plan. The following should be noted: the lower the value of the C2 parameter, the lower the wear rate of the pick.

The conducted tests of the wear rate of conical picks showed that the type of protective layer on the operational part of the pick, the steel grade applied to the picks' bodies and the pick position on the test drum, have a significant influence on their durability. A further search for the protective layers of the operational part of the pick is required to determine the best and the cheapest protective layers to increase their durability, especially in hard and/or abrasive rocks.

References:

1. Kotwica K.: *Effect of selected working conditions of cutting picks on their wear during the mining of hard rocks*. Quarterly Mechanics and Control 3/2010, pp. 110–119.

2. Krauze K., Bołoz Ł., Wydro T.: *Parametric factors for the tangential – rotary picks quality assessment.* Archives of Mining Sciences 1/2015, pp. 265–281.

3. Krauze K., Skowronek T., Mucha K.: *Influence of the hard – faced layer welded on tangential – rotary pick operational part on to its wear rate*. Archives of Mining Sciences 4/2016, pp. 779–792.

4. Krauze K., Bołoz Ł., Wydro T., Mucha K.: *Durability testing of rotary-tangential picks made of different materials.* Mining – Informatics, Automation and Electrical Engineering 1/2017, pp. 26–34.

5. Bołoz Ł.: *Results of a study on the quality of conical picks for public procurement purposes*. New Trends in Production Engineering vol. 1 iss. 1 2018, pp. 687–693.

NUMERICAL CRASH TESTS OF MODERNIZED HEAD STRUCTURE OF THE ED72 ELECTRICAL TRAIN UNIT ACCORDING TO THE EN 15227 STANDARD

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The aim of the project was the modernization of the head structure of the ED72 train unit including static (EN 12663 standard), crash (EN 15227 standard) and fatigue strength (DVS 1612 standard) requirements. The ED72 is an electrical train unit consisting of four wagons (two steering and two motor) [1, 2].

The work presents numerical crash calculations of the modernized head structure of the ED72based on EN 15227 standard. The focus was on collision scenario with the large deformable obstacle LDO [3]. The calculations were carried out in the Altair HyperWorks environment.

The EN 15227 standard classifies rail vehicles in four categories [3]:

C-I - vehicles designed to operate on TEN (Trans European Network) routes, international, national and regional networks (which have level crossings); e.g. locomotives, coaches and fixed trainunits,

C-II - urban vehicles designed to operate only on a dedicated railway infrastructure, with no interface with road traffic; e.g. metro vehicles,

C-III - light rail vehicles designed to operate on urban and/or regional networks, in tracksharing operation, and interfacing with road traffic; e.g. tram trains, peri-urban tram,

C-IV - light rail vehicles designed to operate on dedicated urban networks interfacing with road traffic; e.g. tramway vehicles.

The ED72 train unit belongs to C-I category according to EN 15227 standard. For this category, three collision scenarios are required [3]:

1/ collision with an identical train unit- collision velocity 36 km/h,

2/ collision with the 80 tons wagon - collision velocity 36 km/h,

3/ collision with the large deformable obstacle (LDO) - collision velocity v_{lc} - 50 km/h ≤ 110 km/h collision velocity (v_{lc} - maximum train unit operational velocity at a level crossing).

LDO must have mass of 15 tons and a center of mass 1 750 mm above the rail level [3].

The stiffness characteristic of the LDO in the collision direction must match to the stiffness specified by the standard (the standard curve is the minimal characteristic; fig. 1b) [3].

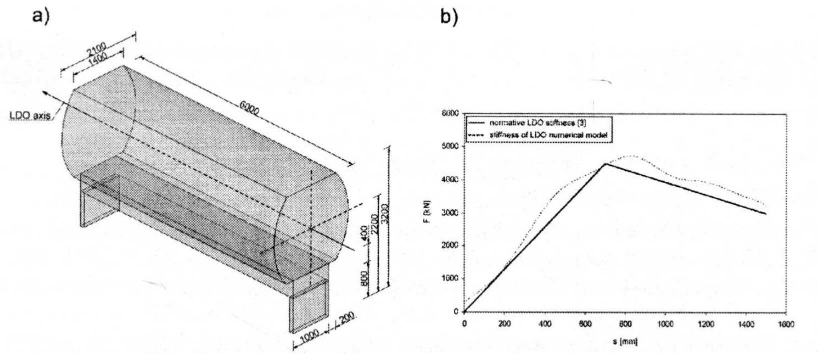

Fig. 1. Large Deformable Obstacle LDO: a) geometry; b) stiffness characteristics [3, 5]

The matching to the standard characteristic is obtained by the numerical crash test of a rigid sphere of diameter of 3 m, mass of 50 tones and initial velocity of 30 m/s, impacting in to the LDO model.The closer are the obtained characteristics to the standard characteristic, the more favorable results can be expected using the obstacle model in numerical simulations [4].

Fig. 2a present the modernized ED72head structure, developed based onstatic and fatigue (base material and welds) strength calculations.The results of the numerical collision analysis with the LDO showed the necessity of significant structural changes in the ED72 head structure (Fig. 2b).All the reinforcements were aimed at limiting the deformation of the head structure, so that during the collision do not disturb the survival space around the driver.

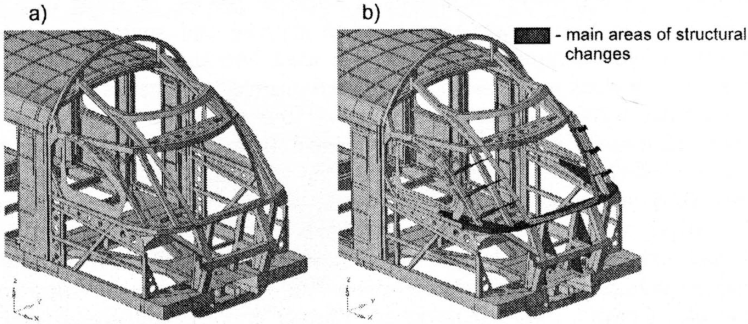

Fig. 2. The modernized ED72 head structure: a) after static and fatigue strength calculations; b) main additional changes after crash test with LDO

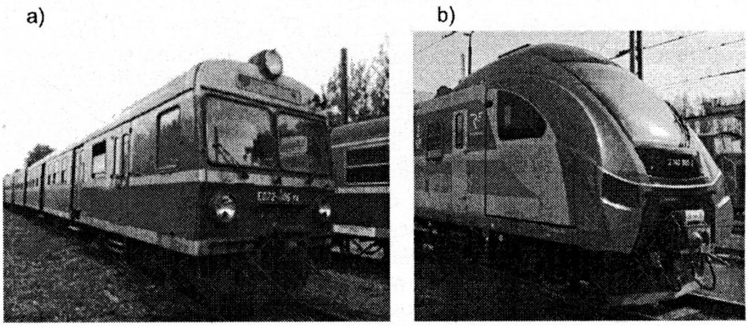

Fig. 3. The ED72 electrical train unit: a) before head structure modernization; b) after head structure modernization [5]

References:

1. Terczyński P., Elektryczne zespoły trakcyjne w Polsce – stan obecny i bliska perspektywa, Technika Transportu Szynowego, 5-6 (2010), p. 13–20.

2. Terczyński P., Elektryczny zespół trakcyjny serii ED72, Świat kolei, 8 (2001), p. 37.

3. PN-EN 15227:2008. Kolejnictwo – Wymagania zderzeniowe dla pudeł pojazdów szynowych.

4. Spirk S., Kemka V., Kepka M., Malkovsky Z., Design of a large deformable obstacle for railway crash simulations according to the applicable standard, Applied and Computational Mechanics, 6 (2012), p. 83–92.

5. Frączek R. et al., Modernization of the head structure of the ED72 electrical train unit, Mechanik, [in Polish, in press].