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## **Analytical aspects of the track facilities functioning efficiency upgrading with considering processes variability**

In this article the authors present and offer methods of upgrading the track facilities functioning efficiency based on defects generation in the track rails processes variability statistical analysis results. For that the scientists offer to use statistical analysis of data concerning the found discovered track rails of Kyiv underground railway, due to the fact that they performed this analysis and based on this analysis the authors offer the conclusion that most of these problems are associated with processes of the rails materials contact failure. In this context the authors offered ways to upgrade efficiency of using such main resources as rail track. The performed analysis gave statistical data concerning different types of problems spreading in underground railway. The achieved results allowed authors to offer courses of reducing defectiveness, which will cause upgrading efficiency of the enterprise functioning. Due to the fact the competence among different types of transport increases, the enterprises are supposed to optimize performance by decreasing capital and current investments into infrastructure of the enterprise. So in the article the authors offer some measures concerning upgrading track facilities functioning efficiency of industrial and industrial facilities.

**Keywords:** *industrial track, underground railway, variability, track, defect, rail, project management, cost effectiveness.*

**Challenge problem.** Transport is the main drain of any economically developed state's economy, which satisfies need of the society in transporting freight and passengers. Volume of transportations largely reflects the state's economy development level, at the same time efficient work of transport ensures the economy development.

Importance of certain transport in the transportation structure depends on geographical environment and economical growth characteristics. For majority of the developed countries of the world railway transport plays a key role in freight and passengers transportations processes. In a transport system of providing the transportation of big enterprises' heavy load the first place belongs exactly to railway transport. In transport systems of city network in transportation of the passengers they increasingly frequently use railway transport. Underground railway is an electrified railway for passenger service, located

mostly in tunnels, on elevated structures or just on ground. Specific weight of passengers' transportations by underground railways in the city transport system with considering trip distance, exceeds 50%.

Contemporary city transport growth vector in big cities is typical for its worldwide trends to mainstreaming the underground railway. Such factors as increasing of the cities' territories and of the population, growth of urban concentration and absence of opportunity to reconstruct the street network – all they lead to serious complications in the city transport work. As a result – traffic jam on the streets, safety level of traffic decreases, travel time increases. Thanks to these factors there is a need in growth of the underground railway networks, which will be able to provide trouble-free transport link for minimum time interval.

Contemporary vector of the industrial track transport network of the enterprises is similarly oriented on increasing the role of the railway transport as one of thoroughfare of the global economy.

Evaluation of the railway transport enterprises efficiency is based on the ground of several indicator sets:

- 1) summarizing indicators of the enterprise working efficiency;
- 2) indicators of the working force usage efficiency at the enterprise;
- 3) indicators of efficiency in using the capital stock of the enterprise
- 4) the enterprise' financial resources usage efficiency indicators.

The capital fund of the enterprise makes a considerable part of both the enterprises' cost in heavy equipment industry and the underground railway. All the engineer construction are related to them. This is why one of the main parameters in the railway infrastructure efficiency management is its capital funds usage efficiency.

The base of the railway transport is a track complex, a part of which makes more than 45% of all the capital funds of the railway and underground railway.

The railway service continuity process gets more complicated with each year of track operation it causes increase in intensity of accumulation of permanent strains in it, and also wear, fatigue damage occurrence probability and other damage in the structure elements of the track is high. Distinctive features of arrangement of the track in tunnels do not allow to conduct engineering works when the trains are moving, and principle of their work means that the track infrastructure is highly reliable and failure-free performance.

**Statement of basic materials.** Efficiency of using the capital funds is associated with such indices as service lifetime and cost of their maintenance work.

Service lifetime of the track rail is determined either by tonnage put through it, or by defects available there, which is the reason to replace that rail immediately.

Operation experience shows that most of the rails are replaced by the new ones because of such defects.

Defect means that it is a breakdown, occurred either because conditions of operation or production of rails are breached, or due to the material fatigue natural process.

According to Classification and Catalogue of defects and breakdowns of the rails in the railroads of Ukraine [1], all the defects are coded by three figures. The first figure of the code determines the type of the defect and location where it occurs; the second figure determines variety of the defect, provided that the upstream cause of its formation and development is considered; the third figure determines location place location of the defect over the length of the rail.

Let us consider the main types of the defects which we can see while we perform the analysis.

The defect with code 10 – shelling and liftoff of the metal on the surface of the rail top. The reason why these defects often occur is the shortages in manufacturing technique, and as a result they often find hair cracks, ruptures, rolling laps, flax in the rails, which under effect of contact voltages cause formation of shelling and liftoffs of the metal on the surface of the rail rolling.

The defect with code 11 – shelling of the metal on the lateral working screwdriver of the rail top. The reason of this defect is insufficient quality of the rail steel, due to nonmetallic inclusions available there.

The defect with code 17 – shelling and liftoffs of the metal on the surface of rolling in hardened layer. The reason may probably be breach of the rails hardening technique which leads to abrupt change of speed-load curve of the material, in the places where they are available, in which there is a high probability of liftoff.

The defect with code 18 – shelling of the pad weld on the surface of top rail rolling, including due to violation of the wire bonds welding technique. The other reason why these defects occur is violation of rail deposit welding technique.

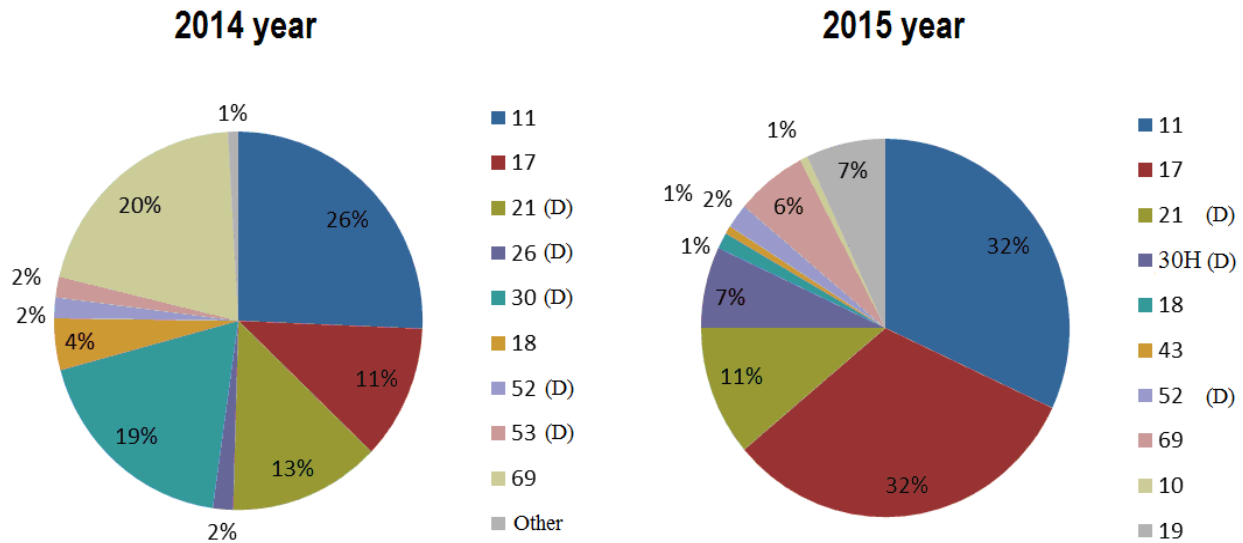
The defect with code 21 (D) – transverse cracks in the top looking like light and dark spots. The reason they occur may be nonmetallic inclusions in steel, which are pulled out during rolling, being the stress concentrators. Under the effect of the railway load the cracks start to occur.

The defect with code 26 (D) – transverse cracks in the top due to violation of the rail welding technique. The reason why these defect occur is може бути violation of engineering process and welding conditions, availability of nonmetallic inclusions in the places of welding.

The defect with code 27 (D) – hardened cracks in the hardened layer of the metal top and angularities because of them. The reason why they occur may be violation of rail hardening technique.

The defect with code 30H (D) – horizontal disintegration of the top due to nonmetallic inclusions. The reason why they occur is that in the top there are nonmetallic inclusions, which are pulled out along direction of the rolling.

The defect with code 69 – corrosion, burning or local wear of the rail base, which leads to fatigue cracks. Corrosion of the rails happens as a result of atmospheric effect and contact with materials, which accumulate moisture. The defect is typical for tunnels and places with moist climate.



**Figure 1.** Statistical distribution of the defects found in the rails (2014) (on the left) Statistical distribution of the defects found in the rails (2015) (on the right)

You can see the other types of the defects and reason why they occur in [1].

Analysis was conducted for statistics concerning the defects found on the rails of Kyiv underground railway in 2014-2018.

All the defects found were sorted out according to their code. We will perform analysis on each year separately.

On Figure 1 on the left we can see distribution of the defects by their codes, which were found in 2014 in the rails of Kyiv underground railway.

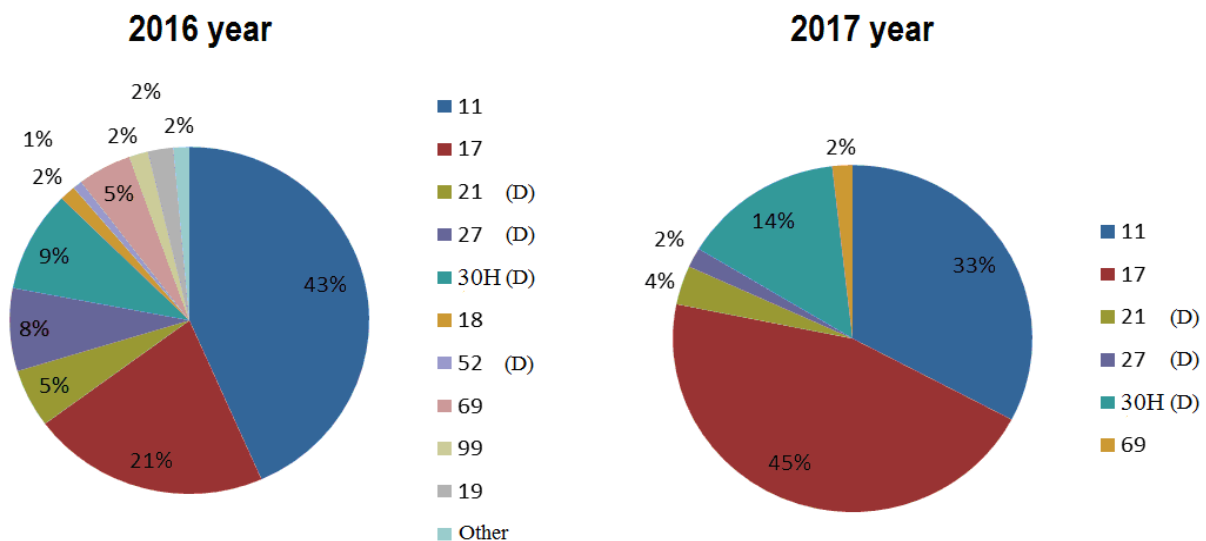
As we can see in the figure, the biggest number (26%) is the number of defects by code 11. A little less number of defects by code 69 was found – 20%

and 30H.D – 19%. The number of the defects by code 21 made 13% and by code 17 – 11%.

On figure 1 on the right we can see distribution of the defects by codes, which were found in 2015 in the tracks of Kyiv underground railway.

As we can see on diagram the number of the defects by code 11 increased and by code 17 – to 32%. Part of the defects by code 21.D made 11%, the defects 30H.D and 19 made 7%, and the defects with code 69 made 6%. It should be noted that the defects by code 19 were not found in precious year.

On Figure 2 on the left there is a diagram of distribution by the codes of the defects, which were found in 2016 in the tracks of Kyiv underground railway.



**Figure 2.** Statistical distribution of the defects found in the rails (2016) (on the left) Statistical distribution of the defects found in the rails (2017) (on the right)

2018 year

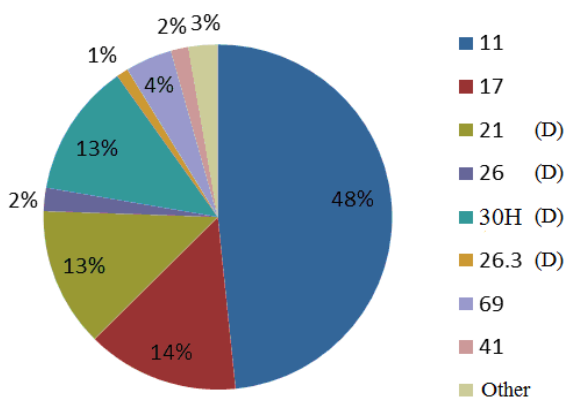


Figure 3. Statistical distribution of the defects found in the rails (2018)

In 2016 the part of the found defects by code 11 raised to 43%. Also the part of the defects by code 17 rose to 21%. The part of the defects by code 30H.D made 10%. The number of the defects by code 27D increased. If in 2014 and 2015 there were no defects by such code, in 2016 their part rose to the overall number and made 8%. Unlike the previous year, no defects by cod 19 were found. Part of the defects by code 69 made 5%. Unlike two previous years they found the defects by code 99, although their part made only 2%.

On Figure 2 on the right there is a diagram of distribution by codes of the defects found in 2017 in the tracks of Kyiv underground railway.

Part of the defects by code 17 made 45%, defects by code 11 – 33%, defects by code 30 – 14%. This year there were no defects by code 30H.D, 19, 99 found.

On Figure 3 there is a diagram of distribution by the codes of the defects found in 2018.

The defects by code 11 made the biggest part – 48%. Part of the defects by code 17 made 14%, by code 21 – 13%, and by code 30H – 13%.

Let us analyze how number of the most widely spread defects changes in quantitative measurements. The data of distribution are on Figure 4.

As we can see there is the biggest number of the defects by code 11, within the stated period there were 334 items found, there were 185 defects by code 17 found, the defects by code 30H (D) – 95 items, the defects by code 21 (D) and 69 respectively – 76 and 58 items.

When we analyze dynamics of increasing number of the defects by types it should be noted that there is no clearly defined tendency.

Number of the defects found by years is distributed in a very non-uniform manner.

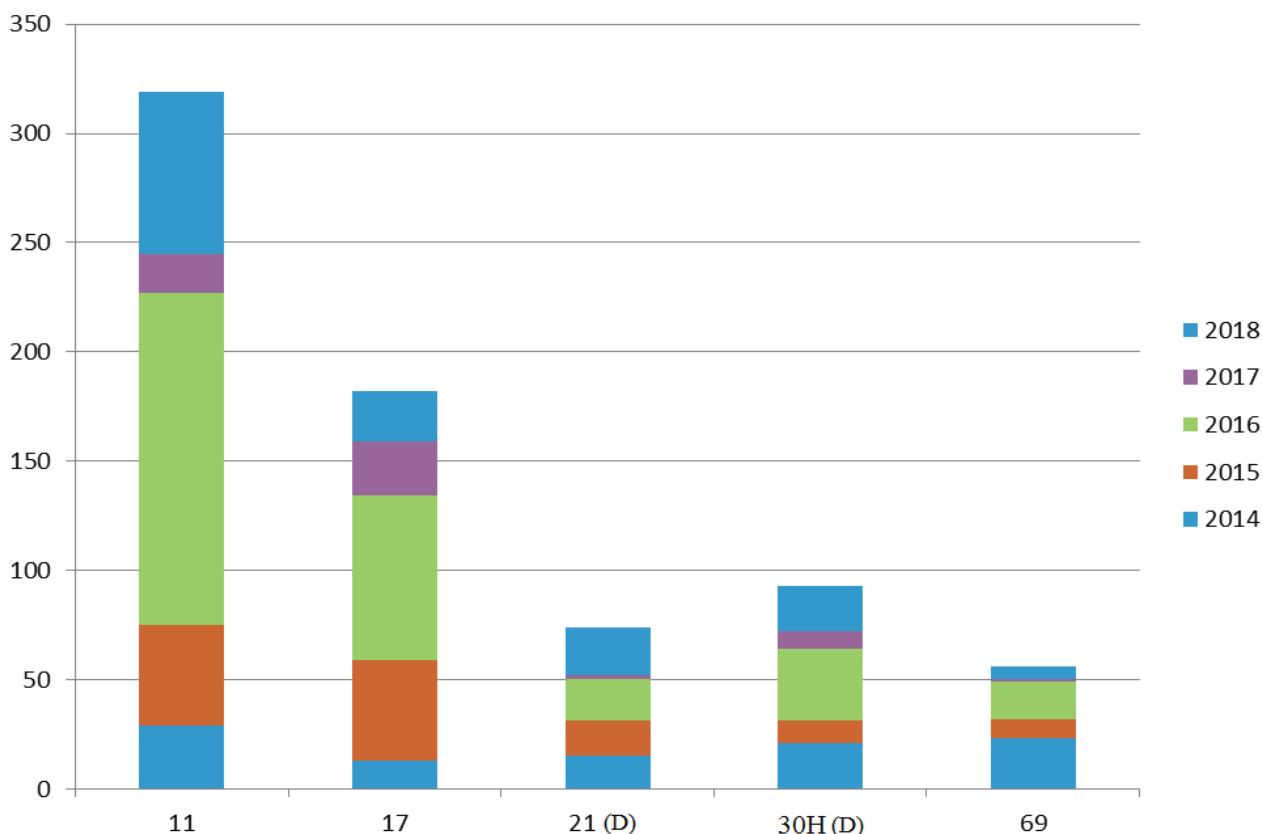


Figure 4 Numeric distribution of the most widely spread defects by years

**Conclusions.** When we analyze the known reasons of defects, as shown on Figure 4, it should be noted that, that they are all united by contact fatigue origin. In order to improve efficiency of utilizing such capital funds as railroad rails, we need to use one of the following means, or all of them in comprehensive manner to obtain the maximum effect:

– Improvement of initial check of the rails to reduce number of the rails in the track with defects from manufacturing.

– Introduction of modern efficient methods to reinforce [3, 4] the surfaces of wheel-rail friction, which will allow to prolong their service lifetime.

– Conduction of scientific researches with using modern methods of computer methods of simulation of interaction between the track and rolling stock [8,9], as their simulation is being influenced by numerous parameters, such as conditions of force interaction [6,7,10], various operational factors [5] and so on. Based on the obtained research data, optimization of the contact pair – wheel-rail, and also the structures, and also the structures, which have immediate effect on nature of this interaction immediate in.

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