STATIC LOAD TEST FOR HYDRO-PNEUMATIC DRIVELINE PROPULSION SYSTEM

SHAIFUL MOHAMMED TASHMIN BIN HALIM

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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SHAIFUL MOHAMMED TASHMIN BIN HALIM

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in fulfilment of the requirements for the degree of
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DECLARATION

I declare that this project report entitled “Static load test for hydro-pneumatic driveline propulsion system” is the result of my research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature :.....

Name :.....

Date :.....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient regarding scope and quality as partial fulfilment of Bachelor Degree in Mechanical Engineering with Honours.

Signature :.....
Name of Supervisor :.....
Date :.....

DEDICATION

To my beloved family for the endless support they had gave, especially to my beloved mother and father, Rokiah Binti Abdullah and Halim Bin Joki.

Supervisor En. Faizil Bin Wasbari.

&

Dear friends

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ABSTRACT

The study emphasized the effect of static load on the performance of the hydropneumatic driveline propulsion system. Hydraulic hybrid vehicle (HHV) is a new technology being developed to enhance fuel economy for passenger vehicles. However, this system is still ranked under the research and development stage. Many things regarding the performance of this system are still unclear. Therefore, research related to the effects of the static load is carried out, which is focused on passenger vehicles. In this research, the functional circuit of the charging and propulsion have been designed and simulated by using Automation Studio software. Chassis dynamometer test has been conducted to obtain performance data of hydro-pneumatic driveline propulsion system with the load imposed. Through the project, it was found that the higher the load, the longer will be the running time due to the energy capacity effect. The maximum 88.6 s running time was recorded by 200 bar pressure and 10 Nm load. It was 31% higher compared to the minimum running time recorded by 2 Nm load. The higher torque at 200 bar was 63% greater than the lowest torque at load 2 Nm. However, there was an opposite effect on the RPM where the higher the given load, the slower the revolution of the wheel. The differential percentage is about 23% slower. Throughout this study, it was concluded that the value of running time under load condition, RPM and torque generated were reasonable, and this system is applicable. For future research, if this technology is to be adopted in the passenger car, the sizing of the accumulator must be taken into consideration so it can fit in the car.

ABSTRAK

Kajian ini memberi penekanan mengenai kesan beban statik terhadap prestasi sistem pendorong hibrid hidro-pneumatik. Kenderaan hibrid hidraulik (HHV) merupakan teknologi baru yang dibangunkan untuk menjimatkan penggunaan bahan bakar kenderaan penumpang. Bagaimanapun, sistem ini masih berada di peringkat penyelidikan dan pembangunan. Banyak perkara mengenai prestasi sistem yang masih belum jelas. Oleh itu, penyelidikan yang berkaitan dengan kesan beban statik dijalankan dan difokuskan pada kenderaan penumpang. Dalam kajian ini, litar fungsi pengisian dan pendorong telah direka dan disimulasi dengan menggunakan perisian Automation Studio. Ujian kerangka dynamometer pula telah dijalankan untuk mendapatkan data mengenai prestasi sistem pendorong hibrid hidro-pneumatik apabila beban dikenakan. Didapati bahawa semakin tinggi beban, semakin lama masa pergerakan roda yang disebabkan oleh kesan kapasiti tenaga. Masa pergerakkan maksimum 88.6 s dicatatkan oleh tekanan 200 bar dan beban 10 Nm. Ia adalah 31% lebih tinggi berbanding dengan masa pergerakkan minimum yang direkodkan oleh beban 2 Nm. Tork yang dihasilkan pada 200 bar – 10 Nm adalah 63% lebih tinggi daripada tork terendah pada beban 2 Nm. Walau bagaimanapun, terdapat kesan yang bertentangan di mana apabila beban yang lebih tinggi dikenakan, semakin perlahan revolusi roda. Peratusan perbezaan kesan ini adalah kira-kira 23% lebih perlahan. Sepanjang kajian ini, disimpulkan bahawa nilai masa pergerakkan di bawah keadaan beban, RPM dan tork yang dihasilkan adalah munasabah, dan sistem ini sesuai digunakan pada kenderaan penumpang berskala kecil. Untuk penyelidikan masa depan, jika teknologi ini diterima pakai, ukuran penumpuk mesti dipertimbangkan supaya ia boleh dimuatkan dalam kereta.

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LIST OF ABBREVIATIONS

DCV	Directional Control Valve
PRV	Pressure Relieve Valve
FCV	Flow Control Valve
HHV	Hydraulic Hybrid Vehicle
ICE	Internal Combustion Engine
MIG	Metal Inert Gases
CH_4	Methane
CO_2	Carbon Dioxide
NYC COMP	New York Composite
N_2	Nitrogen
PHEV	Parallel Hybrid Electric Vehicle
PHHV	Parallel Hydraulic Hybrid Vehicle
SHHV	Series Hydraulic Hybrid Vehicle
SUV	Sports Utility Vehicle
SOP	Standard Operating Procedure
MG	Motor Generator

LIST OF SYMBOLS

E = energy storage of the accumulator (Joule)

K_i = Correction factor

η_M = Mechanical efficiency

$\eta_{overall}$ = Overall efficiency

C = Displacement (m^3/rad)

η_v = Volumetric efficiency

Δp = Pressure different (N/m^2)

p_{gh} = Gas pressure (Pascal)

p_{op} = Pressure of the oil (Pascal)

p_{in} = Pump input pressure (N/m^2)

p_{out} = Pump output pressure (N/m^2)

P_P = Pump power (Watt)

P_S = Shaft power (Watt)

Q_i = Flow rate (m^3/s)

Q_{out} = Pump output flow rate (m^3/s)

Q_{out} = Pump output flow rate (m^3/s)

t_i = Filling time (s)

T = Torque (Nm)

LIST OF SYMBOLS

V_2 = Volume after compression (liter)

V_{gh} = Gas volume (m^3)

ΔV_{ideal} = Effective volume (liter)

ω = Nominal speed (rad/s)

CHAPTER 1

INTRODUCTION

1.1 Background

In this epoch of globalization, hybrid technology advancement has ended up become dominant in the automotive business. To enhance the performance of the vehicle, fuel consumption and greener technology, it was proven by the research and development. The new innovation of the hybrid vehicle types is a hydro-pneumatic hybrid. The combination of hydro-pneumatic hybrid car consists of two or more types of propulsion structure work in a vehicle. The concept of converting hydro-pneumatic into useful energy which reuse losses of energy in breaking. In this automotive field, the meaning of hybrid is a vehicle that has more than one propulsion system to get a motion on the vehicle. There are a many types of hybrid technology which are hybrid electric, hybrid flywheel, hydraulic and pneumatic hybrid. The hybrid technology is popular among the heavy truck, and it is still in a stage of research and development so that this concept can be applied to a passenger car (Wasbari, Anas and Abu Bakar, 2016). Hydro-pneumatic hybrid is a compounding of the internal combustion engine (ICE), the hydraulic system as propulsion and hydro-pneumatic accumulator as an energy source. However, the internal combustion engine consumes more fuel to operate and give small energy efficiency but high performance.

The increased performance of hybrid vehicles makes hybridization especially useful for city-town passenger cars, local delivery for small trucks and urban buses. When driven on highway, hybrid vehicles do not show a specific advance in fuel consumption (Transactions and Techniczne, 2016). Vehicles which are basically used on highway, downsized diesel engines are best equipped to get minimal fuel use of goods and services. The most prominent hybrid system is a hybrid renewable energy organization. However, based on the research and development stage, the innovation of another hybrid system is called hydro-pneumatic hybrid system. Hydro-pneumatic hybrid is the collaboration of the internal combustion engine, propulsion and pneumatic system which hydraulic system act as the energy source. There are four sub-systems of hydro-pneumatic driveline. First, for the hydro-pneumatic driveline, sub-organizations are driving the organization. It delivers energy from the energy storage to the actuator. The storage device that save energy propulsion called as the accumulator (Wasbari *et al.*, 2018). There are several reasons for considering the use of pneumatic systems over the hydraulic system, such as hydraulic liquid exhibit greater inertia than gases as weight of oil give problem when accelerating and decelerating actuators, hydraulic system requires special reservoirs and no leak system design, the pneumatic system use air that is exhaust directly back to the environment, pneumatic system is less expensive than hydraulic system and the hydraulic liquid exhibit greater viscosity than gas (Yavuz *et al.*, 2014).

During innovation of the automobile, the drastic change has been in the field of automobile testing. It supports in building technologies to make sure that the highest standards are met regarding reliability, safety, durability, and product quality. An engineer has been under scope pressure either to improve engine power or to increase the fuel

consumption. So it requires a way to test the power output and fuel economy of automobile engines, and continue the dynamometer for innovation. For this research, the focus point is on the field of hydro-pneumatic. One of the vital components of hydro-pneumatic driveline systems is the driving system. The effects of the system load on the performance of hydro-pneumatic drive-line were analyzed. The research will affect the use of Automation Studio tools to simulate the process and experiment. The outcome of this inquiry will lead to assumption, based on the system efficiency.

1.2 Problem Statement

Initial research has shown that the hydro-pneumatic hybrid system improved the fuel consumption and environmentally friendly, but there is no specific research about the detail drive subsystem of the car section. The crucial part in researching and developing new designs for the automotive industry is testing the powertrain of a vehicle. In this situation, it is a high requirement to further improvement the university's research capabilities by developing automotive research facilities. Besides, there is no previous study related to the performance of hydro pneumatic driveline in term of the test rig experiment.

Therefore, this research, focusing on the effects of the load system based on performance of hydro-pneumatic driveline will be carried out. The data of the experiment will be collected, and it can be referenced in future research. Therefore, experiment will be conducted and simulated via Automation Studio software.

1.3 Objectives

The objectives of the project are as follow:

1. To find the effect of static load to the system performance (running time, revolution speed (rpm), torque, power and velocity by load).
2. To calculate the system velocity (km/h).

1.4 Scope of Project

The main concern in this project is to design the structure of static load test of hydro-pneumatic driveline propulsion system by using Automation Studio software. Automation Studio software is a totally incorporated program package that enables users to create simulation which need to achieve the expected results. The latest version of hydraulic tools which are Automation Studio software v6.1 which implements for design, functional simulation of complex automation, preparation and documentation. It also contains hydraulic, pneumatic and electrical operative devices as well as a command part diagram. In this research, the static load system will apply on hydro pneumatic driveline propulsion test rig to collect new data as a future reference. To apply research on dynamic load is quite difficult because there is no specific apparatus to fulfill the experimental. Furthermore, there are no data from previous research, so it very tough for us to lead as the first researcher in this research. However, to ensure the experiment as work successful, a lot of steps will be planned by starting from designing, then continued by fabricating and collect all data based on the experiment.

1.5 Hypothesis

In this study, the effects of static load on the performance of hydro-pneumatic driveline will be proposed. To improve efficiency and performance, the effects of static load have been taken into consideration in the analysis of hydro-pneumatic driveline. At the end of this research, perhaps that the system should be able to outline the specific parameter to optimize the performance of the driveline system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The beginning of the project as it started, the literature review has been taken place as a references. The purpose of this operation is to search and collect more information and data required to make sure that the project goes greatly and successfully. Since data and knowledge are required throughout the evolution of this project, this process was very helpful continuously until this project accomplished. In this literature review, the structuring of the chapter includes an introduction to the hybrid system, loading of driveline system, propulsion system, type of load and innovation in driveline system which retrieved from previous studies in this area. Moreover, the important parts in this research are keeping the functionality of the system to be clearly. In a nutshell, a very important part of this research is by the theories, journal, internet, article, and thesis from past researched.

2.2 Hybrid System Background

Theoretically, hybrid system studies the behaviour of dynamical systems, technological systems, dynamical of hybrid systems comprises heterogeneous dynamics that interrelate with each other and investigate their behaviours over time. Systems containing two different forms of dynamics: time-driven continuous variable dynamics,