Operational Research of Wear of Railway Buffers Heads Covered with Aluminum Bronze

Wojciech Gamon
The Univeristy of Dąbrowa Górnicza, Poland

In recent years in Europe and in Poland a discernible trend of significant increase safety in rail transport can be observed. Safety improvement is realized at many levels and in many aspects (organizational, systematic, technical etc.). Implementation of Safety and Maintenance Management Systems are an example of activities seeking to systematically increase safety in rail in Europe. Similarly, on the part of technical solutions, there are discernible activities which are aimed at improving the safety level. There offer new construction solutions, new control systems or new communication technologies which are designed to increase reliability and safety of this mode of transport. For innovations introduced in vehicles, almost only improving safety in the field of implementing enhancements in construction of running gear systems of vehicle used to be thought about. However, it is worth remembering that not only the bogie, wheel set or wheels are responsible for the proper cooperation of the vehicle with the track and its safe running. Elements that have not been yet subjected to deeper analyzes are railway buffers whose proper maintenance and cooperation is a guarantee of correct vehicle dynamics, especially when passing through rail curves. This article presents the results of operational research of railway buffers whose heads were covered with an aluminium bronze layer. This solution has helped to increase the durability of their co-operating surfaces, and has allowed the resignation of the now-proposed solution, which consists in periodically covering buffers heads with the grease which has a lot of defects.

Keywords: railway buffer, buffer head, aluminium bronze, wear, friction.

1. INTRODUCTION

Proper running of a railway vehicle on the track is one of the main conditions for its correct and safe operation. Therefore, over the years extensive research has been carried out on the dynamics of rail vehicles [3], [6], the cooperation of the wheel with the rail and their proper profile [1], [11], [13], and all issues related to vehicle running gear systems and their cooperation with track. These issues, as extremely important from the point of view of exploitation and safety, have been the subject of studies which have resulted in the proposition of indicators and quantities describing in a mathematical way the proper cooperation of the vehicle with the track. Examples of such indicators include: Nadal formula and Weinstock criteria, which easily assess the safety of leading on the track, based on the ratio of vertical forces to lateral forces. The other components of the rail vehicles were not subjected to such rigorous testing and analysis. Although in the literature studies on the proper cooperation of the pantograph with the catenary[2], [10], [15] can be found , they are not even similar in scope to test the wheel-rail contact. In addition, in most cases they relate to the proper cooperation between these two elements in terms of their maximum efficient operation, and not with regard to ensuring a smooth and safe running of vehicles. Other elements of railway vehicles which have not been subjected to detailed research so far in terms of the impact on the safety of leading on the track are railway buffers. In the case of vehicles (especially cars) equipped with a classic screw coupling, they are elements that remain in contact with each other while the train is on the move. By remaining in contact, buffer heads convey the vertical, lateral and longitudinal forces acting on the rolling stock during the operation. Their cooperation is particularly important when passing rail curves and turnouts, because their proper contact allows for smooth, safe running, and the proper insertion of the vehicle into the rail bend. For this purpose, the buffer heads are designed with a convexity with a normative[4], [7]–[9]radius, so that their mutual co-operation is deliberate and secure. Due to the contact of buffer heads and the significant forces acting on them, they are subjected to persistent abrasion, reducing their convexity. Flattening of a buffer head is a phenomenon very unfavourable from the point of view of safety because these buffer heads are not able to guarantee beneficial cooperation of the two adjacent vehicles. In extreme cases, during passing the rail curves with very small radius, there is even the possibility of jamming a buffer head which means one buffer head is inserted behind another one, which can even lead to derailment. Therefore, measures are taken to minimize abrasive wear of buffer heads. For this purpose they are periodically covered with graphite grease. This solution however, is burdened with a very large number of defects, including those related to safety. This method requires the application of lubricant by an employee, which is an activity characterized by a high risk of accident. In addition, this grease has an adverse effect on the environment and its application must be repeated periodically, with high frequency. Accordingly, a new method of protecting the buffer heads against abrasive wear has been proposed based on the previous research conducted by the author[5], [14] which would remove the defects of the current method. The conducted metallographic research and research of abrasive wear have allowed the choice of aluminium bronze as a material whose layer was laser cladded on the working surface of a buffer head, which will provide the desired tribological properties.

2. THE METHODOLOGY OF PERFORMED OPERATIONAL RESEARCH OF RAILWAY BUFFER HEADS WEAR

Before starting the operational research, it was necessary to choose a vehicle on which buffers with heads covered with a layer of aluminium bronze will be mounted (Fig. 1.).

The decision on the selection of a suitable vehicle was dictated by the conditions of its operation. It was desirable that the buffers with the testing heads operated under the worst possible conditions in terms of wear of their working surfaces.

Fig. 1. Buffer heads covered with a layer of aluminium bronze.

Therefore, it was decided to mount buffers on the headstock of the vehicle operating in sand and coal mine. This environment is conducive to the accelerated wear of the buffers heads working surfaces due to the presence of sand particles, gravel, stones etc., which can cause scratches and increased wear. In addition, the frequent loading and unloading cycles of the transported materials also increase the risk of getting it into the working surfaces of buffers heads. The vehicle on which the buffers with testing heads are mounted is a 418V freight car. It is a dump car used to transport loose materials such as sand or coal, very common on railway lines in Poland. Two buffers with heads covered with a layer of aluminium bronze were mounted on one of the headstocks of the selected wagons. Buffers on the second headstock were not subjected to any treatment, and measurement of flattening their heads was to be the reference value in relation to the ones covered with bronze. The selected wagon was subjected to repair inspection before research which allows to ensure that the buffers with which it was equipped had a negligible wear. It has been assumed that the measurements of buffer heads flattening should be conducted for at least one year so that buffer heads with aluminium bronze can be exposed to any atmospheric effects (negative temperatures, rainfall, snow etc.). Flattening measurements were made using the gauge used in the maintenance processes (Fig. 2) and the depth gauge at approximately monthly intervals.

Fig. 2. Gauge to measure the flattening of buffer head.

The measurement consisted in the disassembly of the train, cleaning the work surface of the railway buffers using extraction gasoline, and the measuring with a gauge and a depth gauge. Measurements of flattening were made on two buffer heads covered with layers of aluminium bronze and the buffer heads located at the second headstock of the tested wagon, non-covered by any layer except graphite lubricant. During the operation on the wagon, buffers heads covered with a layer of bronze were not subjected to the process of lubrication.

3. THE RESULTS OF THE OPERATIONAL RESEARCH ON THE WEAR OF RAILWAY BUFFER HEADS

The measurement of the buffer head wear was done by measuring the difference between the nominal curvature of the buffer head and the actual curvature. Consequently, the measured values representing the wear (flattening) in millimetres are bigger when buffer heads have become more worn out, and therefore its curvature has shown a greater difference from the normative value. Tab. 1 shows the results of 12 measurements of all four buffers made in one year.

Table 1. Result of measurements of wearing the buffers heads.

Measurement number	Measurement of wear/flattening of buffers heads [mm]			
	Buffers with heads covered with aluminium bronze		Buffers with lubricated heads	
	Buffer 1	Buffer 2	Buffer 3	Buffer 4
1	10.0	9.5	11.5	12.4
2	9.8	9.5	11.8	12.9
3	10.0	9.6	12.0	13.1
4	9.8	9.6	11.9	12.9
5	10.0	9.6	11.5	13.0
6	9.8	9.6	11.8	12.9
7	9.7	9.5	11.8	13.0
8	9.9	9.6	12.0	13.1
9	10.1	9.9	12.1	13.1
10	10.2	9.9	12.5	13.2
11	10.4	9.8	12.4	13.5
12	10.3	9.9	12.6	13.5

In general 12 measurements were taken at intervals of about one month. The first of the measurements was made on 14.07.2015. the last one was 18.07.2016. The measurement results shown in Tab. 1 are also shown in Fig. 3.

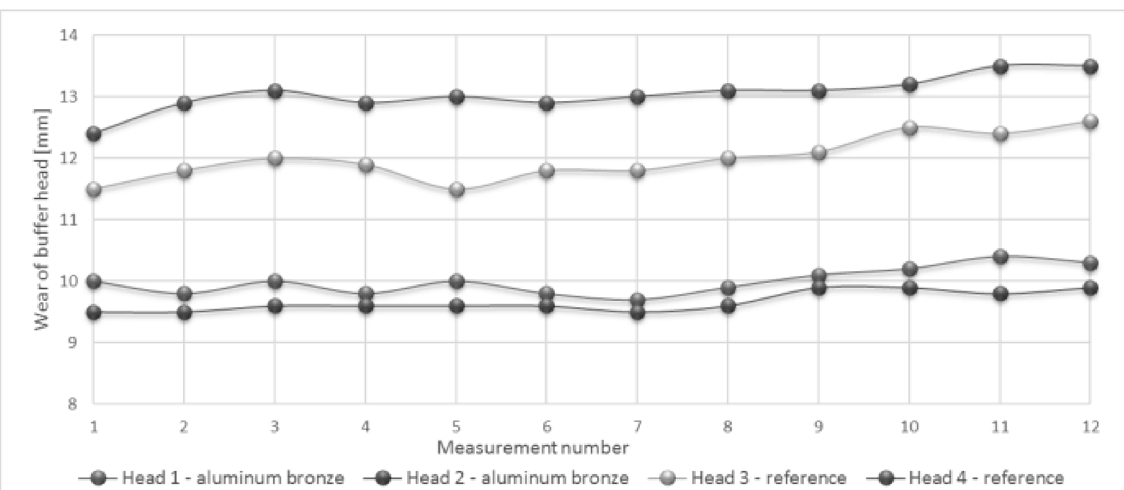

Fig. 3. The results of buffers heads wearing test.

It is apparent from the data presented in Tab. 1 and in Fig. 3. that changes in wear (buffer head flattening) over time are not significant. Even temporary decreases in flattening over time can be seen. This fact is of course due to measurement uncertainty, resulting primarily from the measurement conditions and pollution measurement object (buffer head). Despite this, a certain tendency can be observed regarding the wearing growth over time. Fig 4. shows the regression line determined for each buffer, confirming the above theory.

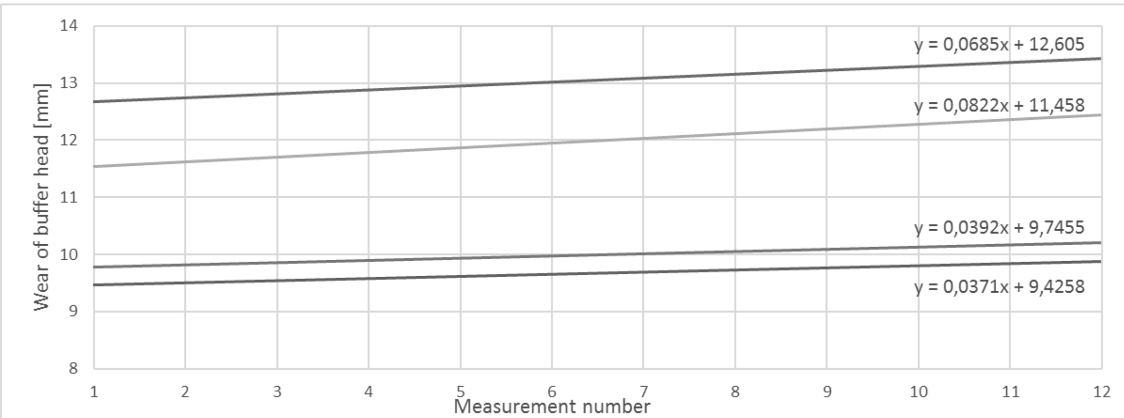

Fig. 4. Regression lines of wearing of the buffer heads.

The measurement results are presented in Tab. 1 and Fig. 3 and Fig. 4 lead to the conclusion that the wear of the railway buffer heads covered with a layer of bronze and covering with a graphite grease are not significantly different from each other. Moreover, based on the regression lines equations determined for each buffer it can be seen that the increase in wear (flattening) over time is smaller for buffer heads covered with aluminium bronze - lower values of "a" coefficients of 0.0392 and 0.0371 respectively for heads coated with bronze and 0.0822 and 0.0685 for lubricated ones. Small changes of wear (flattening) over time and the small difference between the buffers with lubricated heads and with heads covered with a layer of bronze suggest that they are characterized by at least as favourable operating properties in resistance to abrasive wear. It should also be emphasized that during the operational research no cracks or delaminations of the bronze layer were observed on any of the buffers heads.

4. SUMMARY AND CONCLUSIONS

Safety in rail transport is the primary requirement and the most important element of this mode of transport. Due to the very large weight and increasing speed of a moving train, the effects of the rail accident can be devastating. It is therefore extremely important to guarantee safety in rail transport both in the organizational and legal spheres, but also in the technical field [12]. Any measures to enhance the safety associated with the dynamics of the vehicle on the running gear and the wheel-rail system are most needed and beneficial. Other systems of rail vehicles should not, however, be forgotten, as they ensure proper, smooth and safe operation. Therefore, measures to increase the reliability and durability of elements such as railways buffers can significantly contribute to improving the overall level of railway safety. Replacing the methods, techniques and consumables used today by new, devoid of many predecessors' faults, are desirable and ordered. One such action may be replacing the current method of protecting the buffer heads against abrasive wear by a new method, based on the use of aluminium bronzes. The following conclusions can be drawn on the basis of the conducted operational research of wearing of the railway buffer heads:

- The present method of using graphite grease is characterized by a large number of defects, including those related to safety.
- Applying an aluminium bronze layer as a more sustainable method of protecting the buffer head against abrasive wear is beneficial from an operational point of view.
- The results of operational research of wearing of railway buffers heads indicate that the buffer heads secured with layer of aluminium bronze have very similar tribological properties. The new method is devoid of the numerous drawbacks of the method used currently.

– As a part of further research it is necessary to carry out a comprehensive technical and economic analysis in order to unequivocally determine the appropriateness of using the new method in terms of economic viability.

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Wojciech Gamon
The Univeristy of Dąbrowa Górnicza, Poland
wgamon@wsb.edu.pl