AIN-SHAMS UNIVERSITY
FACULTY OF ENGINEERING
DEPARTMENT OF AUTOMOTIVE

EFFECTS OF UTILIZING AN ELECTRO–HYDRAULIC SERVO VALVE ON THE HANDLING PERFORMANCE OF A THREE-WHEEL VEHICLE

A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science in Mechanical Engineering (Automotive)

Submitted by

Eng. Mostafa Tamer Mohamed Noaman Ahmed Nasr El-Din Mohamed Heshmat

B.Sc. in mechanical engineering (Aircraft), Military Technical College, 2000

Supervisors

Prof. Dr. M. Sabry Dwidar
Faculty of Engineering
Ain-Shams University

Prof. Dr. M. Galal Rabie
Modern Academy for
Engineering & Technology

Dr. Mohamed Ahmed Abdelaziz
Faculty of Engineering
Ain-Shams University

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ABSTRACT

This thesis is dedicated to investigate the dynamic behavior of a three-wheel vehicle during steering action. The vehicle is equipped with an electro-hydraulic steering system incorporating directional control valve assembly DCV. This valve consists of three DCVs in one housing. These valves are of 3/2 poppet type direct controlled by three DC solenoids. Moreover, a new steering system is proposed. The new system is based upon an electro-hydraulic servo valve EHSV. The dynamic behavior of both of the systems are compared and analyzed. The investigations are extended to cover the dynamic handling performance of the vehicle during road maneuvers.

The thesis contains a comprehensive summary of the available literature relevant to the subject of the study. The studied literature covered the dynamic behaviors of the three and four wheel vehicles which use hydraulic steering systems. The objective of the present study was determined on the basis of the literature review.

The thesis included a detailed description of all components of the electro-hydraulic steering system used to control the three-wheel vehicle in addition to the mechanical mechanisms constituting the system. The system includes three directional control valves to control the steering angle of the front wheel of the vehicle. Mathematical models have been deduced that describes the static and dynamic performance of the hydraulic system and the mechanisms that the steering system contains. The simulation programs have been developed based on the deduced mathematical models. The transient response of the system to step input were calculated, presented and discussed.

Experimental tests have been carried to measure the fluid flow characteristics through the directional control valves. The experimental results showed good agreement with the simulation results, which validate the simulation program in the steady state operating mode.

A new system was proposed by replacing the directional control valves assembly by an electro-hydraulic servo valve with PI controller. The describing mathematical model was deduced and a simulation program was developed for the proposed system. The transient response of the proposed system was calculated and compared with that of the original system.

The transient handling responses of the vehicle was examined when the steering system equipped with the DCV assembly and when equipped with the proposed EHSV.

The dynamic performance of the vehicle, controlled by the electro-hydraulic servo system, was investigated considering different values of the design and operating parameters. The transient response of the vehicle to diverse inputs was calculated using the simulation program, mainly the step input of the steering pedal, ramp input, sinusoidal input and movement represented by polynomial functions of the fifth order to simulate the input function movement satisfying smooth displacement, velocity and acceleration at the beginning and end of the pedal movement. The vehicle dynamics was studied during changing lane, double lane change, the case of road curvature follow up and the case of U-turn due to the steering pedal input, as well as, the case of subjecting the vehicle body to a side force due to wind.

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STATEMENT

This dissertation is submitted to Ain Shams University for the Degree of M.Sc. in Mechanical Engineering (Automotive).

The author has carried out the work included in this thesis at the Department of Automotive Engineering, Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other University or institute.

Date: ***10^{th} Feb. 2013***

Signature:

Name: ***M. T. Heshmat***

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