EVEN WEAR PROVIDING OF DISC BRAKE FRICTION LINING

Aldis Paeglis, Jānis Feldmanis
Latvia University of Agriculture, Faculty of Engineering, Institute of Mechanics
jaanis.feldmanis@inbox.lv

Abstract. The article analyzes practical research of even wear of disc brake friction linings. The research was carried out to test the theoretical research regarding providing of even wear changing the pressing force application coordinates. Two kinds of the friction body (friction lining on steel base) construction were tested in experimental work. The friction body and brake lever are linked with a pin. The direction of this pin is perpendicular regarding the vector of slipping velocity in the first kind of the construction and parallel – in the second case. The research is significant to the joint-stock company "Jelgava engineering plant" (A/S "Jelgavas masinbuves rupnica") – they produce brakes with such construction. The experimental work was carried out in the brake testing laboratory of this company. The author proved that it is possible to provide even wear of friction lining if the design of the friction body is made so that the resultant force is applied with a definite eccentricity regarding the mass center of the friction lining. The eccentricity depends on the friction body design and friction material properties.

Key words: disc brake, friction pair, wear, friction lining, pressing force.

Introduction

The brakes absorb the kinetic energy of moving mases by help of friction forces. The dynamic of braking process depends on friction pair materials, loading and temperature, as well as impact of an environment [1, 2, 3, 4, 5].

The aim of this experimental research is to test the coherences of the theoretical research [6] regarding providing of even wear changing the pressing force application coordinates.

The problem of uneven wear was awared studying the technical literature and during inspection of worn out friction lining samples in exploitation and experimental work.

The wear depends on friction pair material, specific surface pressure (loading), friction coefficient, sliping velocity and the temperature [7]. During braking process friction pair grow hot and wear out. The pressing force press friction lining to the rotational disc, it generate friction force F_b (Fig. 1) between the friction lining and the disc. The friction force causes the slant of friction lining and the distribution of specific surface pressure stay uneven, as a result the distribution of wear intensity and wear become uneven. There are recomendations to apply pressing force to friction lining eccentrically regarding coordinates of friction lining mass centre to provide desireble distribution of specific surface pressure and even wear of friction surface. It increase the life time of friction lining. Such idea is a novelty in the brake theory.

The friction body and brake lever are linked with a pin. The theoretical research revealed [6] – if the direction of the pin is perpendicular regarding the vector of slipping velocity v (Fig. 1, a), the resultant pressing force R will be applied to the mass center of friction lining, if the pin will design with eccentricity e_x (Fig. 1, b):

$$e_x = f \cdot h, \quad (1)$$

where f – coefficient of friction;
h – distance between a pin and friction surface, mm.

If the direction of the pin is parallel regarding the vector of slipping velocity v (Fig. 2), the resultant pressing force R is applied throw a pin and desirable coordinate e_y of a pin:

$$e_y = \frac{\left(\frac{R_a}{R_i} - 1\right)}{\left(\frac{R_a}{R_i} + 1\right)} \frac{W_x}{A}, \quad (2)$$

where R_a – outward radius of friction lining, mm;

R_i – inner radius of friction lining, mm;
A – area of friction surface, mm^2;
W_x – resistance moment of lining surface area, mm^3.

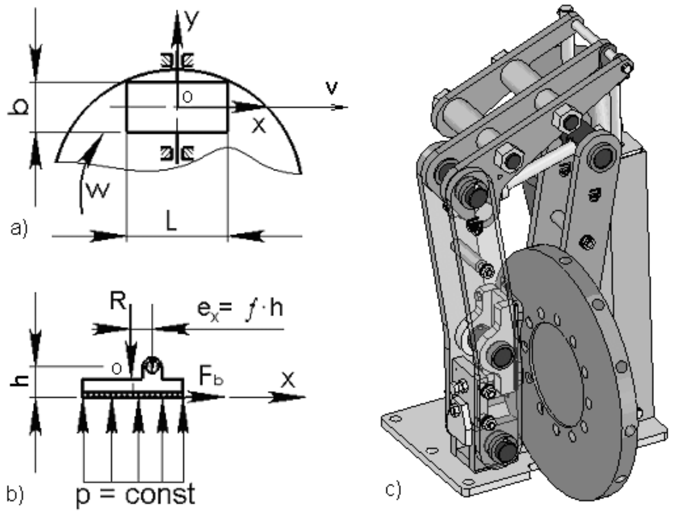

Fig. 1. **Scheme of brake shoe and disc brake design:**
a – the brake shoe attached with a pin perpendiculary the vector of slipping velocity *v*; b – the resultant pressing force *R* will be applied to the mass center of friction lining, if the pin will design with an eccentricity e_x; c – disc brake DBE-1 (the front lever is demonstrate transparent in cad-model)

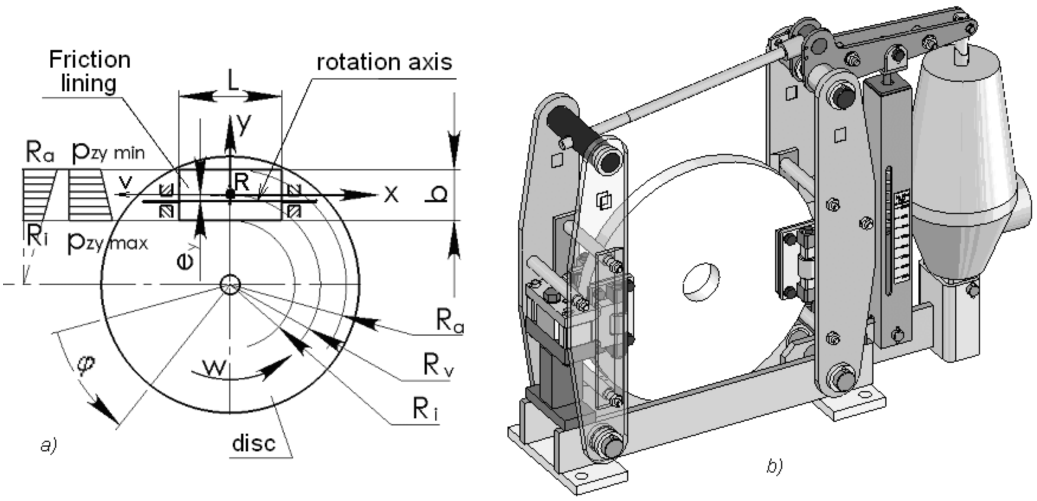

Fig. 2. **Scheme of brake shoe and disc brake design:**
a – the brake shoe attached with a pin parallely the vector of slipping velocity *v*; b – disc brake JDB (the front lever is demonstrate transparent in cad-model)

The research is significant to the joint-stock company "Jelgava engineering plant" (A/S "Jelgavas masinbuves rupnica") – they produce brakes with such construction.

Materials and methods

The experimental work was carried out in the brake testing laboratory of join stock company „Jelgava engineering plant. The wear was tested in experimental work using two kind of friction shoe design, in first case – the direction of shoe pin was perpendicular (Fig. 1, c) regarding the vector of slipping velocity *v*, in the second – parallel (Fig. 2, b). During experimental work the brake worked in short time repeating regime six hours, the braking intensity two times per minute, specific surface pressure p = 1.15 MPa, revolution of disc at the begining of braking n = 1000 turn/min, the value of the pressing force F = 10 kN, sliping velocity of friction surface at the effective friction radius

v = 19 m/s. The thickness of the friction lining was measured before and after the experiment (the difference equals to the wear) using micrometer (the value of section 0.001 mm) on nine or five points on friction surface (Fig. 3, a, b).

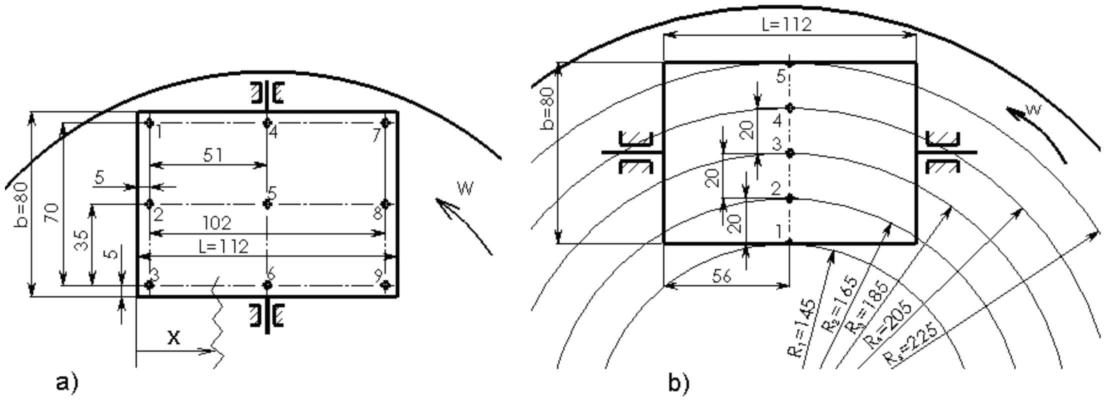

Fig. 3. **The dimensions (in millimeters) of friction lining and the coordinates of wear measuring:**
a – the brake shoe attached with a pin perpendiculary the vector of slipping velocity v;
b – the brake shoe attached with a pin parallely the vector of slipping velocity v

In the first case friction linings „Dafmi" (Ukraine) were used in experimental work. Firstly the friction lining was attached symetricaly regarding a pin of brake shoe. Secondly, the friction lining of the same dimensions was attached asymmetricaly regarding a pin of brake shoe with eccentricity $e_x = f \cdot h$ = 0.35 · 48 = 16.8 mm [6].

In the second case two kind of friction linings were used - „ЭМ-1" (Russia) and „TWG" (Spain). The wear was measured in five points on friction surface (Fig. 3, b). After – the friction lining was attached symetricaly regarding a pin of brake shoe, after – brake shoe with a eccentricaly design pin regarding friction lining mass centre was used. The theoretically calculated [6] value of optimal eccentricity e_y = 3 mm.

Results

The results of experimental work (Fig. 4) prove that the wear of friction surface is almost even at first kind of brake shoe design (Fig. 1), if the optimal eccentricity e_x = 16.8 mm is provided in conformity with theoretical coherence (1). The wear is not absolutely even because the friction coefficient f and distance h change a little during experiment. If the recommendation (1) is noticed, the wear of friction lining surface is almost even.

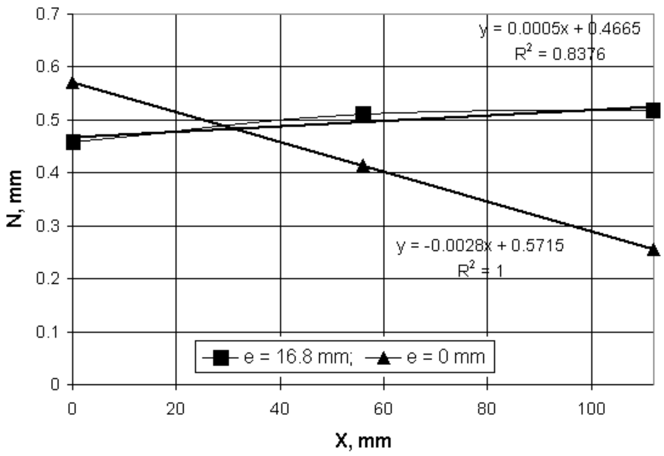

Fig. 4. **The friction lining wear *N* in different split at distance *x***

There is real uneven wear of symmetricaly (regarding a pin) attached friction lining, although the brake DBE-1 is equiped with a brake shoe support screw. The target of support screw is to provide distance between friction surfaces of friction pair when disc rotates.

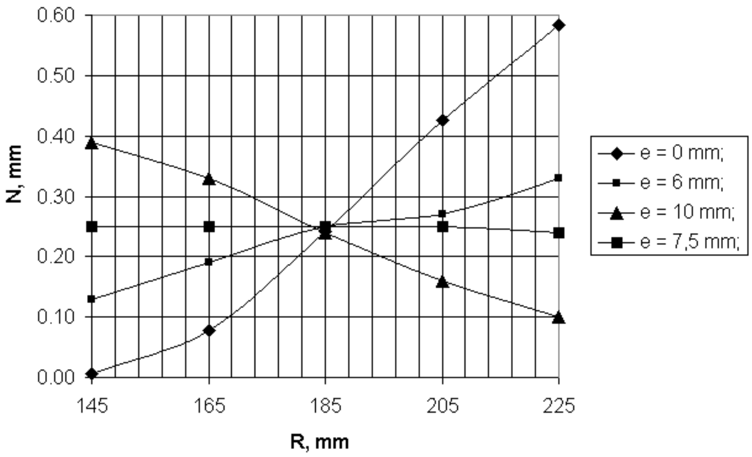

Fig. 5. **The wear *N* of friction lining “ЭМ-1” at different friction radius *R***

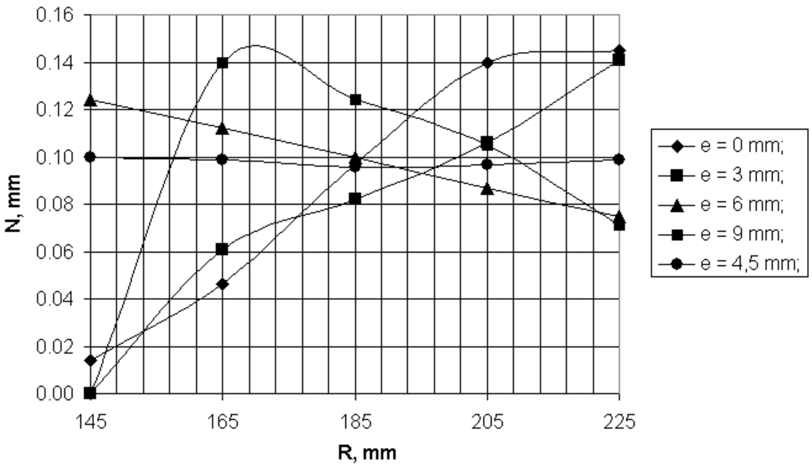

Fig. 6. **The wear *N* of friction lining “TWG” at different friction radius *R***

The results (Fig. 5, 6) of the experiment prove that the wear of friction surface is even if the friction lining is attached with definite eccentricity (brake shoe design at Fig. 2). The optimal value of eccentricity depends on friction material. Optimal eccentricity e_y = 7.5 mm for friction material „ЭМ-1” and e_y = 4.5 mm for “TWG”, the explanation – there is no proportionality between intensity of wear and the friction work, because the sliping velocity and specific surface pressure have different impact on wear intensity [3]. The sliping velocity impacts wear intensity more than specific surface pressure.

Discussion

If a pin of brake shoe is parallel regarding the vector of slipping velocity *v* (Fig. 2), the theoretically calculated (2) value of optimal eccentricity e_y = 3 mm. The friction work is equal at all friction radius with such eccentricity, because the multiplication of specific surface pressure and sliping velocity is constant for all friction radius. It proves that the sliping velocity impacts wear intensity more than specific surface pressure.

Conclusions

1. If the direction of the brake shoe pin is perpendicular regarding the vector of slipping velocity, the wear of friction surface is almost even if the friction lining attached with eccentricity $e_x = f \cdot h$;
2. If a pin of brake shoe is parallel regarding the vector of slipping velocity, the value of optimal eccentricity depends on material - optimal eccentricity e_y = 7.5 mm for friction material „ЭМ-1” and e_y = 4.5 mm for “TWG”.
3. If a pin of brake shoe is parallel regarding the vector of slipping velocity, the value of optimal eccentricity mast find experimentaly.
4. The sliping velocity more than specific surface pressure impact on wear intensity.

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