Experiments on composites meant for making brake pads for the rolling stock

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Abstract. For noise rail decrease and observance of the limits in UE rolling stock must be equipped with silent brake blocks of composite material to replace the conventional cast-iron blocks. For testing composite materials test pieces have been produced according to the characteristics of the experimental installation. The paper presents the laboratory experimentation phase on obtaining composite materials for brake blocks and wear behavior of the experimental test pieces.

1. Introduction

The railway is considered to be an ecological means of transport, but its contribution to noise pollution is significant. This is a threat to human health and its reduction is needed both for comfort reasons and in order to dim out its impact upon human health. Experts have identified the noise of freight carriages as being the most important source of railway noise [1], [2].

In some European regions there is significant opposition to rail noise from public opinion, demanding political initiatives on its decrease. If no remedial actions are taken, this might lead to restrictions on rail traffic along the most important European rail corridors, especially on freight trains, and the resulted activity gaps could have adverse effects on European economies. European legislation [2], [3] imposes limits for both new rolling stock as well as the reconditioned and put into circulation in the European area. In this way, equipping the rolling stock with noise brake blocks is required, which will significantly reduce noise emissions.

Brake blocks from composite materials are used to replace the conventional cast-iron blocks, which are considered an important source of noise. Experts [4], [5] recommend to give priority to measures at source (vehicles and tracks) because they offer a better “cost / benefit” rate. Acoustic barriers could incontestable be, an efficient element part of noise reduction programmes, where necessary for example in dense urban areas. If barriers are coupled with measures at source, the length or height of barriers can be reduced, leading to significant cost savings.

In order to solve the problems at source and achieve interoperability along railway lines, in December 2005 the Commission adopted technical specifications for interoperability relating to rail noise (STI "noise") [3], [5] introducing limits for rolling stock used in European Union. These limits apply to new and renewed rolling stock including for freight wagons, which must be equipped with noise brake blocks (of composite material), which reduce noise emission.
At present brakes are equipped with two types of K-blocks and LL type [6], [7]. The composite material K is recommended for new vehicles or wagons in circulation when it has the funds necessary to change the brake system. Also is noticed an series of advantages in case of using composite materials LL type, due to low expenses with the adjustment to brake blocks assembly, lower the weight of the shoe, the coefficient of friction similar to that of cast iron blocks.

Evaluating the quality of blocks in operation is made based of the criteria [8-11]: road the braking stability, wear the smallest specific capacity as high thermal load, susceptibility to breakage as small as and low tendency to formation of sparks.

From the analysis of the characteristics of the thermo-physical characteristics of the materials from which are manufactured the brake shoes (cast iron or composite materials) is observed behavior superior to composite materials characterized by obtaining lighter products, which work quite well at temperatures sometimes high during the braking process.

In the case of using the composite material the brake shoes is noted that [7], [8], [11]:
- Small adjustment expenses in order to mount brake blocks (for LL-blocks);
- Lower weight of the shoe;
- Coefficient of friction similar to that of the conventional;
- Values similar to wheel wear;
- Noise reduction by approx. 50%;
- Decrease costs by approx. 30% the braking system maintenance;
- Higher wear resistance of approx. 5 times;
- Does not give off toxic dusts braking.

2. The Experimental Part
Objectives of the experimental part (laboratory experiments): manufacturing the composite materials for rolling stock brake pads, characterization of the samples obtained and interpretation of the results.

For the preliminary tests of the composite materials the following have been established:
- The composition of the experimental recipes;
- The technology of sample manufacturing;
- The assessment of the tribological behavior of the samples;
- The analysis of the results.

For the laboratory the following test rods have been established 10 test rods made of composite material. For the composite material, 10 experimental test rods were made, using the following components: 20-38% novolac, 6-10% hexamethylenetetramine, 0-5% sulphur, 10-12% carbon fiber, 0-10% graphite, 0-28% aluminum, 0-28% brass and 0-30% rubber.

Composition of recipes is shown in Table 1.

| Component recipes | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
|-------------------|----|----|----|----|----|----|----|----|----|----|
| Novolac           | 22 | 20 | 22 | 24 | 38 | 28 | 30 | 20 | 25 | 36 |
| Hexamethylenetetramine | 6 | 6 | 6 | 6 | 10 | 8 | 6 | 6 | 8 | 10 |
| Sulphur           | 4 | 4 | 5 | 5 | 0 | 0 | 0 | 5 | 0 | 0 |
| Carbon fibre      | 10 | 10 | 10 | 10 | 12 | 10 | 10 | 10 | 10 | 12 |
| Graphite          | 0 | 11 | 0 | 0 | 8 | 10 | 0 | 0 | 10 | 10 |
| Aluminum powder   | 16 | 0 | 0 | 0 | 20 | 0 | 15 | 23 | 12 |
| Aluminum chips    | 0 | 13 | 15 | 15 | 12 | 0 | 14 | 0 | 0 | 0 |
| Brass powder      | 20 | 0 | 0 | 0 | 20 | 24 | 14 | 14 | 24 | 20 |
| Brass chips       | 0 | 6 | 22 | 28 | 0 | 0 | 0 | 10 | 0 | 0 |
| Rubber            | 22 | 30 | 20 | 12 | 0 | 0 | 26 | 20 | 0 | 0 |
The (cylinder-type) test rods have a diameter of ø14 mm and a height of about 30 mm. The composite sample is presented in Figure 1.

![Composite sample](image1)

**Figure 1.** Composite sample

The resulting test rods were submitted to a wear test on an installation of testing abrasive wear with abrasive disc (Figure 2).

![Installation of testing abrasive wear with abrasive disc](image2)

**Figure 2.** Installation of testing abrasive wear with abrasive disc

The trials were performed according to STAS 9639 – 81 [12], [13]. HE 16 polishing silicon carbide paper was used as abrasive, which is supplied as ø310 mm diameter discs. The length of the wear spiral trajectory results from the combination of the two movements (rotation and advance) and has the value of 70 m during 7.08 minutes [14], [15]. The assessment of the behavior of the test rods has been done by the gravimetric method (mass loss).

3. **Results and Discussions**

The variation of the mass wear of the experimental samples is given in Figure 3.

As a result, the mass wear was determined at various time intervals. The variation of the test rod mass with time for the sample under analysis is given in Figure 4. Processing the resulting data in Excel leads to the correlations for the parameters in question, correlations that are expressed both graphically and analytically and shown in Figure 5-9.
Figure 3. Wear mass experimental samples

Figure 4. Sample mass variation function of time
Figure 5. The variation in time of the mass wear for sample 7

Figure 6. The variation in time of the relative mass wear for sample 7
Figure 7. The variation in time of the height for sample 7

Figure 8. Absolute reduction of height for sample 7
The analysis of the data shows that the lowest mass wear of the composite material is that of samples rod 1, 5 and 10. Experimental samples rod 7 and 8 showed the highest wear.

4. Conclusions

Through the research and experiments in laboratory phase was aimed at obtaining of composite materials for the manufacture of brake shoes with characteristics superior to those already in operation.

The analysis of the experiments and their results leads to the following conclusions:

- The test rod with the highest resistance to abrasive wear is 1, 5 and 10;
- The resistance to abrasive wear is satisfactory in case of test rods 2, 3, 4, 8 and 9, due to the fact that the manufacturing technology is the same and the structure of the components varies within narrow limits.

In comparison with iron phosphorous (conventional material for brake shoes) test pieces experimental of composite admit a larger wear mass but have a similar behavior to composite
materials used in practice. You also need to take into account the behavior of friction and high temperature considering operational use of brake blocks. Considering the results, the best behavior to wear of the experimental composite materials, was the one of test rods produced according to recipe 5. Experiments will continue in order to finalize the recipe and the manufacturing technology, in order to obtain the best values for the indices under consideration.

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