MINAR International Journal of Applied Sciences and Technology
ISSN: 2717-8234
Article type: Research Article

Received: 12/12/2022 **Accepted:** 30/01/2023 **Published:** 01/03/2023

NUMERICAL SIMULATION FOR MECHANICAL BEHAVIOR OF THE DISC/PAD BRAKING TORQUE

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Abstract:

A braking system is very important to a vehicle. It absorbs energy from moving parts, slows the vehicle through friction, and converts the vehicle's kinetic energy into heat energy that is released into the atmosphere. Disc brakes create an opposing torque on the wheel shaft, converting the wheel's kinetic energy into heat.

During braking and when the rotating disc is in contact with the brake pad, which constitutes a friction body on the disc, the contact zone is subject to mechanical stress due to fatigue. The heat resulting from friction generated at the interface between the rotor and brake pads can exceed critical values, leading to very strong heating of the latter, causing undesirable effects such as deterioration phenomena, thermal cracking and thermoplastic instability. There is a possibility.

In this study, a numerical simulation for the mechanical behavior of disc/pad has been used braking torque. This behavior was analyzed using the ANSYS computational code based on the finite element method for von Mises equivalent stress. It depends on the geometric parameters and mechanical properties of the disc and brake pad at the braking time t = 4.5 s.

The purpose of this work is to identify the damages, improve the braking system, extend the life of this system and make it more reliable, the best choice and more resistant to damage to economical brake discs and pads.

Keywords: Disc Brake, Brake Pads, Mechanical Behavior, Ansys, Von-Mises Equivalent Stress.

http://dx.doi.org/10.47832/2717-8234.14.11

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I. Introduction

Vehicles are getting stronger and faster due to the continuous development of new technologies in the transportation industry. This creates a system in which the brakes must follow this forward speed. Safety is therefore still a much-studied component by engineers. In addition to concerns about efficiency, reliability and comfort, automotive competition is becoming increasingly fierce. Low cost and production time. The goal of engineers to find the best economical compromise between these safety requirements and these technical limitations. To get closer to the "ideal" solution, numerical methods can be used to identify disc and brake pad damage and optimally select this torque design.

The automobile brake disc can suffer degradation, the origin of which lies in the coupled mechanical stresses (pressure of the linings on the disc and tightening of the disc on the hub) and thermal (heating by friction). Because of the complexity of the system, numerical models are only possible if they are based on simplifying assumptions. The assumption of asymmetry is commonly made and the rotation of the disc and the three-dimensional phenomena are neglected. These insufficiencies, which make it possible to gain calculation time, make the prediction of the thermomechanical response of the disc poor.

Several numerical and experimental studies are carried out by several authors concerning the thermal and mechanical problems related to the contact by friction of the braking torque disc / automotive brake pads to ensure the proper functioning of the brakes under the effect of several parameters and all conditions. [1] studied numerically and experimentally the tribological behavior of sliding contacts - application to disc brakes, the modeling of the dry sliding contact with friction of the pin-disc tribological couple by the finite element method (ANSYS). [2] Studied the thermo-structural analysis of the disc-brake pad assembly of an automotive braking system.

This study concerns the static calculation of contact by friction of the two bodies (pad and disc) during braking to a standstill, which determines the stress fields of the disc and the pad, Considers the contact with friction of a deformable pad on a rigid disc while performing a parametric study such as (Young's modulus of the pads, coefficient of friction, type of loading, speed of rotation of the disc,..) to see its sensitivity on the results of calculation.

II. Numerical simulation

II.1. Torque Component Materials (Disc/Plate)

The manufacture of brake pads requires the application of several techniques [3]. They are made up of two components; the standard steel support, to distribute the force exerted by the piston over the entire surface of the seals. Linings are composite materials with an organic matrix, which must have a high and stable coefficient of friction with a low rate of wear regardless of variations in temperature, pressure or speed with a low rate of wear [2][4].

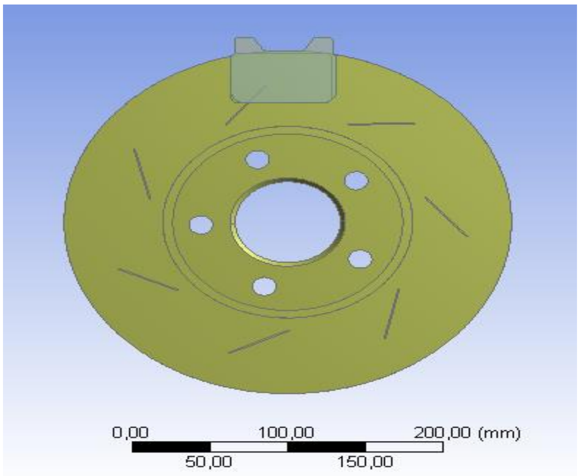
In the automotive industry, the material chosen for the disc is high carbon cast iron with lamellar graphite which is the most commonly used in the automotive industry [5][6] and the brake pads have an elastic behavior whose mechanical characteristics used, they must withstand high temperatures related to friction against the disc [7]. Table 1 presents the mechanical characteristics of these materials.

Table1. The mechanical characteristics of the braking torque (disc/pads)

Material properties	Disc (gray cast iron	Linings (composite material with an organic matrix [8]
Density (kg / m^3)	7250	1400
Young's modulus (Pa)	1,38E+11	1E+09
Poisson ratio	0.28	0.25

II.2. The geometry of the braking couple (disc/brake pads) and the mesh

Fig 1.2 shows the geometry of the braking torque (disc/pads) and the meshes of these two geometries to have a better view of the parts that interest us.



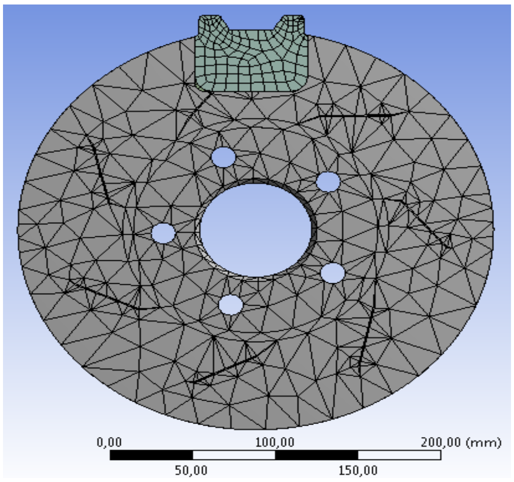


Fig1. Torque geometry (disc/pads) [9]

Fig2. Torque mesh (disk/pads) [9]

II.3. Boundary conditions

For the boundary conditions a ventilated grooved disc with two flexible pads in organic matrix composite material with a rigid gray cast iron disc have been used the contact pressure applied to the brake pad at a force of 1 MPa, and an angular velocity ω = 152.28 rpm is kept constant throughout the simulation. The coefficient of friction µ = 0.3 remains constant during braking. The behavior of the disc/pad braking couple during braking was analyzed in terms of stresses and deformations. The influence of the variation for some parameters on the torque response was also analyzed. (fig3)

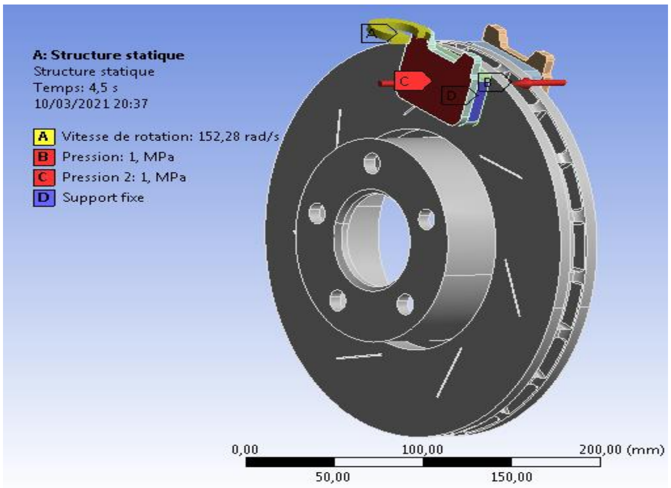


Fig3. Boundary conditions

III Results and discussions

III. 1. Stress distribution by Von Mises theory

Figure 4 shows that a high concentration of the equivalent Von-Mises stress is located in the contact zone and at the level of the outward-facing groove with a value of 122.42 MPa, and it propagates towards the zone of track-bowl connection and towards the ventilation fins with low values.

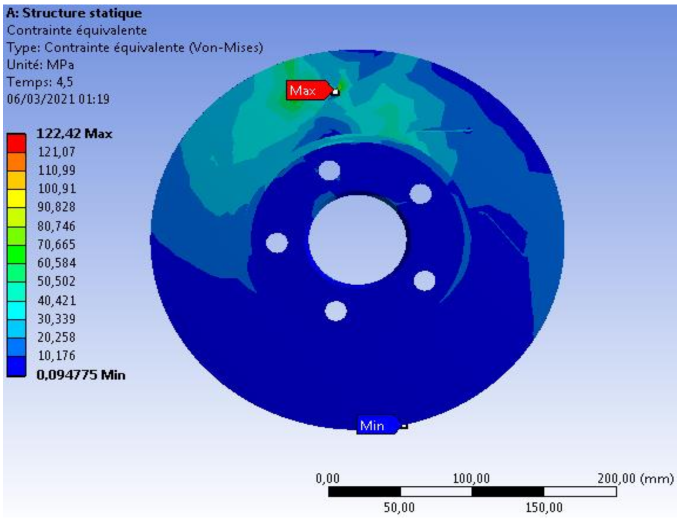


Fig 4. Equivalent stress distribution

III.2. Influence of disc material change the variation of Von-Mises equivalent stress field

For the other materials making up the discs, which are respectively gray cast iron and stainless steel, the mechanical properties are given in table 2.

Table 2. Mechanical properties (Grey cast iron, stainless steel) [9]

Mechanical properties	Grey cast iron	stainless steel
Density [Kg/m³]	7250	7750
Young's modulus [Pa]	1.38E+11	1.93E+11
Poisson ratio	0.28	0.31

Under the effect of change in the material making up the two types of disc which are respectively gray cast iron, stainless steel and depending on the braking time; Figure 5 shows that material loading plays an important role in the behavior of the braking torque.

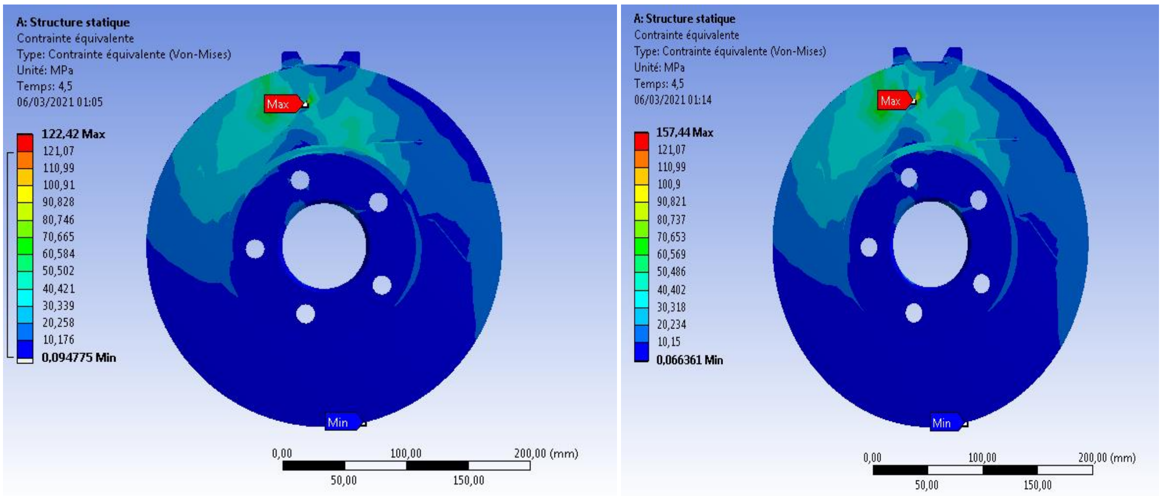
In figure 5 the highest value of the equivalent stress appears in the stainless steel disc with a value of 157.44 MPa, and with a value of 122.42 MPa in the gray cast iron disc.

Gray cast iron is the most commonly used in the automotive industry thanks to its high carbon content.

-Ensures good thermal behavior and good mechanical resistance.

-Reduces breaking strength and modulus of elasticity.

- Has low wear, can better resist cracking despite high temperature.



a) Grey cast iron disc b) stainless steel disc

Fig5. Influence of the change of brake disc material on the variation of the equivalent Von-Mises stress field.

III.3. Effect of changing disc shape on variation of von-Mises equivalent stress field

To study the influence of the geometry on equivalent Von-Mises stress field have been used a ventilated drilled disc which looks like two solid discs superimposed with a space between them in the same boundary conditions and the same material composing the two types of disc.

The comparison between the results of these two couples shows that a strong concentration of the stress is localized in the zone of contact and at the level of the groove oriented towards the outside, and at the level of the perforations, and it propagates towards the zone track-bowl connection and towards the ventilation fins with low values. The maximum value of the equivalent stress appears in the drilled disc is equal to 66.887MPa is smaller than that obtained in the grooved disc.

So the drilled disc supports better than the grooved disc, and this is because of the perforations which allow the disc to be cooled faster than the grooved disc and guarantee a better heat dissipation capacity compared to the grooved disc.

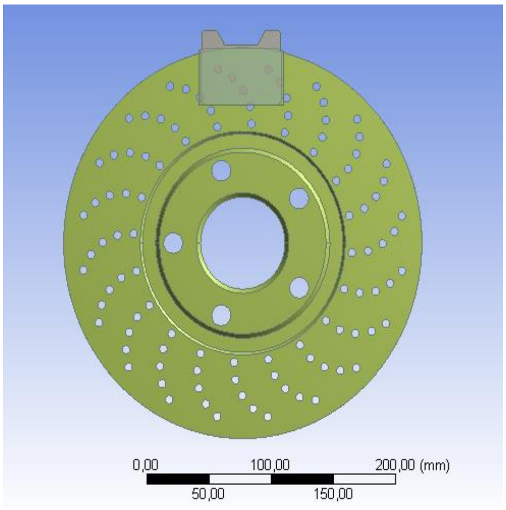


Fig6. Geometry (drilled disc/pads)

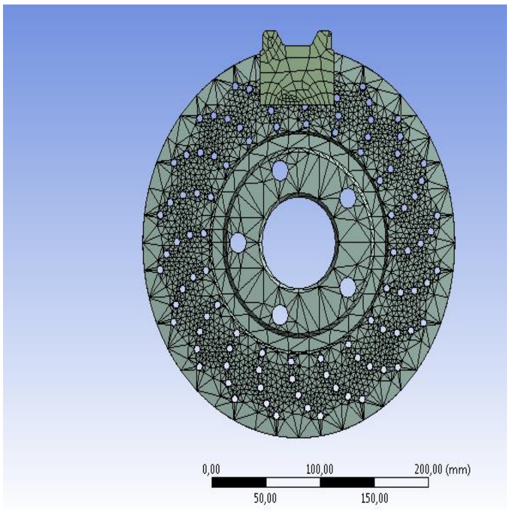
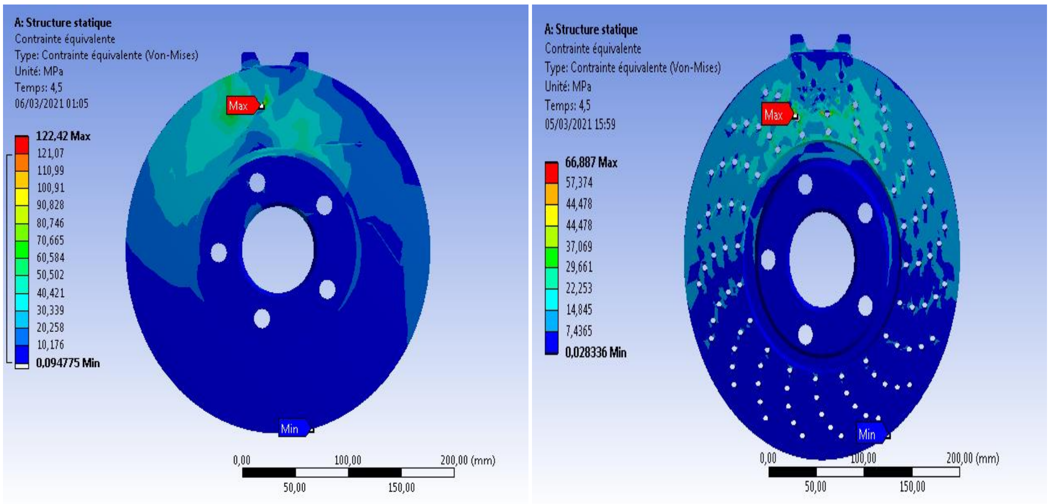


Fig 7. Mesh (drilled disc/pads)



a) Grooved disc b) Drilled disc

Fig 8. Effect of changing disc shape on variation of von Mises equivalent stress field

III. Conclusion

In this work, a numerical simulation of the mechanical behavior of the disc/pad braking couple using the ANSYS 14.5 calculation code, based on the finite element method have been used. For comparative purpose two types of disc have been distinguished a grooved disc in rigid gray cast iron with flexible organic matrix composite pads and a disc drilled under the same conditions and the same material composing the disc.

Under the influence of certain essential parameters on the braking behavior and under the influence of mechanical characteristics of the torque materials and the geometric parameters, the numerical simulation concludes the following results:

-The drilled disc resists better than the grooved disc, which allow rapid cooling and guarantee a better heat dissipation capacity compared to the grooved disc.

- Gray cast iron is the most commonly used in the automotive industry which has a high carbon content, ensures good thermal behavior and mechanical strength, deprives the breaking strength and modulus of elasticity, low wear, can better resist cracking despite high temperature. It is distinguished by better mechanical behavior.

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