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STRUCTURAL ANALYSIS OF BRAKE DISC USING DYNAMIC SIMULATION

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ABSTRACT

This paper deals with the natural frequency simulation test of disc brake functionality using computer aided engineering software. The finite element analysis technique is applied to predict the failure region on the brake disc and to identify the critical locations of disc brake. The disc brake rotor implemented on the front axle of Perodua Myvi 1.3 L model with grey cast iron materials which commonly used in industry was studied. The disc brake rotor surface thicknesses on both sides were reduced into 3 steps, 0.5 mm, 1.0 mm and 1.5 mm by using CATIA V5 software. Modal analysis was applied for each type of disc brake rotor model including normal brake disc surface to investigate the natural frequency for each type of brake disc rotor model. The results of natural frequency from each type of the disc brake rotor surface thickness were recorded. 24 types of mode shapes were obtained from the simulation and compared with 4 types of surface thickness. The same mode shape shows that the highest reduction mass becomes the lowest value of frequency and the highest mass becomes the higher value of the frequency. It is due to the effect of Inertia Force. However, at the last mode shape on highest reduction of mass shows, the frequency was maximum. It is predicted that the instabilities are due to the repetitions of force applied to the rotor area.

Keywords: CATIA, ANSYS, inertia force, natural frequency, mode shape.

INTRODUCTION

For many reasons, especially safety aspects, a brake system must fulfil customer requirements for performance, durability and less noise [1, 2]. In recent years, disc brakes have become an issue to be concerned about in automotive industries, especially to the manufacturers of disc brake systems [3-5]. There are a lot of problems that occurs for example, brake noise, brake judder, brake groan, brake squeal and etc. Based on these problems, there are numerous studies of this phenomenon which have been carried out through years; however understanding of its excitation mechanisms remains rather limited. Braking systems has common dynamics with friction parts [6-9]. The main function is to reduce the kinetic energy of rotation motion of the masses by means of friction forces that can stop/slow down wheels during braking [10]. The brake systems must provide such as (a) stopping of the machine or the friction pair on the desired way in the specified time; (b) stable operation within the entire load range and the speed of service, that can help driver to avoid accidents and (c) long-lasting work [11]. Furthermore, the operating characteristics of the brake system, the magnitude and the stability of brake torque, the variation of the speed and temperature limitations, mechanical and thermo physical properties of materials of friction pairs and their resistance to wear should be consistent with the requirements that result from the conditions of exploitation [11, 12]. The knowledge gained from this paper will enable the understanding of the steps needed in natural frequency of disc brake rotor by using FEA method. The method used in this paper can be used in future as reference for similar research and development. There is the wide range of studies on the disc brake rotor. Various aspects of the disc brake rotor could be studied such as vibration on the disc brake, noise and squeal of the disc brake, etc. However, this study will focus on the detailed natural frequency of disc brake analysis on the disc brake rotor and attempt to determine the structural behavior of the disc brake.

SIMULATIONS SET UP

Design of Simulations

The numerical analysis is good method to reduce the extensive experiment cost [13]. In this simulation the ANSYS software has been used to determine the result based on the previous studies in the literature review and methodology. The most important task is to define the parameters that are involved with the simulation, for example to determine the material use, the young's modulus and the poison ratio. All this parameter will affect the result. Natural frequency was obtained and simulated by using original thickness and by reducing the thickness to 0.5 mm, 1.0 mm and 1.5 mm.

Modal Analysis

Tables-1 and 2 show the parameters used for this simulation. It is important to have the right parameters to determine the results [14]. Table-1 shows the isotropic Elasticity that referred to the journal studied in literature review. Table-2 shows the mass and volume for disc brake when the thickness is reduced. The natural frequency in this study is referring on the total deformations that are produced by the front Perodua Myvi disc brake. The higher the natural frequency, the lower the damage that can happen to the disc. The highest natural frequency that

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can be produced by this is 2990.9 Hz at mode 6 with 1.5 mm thickness reduction. Once the natural frequency reaches the highest point resonance will occur and damage will probably happen at the weakest point.

RESULTS AND DISCUSSION

Mode Shape

Figure-1 shows the mode shape of total deformation with 6 modes applied.

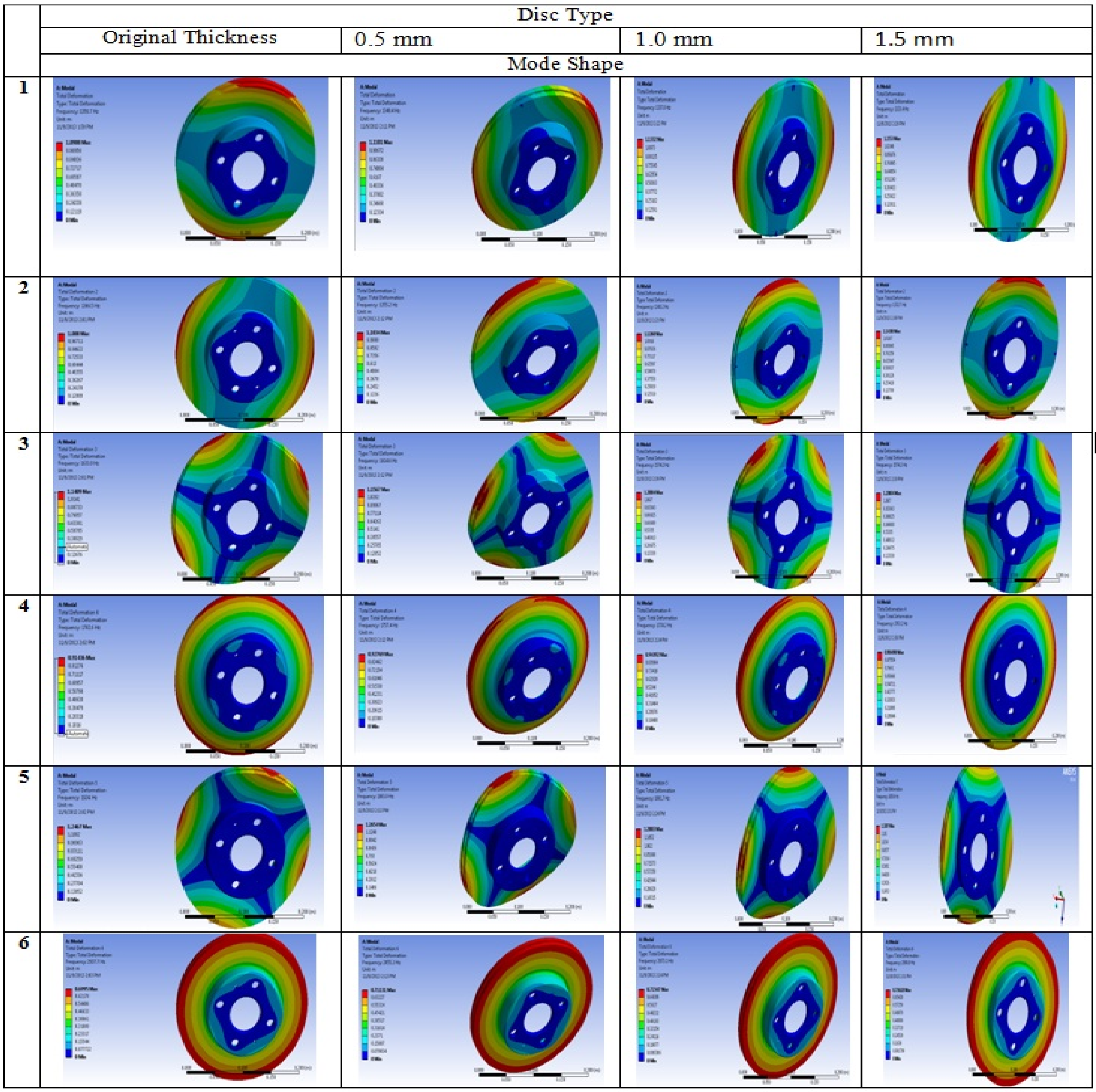

Figure-1. Type of deformation of each mode.

Table-1: Isotropic elasticity for grey cast ion.

Young's Modulus (Pa)	Poisson's Ratio	Bulk Modulus (Pa)	Shear Modulus (Pa)	Young's Modulus (Pa)
1.35e+011	0.29	1.0714e+011	5.2326e+010	1.35e+011

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Table-2: Properties of the disc brake rotor.

Disc brake reduction type (mm)	Original thickness	0.5	1.0	1.5
Mass(Kg)	4.0593	3.9402	3.8211	3.702
Volume(m^3)	5.6379e-004	5.4725e004	5.3071e-004	5.1417e-004

Comparison between Modes Shapes

Figure-2 shows the results of natural frequency from each type of the disc brake rotor surface thickness that were recorded and the results are shown in Table-3. The results are taken from 24 types of mode shapes from the simulation. The graph shows the comparison between 4 types of surface thickness reductions. For every thickness reduction the frequency was increased in each shape mode. The mode shape 6 shows that the frequency produced is higher. At the same mode shape, the highest reduction mass becomes the lowest value of frequency and the highest mass becomes the higher value of the frequency. This is due to the effect of inertia force. The mode shape 6 shows that the frequency was maximum: it is predicted that the instabilities are due to the repetitions of force applied to the rotor area.

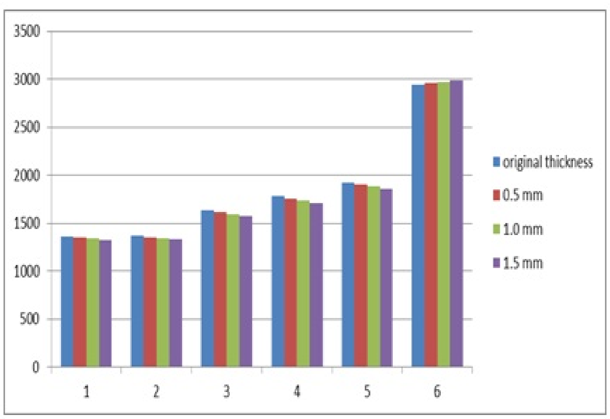

Figure-2. Natural frequency and thickness reduction for different mode shape.

Table-3 shows the result of natural frequency which was applied to the rotor with reduction on original thickness, 0.5 mm, 1.0 mm and 1.5 mm. It is consisted by 6 modes. For each mode with normal until thickness reduction to 1.5 mm the trend of frequency decreased except for the mode 6 with 1.5 mm reduction of thickness.

CONCLUSIONS

This paper shows the result and discussion on disc brakes with respect to the natural frequency simulation by ANSYS. Based on the results, the reduction of the thickness will be effected on the frequency. The result shows that at the same mode shape the higher reduction of mass becomes the lowest value of frequency. It is suggested that this is due to effect of inertia force. The last mode shape shows that the natural frequency was maximum as predicted due to the instabilities arising from the repetitions of force applied to the rotor area. The results confirmed that more studies are needed to determine the beneficial and cost effective applications of the brake disc system.

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Table-3: Natural frequency for each type of disc reduction.

Disc	Original thickness	0.5 mm	1.0 mm	1.5 mm
Mode		Frequency (Hz)		
1.	1359.7	1349.4	1337.8	1323.4
2.	1366.5	1355.2	1342.2	1332.7
3.	1633.9	1614.6	1594.9	1574.2
4.	1782.6	1757.4	1730.2	1703.2
5.	1924	1903.8	1881.7	1859.8
6.	2937.7	2955.3	2973.1	2990.9

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