DEVELOPMENT OF A DIRECT FUEL INJECTOR FOR A TWO-STROKE GASOLINE ENGINE

MAS FAWZI BIN MOHD ALI

UNIVERSITI TEKNOLOGI MALAYSIA

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Alamat Tetap:

NO. 2, JALAN S/P 7
TAMAN SRI PANCHOR
83000 BATU PAHAT, JOHOR.

PROF. IR. DR. AZHAR ABDUL AZIZ
Nama Penyelia

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Tesis ini telah diperiksa dan diakui oleh:

Nama dan Alamat Pemeriksa Luar : **Dr. Victor Chelliah**
Technical Advisor
Blok K, PSSS
Lots 3288 & 3289, Off Jalan Ayer Hitam
Kawasan Perindustrian Bangi
43000 Kajang
Selangor

Nama dan Alamat Pemeriksa Dalam I : **Dr. Jamaluddin bin Md Sheriff**
Jabatan Termo Bendalir
Fakulti Kejuruteraan Mekanikal
UTM, Skudai

Pemeriksa Dalam II :
(Tiada)

Nama Penyelia lain :
(jika ada)

Disahkan oleh Timbalan Pendaftar di Fakulti Kejuruteraan Mekanikal:

Tandatangan: .... Tarikh : ....

Nama : MOHAMED TAJUDDIN BIN OSMAN

DEVELOPMENT OF A DIRECT FUEL INJECTOR FOR A TWO-STROKE GASOLINE ENGINE

MAS FAWZI BIN MOHD ALI

A thesis submitted in fulfillment of the
requirements for the award of the degree of
Master of Engineering (Mechanical)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

FEBRUARY 2007

DECLARATION

I declare that this thesis entitled "*Development of a Direct Fuel Injector for a Two-stroke Gasoline Engine*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : Mas Fawzi bin Mohd Ali

Date : 27.2.2007

DEDICATION

To my beloved family, friends
and to all mankind.

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ABSTRACT

A prototype pressure-swirl injector was designed to suit an arbitrary two-stroke, gasoline direct injection engine requirement. A commercial computational fluid dynamics software *FLUENT* was used as a tool to analyze the performance of the conceptual design. A prototype injector was fabricated once the conceptual design met the requirements. The fabricated prototype injector was then subjected to a series of specification tests such as leak test, static flow rate test and discharge coefficient test. A dedicated test rig was set up to evaluate the performance of the prototype injector. The spray images at specified time frame were illuminated by Nd:YAG laser sheet and captured using a high-speed digital camera. The stored images were analyzed to give data of spray angle, and droplet Sauter mean diameter at fuel-air pressure differential ranging from 1.0 to 5.0 MPa, with a step size of 1.0 MPa. From the tests, the prototype injector static flow rate, half spray cone angle and the droplet Sauter mean diameter at fuel injection pressure of 5.0 MPa was found to comply with the outlined requirements, which are approximately 475 cc/min, 32° and 19 μm respectively. Finally, the experimental data was compared with the calculated data. It was found that the measured data of static flow rate, discharge coefficient, and droplet Sauter mean diameter were higher than the computed data at fuel-air pressure differential between 1.0 and 3.0 MPa. In contrast, the calculated initial spray angle was overestimated by 3% at all tested fuel-air pressure differentials.

ABSTRAK

Sebuah prototaip penyuntik tekanan-pusaran telah direkacipta untuk menepati keperluan sebuah enjin petrol dua lejang suntikan terus. Sebuah perisian komersial pengkomputeran mekanik bendalir *FLUENT* telah digunakan sebagai alat untuk menganalisa prestasi rekabentuk konsep tersebut. Sebuah prototaip telah difabrikasi bilamana rekabentuk konsep tersebut memenuhi kesemua kehendak yang telah digariskan. Prototaip berkenaan kemudiannya melalui beberapa ujian spesifikasi seperti ujian kebocoran, ujian kadar aliran statik dan ujian pekali semburan. Sebuah radas ujikaji khusus telah dibina untuk menilai prestasi prototaip tersebut. Imej semburan yang disinari dengan helaian laser Nd:YAG pada ketika tertentu telah dirakam menggunakan kamera digital berkelajuan tinggi. Imej tersebut telah dianalisa untuk mendapatkan data sudut semburan dan purata diameter Sauter titisan pada beza tekanan bahanapi-udara dari 1.0 hingga 5.0 MPa dengan kenaikan 1.0 MPa. Daripada ujian-ujian tersebut, prototaip tersebut telah menepati kehendak yang telah digariskan iaitu kadar aliran statik sebanyak 475 cc/min, separuh sudut semburan bersaiz 32° dan purata diameter Sauter titisan bersaiz 19 μm. Akhir sekali, data eksperimen berkenaan telah dibandingkan dengan data pengiraan yang telah dibuat terdahulu. Didapati bahawa data eksperimen untuk kadar aliran statik, pekali semburan, dan purata diameter Sauter adalah lebih tinggi daripada hasil pengiraan pada beza tekanan bahanapi-udara diantara 1.0 hingga 3.0 MPa. Sebaliknya, data pengiraan sudut semburan melebihi jangkaan sebanyak 3% pada kesemua beza tekanan bahanapi-udara yang diuji.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

English Symbols

A_0	–	Cross-section area of final orifice [mm^2]
A_P	–	Total inlet port area [mm^2]
A_w	–	Cross-section area of wire [mm^2]
B	–	Magnetic field [mTesla]
C_D	–	Discharge coefficient [-]
C_θ	–	Spray angle correction factor [-]
$\overline{D}$	–	Droplet mean diameter [μm]
d_w	–	Diameter of wire [mm]
FN	–	Flow number, $\dot{m}_L/(\Delta P_L \rho_L)^{0.5}$ [-]
I	–	Current [A]
I_C	–	Collector current [A]
k	–	Turbulence kinetic energy [m^2/s^2]
k_{max}	–	Wave number of the dominant perturbation [-]
l_0, d_0	–	Length and diameter of final orifice [mm]
l_S, d_S	–	Length and diameter of swirl chamber [mm]
$\dot{m}$	–	Mass flow rate [g/s]
n	–	No. of droplets [-]
N	–	Engine speed [RPM]
N_w	–	No. of turns (wire) [turns]
P	–	Pressure [MPa]
P_D	–	Total power dissipation [Watts]