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NUMERICAL ANALYSIS OF STRENGTH OF REAR BRAKE HOLDER FLAT ON THE MOTOR CYCLE DUE TO IMPACT LOAD

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Abstrak

Rem adalah salah satu peralatan vital sepeda motor yang berfungsi sebagai mekanisme pengurang kecepatan. Bagian ini diperkuat dengan plat penahan yang berfungsi untuk memberi keseimbangan ketika proses pengereman berlangsung. Penelitian terhadap kekuatan plat tersebut masih jarang dijumpai. Distribusi tegangan yang terjadi pada plat akibat beban kejut tidak diketahui. Oleh karena itu, pada studi ini bertujuan untuk mendapatkan kekuatan plat panahan dengan menggunakan analisa numerik terhadap distribusi tegangan dan deformasi yang terjadi pada plat. Penelitian dikerjakan dengan dua cara, yaitu secara eksperimental dan simulasi numerik. Secara eksperimental, pengukuran langsung pada besaran tegangan yang terjadi pada plat. Penelitian ini dikerjakan dengan meletakkan alat strain gage pada hubungan plat dan rem. Pada simulasi, dengan menggunakan software MSC. Nastran berdasarkan data-data primer hasil pengukuran secara eksperimental. Berdasarkan hasil analisa nunmerik terhadap distribusi tegangan yang terjadi diperoleh bahwa distribusi tegangan maksimum terjadi disekitar yang kontak langsung dengan rem. Oleh karena itu, pengendara sepeda motor harus berhati-hati pada bagian ini dan mempersiapkan struktur penguat tambahan pada plat penahan rem belakang tersebut.

Kata Kunci: Analisa Numerik, MSC. Nastran, Plat Penahan

Abstract

Brake is one of vital motorcycle element, which serves as a speed reduction mechanism. This section reinforced with retaining plate which serves to hold the wheels when braking process occurs. Research on the plate strength is still rarely found. Stress distribution that occurs on the plate due to shock loads is also not well known. Therefore, this study aims to obtain the strength retaining plate with a numerical analysis of the distribution of stress and deformation which occur on plate. Research done in two ways, experimentally and numerical simulations. Experimentally, direct measurements on the amount of stress that occurs on the plate. The research was done by putting strain gage on the connection plate and brake. In simulation, using Nastran software with the primary data based on the results of the experimental measurements. Based on the results of the numerical analysis of the stress distribution that occurs is obtained that the maximum stress distributed around the staging area in direct contact with the brake. Therefore, motorists should be aware that section and provide additional anchoring structure to further strengthen the structure of the retaining plate rear brake.

Keywords*: MSC. NASTRAN, Numerical Analysis, Retaining Plate*

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INTRODUCTION

Motorcycles are the most widely used vehicles by the general public because of the ease of use, relatively cheap, easy maintenance, and fuel consumption is relatively quite economical than other types of transport vehicles (Chen, Chen, & Lin, 2018). In addition, this tool can reach locations that are quite difficult to reach by car with a narrow road width. One of the most vital parts of the motorcycle is the speed-reducing section that makes it easy for the rider to control its speed.

The speed reduction section consists of several component parts, namely: friction plate, brake mechanism, and retaining plate at motorcycle brake housing (Ginzburg, Evtiukov, Brylev, & Volkov, 2017). This plate serves to maintain the balance of the motorcycle when the braking process occurs. The shape and position of this tool on the motorcycle is shown in Figures 1 and 2.

This tool is made of medium carbon steel which is formed into sheet plate form used as other automotive components (Cox & Mutel, 2018). This type of steel has a good enough resistance to the impact load.

Figure 1. The location of the brake retaining plate on the back of the motorcycle

Figure 2. Retaining plate against impact load on motorcycle brake house

Current technological developments of materials make a significant contribution in the manufacture of these tools. The use of carbon steel with the following carbon composition: 0.05% - 0.20% C is generally used for the manufacture of automobile body equipments, buildings, pipes, chains, rivets, screws, and nails. While the carbon composition between 0.20% - 0.30% is generally used for the manufacture of gears, shafts, bolts, forgings, bridges, and buildings (Chen, Rana, Haldar, & Ray, 2017).

Steel is a metal whose main components are composed of iron elements, while carbon serves as the main alloy material. Carbon steel is one of the most common metallic carbon alloys, in which the percentage content of carbon weighs up to 2.11%. The carbon steel has a C content of up to 1.2%, Mn 0.30% -0.95%, Si 0.60%, and Cu 0.60% (Chen, Rana, Haldar, & Ray, 2017).

Carbon is a chemical element with an atomic number 6 and an oxidation rate of 4.2, whereas Manganese is a chemical element with an atomic number 25 and an oxidation rate of 7.6423. Carbon and Manganese are the main ingredients to raise the strength of pure steel (Hu, Luo, Yang, & Dong, 2017). Carbon is the major chemical component that determines the properties of steel, where the higher the carbon content in the steel, the higher the tensile strength and the melting stress of the steel, but the expansion coefficient of material decreases and the steel gets brittle. Carbon also has a major influence on the properties of material welding. The higher the carbon content will degrade the properties of welding materials.

The Finite Element Method (FEM) is a method that aims to derive problem solving of complex techniques through the approach of partial differential equations (PDE). Although the embryo of FEM theory has existed since the 1940s, but only in the 1970s this method formulated formally. Initially this method is used in the field of aviation engineering for the calculation of the strength of aircraft structures. But today, FEM has been applied in a variety of engineering issues, such as structures, fluid dynamics, heat transfer, acoustics, and electromagnetics (Kalikate, Patil, & Sawant, 2018).

FEM uses integral completion to generate algebraic equation systems and uses partial continuous functions to detect unknown quantities or some quantities. In general there are five basic steps in FEM, namely: (1) Discriminating areas that include the placement of nodal points, numbering of nodal points, and determining their coordinates; (2) Determining the degree or order of linear or quadratic approximation equations, (3) Creation of the equation of nodal function, (4) Rearrange the equations, and (5) Complete equations simultaneously (Cao & Huang, 2018).

Calculation of quantity solved is the quantity of stress components and others. The equation in FEM in general is (Ma, Wu, Chu, & Zhu, 2018):

$$[\,k\,]\,\{\,u\,\} = \{\,F\,\} \tag{1}$$

Where: [k] = Stiffness matrix, {u} = The column vector with the matrix component is the nodal value, and {F} = The force acting on the node.

In practice, for more complex and complicated cases, the FEM solution requires a FEM software calculation tool. In this research the software used is MSC. Nastran.

MSC NASTRAN is a software developed in the United States by National Aeronautics and Space Administration (NASA) (Sairajan, Aglietti, & Mani, 2015). This software is a finite element analysis program for stress, vibration, and heat transfer analysis of mechanical structures and components. In this software there are two main programs, namely: (1) Pre / post processor called Femap. Femap functions to model, validate, and see the results of finite element analysis, and (2) the program / code of the finite element / numerical oriented element method which functions to analyze the desired model, so that it can result according to the type of analysis.

Process analysis with MSC. NASTRAN consists of three processes, namely: (1) Pre-processing is the activity of making geometry. This process can be done using CAD software, such as AutoCAD, CATIA, etc. Step (2) Meshing can be made with various methods, namely Generate between, Generate region, on geometry, Boundary mesh and transition, and step (3) Post-processing is the process of analyzing the geometry.

The purpose of this study is to obtain the distribution of stress that occurs on the retaining plate of motorcycle brake house due to impact load with MSC Nastran numerical simulation software. The distribution of these stresses shows the strength of materials and construction. The results obtained will be used to design a better retaining plate shape in the future.

RESEARCH METHODOLOGY

Modeling of motorcycle brake retaining plate is done by using AutoCAD version 2007 software and converted to 2002 version. It aims to ease in making object images in 3D. The result of modeling with this autocad software is exported to MSC Nastran program so that all objects can be discretized. The 3D object shape represented by the AutoCAD software is shown in Figure 3, whereas the object form that has been exported to MSC Nastran is shown in Figure 4.

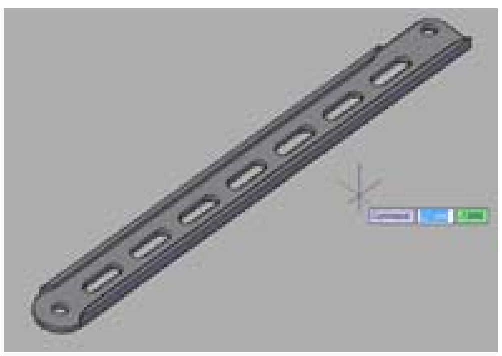

Figure 3. 3D Model in Autocad format

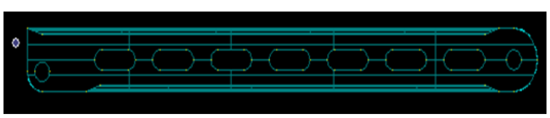

Figure 4. 3D Model in MSC Nastran format

The material used in this research is from SI Carbon Steel material with mechanical and thermal properties are shown in tables 1 and 2, respectively.

Tabel 1. Mechanical properties of SI Carbon Steel.

Mechanical Properties	**Value**	**Unit**
Young Modulus (E)	1.999 E+11	N/m^2
Shear Modulus (G)	7.5842 E+10	N/m^2
Poisson's Ratio (nu)	0.32	-

Tabel 2. Thermal properties of SI Carbon Steel

Thermal Properties	**Value**	**Unit**
Expansion Coeff (a)	1.05 E-5	m^2
Conductivity (k)	0	kg/m^3
Specific Heat (cp)	0	K
Heat Geneion Factor	0	K

The retaining plate experiences a load of 2 kN derived from a motorcycle weight of about 1 kN and a rider's weight (assumed to be 2 persons). As a result of this load, the brake retaining plate of the motorcycle experiences an axial force that causes tensile forces on the plate.

Steps to create brake retaining images with AutoCAD software are: (1) Open AutoCAD program, (2) Create rectangle @ 340,32, (3) Click fillet, make radius 10 on left corner and radius 16 at right corner, (4)) Click circle, make a diameter of 10 on both ends of the rectangle that is already in the fillet, (5) Create rectangle @ 28,10, difilet with radius 5, (6) Place middle rectangle @ 340,32, (7) Copy to the right and left and right respectively three ractangles with a distance of 12, (8) Union of all objects to be transformed into 3D, (9) Objects extruded by thickness 6, and (10) Circle and rectangle in the hole by subtract.

Making an image of the object model is done by downgrading AutoCAD 2008 version to version 2002. After that format AutoCAD version 2002 is converted to MSC Nastran software by using import file facility. The steps are as follows: (1) Open the modeling in the Auto CAD application, (2) Select File menu → click export, (3) In the dialog box select Acis file type → Save. Select object, (4) Open MSC Nastran software, (5) Select File menu → click import, (6) Select exported file, and (7) Select open, then dialog box will be shown in figure 5. Select Geometry menu - Click Boundary Surface, it will appear the boundary surface dialog box and then click select All → Ok.

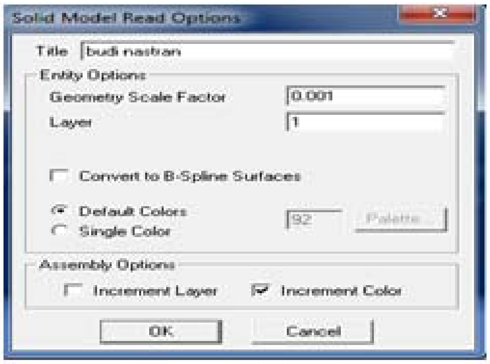

Figure 5. Import model settings

The material selection for the model is by selecting Model → Material, in the dialog box type "Material". Click the Load button so that the Select from Library dialog box appears. Select Carbon Steel SI material → OK → click OK, as shown in figure 6.

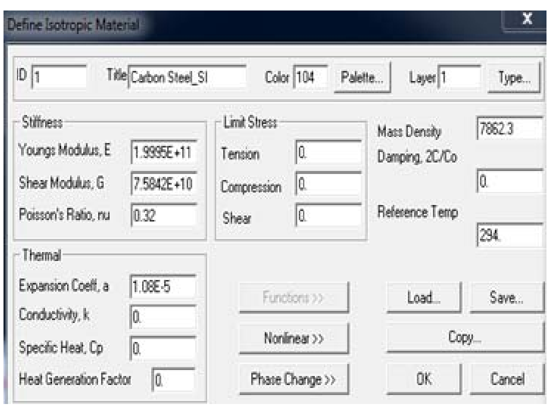

Figure 6. Material properties

RESULT AND DISCUSSION

The nodal displacements occurring in each of the simulated nodes are shown in Fig. 7. Based on these results can be seen the displacement on each nodal and elements in the object can lead to deflection in the model. Nodal displacement occurs between deflection angles along the brake support rods. This occurs because of the magnitude of the axial tensile force on the brake retaining plate that goes beyond the capacity of the material's ability to withstand a given load.

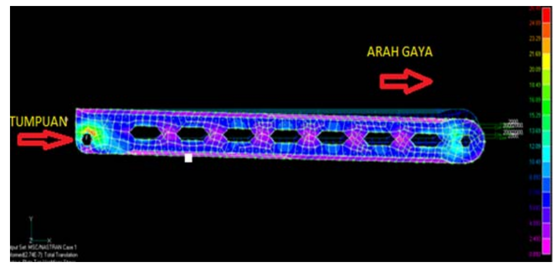

Figure 7. Nodal displacements

The stress distribution that occurs on each node in the plate is based on the result of numerical simulation shown in Fig. 8.

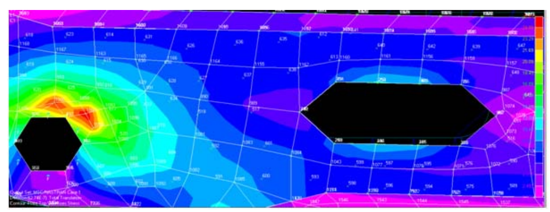

Figure 8. Stress distribution on the plate

Based on the results of numerical simulation shows that the voltage on the brake motorcycle brake plate that occurs on each element has a voltage that varies according to the concentration of load that occurs. This is due to the axial force at the end of the plate due to the braking force that occurs. However, the greatest force occurs in the connection of the retaining plate with the brake housing.

CONCLUSION

Based on the results of numerical simulation analysis, seen from the voltage distribution that occurs, it can be obtained that the maximum voltage is distributed around the connection area between the retaining plate and the brake housing. Likewise, the greatest nodal deformation occurs in the area of the connection and indicates a deflection in the retaining plate. These results can predict the likelihood of damage occurring in the connection area or the bolt bond between the retaining plate and the brake housing. Therefore, motorcyclists should be aware of these parts and provide additional retaining structures to increase the strength of the brake plate structure. For the future, the motorcycle manufacturer needs to redesign the better brake retention plate form so that the strength and security of the structure is guaranteed.

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