UNIVERSITI PUTRA MALAYSIA

INTAKE VALVE MODELLING OF A FOUR STROKE INTERNAL COMBUSTION ENGINE AT IDLING SPEED

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INTAKE VALVE MODELLING OF A FOUR STROKE INTERNAL COMBUSTION ENGINE AT IDLING SPEED

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in the Fulfillment of the Requirements for the Degree of Doctor of Philosophy (Ph.D.)

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Dedicated to my parent whose sacrifices are not repayable and even the Creator has asked all the mankind to be submissive and dedicated to their respective parent evaluating the their roles during thirty months of childhood and ten months before childhood of every human being.

Abstract of this thesis presented to the Senate of Universiti Putra Malaysia in the fulfillment of the requirement for the Degree of Doctor of Philosophy

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By

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August 2002

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Intake valve of a four stroke internal combustion (IC) engine has been modelled to investigate the effects of intake valve diameter and intake valve angle on volumetric efficiency and air flow properties of intake air in a four stroke internal combustion engine. It is found that the increase of intake valve diameter increases the peak vertical velocity component but decreases the peak horizontal velocity component of intake air in suction stroke. It is also found that the increase of intake valve diameter decreases the peak turbulence kinetic energy and dissipation rate of intake air to a small extent. The effects of intake valve diameters on the cylinder pressure in suction stroke become significant from the suction valve full opening timing to the middle of suction stroke but its effects become insignificant (diminished) at the time of suction valve closing. The effects of intake valve diameters on the intake air temperature are also found very small at the end suction stroke. Thus, the small variations between the computed pressure and temperature

inside the cylinder at end of suction stroke for different intake valve diameters have little influence on volumetric efficiency.

While investigating the effect of intake valve angle on the airflow properties, it is found that the larger intake valve angle decreases the vertical velocity component as well as the horizontal velocity component. The increase of intake valve angle decreases the turbulence kinetic energy and dissipation rate moderately. The effects of intake valve angles on the cylinder pressure and temperature in suction stroke are very small from intake valve opening timing until the end of suction stroke.

Thus, the present investigation shows that variation in intake valve diameter has very small effect on volumetric efficiency and the necessity of increasing intake valve number is not so important. Moreover, intake valve angle can be increased in order to increase valve thickness and valve life.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan Ijazah Doktor Falsafah

PEMODELAN INJAP MASUKAN BAGI INJIN PEMBAKARAN DALAM EMPAT LEJANG

Oleh

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Injap masukan bagi sebuah enjin pembakaran dalam empat lejang telah dimodelkan bagi mengkaji kesan-kesan saiz injap masukan dan sudut injap masukan ke atas kecekapan isipadu dan pergerakan aliran udara dalam sebuah enjin pembakaran dalam empat lejang. Didapati bahawa pertambahan luas aliran injap masukan menambahkan komponen halaju menegak puncak tetapi mengurangkan komponen halaju mendatar puncak. Selain itu, didapati juga bahawa pertambahan diameter injap masukan menambahkan tenaga kinetik turbulen puncak dan kadar lesapan pada tahap yang kecil. Kesan diameter-diameter injap masukan ke atas tekanan silinder dalam lejang sedutan menjadi penting apabila pemasaan pembukaan penuh injap sedutan, ke pertengahan lejang sedutan tetapi kesan-kesannya menjadi tidak penting (berkurangan) pada akhir lejang sedutan apabila injap sedutan tertutup sepenuhnya. Kesan-kesan diameter-diameter injap masukan ke atas masukan suhu udara sangat kecil pada penghujung lejang sedutan. Satu perbezaaan yang kecil di

antara pengiraan tekanan dan suhu di dalam silinder pada akhir lejang sedutan dengan diameter-diameter injap masukan yang berbeza menunjukkan satu perubahan kecil ke atas kecekapan isipadu .

Dalam mengkaji kesan sudut injap masukan ke atas lejang sedutan injin dan prestasi injin telah didapati bahawa sudut injap masukan yang lebih besar mengurangkan komponen halaju menegak tetapi menambah komponen halaju mendatar. Pertambahan sudut injap masukan menambah tenaga kinetik turbulen dan kadar lesapan secara sederhana. Kesan sudut-sudut injap masukan ke atas tekanan silinder dalam lejang sedutan adalah sangat kecil berbanding dengan pembukaan injap sedutan hingga akhir lejang sedutan.

Oleh demikian, hasil kajian menunjukkan perbezaan di dalam diameter injap masukan mempunyai kesan yang sangat kecil ke atas kecekapan isipadu dan amat penting untuk peningkatan jumlah injap masukan adalah tidak penting. Tambahan pula sudut injap masukan boleh ditambah bagi menambah ketebalan injap dan hayat injap tanpa memberi kesan kepada kecekapan isipadu.

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Md. Syed Ali Molla

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DECLARATION

I do hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that this thesis has not been previously or concurrently submitted for any other degree at UPM or other institutions.

MD. SYED ALI MOLLA
Date

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LIST OF ABBREVIATIONS

Symbol	Description
BDC	Bottom dead centre
CFD	Computational fluid dynamic
CAD	Computer aided design
k	Turbulence kinetic energy (TE)
k^+	Near wall dimensionless turbulence kinetic energy, ($k^+ = C_\mu^{-1/2}$).
l	Length scale
l_m	Mixing length scale
g	Standard gravitational constant
g_m	Gravitational field components
p	Absolute piezometric pressure = $p_s - \rho_o g_m x_m$
p_s	Static pressure = Piezometric pressure if there is no gravitational force
P	Average absolute piezometric pressure = Average static pressure if there is no gravitational force
Psg	Stagnation pressure
S	Cell surface face
s_m	Mass source
s_i	Momentum source
$\hat{S}$	Projected surface (surface vector)
S_j	Discrete surface faces (1, 2, 3.. … N)
t	Time
T	Temperature in Kelvin
TDC	Top dead center
U	Average horizontal velocity (U_i)
u_i	Asolute velocity component in direction x_i
u_j	Absolute velocity component in direction x_j
$\tilde{u}_j$	$u_j - u_{cj}$, relative velocity between fluid and local (moving) coordinate frame that moves with velocity u_{cj}
u_i'	Fluctuating component of u_i
u^+	Dimensionless velocity at wall
u_w	Velocity parallel to wall
u_r	Relative velocity between fluid (u) and moving coordinate
u_τ	Friction velocity at wall
U_i	Mean horizontal velocity of u_i (U1, U2, U3………)
U_j	Mean vertical velocity of u_j (V1, V2, V3..)
V	Average vertical velocity (U_j)
V^o	Old (previous) volume
V^n	New volume
x_m	Coordinates from a datum where ρ_o is defined