

## МОДИФИКАЦИЯ НА РЕДУКТОРНИЯ КОРПУС НА ТЯГОВИТЕ ПРЕДАВКИ НА ЛОКОМОТИВИТЕ EL-2

**Нели Стефанова<sup>1</sup>, Матей Матеев<sup>2</sup>**

<sup>1,2</sup> МГУ "Св. Иван Рилски", 1700 София

**РЕЗЮМЕ.** Статията разглежда модификация на редукторния корпус на тяговите предавки, направена с цел подобряване на експлоатационните качества и ремонтпригодността, и намаляване на разходите при експлоатацията на локомотивите EL-2.

### MODIFICATION OF THE GEAR BOX CASING OF THE LOCOMOTIVES EL-2 TRACTION TRANSMISSIONS

**Nely Stefanova<sup>1</sup>, Matei Mateev<sup>2</sup>**

<sup>1,2</sup> UMG ST. IVAN RILSKI, 1700 Sofia

**ABSTRACT.** The paper treats a modification of the gear box casing of the traction transmissions, made in order to improve the exploitation properties and maintainability, and decrease in the expenditures at the exploitation of the locomotives EL-2.

Until recently, the 100 t direct current contact electric locomotives EL-2 were the basic tractive unit for the haulage realization of the mine body on the stripping and production horizons of the opencast mines TROYANOVO-SEVER and TROYANOVO-1 of MARITSA-IZTOK MINES.

At the present moment, they serve only the coal haulage of the mentioned opencast mines from the transfer points of the sections to BRIKEL and TERMO-ELECTRIC POWER STATION-2.

EL-2 assigns to the category of the industrial locomotives and, as it is known, can be described with the fact that their power (1400kW) is mainly used for the creation of considerable tractive forces (including up to the restricted by the cohesion condition maximum value) at comparatively low speed of movement (the average speed for EL-2 is 25 km/h and the design – 65 km/h).

This peculiarity of the industrial locomotives, complicated by the necessity of safe and trouble-free movement on the mine railroads (especially on the temporary) lays down special requirements to the drive and the design of the running gear. The design solutions are generally depicted by the so called locomotive wheel formula, which is  $B_0+B_0$  for EL-2, and the individual drive of the four driving wheelsets is realized by the respective number of direct current tractive motors type GBM-350/1500 (for voltage  $U=1500$  V at hour duty parameters  $N_{\text{hour}} = 350\text{kW}$ ;  $I_{\text{hour}} = 250$  A;  $n_{\text{hour}} = 820$  tr/min).

Every driving wheelset of the locomotive EL-2 is individually driven by the GBM-350/1500 motor - directly suspended to it and to the bogie's frame (fig.1). The motor shaft is connected with that of the wheelset by a double-side gear transmission. Because of the hard operating conditions, the gear wheels are

made from chrome-nickel steel and are subjected to a heat treatment. The small gear wheel has a coning opening. It is packed to the shaft of the tractive motor and fixed by a nut. The big gear wheel is shrunk to the extended hub of the traveling wheel.

The gear ratio of the tractive transmission is  $i = 5.58$ , the driving and driven gear wheels have 12 and 67 skew cogs respectively and diameters of the base circles 144 and 804 mm. The cogs module  $m = 12\text{mm}$  and width  $b = 100\text{mm}$ .

The original transmission is closed in a two-part welded case from steel sheet thick 4 mm. Its lower part is reinforced by an additionally welded steel strip, which thickness is 3 mm. The gear wheels are lubricated by an oil bath, where the lower part of the driven wheel is flooded. Both the half-cases (for left and right mounting) of the tractive transmission can be fitted by two bolts and two pairs of eyes (welded to the half-cases). The mentioned elements also provide the connection of the case to the  $\Gamma$ -shaped arm (12, fig. 1), consolidated with the external bearing liner on one hand, and on another hand to the to the prism (13, fig. 1), mounted to the front shield (2, fig. 1) of the tractive motor. Apart from that, the two case halves (upper and lower) are mounted to the front shield and adjusted towards the motor shaft by two, welded to them, half rings, comprising the projecting cylindrical part of the respective (left or right) bearing cap (5, fig. 1) of the motor. At the original gear box, the shafts of the motor and the wheelset are sealed with strips of felt and leather collars respectively. The dynamically changing in wide range motor and brake torques passing through the transmission and its operation in dusty, humid medium with considerable temperature changes are the factors jeopardizing the normal work not only of the separate driving group but of the whole locomotive drive as well.

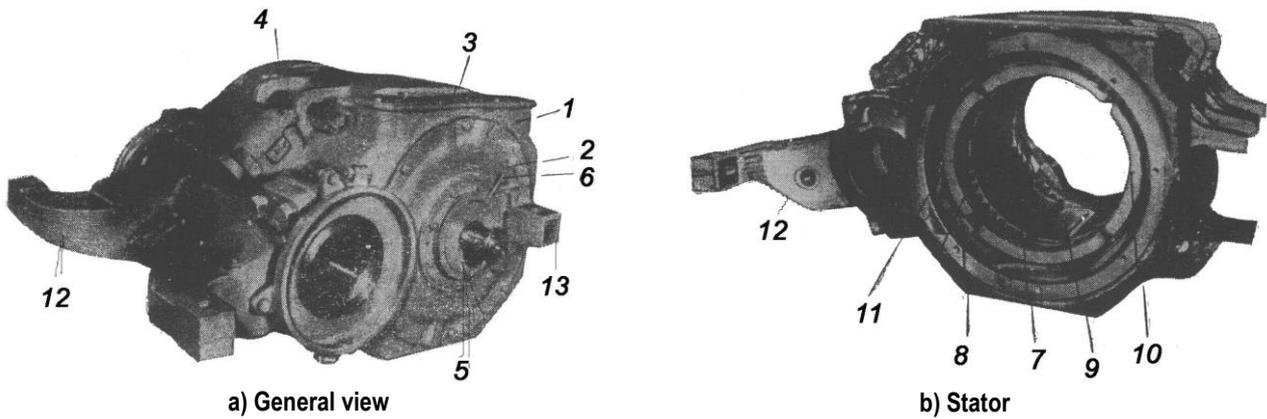


Fig. 1.

The design of an original, single drive of the locomotive EL-2 is presented in fig. 2, where A, B, C, and D are respectively: the tractive motor, case of the tractive transmission, traveling wheels and the motor shaft. No 12 and 13 correspond to the numbers in fig.1. The necessity of development of Bulgarian

case for the tractive transmissions of EL-2 as a modification of the original one practically emerges after 1987 when the import of the locomotives EL-2, units and spare parts for them from German Democratic Republic has been stopped.

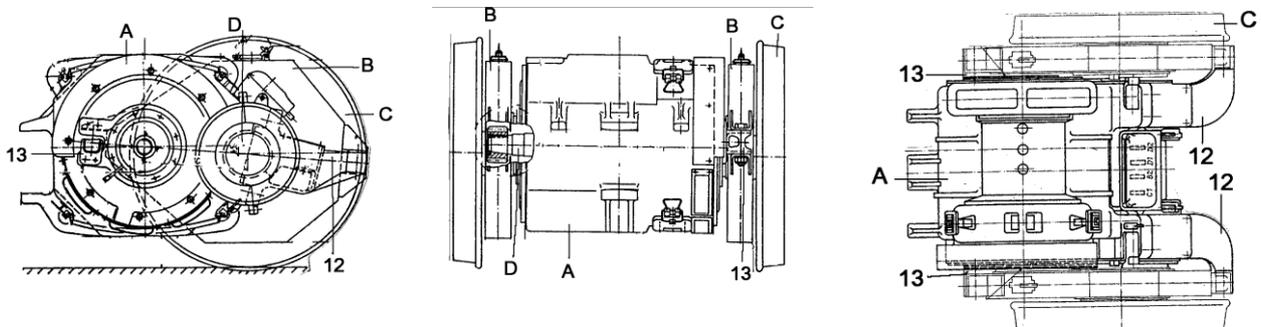


Fig. 2

In fact, the gear box, which peculiarities are treated in the present paper, is the second Bulgarian modification of the German prototype and has been designed by the MINE HAULAGE LABORATORY at the Scientific Research Sector of the University of Mining and Geology ST. IVAN RILSKI – Sofia under a contract with MARITSA-IZTOK MINES.

The design solutions in the new gear box are in accordance with the general requirements to this type equipment and with the results from the critical analysis of the problems, connected with the service and maintenance of the tractive transmissions of the locomotive EL-2, operating in opencast mine.

The results from the analysis show that:

a. The sets of gear wheels and protective cases produced by REMOTEX-RADNEVO are interchangeable with the German prototypes, which allows the Bulgarian sets to be substitute (fully or partially) for them at the repairs of the tractive transmissions;

b. A process of fast (breakdown) wear of the transmission's gear wheels can start in case of:

- Two different in origin gear wheels with differences in the cogs angle or non-axial keyslots have been combined for joint work;
- The lubrication of the gear wheels has been fully stopped because of punctured case or seal failures at irregular control and correction of the oil level. At late determination of

this emergency operation, the boundary allowable wear of the gear wheels could be obtained just in few working hours.

c. The designed during 1985-1986 by the CENTRAL REPAIR BASE – RADNEVO two-part case for the tractive transmission of EL-2, which is still in production, represents a moderately simplified (in order higher manufacturing and lower net cost to be obtained) modification of the original German case. On one hand, the former excels the latter in that the leather cup seals are changed with more contemporary rubber, but on the other hand in comparison with the prototype it has the following disadvantages:

- Lower rigidity of the oil case, which has no a strengthening steel strip;
- Lower accuracy at the mounting of the two cases (stamped eyes are substituted for the welded design of the prototype).

The substitution of slide sheet gate for the socket-jointed cover (as it is at the German version) of the filler and the withdraw from the mounting steel strips of enough length to the internal walls of the upper case in the zone of its jointing to the lower one are the probable reasons for more frequent, bigger in volume leaks of oil at the Bulgarian cases.

d. At the equal, for both types of cases (German and Bulgarian), way of the transmission lubrication by flooding the driven gear in an oil bath, the strictly filling up oil above the

minimum allowable level can prolong the lifetime of the gear wheels up to ten years;

e. The absence of an air escape hole, as well as that of control devices (holes equipped with drain plugs or oil dipsticks) at the both types of cases are their common design disadvantages and the second one forces the maintenance personnel to assess the oil quantity (which at the check inspections planned, has to be filled up in the oil case in order the level of the oil bath to be normalized) "by sense", i. e. subjectively;

f. Another disadvantage, common for the both types of cases is the absence of a bleed hole on the bottom of the lower case for the oil running off in case of necessity;

g. A considerable and unavoidable disadvantage of the cases is their two-part design, due to the mechanical diagram of the electro-mechanical group "driving wheelset". The design leads not only to the hardly obtainable sealing of the half-cases joint, which has to be made in the restricted space between the tractive motor and respective (left or right) traveling wheel, but to the impossibility of using modern and more effective seals – labyrinth or shaft seals, helical rings and bushes, etc.

The listed technical means for sealing the working space of the tractive transmission are broad and successfully applied in the main line locomotives and the metro motorailers. Due to the high-speed motors (with smaller overall dimensions) used in these cases there are spaces large enough for gear boxes with more complicated and voluminous design to be mounted.

The inconveniences connected with the with the change of a shaft seal, mounted on the driving wheelset of the abovementioned tractive units even in cases of two – part gear box, i. e. the necessity of consecutive dismantling and mounting the traveling wheel from and to wheelset, which on its part imposes the realization of all the technological operations attending the liquidation and recreation of a force fit.

h. The half-cup seals used in the protective cases could be assessed as an acceptable technical mean, however it is obsolete and works more as a cleaner (i.e. an element protecting from dust and moisture entering from the environment in the gear space) than as a seal (i. e. an element preventing the oil running out of the gear box).

On the basis of the assessments and conclusions, the following approaches, directed to the case design improvement and respectively to the improvement of the lubrication of the gear tractive transmissions of the locomotives EL-2 have been formulated:

1. Without any changes are kept:

- The mounting of the half-cases as well as their fixing to the body of the tractive motor;
- The oil feeding to the friction surfaces of the transmission's cogs by flooding of the driven gear wheel in an oil bath (in the oil case).

2. Realized are:

2.1 Selection and tests of combined elastic elements, which to be able to play the part of a cleaner as well as that of a seal;

2.2 Changes in the design in order around the two through holes of the gear box to be realized grooves, where the sealing elements to be placed;

2.3 Changes in the design of the upper half-case, which could be described by:

- Reconstruction of the feed hole;
- Mounting of an air-escape hole;
- Bilateral welding of external and internal protective strips along the separating plane of the half-case.

2.4 Changes in the design of the case's lower part in connection with its strengthening and creating a possibility for operative control and correction in the quantity and condition of the oil;

2.5 Mounting and testing of all the eight cases to one locomotive EL-2, determined and prepared by the staff of the opencast mine;

2.6 Marking, completing with seals and lubricant supply of the cases in accordance with the requirements presented in Table 1, which shows that the tests comprise 8 gear boxes, 4 types rotating and 2 types static seals, 3 types of oils and a semi-liquid grease.

The design peculiarities of the modified gear box case (for left mounting, in this case) are presented by the drawing, shown in fig. 3 and the general view - in fig 4 (assembled) and fig. 5 (dismantled).

The cross sections of the cords, rods, strips and special profiles extruded from oil-resistant rubber, Teflon and ERDM material are shown in fig. 6. The combined from them 25 seals (all fit for mounting in a groove with sizes 14x10,5 mm) – in fig. 7. The numbers of the most appropriate seals are underlined.

Fig. 8 represents a photo of the stages of the modified cases mounting to the tractive motor, taken in the depot of the opencast mine TROYANOVO – 1.

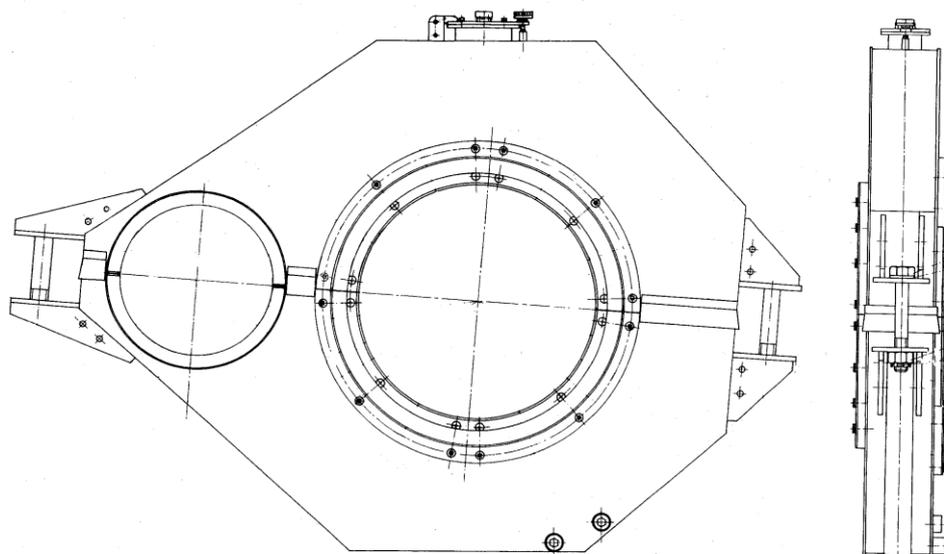


Fig. 3

Table 1

No of the driving wheelset	No of the gear box	Identification mark	Type of the mounting		Seals						Lubricants				Quantity	
					Rotation (d = 420 mm)				Static condition (D= 515 mm)		Oils		Greases		Oils [kg]	Greases [% of the free volume]
			Right	Left	A	B	C	D	E	F	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	G	2.5	20
I	1	KD-I-1														
	2	KL-I-2														
II	3	KD-II-3														
	4	KL-II-4														
III	5	KD-III-5														
	6	KL-III-6														
IV	7	KD-IV-7														
	8	KL-IV-8														

**NOTE:** A, B, C and D – combined seals with cross sections corresponding to 3, 5, 12 and 23 in fig. 2; E – rubber hose (h, fig. 1); F – combined seal (13, fig. 2); M<sub>1</sub> – automobile transmission oil Mobilube HD 80W – 90; M<sub>2</sub> - automobile transmission oil Mobilube HD 80W – 140; M<sub>3</sub> – special synthetic gear box oil Mobilgear SHC XMP 460; G – semi-liquid lithium grease Mobilux EP 0004.



Fig. 4



Fig. 5

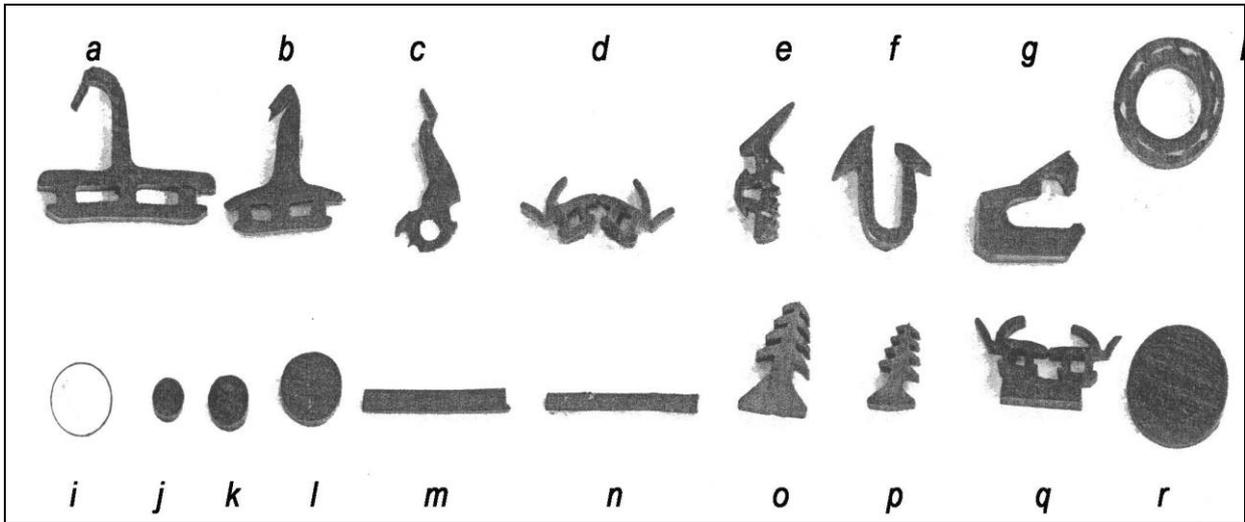


Fig. 6



Fig. 7

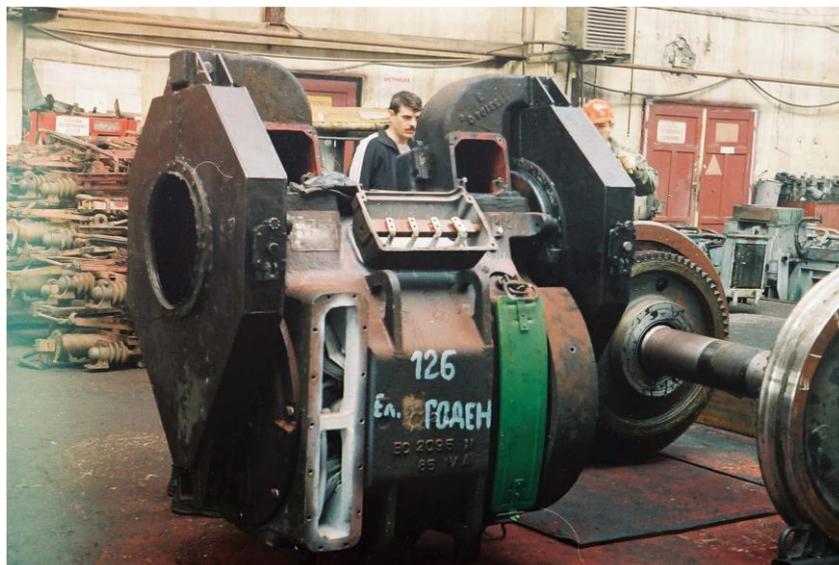


Fig. 8

## CONCLUSION

The tests of the eight modified cases have been successively completed and the locomotive EL-2 (with number 91), equipped with them operates in the opencast mine TROJANOVO- 1 since 28.02.2006. As a result, the production of twelve additional cases has been ordered.

## REFERENCES:

Бошнаков, Б. С., Михайлов, М. Я., Матеев, М. Н., Андонов, М. Ф. *Експлоатация и поддръжане на електро-локомотива EL-2*. С. Техника. 1967.

Препоръчана за публикуване  
Рецензент: доц. д-н. Св. Токмачиев