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THE IMPACT OF THE CHANGE TYPE OF WAGON ON THE EFFICIENCY OF THE SINGLE WAGON CONSIGNMENTS

Abstract. The transportation of shipments by rail is usually more expensive than other modes of transport. The costs are dependent on different factors, like the length of the train route, energy consumption based on traction, or the number of crew members in the train. The total price for using the railway infrastructure is also calculated, as is the total weight of the railway vehicle—the weight of the shipment and the weight of the wagon. The different types of wagons have different properties. For the operators, it is an ideal situation to have good values of the technical coefficient of tare. In the case of good values, the operator has effectively used their vehicle park. Railway transport should be affordable for customers. By operating non-efficient wagons, transport is more expensive and has low efficiency. By reducing the dead weight of the wagon, it is possible to reduce the cost rate. In synergy with this, more efficient and eco-friendly transportation can be achieved by reducing energy consumption. By reducing energy consumption, it is possible to get closer to the goal of the European Union, which is to reduce greenhouse gases from transport.
Keywords: single wagon consignment, cost efficiency, rail freight transport, type of wagon

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Introduction

Rail transport is considered the most ecological transport. The goal of the European Union is also to transfer part of freight transport from road transport to rail transport. However, railway freight transport has high competition with road transport. For this reason, it is necessary for rail freight transport to be attractive to customers. One of the decisive factors that influences the decision when choosing transport is the price. The cost of transporting goods can be reduced in several ways, for example by reducing certain operating costs. One option is to transport goods on other types of wagons. Total operating costs also depend on the type of wagon used but also on the efficiency of wagon use.

In the railway transport system, many types of wagons are used. However, the goods have their properties. It is not possible to transport the goods in all types of wagons with regard to the properties of the shipment. For this reason, it is necessary to use suitable types of wagons for transportation. Every wagon has properties like dimensions, loading volume, or loading weight. For every type of good or material, there are different wagon series. The goods or material have their own properties, like weight, dimensions, or volumetric bulk density. When selecting the best type or series of wagons, it is necessary to specify the goods in question. For one kind of good or material, it is usually possible to use many series of wagons that have similar properties and determination. In case study, there is focused on the transportation of wood from the Jesenicko region in the Czech Republic to other parts of the country or abroad. In Jesenicko, there are many forests where logging is in progress. Railway transport is used to transport the logged wood. The transportation is provided by handling and through freight trains via Ostrava marshalling station to the customers.

1. Methodology

With regard to economy, it is necessary to choose the best type of wagon. On the other side, it is possible to achieve high dead weights, which are directed towards higher financing for transportation. This dead weight will manifest in running costs and ultimately in the total price of transport. Along with that, energy consumption tends to increase. Because of higher energy consumption, there are higher greenhouse gas emissions. So it is good to choose the best type of wagon because it has an influence on the economy and ecology.

To make freight railway transport more sustainable and cheaper, it is needed to take some measures. By using measures, it is more competitive with other types of transport. Using more effective types of wagons will manifest itself in some types of cost items. Lower weight is manifested in case study in these cost items:

- energy cost,
- cost for using the infrastructure,
- locomotive costs.

Masharipov, M. et. al. (2024) points out that the energy consumption of locomotives is addicted to the weight of transported trains. Zakhirehkar Sahih, A. et. al. (2023) were focused on better allocation and optimalization of the wagon fleet size. They used the case study to transport the minerals, saving 10% of the needed wagons.

Loading coefficient of the tare

To determine the efficiency of using the freight wagons, we use the technical coefficient of tara. This coefficient determines the weight of the wagon relative to the weight of the shipment or material loaded into it. It is important to have the technical coefficient of tara at the lowest values. Low values of the coefficient consider the utilisation capacity of wagons efficiency. High values of the coefficient have wagons, which have special construction. It is needed to calculate the coefficient to determine the best type or series of wagons (Mašek, Čamaj, 2012).

Energy costs

The weight of the wagons and shipment is a significant factor in calculating the energy costs. Energy costs are a significant part of total running costs. As follows from formula 1, the calculation of the energy costs considers the total length of the train route, the total weight of wagons and locomotives, and the next cost items. Reducing the weight of wagons and using more efficient types of wagons contributes to reducing the total weight of the train. By moving the shipment to a more efficient type of wagon, it is possible to reduce the number of needed wagons to transport the volume of shipment. This results in a reduction in the total weight of the trains. (Dolinaynova, Nedeliakova, 2015):

$$Ne = \frac{\sum hrtkm^c * me * k_{tn} * S_e}{1000} \qquad (1)$$

where:
n_e - Energy costs [CZK],
$\Sigma hrtkm^c$ - total gross tonne kilometres [hrtkm],
m_e - specific energy consumption [l/1000 hrtkm],
k_{tn} - traction coefficient,
S_e - energy rate [CZK/l].

Cost of using the railway infrastructure

The price for using the railway infrastructure and methodology to calculate it are different per manager of the infrastructure and the individual states. The case study is focused on the transportation of single wagon consignments in the Czech Republic. In the Czech Republic, the price is mainly dependent on the number of the number of kilometres of train journey, the allocation of the capacity of the infrastructure, or the creation of the train schedule. In the methodology, one factor is dependent on gross tonne kilometres. In the case of reducing the gross weight of trains, it is possible to reduce the gross tonne kilometres, which leads to reducing the total cost of using the railway infrastructure (Network Statement on Nationwide and Regional Railways, 2022).

The locomotive costs reduce the total costs to very few. It is possible to save by using more efficiency types of wagons by reducing the total weight of the train. In cases of reduced weight, it can reduce the number of needed locomotives. However, in other cases, it can be possible to add more wagons. For this reason, it is possible to increase the efficiency of the transport process. In this case, the study does not affect total costs because the transportation had low performance values and was operated on sloped railways.

2. Case study

The Jesenicko region is rich in forests, and therefore also in forestry. Timber is one of the commodities most often transported from the region to its customers. There are also small-scale industries that focus on iron processing, among others (Association of Towns and Municipalities of Jesenicko, 2024).

The case study is focused on the operation of handling and through freight trains in the Jesenicko region of the Czech Republic. Regarding the abundance of types of shipment, the case study focused on the transportation of wood from the region to their customers. Calculating the costs was focused only on the part of the journey of these handling and through freight trains from Ostrava´s marshalling station to the Jesenicko region in the northern part of the Czech Republic. The wood is the most transported commodity from the Jesenicko (documents of ČD Cargo, 2022).

In the case study, the wood is transported mainly in high-wall wagons. Used wagons are mainly of the universal type rather than special wagons. The most common are used wagons by type Eas and their similar series. These wagons are designated to transport lump goods. With regard to the construction of this type of wagon, the Eas are high-wall wagons, and thus they have a large dead weight. This universal wagon is suitable to use in case this type of wagon is needed for other transportation in the region. In order to efficiently use a wagon to transport the shipment to and from the region, using this type of wagon is practical. In cases of uneven transport, using this type of wagon is not efficient. The unevenness transport means the transportation contains a loaded direction and an empty direction. That considered, the wagons are loaded only for one journey. There is no effectiveness in using wagons because, on the reverse journey, the wagon is empty. Typically, operators do not profit from such transportation (Morihladko, 2023, Dolinayová et. al., 2016).

The wagons, which are the best for the transportation of wood based on calculations of the coefficient of tara, are platform wagons. Platform wagons have not wall than high-wall wagons. For this reason, their weight is lower. The construction of this type of wagon is better because these wagons have more length, so the volume of this wagon is higher. It means this type of wagon is more effective than high-wall wagons because they have a lower weight and, simultaneously, it is possible to load more volume of wood than to other types of wagons. However, not every series of platform wagons is determined and effective to transport the wood. For example, the series of Roos has a very large coefficient of tara. Even though this platform wagon is useful, the use is not so effective due to

their high dead weight. The disadvantage of the platform wagon is their specific use. It is usually not possible to use the Snps wagon for other transportation in regard to the diversity of commodities transported. This disadvantages this type of wagon (Morihladko, 2023, documents of ČD Cargo, 2022).

Operational evaluation of used and proposed wagons

Often used high-wall wagons are designed for the transport of loose materials as well as piece goods. These wagons do not have weather protection. In the case study, wood and scrap are the most frequently transported in such wagons. For a given line class, approximately 57 tonnes can be loaded per wagon. The wagons are shorter in length and therefore have a low volume. A schematic representation of the wagon is shown in figure 1 (ZSSK Cargo, 2018, documents of ČD Cargo, 2022).

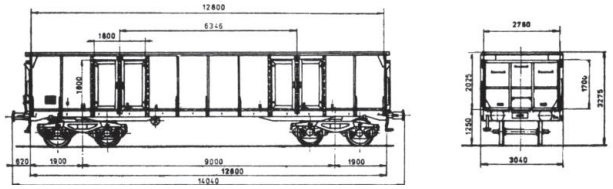


Fig. 1. Diagram of the Eas freight wagon (ZSSK Cargo, 2018)

Each wagon has its own specific characteristics, such as length, height, or even volume. Similarly with the goods transported in the wagons. The following table shows the number of wagons required for the transport of wood over a period of one year.

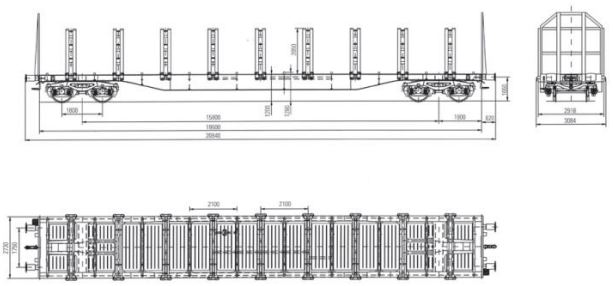


Fig. 2. Diagram of the Snps freight wagon (ZSSK Cargo, 2018)

Platform wagons are designed for the transport of bulky goods, wood, and vehicles. The possible commodities transported vary depending on the wagon series. Some flat wagons have ramps for transporting timber. The wagons are not covered and, therefore, not protected from the weather. The Snps series wagons, which came out as the most favourable in the tare factor, have a load weight of 57,5 tonnes. The wagon volume is much higher compared to the high-wall wagons because the wagons have a longer length. Because of this, it is possible to load more bulky goods in the wagon than in the high-wall wagons 1 (ZSSK Cargo, 2018, documents of ČD Cargo, 2022).

Table 1. Comparison of the number of wagons needed

Type of wagon	Number of needed wagons
Eas-u	239
Ealos	237
Roos	226
Snps	208

Source: Morihladko, 2023

As can be seen from table 1, the Eas wagon range currently in use is the least favourable with respect to its parameters. This is due to the fact that this wagon has a smaller loading volume than the other wagons. The other wagons have a significantly higher loading capacity. From this comparison, the Snps series, which has a high loading capacity, came out the best. These are platform wagons that are also designed for wood transport. However, other factors were also included in the calculations, such as the loading weight of the wagon depending on the class of line in use on the line in question (Morihladko, 2023).

Results

The commodity of wood can be loaded into platform, low-wall, and high-wall wagons. However, with regards to the volumetric bulk density of wood, it is not effective for transportation in all types of wagons. The wood has a lower volumetric bulk density than other types of transported materials. For calculation, the volumetric bulk density of wood was 700 kg/m3. In order to compare different types of wagons, it was necessary to calculate how much wood could be loaded into the wagons based on their parameters. In comparison, we considered five types of commonly used wagons. Based on calculations, the most advantageous types of wagons were Snps, with the best technical coefficient of tara. On the opposite side, the worst value is the Roos type of wagon, which is from the monitored types of wagons and is at least effective.

It is necessary to take into account the economies of both cases - using the common universal wagons or using the special wagons with many empty routes. This case study compares the transportation of wood from the Jesenicko region. In comparison, the same volume of wood was transported in one year. In calculating, nowadays transportation is included in universal high-wall wagons and transportation of the same volume of wood in platform wagons. Table 2 shows the results of calculating the selected running costs.

Table 2. Comparing the total running costs

	Nowadays used wagons	Proposal used wagons	Difference
Total costs	100%	98%	-2%

Source: Morihladko, 2023

Table 2 shows a comparison of nowadays used wagons and a proposed use of wagons on the handling and freight trains from Ostrava to Jesenicko. It is possible to

save 2% of total running costs if the operator uses proposal wagons to service this region. This result is not final because it is focused only on one commodity, and that is wood. The area's economy is not only based on wood but also on other commodities. Regarding the scope of this problem, only the transportation of wood was chosen for this case study due to its abundance. More running costs can be saved by focusing on increasing efficiency in this issue, targeting all types of goods transported.

Conclusion

In the case study, we focused on the transportation of wood by handling and through freight trains from the Jesenicko region to Ostrava due to the variety of customers and the complexity of such a study. As stated in the case study, timber is one of the most transported commodities in the region. By the proposed change of the wagons used, it is possible to save on the operating costs of these service trains. In total, 2% of the costs can be saved. However, the figure may be different due to the fact that, in some cases, wood may be transported in currently operating wagons. This is due to the efficiency of the use of the operator's vehicle park. In the event of a shipment being overloaded in high-wall wagons towards the region, these wagons can be used on the return journey for the transport of the wood in question. This change is most worthwhile if the Eas type of wagons currently in use do not have even traffic and are therefore not used efficiently on these service trains. Universal wagons are therefore at an advantage opposite these wagons due to possible more efficient use in this region. Considering the available data and the nature of the service trains, it is possible to replace part of Eas series wagons with Snps series wagons due to the numerous unevenness's in the transport.

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