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Case Study

Design of Hydraulic Operated Clutch on Typical Motorcycle

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Abstract

The mechanical operated clutch (threaded wire) on the motorcycle has been complained of having many disadvantages, including operational failure due to broken wire and heavy operating force. Therefore, this article reports the design of the hydraulic operated clutch mechanism on the Yamaha RX-King to replace mechanical systems. Modification is done by adding a master cylinder, fluid hose, release cylinder, and push rod. The calculation results show that the hydraulic operated clutch has the potential to reduce the operational force by up to 6 times of mechanical clutch.

Key words: Motorcycle, Mechanical clutch, Hydraulic clutch, Operating force

Abstrak

Kopling operasi mekanik (kawat ulir) pada sepeda motor telah dikeluhkan memiliki banyak kelemahan, termasuk kegagalan operasional karena kawat putus dan gaya pengoperasian yang berat. Oleh karena itu, artikel ini melaporkan perancangan mekanisme kopling operasi hidrolik pada Yamaha RX- King untuk menggantikan sistem mekanis. Modifikasi dilakukan dengan menambahkan master silinder, pemasangan selang fluida, silinder pembebas kopling, dan push rod. Hasil perhitungan menunjukkan bahwa kopling operasi hidrolik memiliki potensi untuk memperkecil gaya operasional hingga 6 kali dari gaya operasional untuk kopling mekanik.

Kata Kunci: Sepeda motor, Kopling mekanik, Kopling hidrolik, Gaya operasi

1. Introduction

The clutch mechanism is an essential part of motorized vehicles, even directly related to the comfort of the driver. Clutch is useful for power control from the crankshaft to the transmission systems. Without a clutch mechanism, gear shifting is difficult because the rotary power from the crankshaft is not interrupted [1]. On mechanical clutch, as shown in Figure 1, many cases of operational failure due to wire breaks and heavy operating forces [2].

Figure 1. Damage on mechanical clutch

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Symbol		
a	:	Gravity (9.8 m/s ^{2})
d	:	Spring wire diameter
D	:	Spring diameter (mm)
F	:	Force (N)
G	:	Shear modulus, $8x10^3$ (Kg/mm^2)
k	:	Spring constant (kg/mm)
m	:	Mass (kg)
n	:	Number of spring loops
Wt	:	Spring load (Kg)
δ	:	Deflection (mm)

The clutch mechanism on a motorcycle is generally driven mechanically by a handle that pulls the wire to move the clutch lever [3]. There are several weaknesses in the mechanical operated clutch, including friction between the wire and the sleeve, and there are also many cases of broken wire [4]. As a solution, there is the potential to replace the mechanical operated clutch with a hydraulic operated clutch [5]. With a hydraulic system, the friction loss in the wire is replaced by a fluid which has a smaller friction loss, or even none.

2. Method and Materials

2.1. Project Stages

This project consists of needs analysis, idea development, design, prototyping, and testing as presented in Figure 2.

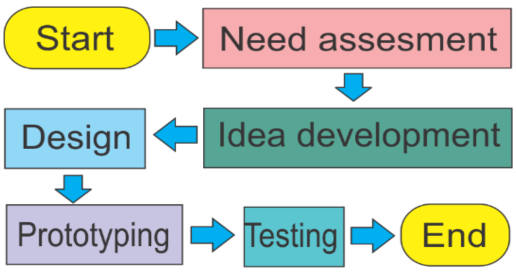

Figure 2. Project Stages

2.2. Main Parts

The hydraulic operated clutch developed consists of three main parts, namely: master cylinder, fluid hose, and release cylinder, as shown in Figure 3. The main component functions to operate the clutch parts shown in Figure 4.

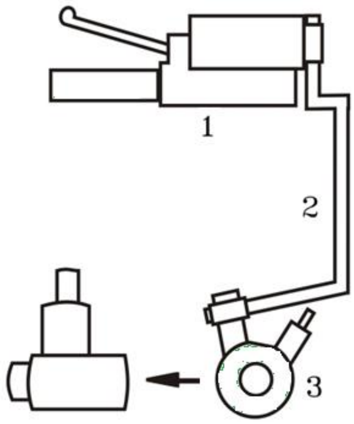

Figure 3. Main parts of the hydraulic clutch mechanism: (1) master cylinder, (2) fluid hose, and (3) release cylinder

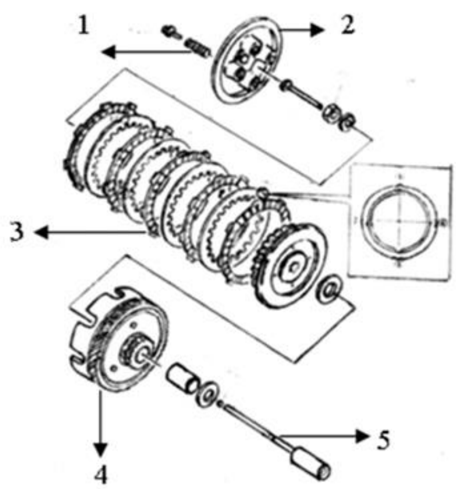

Figure 4. Parts of clutch mechanism: (1) Clutch spring, (2) Spring mount, (3) Clutch disc, (4) Clutch house (primary), and (5) Push rod [1]

The functions of each component as shown in Figure 3 are as follows:

- The clutch spring serves to return the clutch disc when the clutch is free.
- The spring mount functions to hold the position of the clutch spring so that it always stays in place.
- The disc clutch functions as a link between the primary and secondary clutch house.
- The push rod functions to free the clutch disc.

3. Result and Discussion

3.1. Master Cylinder Holder.

Master cylinder holder can make by iron which cut by 20 mm of diameter and 30 mm of length, respectively. Furthermore, the iron pipe is split into two parts, the end of which is holed by10 mm for bolt holder. Finally, another section of iron pipe is made into the master cylinder frame.

Iron plates with a 35 mm of length and 4 mm of thick are mounted parallel with a gap of 11 mm according to the thickness of the clutch lever that is connected to the end of iron plate. Both iron plates are made bolt holders with 10 mm bolt holder according to the size of the master holder. On the connecting iron plate, two iron plates are made with a 10 mm bolt thread as a clutch lever adjuster. The master cylinder holder and clutch lever holder are shown in Figure 5 and Figure 6.

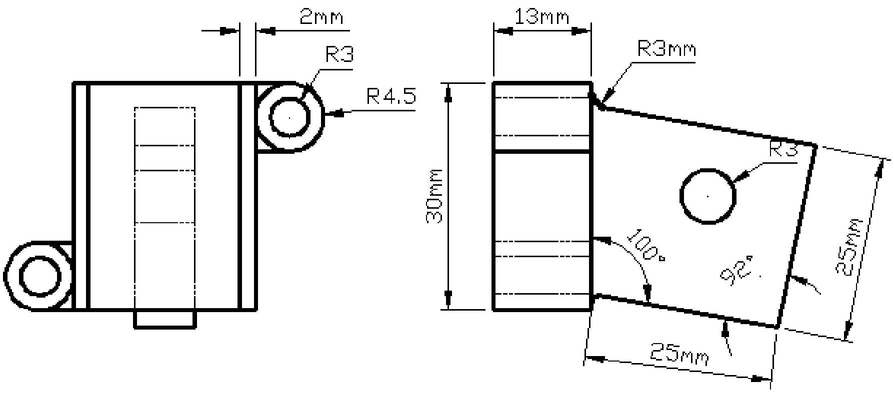

Figure 5. The master cylinder holder

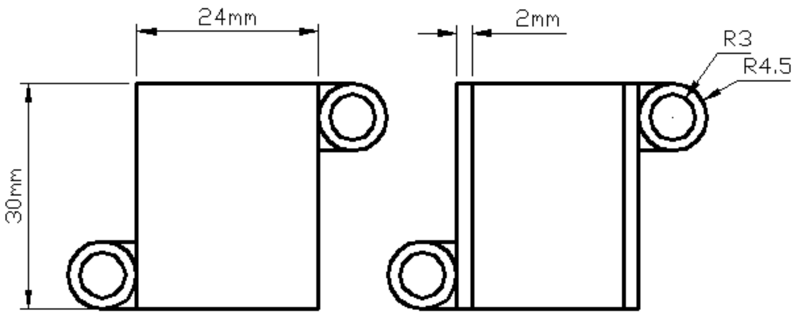

Figure 6. The clutch lever holder

3.2. Release Cylinder and Push Rod

The release cylinder is made by cutting the hydraulic brake cylinder and is adjusted to the Yamaha RX King engine cover, then welded. Next, make push rod anchors from solid iron with a diameter of 37 mm and a length of 8 mm, then make a 30 mm hole (Figure 7). Finally, make push rods from solid steel with an outer diameter of 10 mm for a length of 35 mm and an inner diameter of 4 mm for a length of 135 mm (Figure 8) and release cylinder holder as shown in Figure 9. Then, the hydraulic operated clutch set is presented in Figure 10.

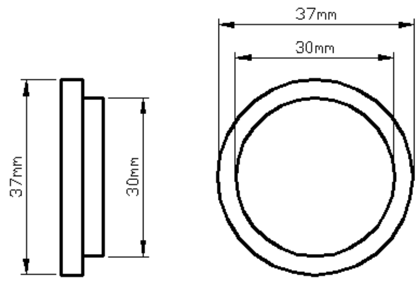

Figure 7. Push rod holder

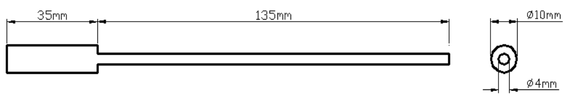

Figure 8. Pus rod

Figure 9. Release cylinder holder

When the clutch lever is pressed, the piston in the master cylinder will press the brake fluid, then push the piston on the release cylinder. The piston in the release cylinder will push the push rod and free the clutch. Conversely when the clutch lever is released, the spring on the clutch and the sil on the piston in the release cylinder will help restore the piston. Brake fluid will return to the reservoir at the master cylinder.

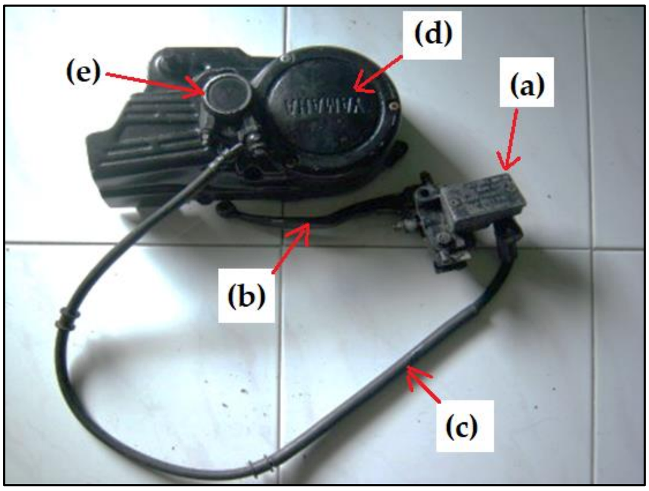

Figure 10. Hydraulic operated clutch set: (a) Master cylinder, (b) Handle, (c) Fluid hose, (d) Engine blok, and (e) Release cylinder

3.3. Force Calculation

The force that occurs in the clutch spring can be calculated using Equation (1) [6]–[8]:

$$Wt = k\delta \qquad (1)$$

Where, Wt = spring load (Kg), k = spring constant (kg/mm), and δ = deflection (mm). Then, the value of k is calculated by the formulation as presented in Equation (2).

$$k = \frac{Gd^4}{8nD^3} \qquad (2)$$

Where, G = Shear modulus, 8x10³ (Kg/mm²), d = spring wire diameter (1,8), n = number of spring loops (6), and D = spring diameter (15 mm).

With the data available, the value of k can be calculated.

$$k = \frac{(8x10)(1.8)^4}{8.6(15)^3} = 0.5184 \text{ kg/mm}$$

k = 0.5184 kg/mm

Then,

Wt = 0.5184 x 2 = 1.04 Kg

So, the force that occurs in the clutch spring (F) is:

$F = m \times a$ (3)

F = 4.16 Kg x 10 m/s²

F = 41.6 kgm/s²

Where, F = force, m = mass (kg), and a = gravity (9.8 m/s²). Because the number of springs is 4, the total Wt is:

Wt x 4 = 4.16 Kg

Thus, the force required for F_2 to suppress the clutch spring through hydraulics is 41.6 kgm/s² or equal to 41.6N [9]. To find F_1, the force needed to suppress fluid in the hydraulic system is as follows:

F_2 = Force on cross section two = 41.6 N

A_1 = Cross-sectional area 1 = 7 mm²

A_2 = Cross-sectional area 2 = 37 mm²

$$F_1 = \frac{F_2 \, x \, A_1}{A_2} \quad (4)$$

$$F_1 = \frac{41.6 \, x \, 7}{37} = 7.9 \; kgm/s^2 = 7.9 \text{ N}$$

The force required to press the clutch lever is as follows (see Figure 11 for illustration).

Base on Figure 10, *Fa* value can be found using formulation as follow [10].

Fa x 118 mm = *Fb* x 30 mm

Fa x 118 mm = 7.9 N x 30 mm

$$Fa = \frac{07.9Nx30mm}{118mm} = \frac{23.7Nmm}{118mm} = 2N$$

The results of this modification can be developed to provide more convenience to users with smart fluid applications, as reported by Olszak [11]. Furthermore, to increase comfort, automatic gear shifter that works electronically can be added. The driver can change the speed of the gear just by pressing the button installed on the motorcycle handlebar [12], [13].

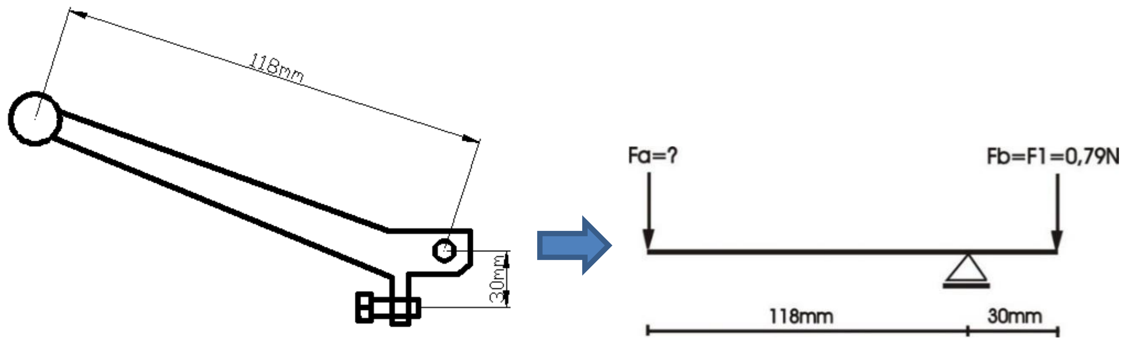

Figure 11. Force balance

4. Conclusion

The calculation results show that to press the clutch lever with a length of 118 mm, a force of 2N is required. The table of strength of the human arm shows that the magnitude of the tensile strength of the human left arm at an angle of 150° is 149.6N [9]. Thus it can be concluded that to press the clutch lever is still safe, because the force required is smaller than arm strength (2N <149.6N).

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