APPLICATION OF FINITE ELEMENT METHOD TO ANALYZE DEFORMATION AND STRESS OF THE FRICTION CLUTCH STRUCTURE

ỨNG DỤNG PHÂN TÍCH PHẦN TỬ HỮU HẠN ĐỂ PHÂN TÍCH BIẾN DẠNG VÀ ỨNG SUẤT CỦA LY HỢP MA SÁT

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ABSTRACT

The car gearbox is driven by the friction clutch. The flywheel acts on the friction clutch plate. Therefore, in order for the friction clutch to work stably, the material used to manufacture the friction clutch must be selected appropriately. The friction clutch model is designed using Solidworks software. The deformation (De) and stress (St) of the friction clutch dics are determined by the finite element analysis method in ANSYS. The simulation results indicated that when increases pressor from 0.15 MPa to 0.25 MPa, the De and St increases from 0.06 mm to 0.1 mm and 38.82 MPa and 66.365 MPa, respectively. The deformation has significantly changed while the stress remains almost unchanged when change materials copper, cast iron and stainless steel SS 304, respectively.

Keywords: *The friction clutch; Deformation of friction clutch; Stress of friction clutch; Finite element analysis.*

TÓM TẮT

Hộp số ô tô được dẫn động bởi bộ ly hợp ma sát. Bánh đà tác động lên đĩa ly hợp ma sát. Do đó, để bộ ly hợp ma sát hoạt động ổn định, vật liệu dùng để chế tạo bộ ly hợp ma sát phải được lựa chọn phù hợp. Mô hình ly hợp ma sát được thiết kế bằng phần mềm Solidworks. Biến dạng (De) và ứng suất (St) của đĩa ly hợp ma sát được xác định bằng phương pháp phân tích phần tử hữu hạn trong ANSYS. Kết quả mô phỏng chỉ ra rằng khi tăng áp suất từ 0,15 MPa đến 0,25 MPa, De và St tăng từ 0,06 mm đến 0,1 mm và 38,82 MPa và 66,365 MPa. Biến dạng đã thay đổi đáng kể trong khi ứng suất hầu như không đổi khi thay đổi vật liệu lần lượt là đồng, gang và thép không gỉ SS 304.

Từ khóa: *Ly hợp ma sát; Biến dạng của ly hợp ma sát; Ứng suất của ly hợp ma sát; Phân tích phần tử hữu hạn.*

1. INTRODUCTION

High durability is required when working of the friction clutch disc, because the disc is always subjected to centrifugal force, compressive load with high pressure. The friction clutch disc is always worn and damaged because the friction clutch disc always works in a high pressure and temperature environment. To meet those requirements, the manufacturing of friction clutch discs requires the selection of suitable materials This problem is a challenge for researchers. Kevlar 49 material was confirmed to perform better than gray cast iron by finite element analysis [1]. The static analysis in ANSYS was utilized to determined the De and St of the single-disc clutch model [2]. A theoretical calculation method and 2D drawings [3] were applied to designed a single clutch disc. The friction clutch discs are analyzed and compared with different materials as Cast iron, alloy steel, and copper by Solidworks software. In addition, ceramic materials are also used to manufacture the friction clutch dics. The influence of the dimension of the clutch on the stress and deformation were determined by finite element in ANSYS [4]. The En – Gjs-400 -15steel was selected to supplant the gray cast iron [5]. The steel materials (En – Gjs-400 -15steel) was used to make friction clutch discs which are more durable than gray cast iron material. Because the finite element analysis results obtained lower stresses. The suggessed 3D model of the friction clutch discs is created to reduce weight 205 g to 225.1 g [6] and 204.8 g to 312.9 g obtained lower stress when the model was analyzed by the finite element analysis in ANSYS. The different radiator groove shapes were designed for the friction clutch dics to analyzed heat. The Hino MB clutch disc models [7] was designed by Solidworks to Analyzed the stress and deformation by finite element analysis. The results of the finite element analysis indicated that the stress of the proposed model with a groove length of 35 mm obtained 12.1 MPa.

In this investigation, the De and the St of the studying model were analyzed by finite element model in ANSYS with the materials as structural steel, copper, cast iron and inox SS304 and input pressure is equal to 0.15 MPa, 0.2 MPa and 0.25 MPa. The remainder of this work consists of methodology for designing the clutch model as presented in section 2. Section 3 is the model of finite elements in ANSYS, section 4 is the results and discussions, and the final section is referenced.

2. THE FRICTION CLUTCH

The 3D model is built based on the friction clutch of the FORD passenger car and the article with the following parameters:

Torque (T) = 330 N.m at 4100 rpm; Number of contact surfaces (n) = 2; The outside diameter and the inside diameter of the clutch D_o = 260 mm and D_i = 150 mm, respectively. The pressor [8] impact on the clutch disc is equal to 0.15 MPa to 0.25 MPa.

Table 1. Material parameters

Materials	Coefficient of Friction	Density [kg/m³]	Poisson's Ratio	Yuong's modulus [GPa]	Tensile Yield Strength [MPa]
Copper [9]	0.28	8300	0.35	135	510
Cast Iron 4.5% C, ASTM A-48	0.21	7200	0.29	180	190
Inox SS 304	0.3	7900	0.3	200	520

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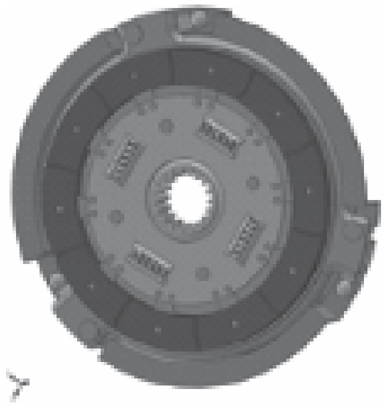


Figure 1. The disassemble model of the friction clutch

The friction clutch disc model was designed in Solidworks as presented as shown in assembly drawing Figure 1 and unassembly drawing Figure 2.

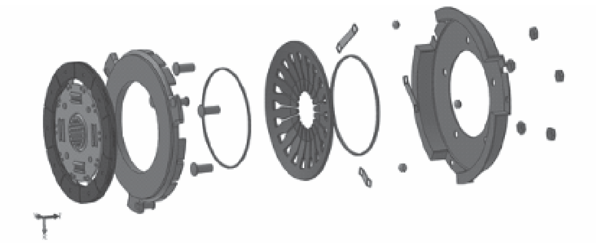
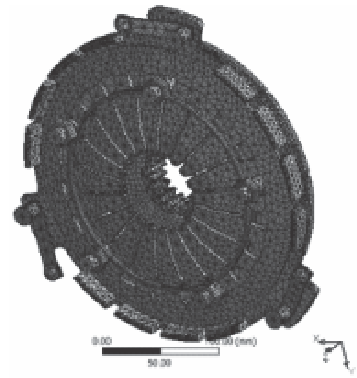


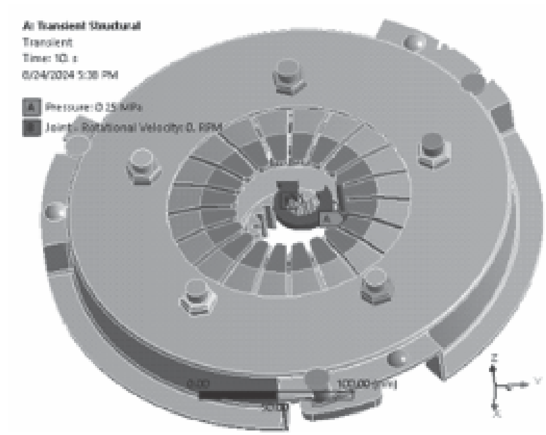
Figure 2. The disassemble model of the friction clutch

3. FINITE ELEMENT ANALYSIS IN ANSYS

The analysis static model in ANSYS was carried out as following: the first the material was selected for all part of the friction clutch by using structural steel, inox SS304, cast iron and copper. The parameters of the material were presented in Table 1. The friction clutch model was meshed by automation with 87415 tri angle elements and 206878 nodes as decpicted in Figure 3a. The revolute joint was set up with rotion velocity is equal to 0 rpm and pressor is equal to 0.15 MPa, 0.25 MPa and 0.25 MPa as presented in Figure 3b, respectively.



a)

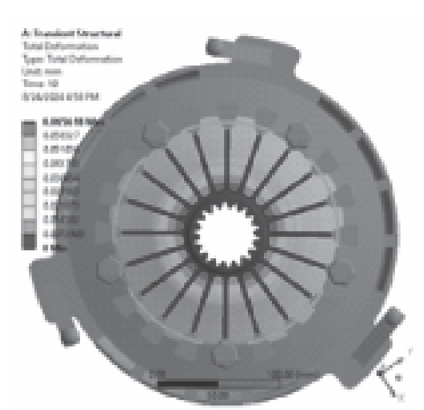


b)

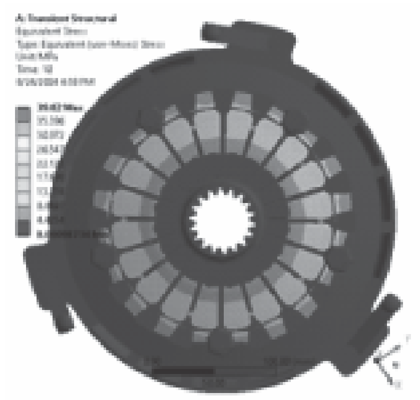
Figure 3. a) Divide mesh for the model, b) Set up condition for the model

4. RESULTS AND DISCUSSIONS

4.1. The analysis results with changed pressor



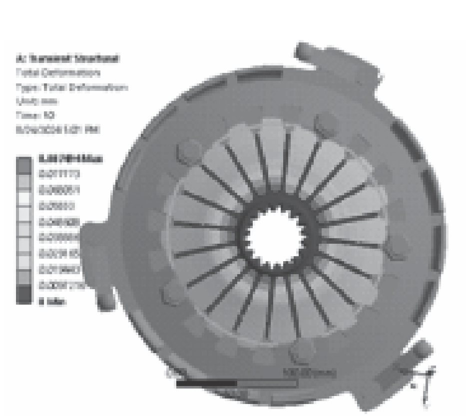
a) Deformation



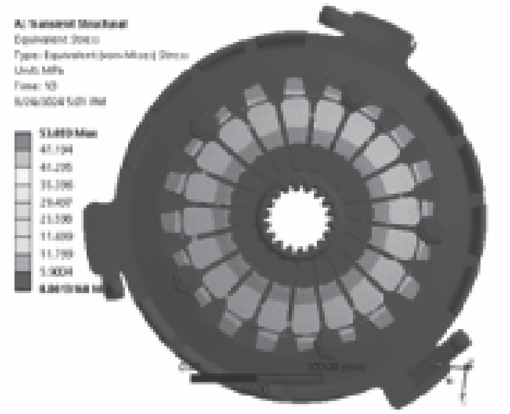
b) Stress

Figure 4. The FEA results with the input pressure is equal to 0.15 MPa

As presented in Figure 4, the deformation and stress obtaine 0.0656 mm and 39.82 MPa when input pressor is equal to 0.15 MPa. As presented in Figure 5, the deformation and stress obtaine 0.0874 mm and 53.093 MPa when input pressor is equal to 0.2 MPa. As presented in Figure 6, the deformation and stress obtaine 0.10937 mm and 66.365 MPa when input pressor is equal to 0.25 MPa. These results indicated that when pressor incresed from 0.15 MPa to 0.25 MPa the deformation and stress increased from 0.0656 mm to 0.10937 mm and 39.82 MPa to 66.365 MPa, respectively. These the obtained results are less than the obtained results in reference [2, 3, 7, 10].

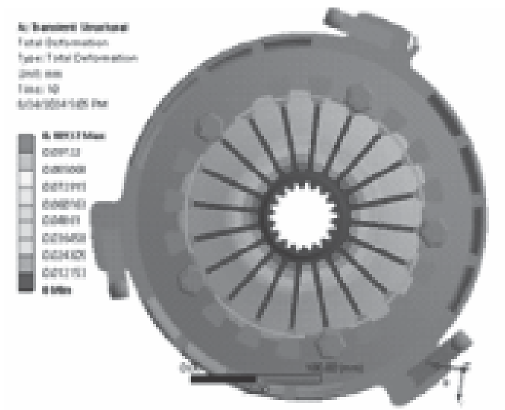


a) Deformation

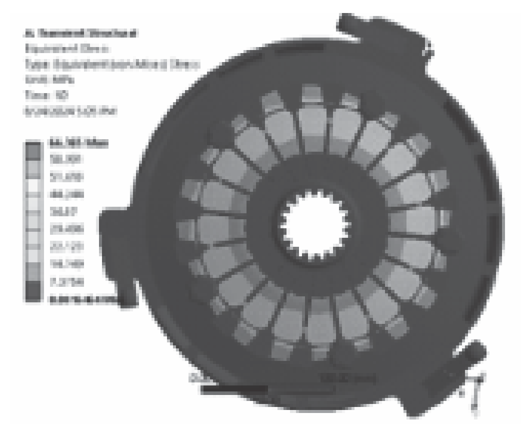


b) Stress

Figure 5. The FEA results with the input pressure is equal to 0.2 MPa



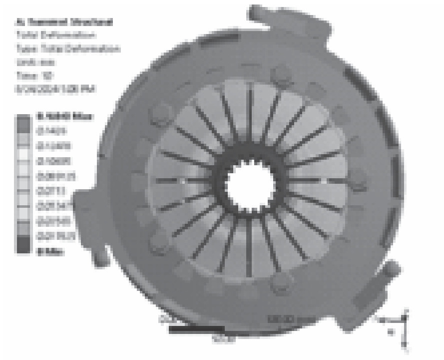
a) Deformation



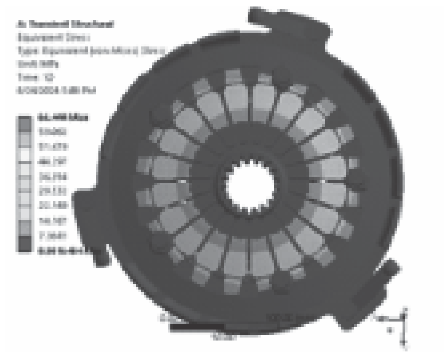
b) Stress

Figure 6. The FEA results with the input pressure is equal to 0.25 MPa

4.2. The analysis results with different materials



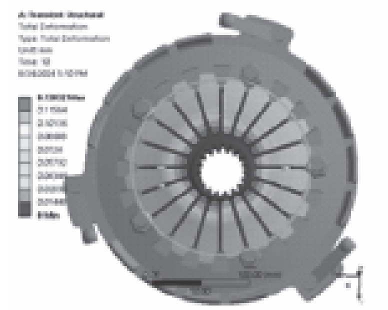
a) Deformation



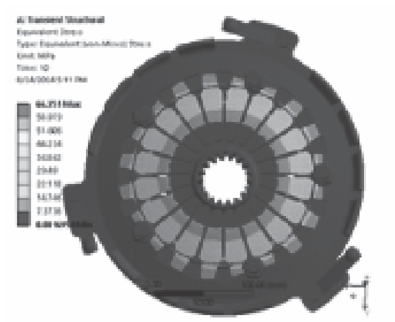
b) Stress

Figure 7. The FEA results with the material of the clutch is copper

As presented in Figure 7, the deformation and stress obtaine 0.16043 mm and 66.444 MPa when input pressure is equal to 0.25 MPa. As presented in Figure 8, the deformation and stress obtaine 0.13032 mm and 66.351 MPa when input pressure is equal to 0.25 MPa. As presented in Figure 6, the deformation and stress obtaine 0.10416 mm and 66.365 MPa when input pressure is equal to 0.25 MPa. These results indicated that when changed the different materials as Copper, cast iron and inox SS304 the deformation decreases from 0.16043 mm to 0.10937 mm while the stress is almost constant. These the obtained results are less than the obtained results in reference [2, 3, 7, 10].

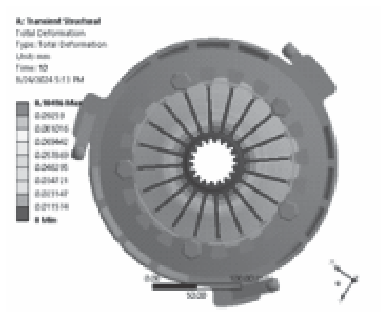


a) Deformation

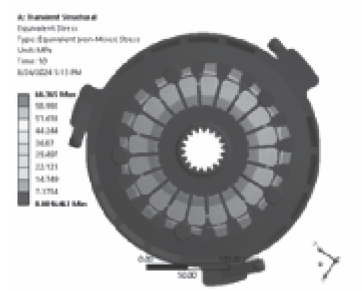


b) Stress

Fiugre 8. The FEA results with the material of the clutch is Cast iron



a) Deformation



b) Stress

Figure 9. The FEA results with the material of the clutch is SS 304

5. CONCLUSIONS

In this investigation, the friction clutch was designed by Solidworks. The deformation and stress of the studying model obtained by the finite element analysis in ANSYS. These results indicated that when pressor incresed from 0.15 MPa to 0.25 MPa the deformation and stress increased from 0.0656 mm to 0.10937 mm and 39.82 MPa to 66.365 MPa, respectively. When changed the different materials as Copper, cast iron and inox SS304 the deformation decreases from 0.16043 mm to 0.10937 mm while the stress is almost constant. In this research, the structure of the friction clutch model has not been optimized yet and the experimental model has not been carried out yet. The theoretical finite element model has not been carried out yet. These issues will be carried out in the future.❖

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