Ain Shams University

Faculty of Engineering

Mechanical Automotive Department

Investigation of Digital Hydraulic System Efficiency

A Thesis submitted in partial fulfillment of the requirements of the degree of Master of Science in Mechanical Engineering
(Automotive Engineering)

By

Essameldin Mohamed Abdelhafeez Elsaed

Bachelor of Science in Mechanical Engineering

(Automotive Engineering)

Faculty of Engineering, Ain Shams University, 2014

Supervised by

Prof. Nabil Abdel Aziz Mahmoud

Dr. Mohamed Ahmed Abdelaziz

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Eng. Essameldin Mohamed Abdelhafeez Elsaed

B.Sc. in Mechanical Engineering (Automotive)

Faculty of Engineering – Ain Shams University

EXAMINERS COMMITTEE

Prof. Ahmed Majed Ahmed Mohamed Osman …….

Mechanical Engineering Dept.
Faculty of Engineering in Shoubra
– Benha University

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Design and Production Engineering Dept.
Faculty of Engineering – Ain Shams University

Prof. Nabil Abdelaziz Mahmoud Youssef …….

Mechanical Power Engineering Dept.
Faculty of Engineering – Ain Shams University
(Supervisor)

Date:1/11/2018

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Mechanical Engineering (Automotive Engineering), Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Student Name

Essameldin Mohamed Abdelhafeez Elsaed

Signature

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Researcher Data

Name	: Essameldin Mohamed Elsaed
Date of birth	: 01/05/1991
Place of birth	: Cairo, Egypt
Last academic degree	: B.Sc.
Field of specialization	: Mechanical Engineering
University issued the degree	: Ain Shams University
Date of issued degree	: 2014
Current job	: Teaching Assistant at Faculty of Engineering - Ain Shams University

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List of Publications

Elsaed, E., M. Abdelaziz, and N.A. Mahmoud, Investigation of a digital valve system efficiency for metering-in speed control using MATLAB/Simulink., in International Conference on Hydraulics and Pneumatics-HERVEX-23rd edition. 2017: Băile Govora, Romania. p. 120-129.

Abstract

Energy efficiency has a prominent role in fluid power researches. One technique to improve the efficiency is through decreasing flow control losses, a unique way to do so is called Digital Hydraulic Valves (DHV), in which the output flow is the summation of smaller discrete values exhausted from parallel connected valves with common input and common output nodes. The valves configuration is based on the Pulse Code Modulation (PCM) control, although this scheme is characterized by small package size and low energy consumption, it faces challenges such as higher flow peaks more than the other coding schemes, and thus resulting in poor tracking accuracy. This dilemma manifests once a transition occurs between specific flow rates.

These problems can be solved by introducing a delay in the signal opening the following valve, subsequently giving the previous valve a sufficient time to ensure its closure and hence decreases the overlapping. The delayed signal samples feeding the feedforward Neural-Network controller is acquired through Genetic Algorithm. The controller role appears in regulating the speed of a hydraulic cylinder through controlling the Digital Flow Control Unit (DFCU) valves. The DFCU —placed in a metering-in circuit— has five on/off valves. The analysis has been executed with the aid of MATLAB Simscape Fluids.

The results indicated a dropping of 93% in energy consumption for DFCU when compared with a proportional valve. The results also show a good tracking accuracy, wherein some conditions, the error decreased by one third. On the other side, the system experiences low accuracy at higher acceleration demands and sudden loads; thus, it requires fast switching valves. However, the studied system succeeded in raising the accuracy slightly at these conditions.

In conclusion flow control via employing parallel connected on/off valves has witnessed an increase in accuracy and efficiency, however, a high switching with low response time valves are recommended.

Keywords: Digital valves, MATLAB Simscape, tracking control, digital hydraulics, pulse code modulation, pressure peaks, energy efficiency.

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