AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
DEPARTMENT OF AUTOMOTIVE ENGINEERING

BASES OF AUTOMATED ENGAGEMENT OF DRY FRICTION CLUTCH IN MOTOR VEHICLES

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN MECHANICAL ENGINEERING

BY

NABIL RAGHEB MOHAMMAD EL-NAGGAR

B.Sc. Mechanical engineering, 1968

Supervised by:

Dr. A.I. ABDEL-AZIZ
Prof. Assistant
Ain Shams University

Prof. Dr. T. A. NOSSEIR
Professor of Automotive Eng.
Ain Shams University

Cairo, November 1993

EXAMINERS COMMITTEE

Name, Title, and Affiliation. Signature:

1- Prof. Dr. Abdel-Dayem S. Sharara
Professor of Auto-Engineering,
Faculty of Engineering & Technology,
Helwan University.

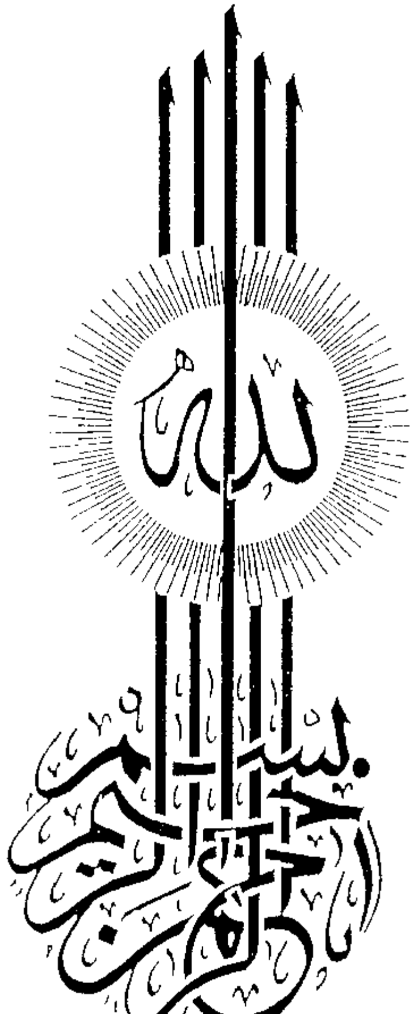
A S Sha

2- Prof. Dr. Mohammad M. El-Alaily
Professor of Auto- Engineering,
Faculty of Engineering,
Ain-Shams University.

M. M. El Alaily

3- Prof. Dr. Tayseir A. Nosseir
Professor of Auto-Engineering,
Faculty of Engineering,
Ain-Shams University.

T. Nosseir


بسم الله الرحمن الرحيم

STATEMENT

This thesis is submitted to Ain-Shams University for the degree of : Master in mechanical engineering.

The work included in this thesis was carried out by the author in the department of Auto-Engineering, Ain-Shams University

from October 1988 till November 1993.

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

Date : November, 1993

Signature: Nabil El-Naggar

Name: NABIL RAGHEB MOHAMMAD EL-NAGGAR

C.V OF THE AUTHOR

Name : NABIL RAGHEB MOHAMMAD EL-NAGGAR

Birth Date : 9 June, 1946

Birth Place : Shobra - Cairo

First University Degree : B.Sc. of Mechanical Engineering

Specialization (Auto-Eng.)

Source of Degree : Military Technical College

Degree Date : April, 1968

Other Certificates, their dates, and their sources:

Summary of previous experience: Working in the motor-vehicle units, of the Egyptian Army till rank of Brigadier General.

Recent Job : Free Engineer.

FOR MY BELOVED FAMILY

WHO ALWAYS ENCOURAGES ME AND

OVERSHADOWS ME WITH THEIR

CONTINUOUS LOVE AND CARE.

CONTENTS

ACKNOWLEDGMENT

The author wants to express his deep gratitude and thanks to his supervisors:

1- Professor Dr. T. A. NOSSEIR,
Prof. of Automotive Engineering,
Ain-Shams University.

2- Prof. Assistant Dr. A. I. ABDEL-AZIZ,
Lecturer of Automotive Engineering,
Ain-Shams University.

And thanks to the persons who supported me in this research work:

1- Gen. Eng. F. M. EL-AWADY,
Chief of A.F. Main Work Shop for Vehicles.
2- Brig. Eng. S. M. MABROUK,
Chief of A.F.Vehicles Training Center.
3- Staff of Automotive Laboratory, Energy and Automotive Engineering Department,
Ain-Shams University.

And thanks to :

The Egyptian AIR FORCE Technical Units for Vehicles, Repair Work Shop and Training Center.

SUMMARY

The dry friction clutch plays important functions in motor vehicles during the movement of stationary vehicles, and ensures easy gear shifts during the speeding up and slowing down motion. On the other hand, the driver skill and behaviour in operating the clutch during engagement and disengagement has unquestionable effect on the achievement of the desirable performance and on the service life of the clutch. Further, the service life has direct relation to the high repair costs, and down time needed for the early damaged clutch. Moreover, the optimum operation of the clutch has a great impact on the fuel savings.

An apparatus was designed and built to record the clutch pedal and the accelerator displacements during the disengagement and engagement of the clutch at the different speed shifts of the vehicle.

Tests were carried out on eight drivers of different skill levels , using the same test vehicle, and under the same operating conditions. Results of the tests were recorded and used to deduce the clutch slip time, and the amount of the generated heat as a result of that slip. Comparisons between the drivers' performance have been carried out.

NOMENCLATURE

SYMBOL	MEANING	UNITS
A_f	Frontal area of the vehicle.	[m^2]
f_r	Tyre rolling resistance coefficient.	
F_a	Air resistance to the vehicle motion.	[N]
F_d	Draw-bar pull of the trailer.	[N]
F_g	Grade resistance to the vehicle.	[N]
F_i	Inertial resistance of the vehicle.	[N]
F_r	Rolling resistance at wheels.	[N]
F_R	Total resistance force acting on wheels.	[N]
g	Gravitational acceleration constant, 9.81	[m/s^2]
i_g	Gear box ratio.	
i_o	Final drive reduction ratio.	
I_1	Equivalent mass moment of inertia of the engine moving parts.	[kg m^2]
I_2	Equivalent mass moment of inertia of the vehicle, referenced at the speed of the clutch shaft.	[kg m^2]
I_{eq}	Equivalent mass moment of inertia of the vehicle, seen at the driving wheels' axle.	[kg m^2]
I_w	Inertia moment of the wheels.	[kg m^2]
k_a	Air resistance coefficient.	[$N.S^2/m^4$]
M	Mass of the vehicle.	[kg]
n_1, n_2	Indices of engine and clutch torque functions chosen generally as: 0,0.2,0.4,0.6,0.8,1,1.2,1.4,2,3,4,5	
r_d, r_r	Dynamic & rolling radii of the driving wheels.	[m]

TC	Maximum clutch torque.	[Nm]
TE	Maximum engine torque.	[Nm]
Tc(t)	Clutch torque function.	
Te(t)	Engine torque function.	
Tr(t)	Total resisting torque on wheels, referenced at the clutch output shaft, function of time.	[Nm]
Tw	Resultant torque on wheels.	[Nm]
t	Time.	[s]
W	Weight of the vehicle.	[N]
x	Linear translation of the wheels.	[m]
$\ddot{x}$	Linear acceleration of the wheels.	[m/s^2]
α	Road slope angle.	[$^\circ$]
δ_1	Relative delay time of accelerator pedal movement.	[s]
δ_2	Relative delay time of clutch pedal movement.	[s]
γ	Ratio of engine maximum torque, [$0 < \gamma < 1$].	
η	Mechanical efficiency of the vehicle transmission.	
τ_1, τ_3	Build up time of the engine torque.	[s]
τ_2	Build up time of the clutch torque.	[s]
Ω_1, Ω_2	Initial angular velocities of the engine and the friction plate (s), respectively.	[r.p.m]
ω_1, ω_2	Instantanious angular velocities of the engine and friction plate (s), respectively.	[r.p.m]
θ	Angular displacement of driving wheels.	[rad]
$\ddot{\theta}$	Angular acceleration of driving wheels.	[rad/s^2]

LIST OF FIGURES, TABLES, AND PLATES