CONTACT AREA INCREASE OF THE WORKING ELEMENTS
OF THE BLOCK BRAKE BY MEANS OF DESIGN METHODS

Oksana Sergiyenko

Volodymyr Dahl East-Ukrainian National University, Lugansk, Ukraine

Summary. There offered the design of the block brake which is characterized by sectionalization of the working material that ensures the increase of the heat removal total area and the level decrease of mechanical and thermal deformations. The consequence of it is the temperature decrease of the contact area of the block and rail and coefficient increase of block brake elements.

Key words: rolling stock, block brake, contact area.

INTRODUCTION

Nowadays the mechanical brake systems are widely used in the rolling stock and are the irreplaceable means of the rolling stock braking [2, 14].

However, the use experience of frictional brake systems showed their imperfection from the point of view of heat capacity [1, 6, 13] and it creates definite problems in the result of overheating of the friction elements and it brings to the decrease of the friction coefficient and the increase of the wear intensity. Thus, the heat removal improvement and the temperature decrease of the block brake friction zone is an actual technological problem.

OBJECTS AND PROBLEMS

According to molecular and mechanical ideas of friction of the solids [4, 5, 12] external friction forces are determined as the sum of resistances relatively to the displacement of the solids stipulated by atom-molecular interaction and deformation of the surface layers by inculation microunevennesses. Hence, the simple way of the friction force rise of the elements is the contact area increase of the interacting elements [8].
The increase of the contact area of the block and a wheel of the rolling stock allows to obtain additional advantages which are understandable from the point of view of logic. It means the prolongation of service life of cast-iron blocks.

Practically, the increase of the contact area of a block and a wheel due to the size increase of the block is problematic because the blocks are heated and deformed while braking. As a result, the shape and a block outline are distorted and it is unevenly snug against the wheel. Besides, while increasing the block length, the block rigidity is decreased stipulated by the size "d" and it also has an influence on the homogeneity of the block pressing to the wheel. As a result, the effect from the increase of the contact area (the length of the block) does not bring the expectable result (fig. 1).

It is experimentally ascertained that the size of the blocks, particularly their length (the width of the block is determined by the thickness of the tyre), where thermal deformations are not told, is not to exceed 230 - 330 mm [11].

Fig. 1 offers the illustration of a new design of the brake block which gives the possibility to increase the summable area of all the blocks. A main idea of the offered principle consists in the sectionalization of the block working surface that has an influence on the level decrease and nature of thermal and mechanical deformations and it ensures both the contact area increase and it is snug against the wheel in comparison with the prototype. In this case the bearing density of the block to the wheel is determined only by the rigidity of the block arm stipulated by the size “d” which can be raised by design methods.

Fig. 1. A new principle of the brake block design which ensures the increase of the contact area with a wheel
1 – a rolling stock wheel; 2 – shoe; 3 – brake block; 4 – elastic elements
Ordinary calculations show that under the conditions of conservation of the rigidity level and absence of mechanical and thermal deformations it is possible to increase summary length of the brake blocks up to 550 mm (in comparison with 380 mm of the series block).

Such a length increase of the brake blocks promotes to the increase of the total contact area by 40%. In this case the friction force is increased and wear intensity is decreased.

This is confirmed by the calculations of the friction force and wear intensity which are made on the basis of the friction theory formula [3, 5, 10, 12]. The calculations are made for rigid non-saturated contact of a wheel and a block [8]:

\[
F = A_e b v (v - 1) e^v \left[ \pi R_{\text{max}} \tau_0 + \frac{0.4 \pi f h R_{\text{max}}^{1/2} E_{\text{e}}^{1/2} R_{\text{max}}^{3/2}}{1 - \mu^2 \sqrt{v} (v - 1) (1 - \mu^2)} \right] \; (1)
\]

\[
f = \frac{2.4 \tau_0 (1 - \mu^2)^{4/5}}{p_c^{1/5} \Delta^{2/5} E^{4/5}} + \beta + 0.24 \alpha_{\text{e}} \phi P_c^{1/5} \Delta^{2/5} \left( \frac{1 - \mu^2}{E} \right)^{1/5} \; (2)
\]

Formulas (1) and (2) set the interconnection between the friction force \( F \), friction coefficient \( f \) and parameters which characterize the properties and conditions of the brake block and wheel of the block brake.

Correspondingly, the wear intensity of the block was calculated in accordance with the formula:

\[
I_h = \frac{0.34 (k')^4 (1 - \mu^2) p_c}{\sigma_B E} \left[ \tau_0 + 0.5 \beta P_c^{1/5} E^{4/5} \Delta^{2/5} \right]^{3/4} \; (3)
\]

The formula includes:
- \( p_a \) – nominal pressure;
- \( \tau_0 \) – molecular shear strength;
- \( R_{\text{max}} \) – maximum height of microroughness;
- \( R \) – curve radius of microroughness peak;
- \( v, b \) – parameters of degree approximation of initial part of support curve;
- \( k_1 \) – integration constant depending on \( v \);
- \( A_c \) – contact contour area;
- \( \beta \) – piezocoefficient of molecular bond;
- \( p_c \) – contour pressure;
- \( \mu \) – Poisson coefficient;
- \( E \) – modulus of elasticity;
- \( \Delta \) – complex criteria of roughness;
- \( \alpha_{\text{eff}} \) – the coefficient of hysteresis losses.
- \( \varepsilon \) - relative rapprochement of contacting surfaces;
- \( \sigma_B \) - stretching tension, resulting in destruction at single influence;
- \( t = 3 \div 14 \) - index of the crooked fatigue;
- \( k' \) - coefficient \( k' = 5 \) - for fragile materials.
Relative rapprochement $\varepsilon$ of surfaces is determined as absolute rapprochement of surfaces $h$ in the ratio of the maximal height of microroughness:

$$\varepsilon = \frac{h}{R_{\text{max}}}.$$ (4)

The calculations show that the friction force under the conditions of sectionalization of the working surface of the friction block is increased by 2.2% while simultaneous decrease of wear intensity by 3.7%.

The brake block design (fig. 2) was developed on the basis of the offered principle and it is defended by the patent of Ukraine [9].

![Fig. 2 A new brake block design](image)

1 – shoe; 2 – brake block

The characteristic feature of a new brake block consists in sectionalization of its working surface. Working sections 2 are installed on the shoe 1. A new brake block is interchangeable with a serial sample.

The application of several sections of brake elements on one shoe allows to obtain one more operation advantage. It is connected with the increase of total external area of brake elements and it gives the possibility to improve heat removal from the body of the brake block into environment.

CONCLUSIONS

1. One of the ways of improvement of the block brake characteristics is the increase of the contact area of the block and the wheel and it is problematic because of the blocks irregularity of heating and deformation while braking. As a result of it, the shape and outline of the block are distorted and it has an influence on the contact area of the block and rail.
2. Sectionalization of the working surface of the brake block allows to increase its contact area with a rail. In this case it is possible to increase friction force by 2.2% while simultaneous decreasing wear intensity by 3.7%. Critical value has not been obtained when thermal deformations begin to be told.

3. There offered a new design of the brake block of the block brake of the railway vehicle which is characterized by sectionalization of the working surface. The design of the brake block is defended by the patent of Ukraine as a helpful model.

REFERENCE


ПОВЫШЕНИЕ ПЛОЩАДИ КОНТАКТА РАБОЧИХ ЭЛЕМЕНТОВ КОЛОДОЧНОГО ТОРМОЗА КОНСТРУКТОРСКИМИ МЕТОДАМИ

Оксана Сергиенко

Аннотация. Предложена новая конструкция тормозной колодки, которая характеризуется секционированием рабочего материала, что обеспечивает увеличение общей площади теплоотвода и снижение уровня механических и термических деформаций. Следствием этого является снижение температуры области контакта колодки с рельсом и повышение коэффициента трения элементов колодочного тормоза.

Ключевые слова: подвижной состав, колодочный тормоз, площадь контакта.