CATHA SAINTIFICA: Journal of Creativity and Innovation Technology
Vol. 2, No. 1, 2024, pp. 51-59
ISSN: 3031-8211, DOI: 10.32699/cathasaintifica.v2i1.7580

DESIGN OPTIMIZATION FOR MAXIMUM EFFICIENCY AND PERFORMANCE

Hamdan Ramadan[1], Syahrul Maulana Rozaki[2]
[1,2]Mechanical Engineering, Faculty of Engineering and Computer Science, Universitas Sains Al-Qur'an, Indonesia

Article Info

Article history :

Received July 12th, 2024
Accepted Agustus 13th, 2024
Published September 1th, 2024

Keywords :

clutch,
cult calculation,
clutch carrier

ABSTRACT

A clutch is a mechanical component used to connect two shaft together in power transmission system. The main function of a clutch in a transmission system is to transmit power from one shaft to another while adjusting the difference in speed or position between the two. This study aims to calculate the critical parameters of the clutch, such as torque, normal pressure, contact area, required force, and centrifugal force on the clutch shoes. This study produces a normal pressure force of Q = 65.99 kg With a force F that is smaller than the maximum allowable force of 24.67 kg and At a minimum rotation of n = 1500 rpm, the centrifugal force generated is F = 626.23 N with a vertical force in the y direction of F = 313.11 N. While at maximum rotation the centrifugal force increases sharp, namely F = 22184.1 N, with a vertical force in the y direction of F = 11092.05 N. The calculation results show that this clutch design is safe to use by meeting all the parameters that have been set. The impact of this research provides increased energy efficiency, system performance and component life, which supports operational cost savings and reduced emissions. In addition, this research encourages technological innovation, development of local industry, and positive contributions to the environment and society.

Corresponding Author :
Ramadan Hamdan
Mechanical Engineering, Faculty of Engineering and Computer Science, Universitas Sains Al-Qur'an
hamdanramadan0322@gmail.com

1. INTRODUCTION

A clutch is a mechanical component used to connect two shafts together in a power transmission system (Kusuma, 2019). The clutch and its operating components are part of the power transmission system in a vehicle (Agus & Rubai, 2019). Clutch The main function of a clutch is to transmit power from one shaft to another while compensating for slight misalignments. In clutch design, the calculation of parameters such as torsional moment, normal compression force, contact area, and centrifugal force is essential to ensure safe and efficient operation (Nu'man, 2023). This study uses data from clutch calculations to analyze and confirm the safety of the design.

Therefore, initially, the engine must be able to rotate first, then slowly transmit power to the rear wheels so that the vehicle can move slowly. In addition, the engine must also be in an idle state (not connected) if the transmission does not want to shift. Therefore, it is necessary to install a clutch between the engine and the gearbox which functions to connect and release the engine rotation (Budiyanto, 2015).

The clutch also serves as a protector for the transmission system. When there is a sudden difference in speed between the engine and the rear wheels, the clutch will "slip" to prevent damage to other components. This is very important to maintain the performance and durability of the transmission system. The clutch helps create a smooth movement when changing gears when the car is driven. This allows for smooth and smooth gear changes, which are very important for driving comfort and efficiency.

Clutches can be grouped according to how they work and the number of plates they have. Common types of clutches are magnetic clutches, friction clutches, and fluid clutches (Paridawati, 2013). Magnetic clutches work with the help of magnets, specifically magnetic fields. Friction clutches work by utilizing the frictional force between the components in contact. Fluid clutches work by using fluid as a medium to connect and disconnect the flow of power. In the mechanical world, there are several types of clutches used in mechanical systems, namely non-fixed clutches and fixed clutches (Pambudi et al. al., 2022). A variable clutch allows the power to be disconnected and connected to the shaft while the engine is still rotating. This type of clutch is usually used in mechanical circuits that need to stop at certain times but still allow the engine to run.

The working principle of the automatic clutch system is when the engine speed is low, the canvas and the plate remain separate so that the engine rotation from the crankshaft is not yet connected to the transmission and rear wheels (Pariwati, 2013). When the engine speed increases, the centrifugal force begins to work on the clutch weight so that the weight moves to press the clutch plate. This causes the canvas and clutch plate to close together, so that the engine rotation and crankshaft are connected to the transmission and forwarded to the rear wheels (Sutarna et et al., 2022). Centrifugal clutch, or often referred to as automatic clutch, has a significant influence on the engine rotation produced. To obtain great power without causing slippage on the centrifugal clutch shoe against the surface of the clutch canvas housing, high-quality canvas material is required and is sensitive to friction. One way to reduce this friction is to conduct experiments using various centrifugal clutch shoe mass models and utilizing centrifugal clutch shoe mass samples (Saimona et et al., 2016).

2. RESEARCH METHODS

The calculation is done based on the formula and parameters obtained from technical literature, especially the books " Sularso " and " Holman ". The input data used include power (P), revolutions per minute (n), friction coefficient (μ), and clutch dimensions. The calculation steps are as follows:

1. Allowable Torsional Moment (T)

   Torsional moment is a moment that occurs in a building when the structural resistance of the building elements is not symmetrical. In other words, torsional moment occurs when the forces acting on the building elements are not evenly distributed.

   With the formula:

$$T = \mu \, Q \times \frac{D_m}{2} \quad \text{(Sularso \& Sugara, 2014)} \tag{1}$$

- T = Torsional moment (kg mm)
- μ = Coefficient of friction
- Q = Normal pressure force on the contact surface (kg)
- D_m = Diameter of friction surface (mm)

Information :

Given: $T = \mu Q \text{ x } \frac{D_m}{2}$

$= 0.3 \text{ x } 65.99 \text{ x} \frac{28}{2}$

2. Normal pressure on the contact surface (Q)

$$Q = \frac{2T}{\mu .\ Dm}$$ (Sularso & Sugara, 2014)

Where : T = Torsional moment
D_m = Diameter of friction surface (mm)
μ = Coefficient of friction

3. Area Required (A)

$$A = \frac{Q}{(Pd)0{,}025}$$ (Sularso & Sugara, 2014)

Where :
Pd = Specific pressure (kg/mm²)

4. Required force (F)

$$F = \text{Q (sin } \theta + \text{Dad cos } \theta \text{)}$$

Where :
- Pa = Axial pressure (kg/mm^2)

5. Centrifugal Force on Clutch Shoes
Centripetal force is the force that causes centripetal acceleration. In general, this force makes an object move in a circle with centripetal acceleration that is directed towards the center of the circle.
- At Minimum RPM (1500 rpm):

$$Fc_1 = m \cdot \omega^2 \cdot R \quad (2)$$

- At Maximum Spin:

$$Fc_2 = m \cdot \omega^2 \cdot R \quad (3)$$

3. RESULTS AND DISCUSSION

Clutch calculation

The shaft used in this clutch will experience torsional and bending loads, but the largest is the torsional moment due to rotation, for that it is necessary to use a transmission shaft. The calculation of the strength of this shaft can be based on the torsional moment for the clutch shaft.

From this planning it can be seen:

Power (P) = 8.9 HP

n = 8000 rpm

a. Allowable torsional moment

Torsional moment is one of the most important indicators that can show the ability of a system to transmit force through friction. The basic equation for torsional moment is as follows:

$$T = \mu \, Q \times \frac{D_m}{2} \quad \text{………….. (Sularso page 74)} \qquad (4)$$

Where : T = Torsional moment (kg mm)

D_m = Diameter of friction surface (mm)

μ = Coefficient of friction

so D_m = $(D_1 + D_2)/4$

= (116+96)/4

= 28 mm

with $\theta = 15^{o,}$ $\mu = 0.3$, $Pa = 0.12$ kg/mm ^{2}

$$T = \mu \, Q \times \frac{D_m}{2}$$

$$= 0.3 \times 65.99 \times \frac{28}{2}$$

= 277.15 kg mm

Value of 277.15 kg mm produced shows that the planned torsional moment is sufficient to be used in transmitting power effectively and will not cause damage to the friction surface, but if supported by good materials and dimensions and meet the specifications (Sularso & Sugara, 2014) .

b. Normal pressure on the contact surface (Q)

Normal pressure (Q) is a force that works perpendicular to the friction surface, which functions to maintain the mechanical contact required when transferring power. The calculation of normal pressure can use the following equation:

$Q = 2T/(\mu D_m)$ …………..(Sularso page 74)

(5)

Where : T = Torsional moment (kg mm)

D_m = Diameter of friction surface (mm)

μ = Coefficient of friction

Then $Q = 2T/(\mu D_m)$

= 2 1034.87 / (1.12.28)

= 65.99 kg

The resulting Q value of 65.99 kg shows that the planned system is capable of maintaining a normal compressive force large enough to support the resulting torsional moment.

c. Required contact area (A)

The contact area (A) is needed to ensure that the resulting pressure distribution is even on the friction surface. The contact area can be calculated using the following equation:

$$A = \frac{Q}{0{,}025} \text{ …………..(Sularso page 74)} \quad (6)$$

$$= \frac{65{,}99}{0{,}025}$$

$$= 2639.6 \text{ mm}^2$$

$$b = \frac{A}{(\pi \times D_m)}$$

$$= \frac{2639{,}6}{(3{,}14 \times 28)}$$

$$= 30.02 \text{ mm} = 30 \text{ mm}$$

Where b= required width (mm)

From the calculation results, it can be seen that the required contact area width is 30 mm, the contact width is sufficient for pressure distribution to be evenly distributed on each friction surface. If the contact area is too small, the specific pressure will increase, this can cause premature wear on the friction surface (Sularso & Sugara, 2014).

d. Required force (F)

The force (*F*) on the friction surface can be calculated by considering the influence of the contact angle and also the amount of pressure on the friction surface. The amount of force required can be calculated using the following equation:

$F = Q (\sin \theta + Pa \cos \theta)$ …………..(Sularso page 74)

$= 65.99 (\sin 15^o + 0.12 \cos 15^o)$

$= 24.67$ kg

The resulting pressure force is smaller when compared to *Q*, which is 24.67 kg < 65.99 kg, the resulting condition indicates that the planned system is safe to use because the actual pressure force is smaller than the maximum capacity allowed. On the friction surface of steel and cast iron, an average diameter of 28 mm x contact width of 30 mm is used.

Clutch Shoes

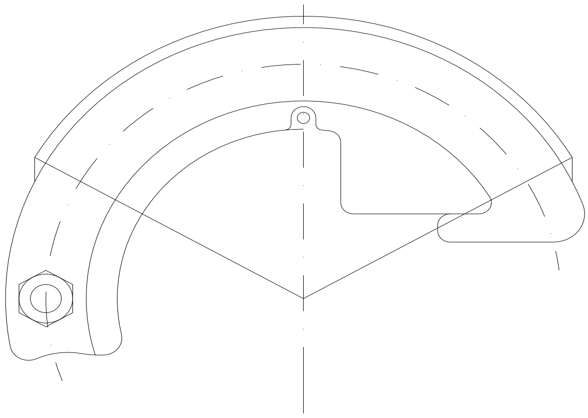

Figure 1. Clutch shoe

If known, P = 6.54 KW
N = 8000 rpm
T = 1034.87kg.mm

In calculating clutch shoes there are several assumptions, including:

- Clutch shoe mass = 0.25 kg
- Minimum clutch start rotation = 1500 rpm

The shoe material is made from lead (Pb) which has a density = 11.373 kg/mm ^{3} (Holman & Lloyd, nd.)

The friction material is a mold (paste) made of asbestos which has a friction coefficient of 0.1 (Sularso & Sugara, 2014) .

Asbestos density = 470 ÷ 570 kg/mm ^{2}

plate size is adjusted to the shoe size

a. Normal Pressure Force Caused By Rotation From Motor Power (N)

$$N = \frac{2 \cdot T}{\mu \cdot D} \quad \text{(Holman \& Lloyd, nd.)} \qquad (7)$$

Where :

T = 1034.87 kg.mm
μ = coefficient of friction of asbestos = 0.1
D = 200 mm

then $N = \frac{2 \cdot 1034{,}87}{0{,}1 \cdot 200}$ = 103.48 N

b. Clutch shoe surface area (A)

$$A = \frac{N}{P_d} \quad \text{(Sularso \& Sugara, 2014)} \qquad (8)$$

Where :

P_d =0.03 kg/mm^2

So:

$A = \frac{103{,}48}{0{,}03}$ = 3449.3 mm^2 (for 2 shoes)

So for 1 shoe:

$$A = \frac{3449,3}{2} = 1724.5 \text{ mm}^2$$

c. Clutch shoe width (b)

$$b = \frac{A}{\pi \cdot D \cdot 120/360} \quad \text{(Sularso \& Sugara, 2014)} \qquad (9)$$

$$= \frac{3449,3}{3,14 \cdot 200 \cdot 1/3}$$

$$= \frac{3449,3}{209,30} = 16.48 \text{ mm} = 16 \text{ mm}$$

d. Spring Force at Minimum Rotation (F_{cl})

The centrifugal force that occurs,

$F_{cl} = m.\ \omega^{2\cdot}\ R$

Where :

$R = 0.1$

$n = 1500$ rpm

So :

$$F_{cl} = \left(2 \cdot 3,14 \cdot \frac{1500}{60}\right)^2 \cdot 0,1$$

$$= 0.25\ (257)^2 \cdot 0.1$$

$F_{cl} = 626.23$ N

$F_{cly} = F_{cl} \cdot \sin \alpha_1 = 626.23 \cdot \sin 30° = 313.11$ N

e. Spring Force at Maximum Rotation (F_{c2})

The centrifugal force that occurs,

$F_{c2} = m.\ \omega^{2\cdot}\ R$

$$= 0.25\left(2 \cdot \pi \cdot \frac{n}{60}\right)^2 \cdot 0,1$$

$$= 0.25\left(2 \cdot 3,14 \cdot \frac{900}{60}\right)^2 \cdot 0,1$$

$= 22184.1$ N

$F_{c2y} = 22184.1 \cdot \sin 30° = 11092.05$ N

4. CONCLUSION

Based on the calculation results that have been carried out, it shows that the friction system must be designed using appropriate parameters to ensure that the designed tool can be efficient and safe to use. In this study, a torsional moment of T = 277.15 kg mm was produced, these results indicate that the ability of the designed system can transmit power effectively. With a normal force of *Q* = 65.00 kg, it can be said to be sufficient to maintain the stability of the contact surface without exceeding the capacity limit of the material used. The resulting contact area of *A* = 2639.6 mm ^{2,} with a contact width of 30 mm can provide an even pressure distribution so that it can prevent the machine from damage and premature wear on the friction surface. With a force *F* that is smaller than the maximum allowable force of 24.67 kg, it can be shown that the designed system is safe to use. At maximum rotation, the centrifugal force generated is still within tolerable limits. This design can be applied to transmission systems with predetermined parameters.

Based on the results of the calculation, the clutch system using lead clutch shoes and friction materials made of asbestos is designed to work optimally and maximally using the calculated parameters. The calculation produces a normal pressure force of *N* = 103.48 N, this force is sufficient to create effective contact between the clutch shoes. The resulting surface area is *A* = 1724.5 mm ^{2} for one shoe, while the width of the clutch shoe is calculated at *b* = 16 mm, which can provide an even pressure distribution on the contact surface. At a minimum rotation of *n* = 1500 rpm, the centrifugal force produced is *F* = 626.23 N with a vertical force in the y direction of *F* = 313.11 N. While at maximum rotation the centrifugal force increases sharply, namely *F* = 22184.1 N, with a vertical force in the y direction of *F* = 11092.05 N. These results can indicate that the designed clutch system can function well at maximum speed. Determining the type of material used also greatly determines the efficiency of the machine being designed, so the selection of materials and designs to be designed must be adjusted to the system and safety criteria that are appropriate and suitable for use.

ACKNOWLEDGEMENT

Thank you to all parties who have provided assistance, support and contributions in carrying out this research. Thank you to the UNSIQ center for intellectual property and technological innovation for the direction and guidance to improve the quality of this research for the better. Hopefully the results of this research can provide benefits for the development of science and society.

REFERENCES

Agus, A., & Rubai, M. B. (2019). Pengaruh Penggunaan Kampas Kopling Racing Daytona Terhadap Performa Mesin Sepeda Motor Honda Supra X 125. *Jurnal Kompetensi Teknik, 11*(2), 1–7.

Budiyanto, roto agus. (2015). *Pengoperasian Dan Perawatan Mesin Jangkar Untuk Mempermudah Proses Berlabuh Kapal-Kapal Negara Karimun Jawa Kabupaten Navigai Kelas Ii Semarang*. *36*(June), 5860.

Harefa, Pau K.S., dkk. (2024). Pengaruh Ukuran Baut Untuk Mengurangi Kegagalan Sambungan Pada Fleksibel Kopling Flange di Unit Thermal Oil Heater. *Jurnal Vokasi Teknik (JuVoTek)*, 2(2), 44-50.

Holman, J. P., & Lloyd, J. (n.d.). *Experimental M Ethods for Engineers*.

Kurniawan, Ari Dwi., Budiyono, & Imam Prasetyo. (2022). Pengaruh Penggunaan Kopling Motor Tossa 200 Pada Mesin Motor Honda Megapro Terhadap Daya Dan Torsi. *Jurnal Surya Teknika,* 5(2), 27-32.

Kusuma, E. W. (2019). *Prinsip Kerja Dan Trouble Shooting Kopling Mekanis Isuzu Panther Hi-Grade*.

Lesmana, Giyano, dkk. (2023). Analisis Penambahan Shim Pegas Kopling terhadap Akselerasi dan Top speed pada Sepeda Motor Yamaha V-Ixion. *JTPVI: Jurnal Teknologi dan Pendidikan Vokasi Indonesia*, 1(3), 433-443.

Marjal, Rio Iqbal, Junaidi, & Fadli A Kurniawan Nasution. 2024. Analisa Keausan Kampas Kopling Serat Serabut Kelapa Dengan Matrix Epoxy Resin. *Jurnal Mesil (Mesin Elektro Sipil),* 5(2), 23-32.

Nu'man, M. S. (2023). *Perancangan Mesin Penyangrai Kopi Kapasitas Satu Kilogram dengan Double Walled Drum*.

Nubly M. Harris, Hartono Yudo, & Kiryanto. (2017). Analisa Kekuatan *Coupling* pada Kapal Inspeksi Perikanan SKIPI Kelas ORCA Menggunakan Metode Elemen Hingga. *Jurnal Teknik Perkapalan*, 5(4), 671-677.

Pambudi, A. A., Santosa, A., Studi, P., Industri, T., Teknik, F., Singaperbangsa, U., & Flens, C. (2022). *Jurnal Ilmiah Wahana Pendidikan*. *8*(1). https://doi.org/10.5281/zenodo.5892468

Paridawati. (2013). Analisis Kopling Sepeda Motor Dengan Menggunakan Sistem Hidrolik. *Jurnal Ilmiah Teknik Mesin*, *1*(2), 77–85.

Rohadi, & Suwarto. (2022). Pembuatan Alat Peraga Kopling Hidrolik. *Jurnal MeKanik,* 15(2), 14-20.

Saimona, N., Widagdo, T., Seprianto, D., & Yunus, M. (2016). Optimasi kopling sentrifugal dengan variasi massa kampas kopling. *Jurnal Austenit*, *8*(April), 3–6.

Saimona, Natabaya, dkk. (2016). Optimasi Kopling Sentrifugal Dengan Variasi Massa Kampas Kopling. *Jurnal Austenit,* 8(1), 1-4.

Sularso, & Sugara, K. (2014). Dasar Perancangan Dan Pemilihan Elemen Mesin. In *Paper Knowledge. Toward a Media History of Documents*.

Sutarna, I Nyoman., dkk. (2022). Analisis modifikasi sistem kopling otomatis ke sistem kopling manual terhadap akselerasi sepeda motor Supra-X tahun 2014. *Jurnal of Applied Mechanical Engineering and Green Technology*, 3, 13-17.

Syahputra, Niko, Juanidi, & Yulfitra. (2023). Analisa Kerusakan Pada Sistem Kopling Mobil Toyota Rush Menggunakan Metode Uji Sem (Scanning Electron Microscope). *Jurnal Mesil (Mesin Elektro Sipil),* 4(1), 25-30.

Wajilan, Harsman Tandilittin, & muhammad Zuhri. (2023). Rancang Bangun Alat Peraga Kopling Hidrolik Untuk Menunjang Pbm Praktikum di Jurusan Teknik Mesin. *Jurnal MeKanik,* 16(1), 22-28.