DOI: 10.32703/2617-9040-2022-39-7

UDC 123:45

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REPAIR OF CEMENT, GRAIN, MINERAL WAGONS AND GONDOLA CARS IN A SINGLE FLEXIBLE ASYNCHRONOUS FLOW

The publication updates the issue of wagon repair in modern conditions and highlights the main problems associated with the method of organization of work. Low productivity is due to outdated equipment and worn-out rolling stock, poor training of staff involved. The article contains the main provisions of changing the method of repair, calculating the possibility of loading production positions, calculating the program of repairing wagons, determining the number of ways of their routes, analyzing the shortcomings of flexible asynchronous flow, developing solutions for testing flexible flow in computer simulations. Summarizing this material provides an opportunity to consider and develop a project based on the Stryi Wagon Repair Plant for flexible flow or its modification to increase repair capacity. The article calculates the time of repair of wagons by the flow method and using a flexible asynchronous multichannel method of repair, the graphs show the difference in downtime between the same types of wagons and the type of repair, provided that they are taken in the same condition before repair work. From these calculations, it can be concluded that the streamlined method of repair has exhausted all its resource potential, and will continue to incur the cost of paying employees, maintenance of equipment and other costs associated with production.

Keywords: *Flexible asynchronous flow, overhaul, depot repair, wagon repair method.*

Introduction. Repair base in modern conditions depends on the location of hub stations and the traffic congestion that run within 200 km.

In Soviet times, all repair companies were divided into certain classes of repair depending on the area of repair positions, the flow method of work organization was often used, the weight of cars was less, their number compared to the current number of wagons is 60%. Since now the weight of an empty wagon is 25 tons one needs to take into consideration the cranes, transport carts, transborders, tilters, the weight and size of the wagon. To make it easier to calculate, the weight of gondola car and the size of the grain wagon are considered [1].

One of the options to improve the repair of wagons is to use a new method of organization (flexible flow) [2], as the best option for the use of time, repair capacity, materials and repair area. This method was developed in the late twentieth century. Since then, the requirements for repairs have changed as well as technologies and instructions; existing wagon models have been modernized, and new models have been developed that are more suitable for transporting various goods (fastenings have been unified).

Analysis of recent research and problem statement. Currently, there are many articles on the organization of repair of wagons by the stationary method and flow, but these methods were proposed in the 50's of last century, when there was a relatively small flow of goods and a small transport network. Now the world is globalizing which encourages people to transport more goods for various purposes. The number of repair units is growing every day, and repair capacity can not abruptly move from one method of repair to another. One more problem problem is that capacity of repairs were developed not only for certain types of repairs but also for certain types of wagons, most of which are grain, mineral wagons, gondola cars, cement wagons and platforms. Whilst there are not many problems with the platforms except for running deficiencies, the situation with all other types of wagons is much more complicated [3]. There are big problems with the construction of the upper and lower strapping, as well as with the intermediate beams and end walls that can not withstand the load when sorting wagons on the slopes.

The purpose and objectives of the research. Over time, the repair base of Ukraine and the CIS countries has not been reconstructed or modernized, exhausted its repair stock and stock for repair capacity, so the equipment that was put into production was not replaced, reached their limits of safety and maintainability, so the failure rate increases in a geometric progression with each start of the equipment, which has theoretically been proved with the help of a new mathematical model, taking into account the random nature of the arrival for repair of different types of wagons, their models, and different types of scheduled repairs (depot repair (DR), depot repair with extension (DRE), overhaul).

This scheme of wagon repair can be used at existing enterprises with low costs for reconstruction, modernization, reconstruction.

The shops provided for repairs according to the flow method scheme can be converted into the one for repairs according to the flexible flow scheme [5] with the help of small adjustments and costs for modernization. It will allow to increase the production of repaired wagons by 20-30% due to the fact that that already repaired and handed over to the receiver wagons are removed from the module (shop) and transported to the station for further operation.

Most depots built in the 70-80's of the twentieth century were divided into classes by species. In this way companies could repair only one type of wagons. There is now a need to focus on the main bulk of wagons transporting cement, mineral, grain, as well as gondola cars.

We developed a project for the reconstruction of the wagon repair shop on the basis of SWRP located in the Lviv region [6]. The wagon downtime was calculated without reducing the quality of the work provided by the technological process. According to the results, 36 modules 5 meters in width can be placed taking into account the size of separate wagon in width. In turn, 36 modules can be divided into 6 repair items. Each module is to be staffed with personnel [7] and equipment that provides a technological process for scheduled repairs (DR, DRE, overhaul) for cement, mineral, grain wagons as well as gondola cars.

These types of wagons are of the largest percentage:

gondola cars – 45%;
grain wagons – 20%;
cement wagons – 15%;
mineral wagons – 10%;
other wagons – 20%.

The above mentioned distribution is due to the types of goods in transit through or produced in Ukraine, it is mainly raw materials. Cargoes follow the route ("Silk Road") and it allows to repair and service the rented transit wagons.

One of the key factors in modernization, reconstruction of already existing repair facilities in western Ukraine is the border with the European Union (its members). This makes it possible to repair European wagons in the territory of Ukraine according to European standards (European wagons are smaller in size than the ones from the CIS countries) [8].

In today's world, businesses seek to reduce the cost of repairing equipment, increase capacity and promote their products. The management of Ukrzaliznytsia is no exception, and wishes to increase the share of repaired cars for transfer to leasing companies, private individuals and to carry out transportation [10]. Against the background of the global crisis, all capacities were then partially, if not completely, suspended. Due to recent events and the background of the gradual launch of capacity and getting the economies over recession, it is possible to increase production, transportation and repair. So we proposed to calculate the possibility of repairing gondola cars, grain, mineral and cement wagons, which make up the bulk of the wagons of the entire Ukrzaliznytsia park. These types of wagons undergo various types of repairs during their operation: DR, DRE and overhaul. The technological processes used to repair such wagons are very different for these types of repairs. So, if, say, shop receives 12 different wagons arrive the types of repair vary depending on the types of wagons. The only common thing is their disability to operate.

Thus, in the late 50's, a flow method was proposed which provided for the sequential placing of wagons. This method allowed to move from object to object [9]. However, taking a closer look at the detail of this repair procedure, one can see that wagons that go in a chain one after another with different amounts of repair cause delays and in some positions they linger longer than others, people and equipment are idle, and work cannot be performed because some positions are occupied by other wagons [12]. It was then proposed to use preparatory areas and leveling positions. This allowed to summon the wagons to one volume of repairs. But this did not bring the desired result. In the late 70's it was proposed to use the division of wagons according to the volume of repairs. Therefore, they were divided into light wagons (small amount of work needed), medium and heavy (with overtime repairs) in combination with preparatory positions and equalizing positions. However, it did not bring much benefit to the repair [11]. At first, reserves were created that allowed to smooth out the beat and rhythm of the release of wagons. Over time, backlogs have decreased, but repair problems have begun. It was impossible to control the quality of repairs; non-compliance with the technological process led to an increase in the percentage of failures during the running of freight wagon. Constant disruptions of monthly (annual) repair plans took place.

Already at the end of 2008 during the global crisis it was clear that all repair methods of the organization had exhausted all resources and new methods of organization were needed. The use of flexible asynchronous multi-channel multiphase flow was proposed in Dnipro National University by Prof. Vladyslav Myamlin. That allowed to repair the wagon regardless of its type and type of repair following a strict structure of the technological process that would be based on its technological condition.

There are two solutions for the transportation of wagons to enterprises. The first is the laying of a track with a width of 1425 mm; the second is the laying of the 3rd rail. In this way, it is possible to unload the border checkpoints and transfer the responsibility for lifting wagons to already existing enterprises.

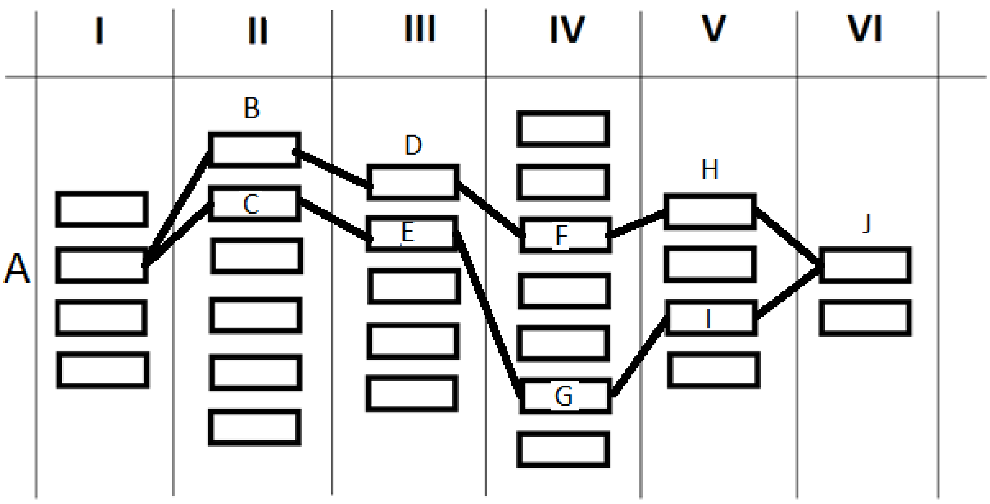

Figure 1. **Organization of a flexible method of wagon repairs**

According to this form of organization and placing of wagons it is possible to organize 125 ways of following the wagon on a separate unique way at the expense of free modules on positions. Due to this, the wagons pass without delay those positions that are not provided by the technological process or are not needed in this case due to their condition. For example, when repairing cement or grain wagon, some cars do not need to repair the roof in the 5th position; nor for a mineral wagon to replace the transom arches, or for gondola car to do the right work and rivet the lower and upper strapping. Given that the wagons can arrive with any damage, regardless of the time between repairs, both DRE or overhaul with extension and only in some cases overhaul can be performed. The latter is now tended to be avoided because the operation time of the wagon after the overhaul is not enough for full payback and benefit to its owner [13]. The following damages are observed after accidents on the railway: the propeller of the spine, broken body racks, deflection of the upper strap, broken (damaged) side frames of the cart, damage to the pivot beam. In such cases, more time is needed to spend on repairs and quality control of repairs to avoid possible complaints. Such wagons can be up to 2 times longer to repair than a normal car undergoing the DR and up to 3-4 times longer than a car passing through DR or DRE. Taking into account such probabilistic factors, the flexible flow can be managed due to the fact that there will always be a free way for the wagon to follow the free module positions. At the same time, the stationary flow will be useful for individual cases of repair of special equipment or special cars where there is not need to follow stable production. Such method is now used only for non-mass models [14]. At the same time, the flow method does not cope with the flow of mass series of wagons and the number of their types undergoing scheduled repairs, thereby causing a load on the stations to which they are driven. This leads to high costs and losses for sorters at stations and for trains following through the station.

Having considered all the problems associated with the flow and stationary method, it can be concluded that the repair facilities need to be urgently converted into new repair methods to prevent shutdowns and collapse at stations and repair plants.

We collected data for 12 variants of cases with different wagons requiring DR, DRE and overhaul: grain, mineral, gondola cars and cement wagons. For each such option, we examined 40 wagons with their downtime at all stages in the technological process [4]. Calculations of the probability of following the wagons on different routes according to the scheme of flexible flow have been carried out. The average downtime of the car, taking into account the probability of repair has been collected and summed up.

The graphs show a downtime of cement, mineral, grain and gondola car at 6 positions for 40 wagons during DR.

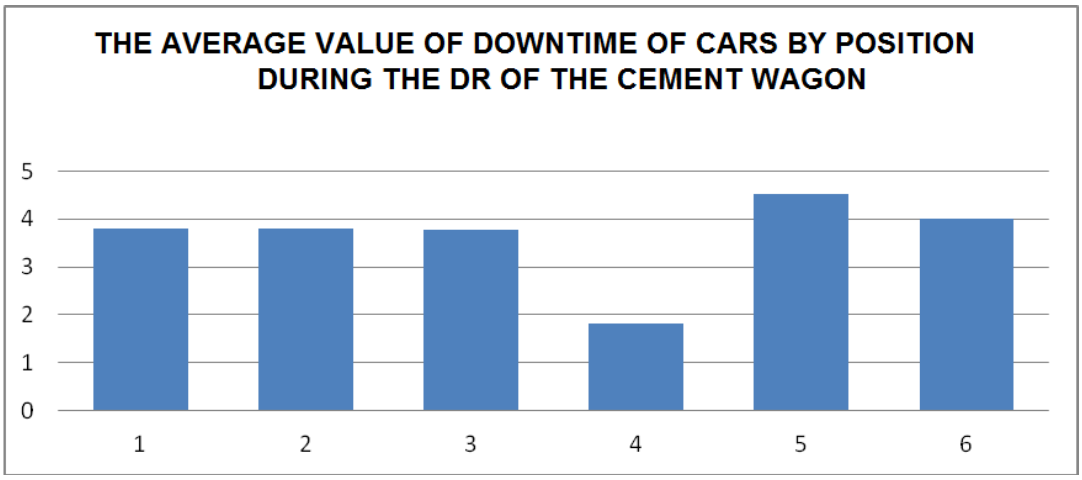

Figure 2. **The average value of downtime of cars by position during the DR of the cement wagon**

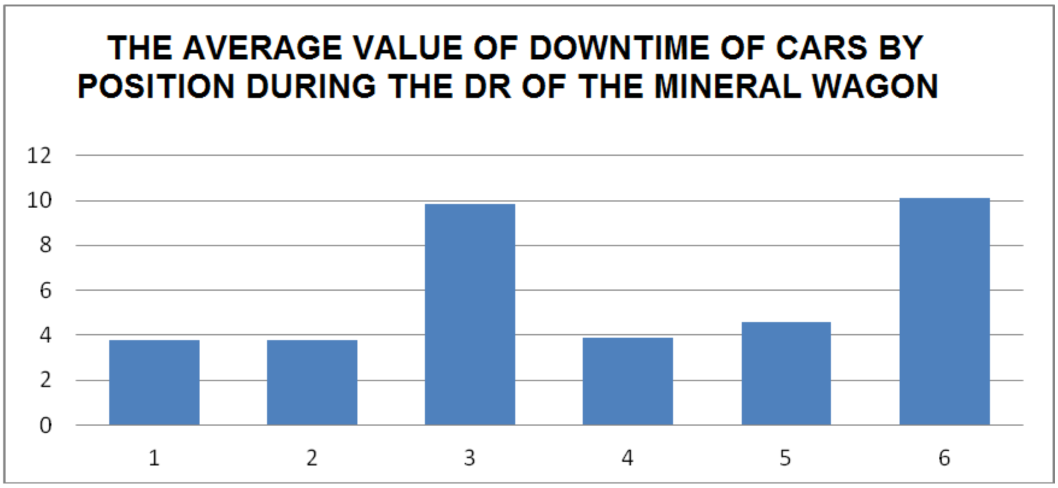

Figure 3. **The average value of downtime of cars by position during the DR of the mineral wagon**

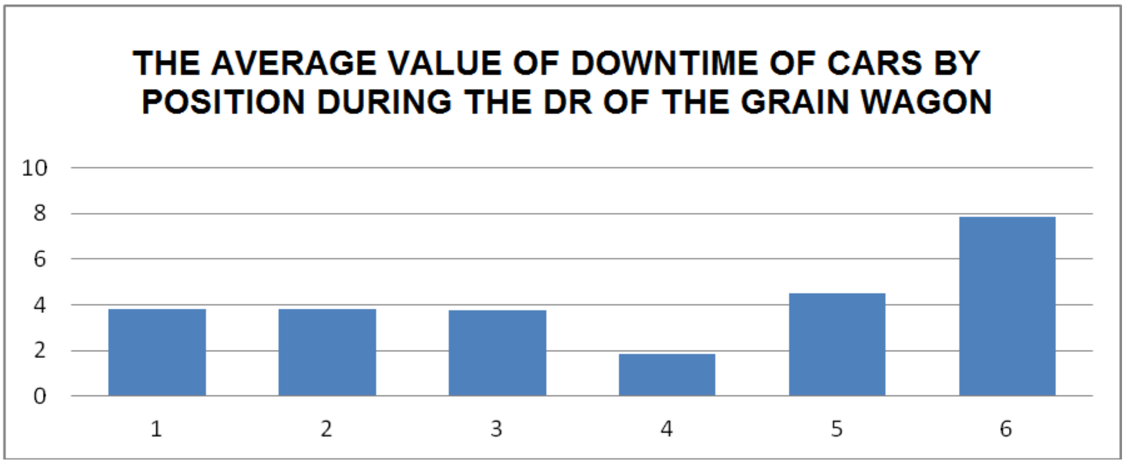

Figure 4. **The average value of downtime of cars by position during the DR of the grain wagon**

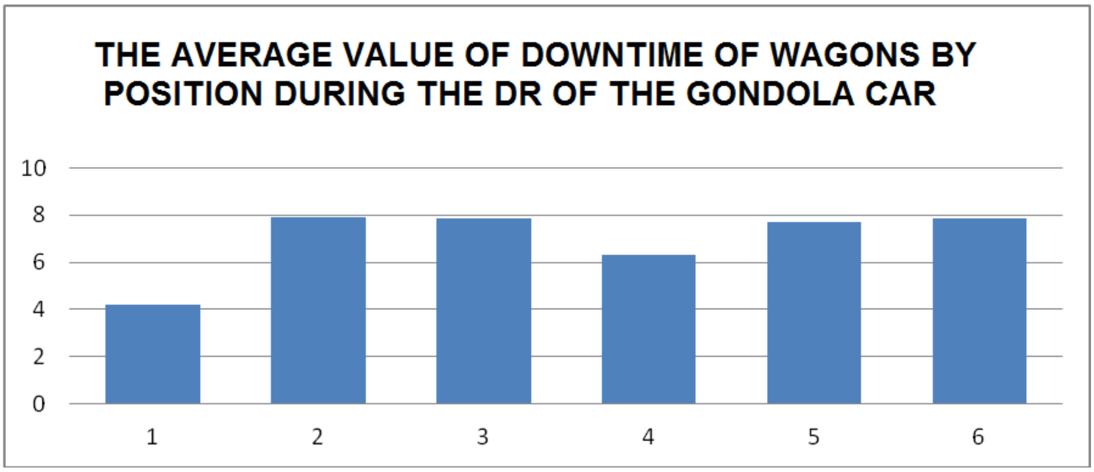

Figure 5. **The average value of downtime of wagons by position during the DR of the gondola car**

From these figures we can conclude that the downtime of cars is a probabilistic number and it cannot be brought to the ideal value in the usual organization of repairs (stationary or flow), so these methods began to bring only loss of time for wagon repairs due to its structure and sequence of actions.

When considering the structure of the flexible flow organization and comparing it with all the repair methods currently proposed, there is an obvious difference in the number of repair modules, which increases the number of repaired wagons in compliance with the technological process.

To ensure the competitive state of the railway, it is necessary to increase the capacity of wagons through repair stages and reduce the downtime of cars at repair positions [15]. To meet these two parameters, one needs to upgrade existing businesses or build new ones. Our research compares both scenarios of further development of the repair of wagons in Ukraine.

Conclusion

It can be concluded that for enterprises located within the city limits, it is easier and more efficient to reconstruct existing enterprises. If the company is located outside the city, it looks reasonable to demolish all constructions and develop a new project. Given that the existing facilities were built and developed in the post-war period, they were located close to the stations, and no one thought about expanding the repair positions and further development of the repair industry. The area around these enterprises got urbanized, which now complicates the work of the company in the installation and removal of repair facilities.

Flexible asynchronous flow is one of the most popular in repair companies, as it allows to use all repair facilities in compliance with the technological process.

Advantages of flexible asynchronous flow:

minor changes in the location of repair positions in wagon repare shops;

adherence to the technological process;

maintenance of quality control;

increased load factor of repair equipment;

increased number of repair units in the annual plan;

Disadvantages.

The main drawback is that this method is not used in the CIS and it is not possible to calculate all the bottlenecks, even using the most advanced calculation methods. There are also no specialists who can train staff to more effectively use all the benefits of this method.

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РЕМОНТ ЦЕМЕНТОВОЗІВ, ЗЕРНОВОЗІВ, МІНЕРАЛОВОЗІВ, ПІВВАГОНІВ В ЄДИНОМУ ГНУЧКОМУ АСИНХРОННОМУ ПОТОЦІ

Публікація актуалізує питання ремонту вагонів в умовах сучасності та висвітлює основні проблеми, пов'язані з методом організації роботи. Низьку продуктивність роботи пов'язану з застарілим обладнанням та зношеним рухомим складом, слабким навчанням задіяного персоналу. Робота містить основні положення зміни методу ремонту, прорахунку можливості завантаження виробних позиції, розрахунок програми ремонту вагонів, визначення кількості шляхів прямування вагонів, аналізом недоліків, пов'язаних з гнучким асинхронним потоком, розробкою рішень, що виникають при перевірці гнучкого потоку при комп'ютерних моделюваннях. Підсумовуючи, цей матеріал надає можливість для розгляду та розроблення проекту на базі Стрийського Вагоноремонтного заводу на гнучкий потік або його модифікації для підвищення ремонтних потужностей. У статті проведено розрахунки по часу ремонту вагонів за потоковим методом та з використанням гнучкого асинхронного полі канального методу ремонту, з наведених графіків видно різниться час простою між однаковими типами вагонів та виду ремонту за умови, що вагони взято з однаковим станом перед початком ремонтних робіт. З цих розрахунків можна зробити висновок, що потоковий метод ремонту вичерпав весь свій ресурсний потенціал, та надалі буде приносити затрати на оплату працівникам, обслуговування устаткування та інші витрати, пов'язані з виробництвом.

Ключові слова: *гнучкий асинхронний потік, капітальний ремонт, деповський ремонт, метод ремонту вагонів.*