UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF HYDRAULIC POWER STEERING SYSTEM FOR STEERING TEST RIG

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

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ABSTRACT

The automotive hydraulic steering system has been a major concern to reduce efforts to steer the steering wheel and give comfort to the car driver. This research aims to design a new concept of the hydraulic power steering system, which carries a similar goal as the system in the conventional car which will be simulated on the steering test rig. The newly developed design simply targeted to improve the previous concepts to simulate the steering test and analyse its durability as well as cost-effectiveness. The criteria of the new innovation are low maintenance, reliable and safe so that the system affordable for the steering test rig. The study of criteria of the hydraulic power steering system is investigated in to predict the best choices for different component parts that will affect the performance of the hydraulic power steering in the test rig. For this project, the electric motor driving the pump will be the main core. The motor bracket has been selected to evaluate its strength under load stress. Next, design criteria and material selection are chosen by analysis. After that, CAD for structure is make in CATIA V5. For this stage the structure must tally with real motor part. Addition, for the analysis structure of motor bracket is test in Solid Thinking Aspire software. In there, stress, displacement magnitude, shear stress, von mises and safety factor being analyse. Result show the maximum and minimum value for all analysis test. In conclusion the material and structure can be evaluated in terms of the component to the fracture in the course of the test rig's life cycle.

ABSTRAK

Sistem stereng hidraulik automotif telah menjadi keutamaan utama untuk mengurangkan usaha untuk menggerakkan stereng dan memberi keselesaan kepada pemandu kereta. Penyelidikan ini bertujuan untuk merekabentuk konsep baru sistem stereng kuasa hidraulik, yang membawa matlamat yang sama seperti sistem dalam kereta konvensional yang akan disimulasikan pada pelantar ujian stereng. Reka bentuk yang baru dibangunkan hanya disasarkan untuk memperbaiki konsep sebelumnya untuk mensimulasikan ujian stereng dan menganalisis daya ketahanan serta keberkesanan kos.. Kriteria inovasi baru adalah penyelenggaraan yang rendah, boleh dipercayai dan selamat supaya sistem itu mampu dimiliki oleh alat uji stereng. Kajian kriteria sistem stereng kuasa hidraulik diselidiki untuk meramalkan pilihan terbaik untuk bahagian komponen yang berbeza yang akan mempengaruhi prestasi stereng kuasa hidraulik dalam pelantar ujian. Untuk projek ini, motor elektrik memandu pam akan menjadi teras utama. Tapak pemasangan motor telah dipilih untuk menilai kekuatannya di bawah tekanan beban. Seterusnya, kriteria reka bentuk dan pemilihan bahan dipilih berdasarkan analisis. Selepas itu, CAD untuk struktur dibuat di CATIA V5. Untuk tahap ini, struktur mesti dihitung dengan bahagian motor sebenar. Selain itu, untuk struktur analisis tapak pemasangan motor adalah ujian dalam perisian Solid Thinking Aspire. Di sana, tekanan, magnitud anjakan, tekanan ricih, von mises dan faktor keselamatan sedang dianalisis. Keputusan menunjukkan nilai maksimum dan minimum untuk semua ujian analisis. Kesimpulannya, bahan dan struktur dapat dinilai dari segi komponen hingga fraktur dalam perjalanan kitaran hidup rig test

DEDICATION

This work is dedicated to my beloved parents, Sharif Ibrahim and Fuziah Hat, my family , and friends whose supports and prayers over a long period of my studies have been end less. Thank you for giving me the best education

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LIST OF SYMBOLS

P	-	Power contribution
$V_{geom.}$	-	Geometrical Pump Capacity
n	-	Pump rev.
I	-	Moment of inertia
P	-	Pressure
W	-	Watt

LIST OF ABBREVIATIONS

HPS	Hydraulic Power Steering
EPS	Electric Power Steering
EHPS	Electro-Hydraulic Power Steering
SBW	Steer-By-Wire
SAE	Society of Automotive Engineers
PAS	Power Assist Steering
ECU	Electronic Control Unit
MPU	Motor Pump Unit
PRV	Pressure Relief Valve
ATF	Automatic Transmission Fluid
AC	Alternating Current
DC	Direct Current
PA	Polyamide

CHAPTER 1

INTRODUCTION

1.0 Background

The steering system is very important in the vehicle. The function of the steering system is the driver's initial interface with the vehicle, which the driver gets significant data about the condition of the vehicle of movement and street condition from the controlling torque accordingly from driver order inputs (Harrer and Pfeffer, 2016). A component of the steering system was the steering wheel, steering column, steering gear and tie rod (steering connection). (**Figure 1.1**).

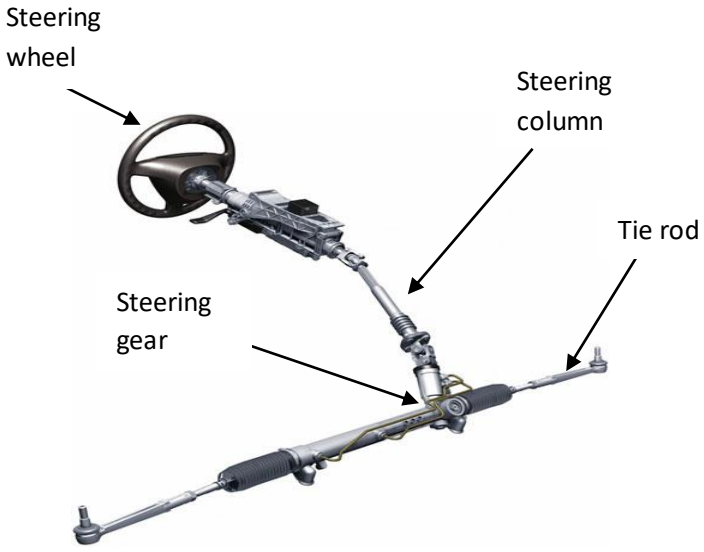

Figure 1.1: Basic structure of a steering component (Harrer and Pfeffer, 2016)

There are several kinds of steering system used on vehicles such as the rack and pinion steering system and the recirculating ball steering system. Nowadays, most commonly used on the vehicle is the rack and pinion steering system utilizing the power steering system. A gear that moves the rack side to side was turned by the steering shafts, and utilizing a power unit built directly onto the rack assembly. It gives less demanding mobility and a superior level of authority over the vehicle, which endeavours free. The new invention has been slowly replacing pure mechanical steering system which is hydraulic assisted power steering (HPS), electric power-assisted steering (EPS) and electro-hydraulic power assisted steering (EHPS). In the future technology, the steer-by-wire (SBW) steering system is the innovation that the steering wheel and the wheels on the road have no mechanical connections because it replaced by mechatronic system. The advantages SBW offers a fast and more precise steering response. Besides that, it will reduce maintenance costs, offer weight savings, and make designing autonomous cars a lot easier.

The steering system is very complex and in order to achieve certification before it passes to be used in vehicle manufacturing so steering system needs to be tested. There are two ways to test the steering system that are by conventional test or lab test. The conventional test runs by drive the vehicle and verifies the type and extent of the steering problem. Using software to runs many tests to gets better performance and comfortability in steering test. This process very important to get specify the level of safety, comfortless and reliability. This test should be handled by experience and product testing could resolve the issues in future developments.

1.1 Problem statement

A real car need a test to study its reliability and durability about hydraulic power steering system. The steering system needs to be tested to ensure the best performance evaluation of different types of steering systems for the passenger car segment to meet the user. Besides that, this test to ensure a quality and assurance steering working properly and gives driving comfortability. If your engine drive belt snaps while you were driving

and sudden loss of power steering, make terrifying because it is hard to turn the wheel without the hydraulic assistance of the power steering system. This is because an engine operated the hydraulic power steering pump. A real car is used to runs the steering test on the road. But it required an amount of time, cost and energy to get accurate data on testing the system. There is some variable should be considered when testing steering system that will affect the result. This test should be tested in a controlled environment with help from a test machine like in the lab. The steering system test should accordingly to the automotive standard. The motor electric motor will have replaced an engine to generate a pump to simulate power steering on the test rig. The hydraulic power system work and effectiveness on the test rig should explore by using a new invention.

1.2 Objectives

The aims of this research are the following:

i. To understand the function and performance of the steering system.
ii. To design a hydraulic power steering system for a steering test rig.
iii. To analyze the mechanism and the strength of the critical parts of the hydraulic power steering system.

1.3 Scope

This is a group project and this project's main scope is:

i. Implement hydraulic steering system analyzes for steering test rig.
ii. Design of a hydraulic steering system for testing the steering system for passenger's cars.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Power steering or otherwise called power-assisted steering (PAS) enables drivers to steer by increasing the steering force of the steering wheel in cars. The drivers simply need to ensure that hydraulic or electrical actuators add controlled energy to the steering system. Besides that, power steering assistance significantly when a vehicle is ceased or moving gradually. In additions, PAS provides some response of force following up on the front wheels to give a progressing feeling of how the wheels are cooperating with the street. PAS for a vehicle increase with an actuator, a hydraulic cylinder part of the servo system and it has a mechanical connection between the steering wheel and the connection that controls the wheels. At the point when these system disappointments (to expand exertion) still allows the vehicle to be directed utilizing manual exertion alone. HPS, EPS and EHPS systems are the main types of PAS system. HPS systems are driving a pump with an engine belt which transports liquid to work a power cylinder piston. In EHPS systems, the hydraulic pump is driven by an electric motor and the speed of the pump is adjusted by an electrical controller to vary the pressure and flow of the pump. An electric motor is to drive the control rack through a gear mechanism directly in the EPS system. It not required pump or fluid and factors influence the energy saving is from independent of engine speed. **Table 2.1** presents an overview of significant qualities compared to other PAS systems.

Table 2.1: Steering systems and functions (Harrer and Pfeffer, 2016)

		HPS conventional	EPHS	EPS
Steering system classification		Passive	Semi active	Semi active
Steering wheel angle—tyre steer-angle		Solid	Solid	Solid
Steering wheel torque—assist torque		Solid	Variable	Variable
In the direction of assist torque		Unidirectional	Unidirectional	Bidirectional
Energy consumption and CO_2	Meeting demand and high efficiency	–	X	X
	Stop/start compatibility	–	X	X
	HEV, eV, compatibility FCV	–	X	X
Safety	Steering intervention and ESP (μ-split, oversteer)	–	–	X
	Lane departure warning	(X)	(X)	(X)
	Lane keeping assistant	–	–	(X)
Comfort	Speed-sensitive power assist	–	X	X
	Controlled parking	(X)	(X)	(X)
	(Semi-)automatic parking	–	–	(X)

X System immanent
(X) requires additional components (e.g. video system)

2.1 History

A man with Fitts ' nickname has obviously introduced the primary power steering system on a car in 1876 (Marc-André Gauthier, 2016). In 1903, the another power steering system was installed on a 5-ton Columbia truck. In April 1900, Robert E. Twyford, incorporated a mechanical power control instrument for the initial four-wheel drive system as a major aspect of his patent. Francis W. Davis, an engineer from Pierce-Arrow's truck division, began to investigate how steering could make the first practical power steering system simpler and in 1926 invented and demonstrated it, yet the automaker determined it would be too costly to even think about producing. During the Second World War, military needs to simplify the control of large vehicles supported the need for power assistance for defensively covered cars and tank recovery vehicles for the British and American armed forces. Chrysler Corporation presented the initial economically accessible vehicle control guidance in the name of "Hydraguide" in 1951. (Tony Rammer,