Logistical Problems in the Field of Railway Tracks Modernization and Maintenance Technology

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The study presents the organization, mechanization and technology in the field of modernization and maintenance of Polish National Railway (PKP) lines, as well as in relation to the activities of the DOLKOM- Wroclaw company. Attention has been drawn to the major overhaul technology (resurfacing), the exchange of switches, surface maintenance and repair of the rail-bed (subgrade). The technological requirements, regarding the renovation and modernization of surface and rail-bed in the PKP railway network, have been discussed. In the field of rail-bed renovation, attention has been focused on the process of technological modernization of the track using a specialized multifunctional machine AHM-800R.

Keywords: modernization and maintenance of railway tracks, overhaul technologies, logistics.

1. RAILWAY OPERATING SERVICES AND THEIR STATUTORY DUTIES

Currently, Polish National Railways SA (PKP) are responsible for the maintenance of railway infrastructure. The main task of operating railway services is to ensure maximum safety of train traffic and that, more or less, depends on the tracks technical condition. An objective and thorough evaluation of the diagnostic status of the track should enable carrying out, in due time, all the necessary works to eliminate the threat [3, 7].

The technical condition of the track, according to the PKP requirements, is evaluated primarily on the basis of measurements made with a specialized measuring wagon. These results, however, do not give a complete picture of the technical condition of the track. Direct measurements involve [3]:

1) measuring the basic parameters characterizing the position of the cross level, i.e.:
   – the width of the track,
   – differences in cross level height,
   – cross level inequalities in both planes.
2) measuring of additional track parameters, involving:
   – the position of the track in the horizontal and vertical planes, in relation to adjustment signs of the track centre,
   – clearances in the classic track contacts, and their comparison with the permissible.

The results of direct measurements and technical research (surveys)of the track are used to determine the order of detected defects removal, schedule repairs and to produce analyzes and assessments of the tracks technical condition. If defects cannot be removed, the appropriate operational restrictions, which are necessary to preserve the safety of railway traffic, should be introduced. As a part of the technical research (surveys) of tracks, direct measurements discussed above should be performed, and the following should be set [3]:

– the degree of wear or damage to the superstructure elements (rails, sleepers, fittings)
– the state of the ballast pollution,
– the state of attaching the rails to the sleepers (diagnosis of rails creep problem)
– the state of the tracks weeds,
– the state of the rail-bed drainage,
– the sleepers spacing and their technical condition.

In order to keep the track surface in a condition for the full efficiency of the rails and railway and

safety of the train traffic, the execution in a timely maintenance and specific track repairs should be performed. The scope of maintenance includes the following works [3]:

- replacement of broken rails,
- replacement of damaged fittings, which connect the rails to sleepers,
- tightening the screws (connecting pad pad/ under-rail pad with a sleeper) and bolts (alloy or rag ones, in the case of a classical track)
- adjusting of the track width,
- elimination of local reductions of longitudinal profile vertical alignment,
- correction of vertical alignment of the track, in the so-called heave in winter,
- removal of vegetation and weeds from the surface of the track,
- adjustment of the track in the plan and profile.

Fig. 1 illustrates an example of the track, which status was assessed as unsatisfactory, due to serious defects in the longitudinal profile [3]. The collapse of the tracks in contact areas of rail links, and in many cases loose screws, which should connect pads with the sleepers are the result of negligence in the maintenance of the track.

Fig. 1. View of the track number 1NA line PKP PLK No.286 Main Station Kłodzko – Wałbrzych. Source: M. Winiarski [3].

Maintenance works are carried out in the periods between repairs of the track, and their scope may include one or all of these activities. The systematic execution of maintenance work allows for extension of time the track is usable, without the need for repairs. Technical condition of the track, which is based on the results of surveys and measurement circuit, determines the need and range of track repair. The different types of track repair are [3]: current, main and investigation.

Current repair of tracks and turnouts is performed in order to restore the operational suitability and to prevent the degradation of railway superstructure, and covers [3]:

- adjustment (alignment) of stress in the contactless tracks,
- screening and supplement of crushed ballast up to 30% of the total weight of ballast,
- tightening screws and bolts (disjoint elements service), up to 30% of the total of these surface elements,
- adjustment the track sections, which exhibit creeping, and regulation of slack contacts rails of the classic track,
- regulation of the track width,
- compacting ballast under the sleepers with adjustable track in longitudinal profile,
- correcting of vertical alignment of the track in the presence of the so-called heave zones and vertical displacements (track subsidence as a result of weak soil),
- profiling deformed track benches and cleaning side ditches,
- replacement of single rails, sleepers and connectors (connecting rails with sleepers), the total number to 30% of the total surface of these components,
- removing undesirable vegetation and weeds from the track,
- adjustment of the guides in the horizontal curves, at level crossings and bridges,
- replacement of worn or damaged turnout parts (a frog, a half-turn switch, bearers up to 30% of the total, single connecting rails, the adjustment of the width of the track at crossover, adjusting the width of the gap between the "nose" of the frog and the "wing" rail, removing defects in steel parts by welding and grinding).

The photograph 2 shows a fragment of the double crossover turnout (like 60E1) with a chipped half-turn switch and notable side wear of the needle [3].

Fig. 2. A fragment of the double crossover turnout (like 60E1) with a chipped half-turn switch and notable side consumption of the needle [3].
Source: M. Winiarski [3] .

Photo no 3 shows a fragment of railway track No. 279, prepared for the exchange of rails [3]. At the external track the new rails type 49E1, intended for mounting, are collected.

Fig. 3. A fragment of railway track No. 279, prepared for the exchange of rails.
Source: M. Winiarski [3].

Major repairs of tracks and turnouts are divided into [3]:

– non-complex, which are works involving a continuous exchange of one or two basic components of the surface; relating to the track they are: rails or sleepers, or ballast and rails and sleepers in total; for switches, only bearers may be covered with repairs, all steel components, steel components including bearers or just ballast only,
– major complex repairs, involving continuous and complex exchange of all elements of rail superstructure, i.e. rails, fittings between rails and sleepers, sleepers themselves, ballast, complete turnouts and strengthening the track substructure (rail-bed).

The photograph 4 shows an example of main non-complex repair [3], which is the crossover dual cross type 60E1 (RKPd-60E1), after replacing the bearers , without crusted ballast replacement.

Fig. 4. RKPd S60 (E1) turnout after replacing the bearers, without exchanging crusted ballast (Example of the main non-complex repair).
Source: M. Winiarski [3].

Modernization - unlike major repairs - are investments including work aimed at increasing the technical efficiency up to the level, referred to the new operating parameters, by replacement with a different type of basic design parameters of the surface [3]. The result of the modernization investments is obtaining, according to the draft, increased technical and operational parameters, by varying the geometry of the track, in conjunction with a swap, regardless of the surface condition, its basic structural elements. Fig. 5 shows the section of the main line of the PKP railway station Oborniki Slaskie during the modernization works [3]. During these works- using pre-stressed concrete bearers - the ordinary turnout with a curvature radius of diverging track R = 500 m (Rm 500) was replaced with an arc sided turnout, of the basic track radius curve R = 1300 m (Rzj 1300 [3]. The flexible attachment of SB3 type in the main running line seems important.

Fig. 5. The section of the main line of the PKP railway station Oborniki Slaskie during the modernization works.
Source: M. Winiarski [3].

Failback repairs are necessary works when removing the damage, caused by natural disasters and rail accidents, and they are performed in order to restore, as soon as possible, negotiability of the track with the specified operating parameters [3].

Here are examples of emergencies that require immediate intervention of the repair teams; in these cases, the effects of accidents has been removed by the DOLKOM Ltd team [3]:

– photograph 6: wagon derailment of a freight train, which consequence was a serious damage to the track (destruction of the geometric plan and longitudinal profile) [3],

Fig. 6. wagon derailment of a freight train, which consequence was a serious damage to the track (destruction of the geometric plan and longitudinal profile).
Source: M. Winiarski [3].

– photo. 7: a state during the repair of the track on the PKP line Luban – Lesna, after a train derailed [3]. The repair consisted of replacing wooden sleepers and track adjustment plan and longitudinal profile.

Fig. 7. A state during the repair of the track on the PKP line Luban – Lesna, after a train derailed.
Source: M. Winiarski [3].

2. LOGISTICAL ASPECTS OF MAINTENANCE AND REPAIR OF RAILWAY INFRASTRUCTURE

The scope and methods of track work

Logistical aspects of the arrangements, relating to the maintenance and repair of railway infrastructure, have been presented on the example of Wroclaw company DOLCOM, who possess the appropriate technological potential and is a regional leader in this regard. The following are the major activities of the DOLCOM company [3]:

– modernization and major repairs of the stations and railway lines, especially the track structure exchange, switches/turnouts and substructure/ rail-bed repairs using UK cranes, SBT track pavers and EDK cranes,
– current repairs of railway lines using efficient heavy equipment by company Plasser & Theurer, dedicated to track works,
– works related to infrastructure maintenance, especially engineering objects, tracks, switches/ turnouts and subgrade, and paving diagnostics and surveying,
– technical projects, inter arrangements and construction of railway sidings.

The tasks carried out in the process of modernization works and major repairs are [3]:

– dismantling of track and turnouts,
– ground works,
– making the under rail layers to improve capacity,
– strengthening the subgrade with geosynthetics (eg. geogrids, geotextiles),

- installation of track with rails 60E1 and 49E1 on pre-stressed concrete sleepers and wood,
- installation of turnouts on pre-stressed concrete bearers (in the main basic tracks and supplementary tracks) and on the wooden bearers (in the side tracks),
- performing drainage of the ground under the tracks and turnouts,
- repairs of rail-road crossings,
- repairs of engineering structures.

The necessity of an efficient, timely and, in accordance with the provisions of the construction law, execution of works listed above requires a timetable and drawing up a plan of machines work as well as the assignment of an adequate number of employees for each stage of work.

Photography 8 illustrates the section of track No. 1 on line No. 279 Luban – Wegliniec after completing the works, related to the replacement of individual sleepers and rails, cleaning the crushed ballast and its mechanical compaction, adjusting the track in longitudinal profile and profiling the track benches and welding the rails [3]. As a result of these modernisation works, the railway contactless track has been received on the relevant section. [3].

Fig. 8. View of the section of track No. 1 on line No.279 Luban – Wegliniec after the modernization. Source: M. Winiarski [3].

Each realization of even an identical project in the track works (exchange of the turnout, replacement of sleepers, replacement of bearers) can be difficult due to its individual character [3]. Thus, for a given type of works and their scope, the method and the process of construction should be developed. In designing the track work, which include heterogeneous - in terms of technology-processes, to carry out the tasks there may be used different methods of work organization, namely: the method of parallel execution of works, subsequent execution of works, regular working method and combining these methods.

Method of parallel execution is based on the simultaneous starting work on all construction sites [3]. The disadvantage of this method is the lack of continuity of the work of individual work teams, because each of them after the work completion on one construction site has to go to the other ones. The method is also characterized by irregularity of daily production of construction, machines work, consumption of building materials, etc. The advantage of that method, however, is the shortest cycle of construction (*Ts)* available - compared with the cycle characteristic of other methods of construction organization. The shortest cycle corresponds to the highest demands in terms of employment and means of production for the duration of construction. A method of subsequent execution of work is to build the objects in the correct sequence [3]. A significant drawback of this method is the lack of continuity of work teams performing different types of work, and lack of continuity of the operation of machinery and equipment, as well as uneven wear of building materials. The value of the construction realization cycle *Ts* in this method is the highest- compared with the cycle on other ways of organizing the construction. The longest cycle corresponds to the lowest needs in terms of employment and means of production for the duration of construction.

Method of regular work, which specific versions are also called stream methods of work organization, was formed as a result of adaptation of the industrial production line method to the needs of construction works [3]. It involves the division of construction sites into a number of parts with equal amounts of work, called working plots (maintaining reasonably regular workload work on each of them), entrusted to perform to fixed brigades, which - going from one working plot to the next – keep doing the same job. Such a division is necessary to create regular working conditions and work rhythm. If the works planned for construction are not large, there is no need to divide them further.

A characteristic feature of the regular working method are particularly advantageous organizational properties [3]:

- achieving the best conditions for the continuity and uniformity of work teams employment, machines and materials

consumption, as well as the building production itself.
– the ability to increase significantly the productivity of employed workers, which results from the ability to organize specialized working teams (i.e. masons with their assistants, fixers and concrete workers, plasterers, etc.) and repeatability of tasks they perform. The most important and most difficult task in the organization of works with this method, is to divide the construction site into the working plots of the same or very similar effort (differences should not exceed 15%), and suitable composition of the specialized working groups. The more working plots, the better results of introducing the regular work method. However, it is important that the working plots are not too small, because the amount of time, consumed by organizing the work place might seem too big in relation to the time of actual work. The length of a stable regular work depends on the number of working plots. The more of them, the longer this period is.

Logistics in the preparation of the project

On receipt of orders for the execution of works, the DOLCOM company gives the works their specific number and directs the request to the execution unit, in which the work will be performed. There, in that unit the following activities, related to the accession to the task execution, are undertaken [3]:

1) examining the place of work and the compliance of the scope of work with the current state in the area, to discuss the possible non-compliance (with the order or the contract),
2) determining the scope of work, the method of implementation and sequencing of individual activities,
3) determining the number of necessary machines and operating personnel,
4) define how to implement the project, in particular setting the following:
   – capability of making it with own resources or the need for subcontracting,
   – the entity providing material (the customer or contractor),
5) preparing the demand for holding tracks for machines, and work trains,
6) starting the preparation of the work schedule.

The essential activities of an organizational nature, to be taken during the preparatory period are [3]:

1) submission of the demand for the closure of rail in the PKP PLK Department of Railways (on the basis of the works technical regulations, prepared by the DOLCOM company):
   – included (waiting time $t_{o,zt}$, counted from the date of the consent pending to the receipt of consent $t_{o,zt}$ is 105 days),
   – periodic ($t_{o,zt}$ = 30 days),
2) developing regulations on turning off line voltage track, where it is deemed necessary,
3) appointing the works manager and preparing works schedule, taking into account:
   – the order of execution of the various tasks and the time needed for their implementation,
   – the need to order machines to carry out the works and determine the time interval of their work,
   – identify the need of material, in terms of quantities and delivery dates.

The stage of handing over the construction site

In the process of handing over the construction site, the representatives responsible for the task completion from both the customer and contractor side, shall be appointed [3]. Moreover, the construction transfer protocol has to contain information about any material deficiencies, diagnosed in the work performed as well as information about tracks, dedicated to withdrawal of working trains. Finally, the construction site is taken over by the appointed works manager, who starts realization of works in accordance with a schedule. The works manager responsibilities are presented in the graph 9 [3]. The tasks of the works manager also include: bringing the project until the end, according to the schedule; preparation of technical documentation on the implementation of works; making a report on applied materials; making the acceptance of works with the customer (investor) and, finally, passing the construction site.

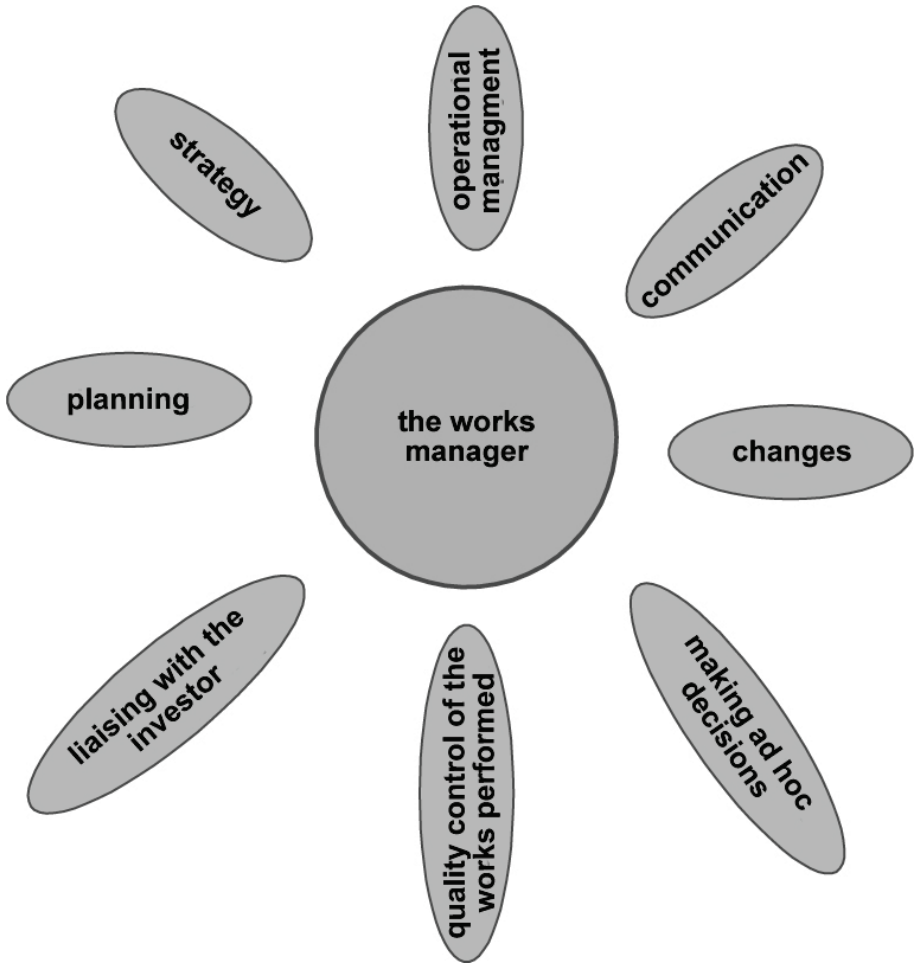

Fig. 9. Tasks of the works manager.
Source: M. Winiarski [3].

Information about the process of technological modernization of railway routes, using AHM 800R machine

A bucket combine AHM 800R is designed to make a continuous replacement of the "active zone" of the track ground substructure, with the possibility of removing the layer of subgrade, without having to remove the track superstructure [1, 2, 3, 4, 5, 6]. The machine raises the track vertically upwards together with "pinned" sleepers. At the same time the material forming the upper layer of subgrade is removed and transported to conveyor belts, where impurities are detached. Meanwhile, on the surface of the subgrade there is a geotextile (which is a reinforcement layer, separating or filtrating) spread, and covered with fine ballast. Now, onto such prepared surface (constituting the "track"), the AHM 800R machine brings again the crushed ballast and moves towards another working plot. Photos 10 *a, b, c* show the combine AHM 800R while working at the track [3]

The advantages of the machine AHM 800R include significant performance, measured in current meters of track by one work shift, and no need to dismantle the existing track superstructure. There are, however, two disadvantages [3]:

– the machine does not eliminate zones in the rail-bed, where there is irrigated soil material which, when in flexible or liquefied state, tends to migrate vertically in the direction of the ballast layer, polluting it and weakening the structure of the track,
– the machine does not "cure" the surface before spreading on the layer of geotextile. "Curing" means the density of the subgrade, which is traditionally done by mechanical means through rolling with a circular static cylinder or dynamically, via the vibrating plate.

a)

b)

c)

Fig. 10. a, b, c. Bucket combine AHM 800R, while working on the track.
Source: M. Winiarski [3].

3. SUMMARY

The selected aspects of the organization, mechanization and technology in the scope of modernization and maintenance of the PKP railway network have been referred to the activities of the DOLCOM- Wroclaw company [3, 6]. This company is well known on both national and international markets for its professionalism, implementation of modern technologies and possessing the specialist equipment. The broad implementation potential of the company reflects in projects like [3, 6]:

- modernization, revitalization and major repairs of railway lines, stations, railway junctions and passenger stops,
- current repairs of railway lines and maintenance of rail transport infrastructure,
- modernization, reconstruction and repairs of existing railway facilities of non-public use (railway sidings) and construction of the new ones,
- repair of machines for rail track works, and machinery for repairs of the traction network and rail cars.

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