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# Friction conditions in the friction brake system of Mi-2 helicopter

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ABSTRACT

An assessment of friction conditions during braking on durability of structural elements of the drum brake is the goal of the work. The analysed brake in a symmetric system is used in Mi-2 helicopter. In the so far applied solutions a friction lining and brake shoe were fastened up by riveting. The new asbestos-free friction linings crack when using riveting technology. One way to avoid cracking is gluing instead of riveting. This paper presents a numerical analysis of the drum brake with the friction lining fastened by gluing. The numerical model includes a three-dimensional structure composed of seven structural elements and comparison of four material groups. A distribution of contact pressure between the frictional elements, and a stress state in the structural elements of the drum brake were determined for the assumed boundary and initial conditions. It was stated that the calculated distribution of the contact pressures is nonuniform and depends on the sense of rotation of the drum brake. This paper also presents the results of comparative tests of bonding strength for three different glues. The tests were carried out on a specially designed for this purpose test stand.



## 1. Characteristic of the drum brakes used in aviation

Problems encountered during exploitation of the brakes used in aviation are similar to those found in other applications [1–3]. Much longer operation time is a characteristic feature of such brakes. The braking distance is limited by the length of the airstrip. In the case of the Airbus A380 weighing 560 t, the aircraft has to land and stop on the airstrip with a length of 4800 m. In the case of helicopters, additional brakes are used to stop the rotor and immobilise it when parking. EC 135 helicopter, in which the rotational speed of the rotor is $n=2500$ rpm, is stopped in about 25–35 s. In this case braking torque of the rotor does not exceed $M=100$ Nm [4]. The civilian helicopter begins a braking process when speed of the carrying rotor drops to 50–70%. Deceleration time is usually between 120 and 10 s. Operating conditions for the considered brakes used in the helicopters Mi-2 and W-3A are as follows:

- braking torque: 1000 Nm (for Mi-2 helicopter) and 1380 Nm (for W-3A helicopter),
- working temperature: up to 350 °C,
- friction coefficient: $\mu=0.3$–0.4
- rotation of the brake: 2557 rpm for Mi-2 helicopter (braking can start when rotations decrease to 20% of rotations of

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the carrying rotor) and 3814 rpm for W-3A helicopter (braking can start when rotations decrease to 10% of rotations of the carrying rotor).

The brakes used in aviation are designed with regard to the high braking torques, high braking speed and long braking time. In the helicopters, the brakes of the rotor cannot be used during the flight. The braking torque on the ground may be limited due to icing. The disc brakes compared to the drum ones are more resistant to thermal loads. They dissipate energy faster and better. However, the disadvantages of the disc brakes include a high price, weight, and lack of self-support [5]. The unit pressures in the disc brakes have to be several times greater than in the drum brakes because of smaller radius on which the frictional pair works. The unit pressures reach 7–8 MPa. The values of friction coefficient in both brake types are similar and do not differ as to the value of friction coefficient observed in similar frictional pairs [6].

## 2. Analytical model of the shoe brake

Shoe brakes are often used in the building of machines and different equipments. In such a solution the jaws are located inside the rotating drum. They are pivotally mounted on the pins and can revolve around them. An expander and a spring are responsible for the motion of the brake shoes. The force applied to the free end of the jaw runs the brake. A hydraulic or pneumatic actuator generates the force. During braking, the linings are pressed down to the drum surface by the jaws. During uploading, the jaws return to the initial position thanks to the spring which is located between the jaws. There are two typical systems of clamping the jaws: symmetric and asymmetric. Brake shoes covered with frictional linings collaborate with inner surface of the drum. Classical approach to the problem described in the technical literature [5,7,8] assumes that the force, which presses the jaw down, is distributed evenly over the whole lining surfaces. Fig. 1, according to this assumption, schematically shows forces acting on the brake shoes.

From an equation of force moments relative to the axis of one of the joints it can be shown that N1 and N2 forces are not identical in the symmetrical system. So, the braking torque for the symmetrical system of the brake shoes can be described by

$$M_h = 0.5 D_h \mu (N_1 + N_2) \tag{1}$$

For the asymmetrical system of the brake shoes holding-down forces are identical ($N_1 = N_2 = N$), and the equation for the braking torque can be described as

$$M_h = D_h \mu N \tag{2}$$

For the elements of the frictional pair of the brake unit pressure is calculated according to

$$p = NA^{-1} \le p_{dop} \tag{3}$$

where A is the area of the contact surface and $p_{dop}$ is the parameter describing the surface strength for the contact pressure.

Classical approach to the problem does not take into consideration all factors which affect unevenness of the contact pressure. A clearance between the jaws and the drum in the initial position has the most significant impact on non-uniformity of the contact pressure distribution. A constant value of the clearance is only in the initial position when the new frictional linings are used. Even though the friction linings are in contact with the drum during action, in the vicinity of the clamping pin the holding down force is limited. The maximum value of the contact pressures changes its position with the changes in geometry of the frictional linings resulting from routine operation. Stiffness of the brake shoes is also of great importance because their deformation can essentially affect the contact pressure distribution.

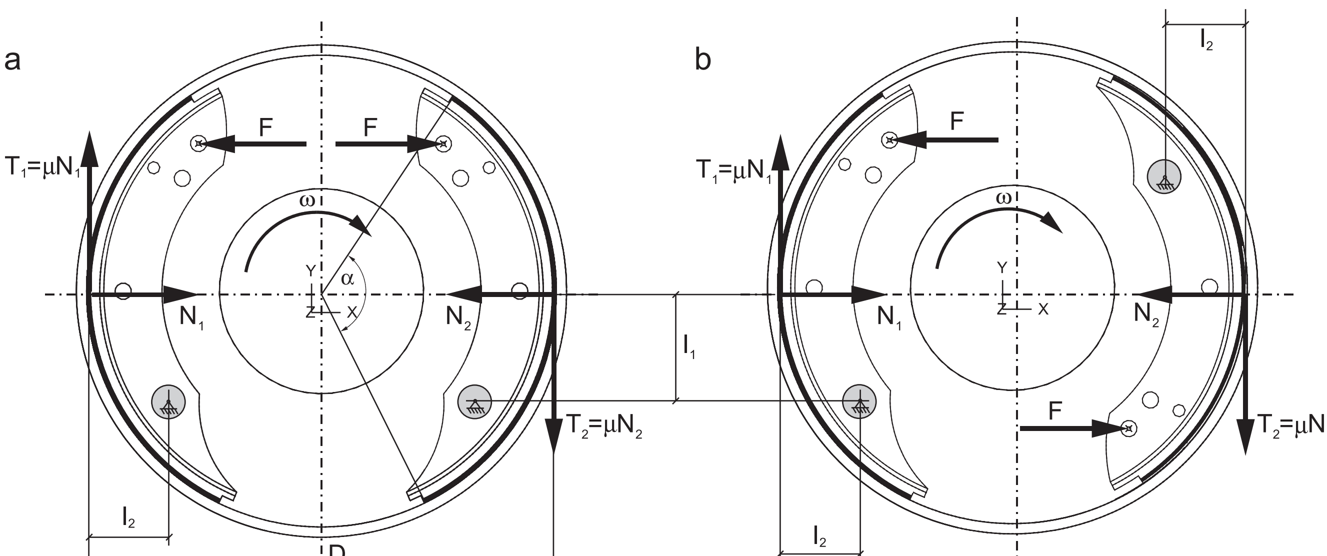


**Fig. 1 – Force system in shoe brake: (a) with symmetrical clamping of the jaws SIMPLEX and (b) with asymmetrical clamping of the jaws DUPLEX.**