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Structure Analysis of Cast Iron for Dry Clutch of Amphibious Vehicle

Muhammad Zahir Bin Hassan[1], Muhammad Fahmi Bin Md Isa[2], Muhamaad Razil Razali[3], Muhammad Zaidan Abdul Manaf[4]

[1]*Center of Advanced Research and Energy (CARE), Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka.*

Abstract— **This paper investigates the structure analysis of cast iron for dry clutch disc of amphibious vehicle. The main focus that needs to be considered is the torque produced from the engine. Optimum parameters must be justified in order to confirm the clutch disc is high durability, high reliability, and minimum in weight. Finite element analysis is use to predict the maximum stress can be apply to the disc. The fabrication process is conduct using a conventional milling machine.**

Keywords— **cast iron clutch disc, finite element analysis.**

I. Introduction

In automobile industry, brake play as important role as one of the main component to the vehicle Disc brake is one of the types of brake that used a squealing technique as a friction to slower or stopping the vehicle depend on circumstance. The disc braking system consists of many parts such as friction pad, master cylinder, wheel cylinder and hydraulic control system [1]. A clutch disc defines as mechanical device that transmit a torque from one to another mechanism and typically is connect to the driven mechanism.

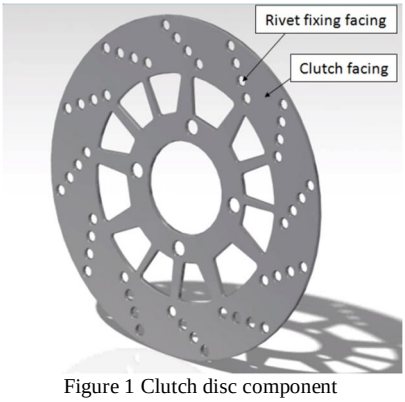

Figure 1 Clutch disc component

Clutch disc is design so it can be grip tightly by pad lining in the calliper. Clutch disc can be divided into two components such as, clutch facing and rivet fixing facing as shown in the Figure 1.

II. Determine Parameter

The capabilities of braking system performance were depend on its design. The design process of clutch disc includes several of steps before the product was fabricated. Some of the parameter needs to be determine in the design process of clutch disc such as diameter of clutch disc, axial force acting on the clutch, translational displacement deformation of clutch and the maximum load that clutch can withstand.

There are also several criteria need to be considering in designing a clutch disc such as:

i. Material selection
ii. Sizing
iii. Ventilation system
iv. Configuration

Material selection and sizing criteria are main parameter need to be considered. Other than that assumption has been made:

i. The applied pressure to the disc is uniform.
ii. Disc is completely been contact.

This assumption is made to determine the maximum stress can be applied to the selection material clutch disc. In addition it helps to determine the parameter of clutch disc such as optimum diameter in finite element analysis.

A. Justifying Maximum Torque Transmitted

This process is to determine the minimum requirement of the clutch disc diameter based on

the automotive application. Clutch disc diameter is be justified by assume:

i. Pressure applied are uniformly
ii. Factor of safety (FOS) is 1.5
iii. Lining pad material is woven asbestos.
iv. Coefficient of friction is set to f = 0.15
v. Maximum pressure applied onto clutch, P_{max}= 682kPa

Once model will be created using CAD software, the final diameter of the clutch disc is decided as described in Table I.

TABLE I
Clutch disc geometrical properties

Properties	Value
Inner radius clutch disc r_i	58 mm
Outer radius clutch disc r_o	220mm

Using

$$T = \pi P_{max} r_i f (r_i^2 - r_o^2) N \quad (1)$$

where:

T = Torque transmit, Nm
P_{max} = maximum pressure applied onto clutch, Pa
f = coefficient of friction
r_i = radius inner
r_o = radius outer
N = number of friction surface

B. Justifying Axial Force

Axial force is force that exert on perpendicular to the surface as shown in Figure 2. For this design, the axial force was representing as calliper that exert on the surface of the clutch. Therefore calculation must be made to be used in finite element analysis.

To calculate the axial force, equation (2) is used

$$F_a = \frac{1}{2}\pi P_{max} D_i (D_o - D_i) \quad (2)$$

where:

D_0 = Outer Diameter
D_i = Inner Diameter

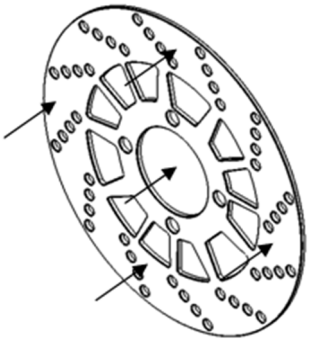

Figure 2 Direction of Axial force of clutch facing.

Hence, the result for maximum allowable torque and axial force is show in Table II.

TABLE II
Clutch disc geometrical properties

Properties	Value
Maximum value of torque T	59.43 Nm
Axial Force F_a	10067.0811 N

C. Finite Element Analysis

For a rotational motion, structure analysis is conducted in static case by using computer aided design (CAD) software ANSYS version 14.0. The properties of cast iron clutch disc used for the present analysis are shown in the Table III.

TABLE III
Properties of cast iron clutch disc.

Properties	Value
Young modulus	1.1×10^{11} Nm^{-2}
Poisson ratio	0.28
Density	7200 kgm^{-3}
Thermal expansion	1.1×10^{-5} K.deg
Tensile ultimate Strength	2.4×10^{8} Nm^{-2}
Compressive ultimate strength	8.24×10^{8} Nm^{-2}

The cast iron material was applied to the model followed by meshing the model as shown in Figure 3. Boundary condition was set by clamping at the static region. The applied moment was set in axial direction with magnitude 59.43 Nm.

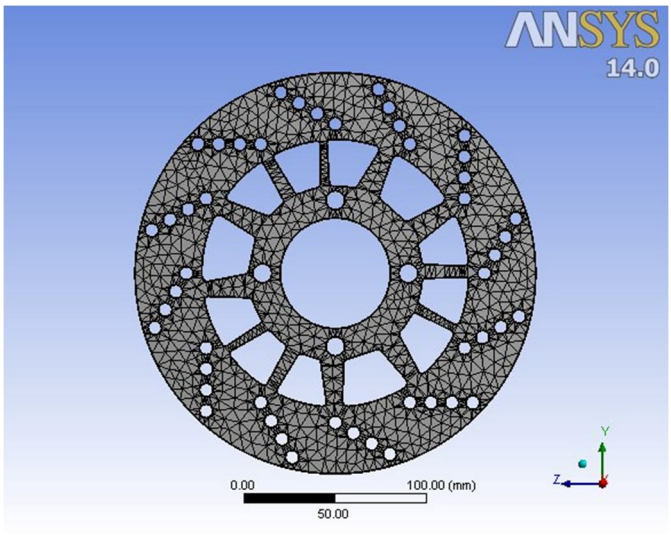

Fig. 3 Meshing model.

The result in finite element analysis was determined and the total deformation is shown in Figure 4. The maximum total deformation is $1.0377x10^{-5}$ mm. Since the gap between clutch disc and pad lining is greater than maximum total deformation. Thus, it is acceptable.

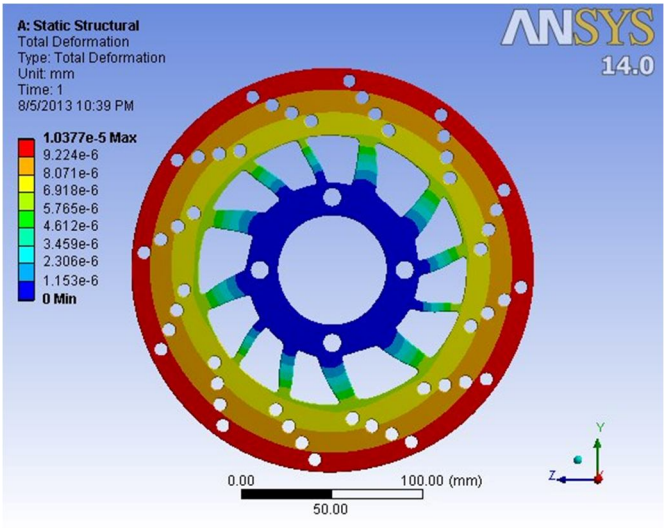

Fig. 4 Total deformation of clutch facing.

The maximum von misses stress is 0.034286 MPa and the minimum von misses stress is $5.24x10^{-6}$ MPa. Both of these results were shown in Figure 5. It shows that the maximum stress will be exert on the four hole that mounted to the wheel hub. Since the result maximum Von-mises stress from finite element analysis is greater than the yield strength of the cast iron, there will be a wear and tear in long period.

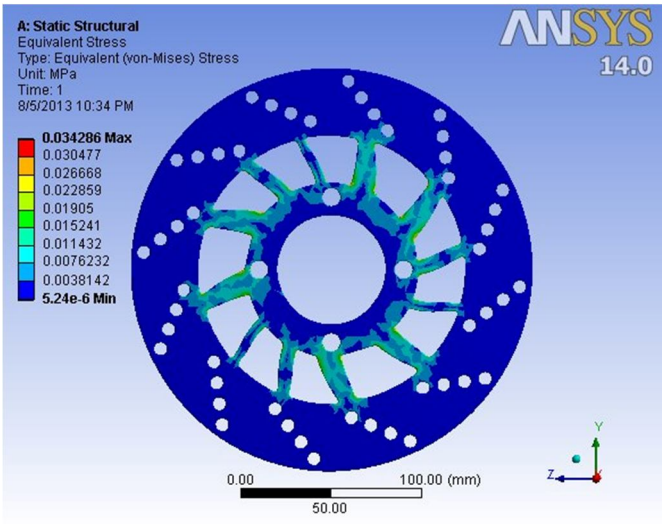

Fig. 5 Von-mises stress of clutch facing.

III. FABRICATION PROCESS

Fabrication process was conducted after the finite element analysis using conventional milling machine as shown in Figure 6. The subject was clamp tightly so there is no slipping during drilling process. In these process four holes was drilled on the clutch disc carefully with tolerance ±0.001mm. These four holes will be used as mounted for clutch disc to the wheel hub in the experimental analysis.

Fig. 6 Conventional milling machine.

IV. CONCLUSIONS

This paper explains about the structure analysis of cast iron clutch disc. The clutch disc will be test in amphibious vehicle for experimental analysis to determine its durability. The result of this paper will be used for the future study in automotive application.

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