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# IMPROVING EFFICIENCY PARAMETERS OF AUTOMOBILE BRAKING SYSTEMS

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The development of automobile transport leads to increasing competition for the best technical solutions used in various systems and components of vehicles. In particular, certain requirements are imposed on braking mechanisms in terms of operating efficiency, reliability, maintainability, economic performance, compatibility with ABS and TCS systems. However, hydraulic disc brakes, the most commonly used form of brakes, can be upgraded to improve the above-mentioned parameters.

At the same time, mechanical actuators have an advantage over hydraulic actuators in terms of reliability, manufacturability and the cost of production and maintenance.

Thus, the objective of this study is to increase efficiency parameters of brake systems of automobiles by implementing a mechanically actuated disc brake assembly with a mechanical drive to the existing brake arrangement using the best features of mechanical actuators and overcoming such disadvantages of mechanical actuators as large dimensions of the assembly required to achieve a high drive ratio and complicated ABS and TCS systems compatibility.

The FN-3 brake fitted to Volkswagen Golf IV was used as a prototype. This hydraulic disc brake has one piston, a floating caliper and is compatible with ABS and TCS systems.

To achieve the objective of the study, a novel braking assembly has been developed. The caliper bracket 2 of the brake assembly is attached to the suspension beam 6 of the car by the bolt 7. The caliper frame 3 can move axially relative to the caliper bracket 2. For this reason, the caliper frame has an axial grove through which the bolt 13 screwed into the caliper bracket 2 passes. The washer 14 is provided to fix the bracket under the bolt 13.

The caliper frame 3 has a cylindrical hole where the barrel 11 is installed. The actuating lever 12 is installed on the hexagonal protrusion on the barrel 11 held from axial movements by the washer 15 and the bolt 8. The screw pins 10 entering the angled groves in the caliper frame 3 are fixed in threaded holes in the barrel 11. To prevent contamination of the friction surfaces between the barrel 11 and the caliper frame 3, two sealing rings 16 are installed. Brake pads 4 with friction linings 5 are fixed in the caliper bracket 2.

The disk brake assembly and its calculation model are shown in Fig. 1 (*a*, *b*).

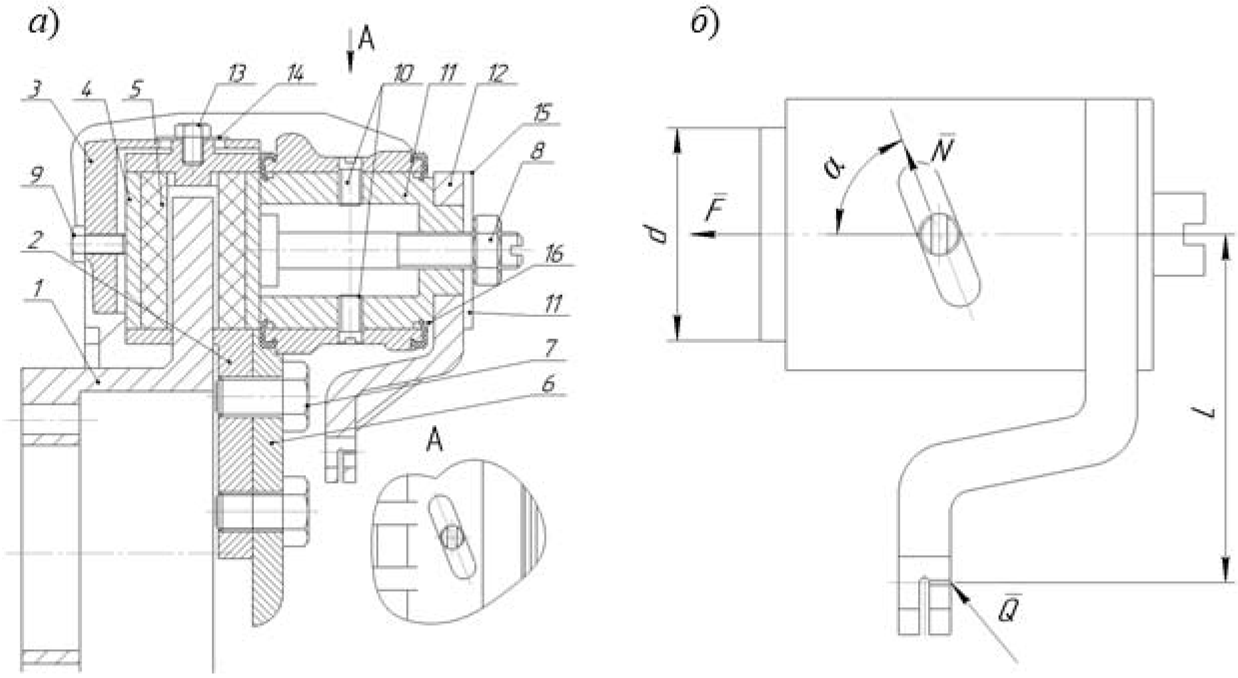


Fig. 1. Disk brake assembly and its calculation model

Whenever the force Q is applied to the actuating lever 12, it rotates around the axis of the barrel 11 and transfers a rotational motion to the barrel by means of a hexagonal engagement. The screw pins 10 installed in the barrel 11, which is set in motion by a force N, slide along the grooves in the caliper frame 3. This motion of the screw pins 10 produces a relative movement of the barrel 11 and the caliper frame 3. In this case, the caliper frame 3 and the barrel 11 perform a reciprocal movement. For that reason, the caliper frame 3 exerts pressure on the outer brake pad, and the barrel 11 exerts pressure on the inner brake pad with a force F, which, in turn, exerts pressure on the disk brake rotor 1 mounted on the wheel hub. To adjust the brake pads, the screws 9 and 8 and the washers 15 of various thickness are used. The developed brake assembly interacts with the ABS and TCS systems through control of the force Q applied to the actuating lever 12. It is possible to use either sliding-friction forces or rolling-friction forces in the operation of the disk brake by integrating the screw pins into the design.

The calculation of the mechanically actuated disc brake includes the functional and strength calculation and is aimed at defining the parameters of the braking system. Some of these parameters are the brake pad engagement force acting on the brake rotor 1,the braking torque produced by the brake mechanism, as well as the force applied to the actuating lever 12 during the operation of the brake mechanism.

In addition, it is necessary to determine the angle between the longitudinal axis of the barrel 11 and the direction of the grooves in the caliper frame 3, the diameter of the barrel 11, the optimal number and diameter of the pins 10.

The brake pad engagement force F is determined according to the following formula:

$$F = \frac{1{,}2QL\cos\alpha}{fd}, \tag{1}$$

where $Q$ is the force applied to the lever 12, N;

$L$ is the length of the actuating lever 12, m;

$\alpha$ is the angle between the longitudinal axis of the barrel 11 and the direction of the grooves in the caliper frame 3, deg.;

$f$ is the friction index between the barrel 11 made of steel and the caliper frame 3 made of cast iron;

$d$ is the inner diameter of the barrel 11.

The braking torque produced by the developed brake mechanism can be determined according to the following formula:

$$M = F \cdot R, \tag{2}$$

where $R$ is the radius of the brake disc 1, m.

In addition, it is possible to set the law of motion of the brake pads when the mechanism is actuated. The law of motion of the pads can be modified by setting the angle of the grooves in the caliper frame 3.

The length of the grooves in the caliper frame 3 is determined on the basis of the gap between the brake pads 5 and the brake disc 1. The gap can be adjusted by the adjusting screws 8 and 9. Provided that this gap is in the range of 0,1…0,3 mm, the length of the grooves is taken to be in the range of 10 to 15 mm. The length of the cylinder 11 is based on the length of the grooves. The angle of inclination between the longitudinal axis of the barrel 11 and the direction of the grooves in the caliper frame 3 is in the range of 60 to 80 degrees in order to provide the maximum efficiency of the brake mechanism while maintaining the optimal force multiplication ratio and the service time of the parts of the brake mechanism.

On the basis of the performed calculations as well as the adopted design characteristics of the disc brake mechanism elements, it is possible to achieve the minimum overall dimensions of the brake mechanism in the longitudinal direction and the overall dimensions along the lateral axis, which will eliminate the need for design and manufacture of the caliper frame 3 of the modified construction compared to the caliper frame of the prototype.

The radius of the brake rotor remains unchanged compared to the prototype mechanism brake rotor. The optimal number and the diameter of the pins 10 and the length of the actuating lever 12 are determined by means of the functional calculation.

The applied design solutions in the mechanically actuated disc brake assembly with the mechanical drive are superior to its prototype and similar mechanically actuated disk brakes: they are characterized by increased reliability, operational and production adaptability, the ability to transfer large forces, accuracy and smoothness of the motion, smooth and quiet action, the ability to develop a large gear ratio. The developed brake is characterized by the brake pad adjustment mechanism as well as ABS and TCS systems interaction.