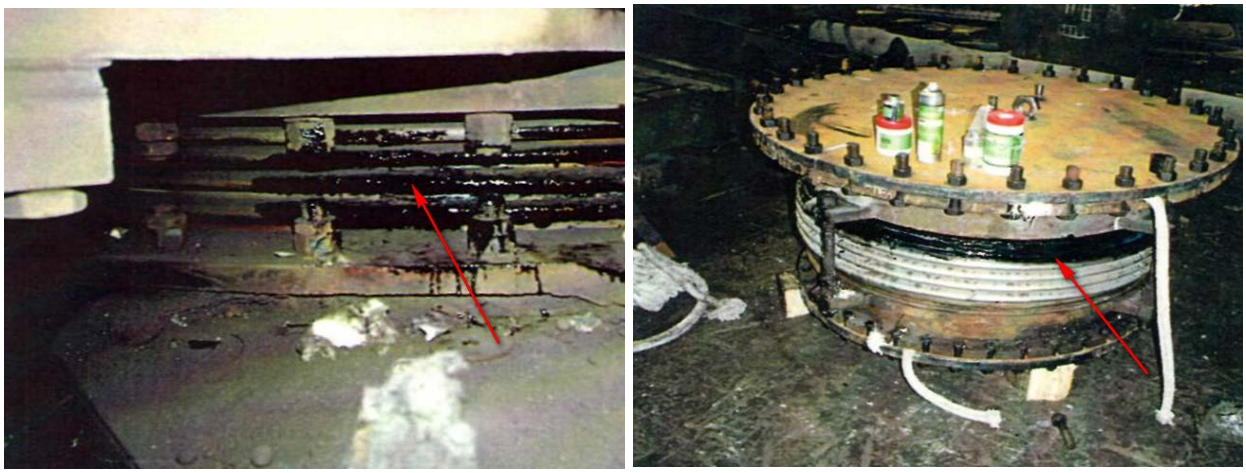


a) b)

Figure 3. Reconstruction of compensator DU 400 before airtight packing a) and after b).

One more repair, which is fulfilled on the operating furnace, referred to hermetization of the blow with the length 150 mm and width 10 mm on the compensator DU 2000 mm. In this case the patch on the defective area was put on with the usage of “diagum” with glass fabric overlapping the defective area twice across the length and width (fig. 4a).The another case of compensator repair refers to recovery of hermiticity of welded seam of double-flanged compensator. In case of welding of stainless thin shell with steel flange of nonuniformity of the seam also lead to “blows”.

To exclude this phenomenon before installation of compensator on the blast furnace, it is checked for hermiticity by means of air discharge. Such check revealed air losses in some areas of welded seams, in consequence of which it was decided to encapsulate by “diagum” (fig. 4b). Compensator on the blast furnace was operated for long term without any notes.



a) b)

Figure 4. Recovered compensators DU 2000 on the blast furnace (a) and DU 1200 in conditions of hermeticity test in the machine workshop (b).

Good adhesive properties and heat stability polymeric material “diagum” in combination with the ability of polymerization without increased temperature and pressure, allow also to encapsulate connectors and jointing, where, for example, oil leak takes place, as a result of failed out compression without dismounting and replacement of compression. In our practice hermetization of connector between body and frame of large marine diesel-generator is fulfilled successfully, local damages of cable sheath were repaired, the surface of rubber-covered roll was recovered, etc.

Conclusions

The technology of application of two-component elastomers during repair of equipment of coke-chemical and blast-furnace departments is developed. Successful exploitation of recovered conveyer belts and expansion bellows proved the effectiveness of application of developed process design solutions when emergency situations arise, when traditional approaches of repair are either inefficient or require big costs.

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