UDC 539.4.01

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Investigation of the Effect of Braking Torque on the Strength of Aircraft Brake Discs

The aim of this study is to investigate the effect of aircraft braking forces on the brake disks. The resistance of the brake disk on a Light or Ultralight aircraft with a single brake disk was examined under different braking torques for strength parameters like stress, strain, and safety coefficient.

Aircraft Brake System

Aircraft braking systems are a critical component used to reduce the speed of aircraft during landing and keep it safely on the ground. The brake system consists of a combination of many different components that serve in aircraft, and brake discs are the most important of these components. Brake discs are subjected to extreme conditions such as high temperature, high pressure and overloads. Therefore, an accurate analysis of the loads, strength and fatigue parameters on brake discs is critical to safely and effectively design aircraft braking systems. Maintaining the integrity of the brake disc during braking is important for flight safety.

Ensuring that aircraft come to a quick and safe stop, particularly during landing and aborted takeoff, is of vital importance to the aviation industry. Therefore, aircraft braking systems are an integral part of the aviation industry. In this study, the strength of the most important component of the system, the brake disk, was examined by creating a mathematical model for stress, strain, and safety coefficient parameters under different braking torques. These parameters were analyzed using the Finite Element Method.

The geometry of the brake disc is shown in figure 1.

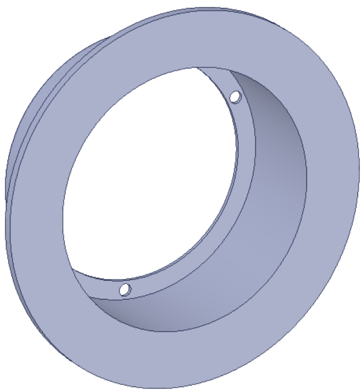

Fig. 1. Brake disc 3D geometry

Mathematical Model

Mathematical models were created in order to perform structural analysis of the created geometries with the finite element method. An example mathematical model for a brake disc in experiments is shown in figure 2.

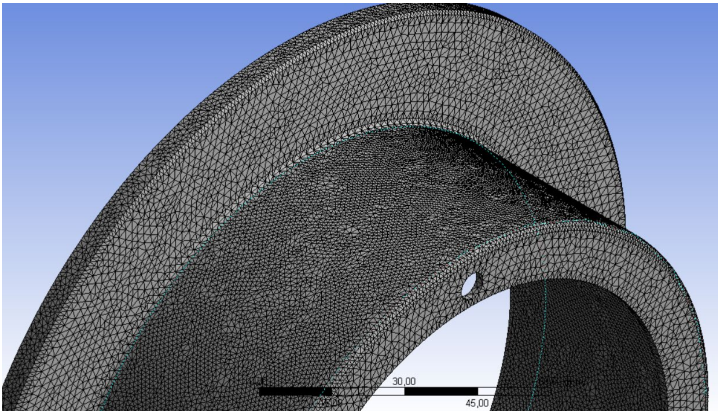

Figure 2. The mathematical model of the brake disk created using the Finite Element Method. (Mesh Statistics Includes 546112 Nodes and 316715 Elements)

Physical Conditions

A moment of 5-3200 N.m was applied to the brake disk shown in the figure. This moment can be different values depends on runaway length.

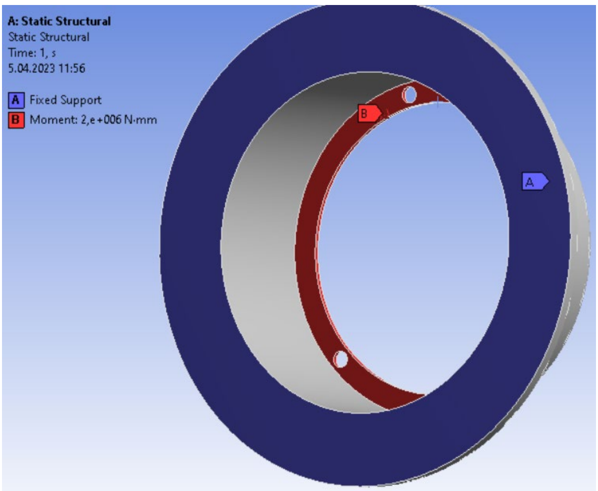

Fig. 3. Physical Conditions 2000 N.m braking torque and braking flange is fixed

Results

According to the created physical conditions, 30 simulations were performed by increasing the braking torque of the brake disc from 300 Nm to 3200 Nm in increments of 100 N.m. The stress, total deformation, and safety factor at 2000 N.m braking torque are shown in figures 4-6. The results of stress, total deformation, and safety factor for all simulations are shown in figures 7 and 8.

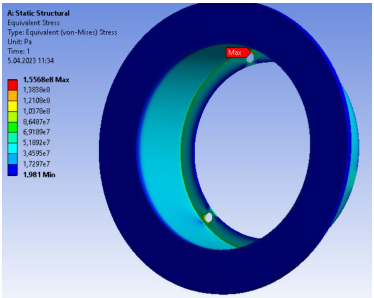

Fig. 4. Results for Stress for a Braking Torque of 2000 N.m

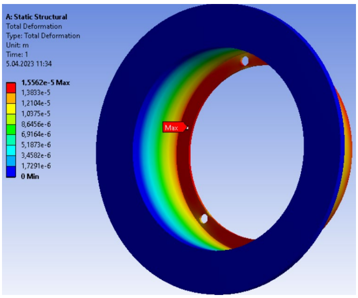

Fig. 5. Results for Total Deformation for a Braking Torque of 2000 N.m

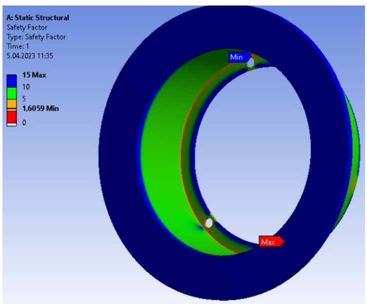

Fig. 6. Results for Safety Factor for a Braking Torque of 2000 N.m

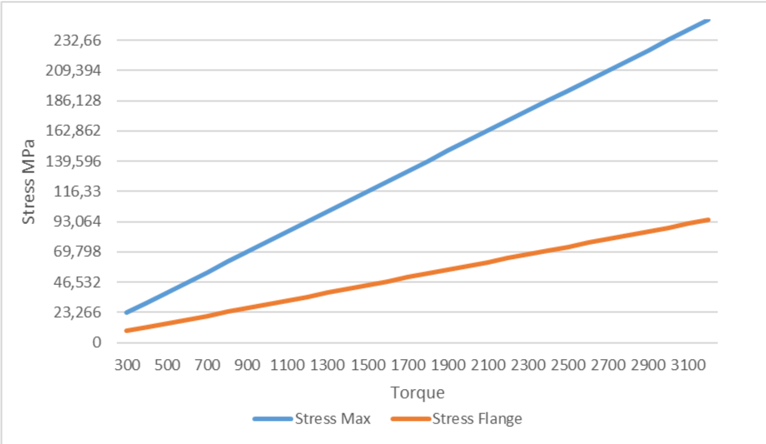

Fig. 7. Results for stress max and stress flange graphic value

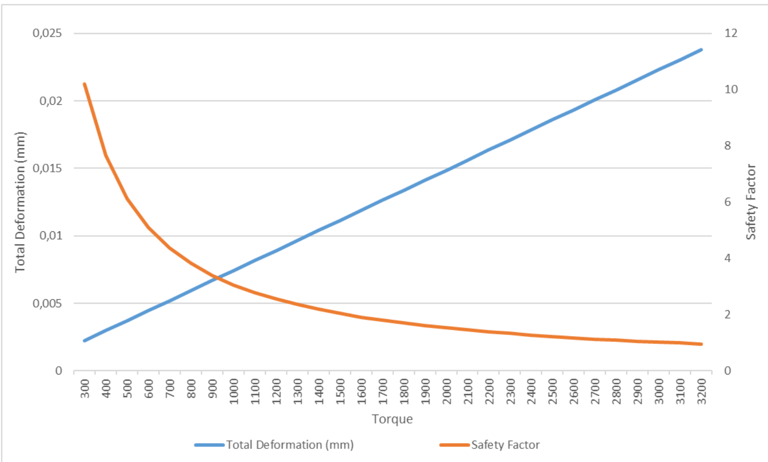

Fig. 8. Results for safety factor and total deformation graphic value

Conclusion

1. When the stress distribution of the brake disc, which is the most important part of the brake system, is examined, it is observed that the stress magnitude in the flange region of the brake disc is lower compared to the bolt connection points. Strengthening the bolt connection areas or increasing the number of bolts in order to brake on shorter runways can reduce the stress value in this region.
2. As the brake torque increases, the total deformation also increases. The increase in stress value along with the proportional increase in total deformation causes fatigue in the brake disk, which can reduce the service life of the brake disk under high braking torque. To ensure flight safety, it is important to replace brake disks exposed to high braking torque on short runways in a timely manner.
3. The safety factor shows an exponential decrease with an increase in brake torque. Measures should be taken to prevent the brake disk from reaching the yield limit at critical locations. Additionally, if the aircraft's tire sizes are to be changed, it is recommended to raise the yield limit of the brake disk material.

References

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