



UNIVERSITI PUTRA MALAYSIA

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

MD. SYED ALI MOLLA

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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.)**

August 2002



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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Faculty: Engineering

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 ENJIN 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 perbezaan 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.

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TABLE OF CONTENTS

DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL SHEETS	ix-x
DECLARATION	xi
LIST OF TABLES	xvi
LIST OF FIGURES	xvii
LIST OF ABBREVIATIONS	xxv
CHAPTER	
1 INTRODUCTION	
1.1 Background	1-1
1.2 Engine Valve	1-3
1.3 Fluid Motion within the Cylinder	1-4
1.4 Turbulence	1-4
1.5 Aim and Objectives	1-7
1.6 Thesis Structure	1-8
2 LITERATURE REVIEW	
2.1 Introduction	2-1
2.2 Volumetric Efficiency of Internal Combustion Engine	2-3
2.3 Turbulence Modelling of Reynolds Average Equation	2-4
2.4 Numerical Solution of Navier-Stokes Equations with k- ϵ Model and Finite Volume Approach	2-5
2.5 Dissipation Equation	2-6
2.6 Flow Study in Engine	2-8
2.7 Industrial Fluid Dynamics and Turbulence Modelling	2-27
2.8 Near-field Behaviour of Rectangular Vena-contra Expansion and Finite Volume Technique	2-31
2.9 Transonic Potential Flow by a Finite Volume Method	2-32
2.10 Multi-grid Relaxation	2-35
2.11 Viscous Compressible Flows	2-36
2.12 Large Eddy Simulation of Compressible Turbulence	2-40
2.13 Near Wall Turbulent Flow	3-46
2.14 Hot and Cold Wire Techniques Measurement in Turbulent Shear Flows near Wall	2-51
2.15 Turbulent Boundary Layer Near Plane of Symmetry	2-57



2.16	Turbulent Prandtl Number	2-60
2.17	Laminar-turbulent Transitional Flow	2-61
3	MATHEMATICAL MODELLING	
3.1	Introduction	3-1
3.2	Mathematical Modelling	3-6
	3.2.1 Constitutive Relation for Newtonian and Non-Newtonian Laminar Flow	3-6
	3.2.2 Newtonian Turbulent	3-7
	3.2.3 Source Term	3-7
3.3	The k- ϵ Model Equation	3-8
	3.3.1 Turbulence Energy	3-8
	3.3.2 Turbulence Dissipation Rate	3-9
	3.3.3 Turbulence Flow Boundary Conditions	3-9
3.4	Discretization Practices	
	3.4.1 Finite Volume Discretization of Continuum Fluid Equations	3-12
	3.4.2 Final Finite Volume Equation	3-15
3.5	Physical Problem Description	3-16
3.6	Modelling Strategy	3-16
3.7	Problem Specification Summary	3-17
4	PROCEDURE	
4.1	Introduction	4-1
4.2	Guidelines of the Application of Methodology in Thermo Fluids Prediction	4-2
4.3	Defining Physical Problems	4-3
4.4	Geometry Modelling and Mesh Generation	4-5
4.5	Mesh Distribution Near Wall	4-7
4.6	Numerical Solution Control and Selection Procedure	4-8
	4.6.1 Selection of Solution Procedure	4-8
	4.6.2 Unsteady Calculation with PISO	4-8
4.7	Monitoring Calculation	4-10
4.8	Assessment of Results	4-11
5	RESULT AND DISCUSSION	
5.1	Introduction	5-1
5.2	Validity of the k- ϵ Model with Experimental Observations	5-2
5.3	Comparison and Validation of Computational Results with Experimental Results	5-5



5.4	Intake Valve Modelling	5-10
5.4.1	Intake Valve (Size) Diameter Modelling	5-11
(a)	Effects of Intake Valve Diameters on Horizontal Velocity Component in Suction Stroke	5-12
(b)	Effects of Intake Valve Diameters on Vertical Velocity Component and its Comparison	5-14
(c)	Effects of Intake Valve Diameters on Cylinder Pressure in Suction Stroke	5-15
(d)	Effects of Intake Valve Diameters on Temperature	5-17
(e)	Effects of Intake Valve Diameters on Turbulence Kinetic Energy in Suction Stroke	5-18
(f)	Effects of Intake Valve Diameters on Dissipation Rate of Turbulence Kinetic Energy	5-19
5.4.2	Intake Valve Angle Modelling	5-20
(a)	Effects of Intake Valve Angles on Horizontal Velocity Component in Suction Stroke	5-21
(b)	Effects of Intake Valve Angles on Vertical Velocity Component	5-23
(c)	Effects of Intake Valve Angles on Cylinder Pressure in Suction Stroke	5-24
(d)	Effects of Intake Valve Diameters on Temperature	5-26
(e)	Effects of Intake Valve Angles on Turbulence Kinetic Energy	5-26
(e)	Effects of Intake Valve Angles on Dissipation Rate in Suction Stroke	5-28
6	CONCLUSION AND RECOMMENDATIONS	
6.1	Intake Valve Diameter Modelling	6-1
6.2	Intake Valve Angle Modelling	6-2
6.3	Recommendations for Future Works	6-3
	REFERENCES	R.1



APPENDICES

AT.1	Table of Vertices	A-1
AT.2	Programme Execution File	A-28
AT.3	Grid Changing File	A-34
AT.4	Program Starin	A-38
AT.5	Comments on Programme Statement Control	A-52

VITA	B-1
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LIST OF TABLES

Table 3.1	Values Assigned to Standard k - ϵ Turbulence Model Coefficients	3-18
Table 3.2	Summary of Specifications in the Model	3-19
Table 4.1	Approximate Upper Limits of Mesh Distribution Factors	4-11
Table 4.2	Unsteady PISO Calculations	4-11
Table 5.1	Comparison of the Present Computational Result with Experimental Result	5-6



LIST OF FIGURES

5.1	Comparison of the predicted results of k- ϵ model with the results of other models.	5-3
5.2	Comparison of the present computational results with experimental results	5-6
5.3	Crank angle Vs. Horizontal velocity component of intake air in suction stroke with 14 mm intake valve diameter	5-30
5.4	Crank angle Vs. Horizontal velocity component of intake air in suction stroke with 17 mm intake valve diameter	5-30
5.5	Crank angle Vs. Horizontal velocity component of intake air in suction stroke with 20 mm intake valve diameter	5-31
5.6	Crank angle Vs. Horizontal velocity component of intake air in suction stroke with 23 mm intake valve diameter	5-31
5.7	Crank angle Vs. Horizontal velocity component of intake air in suction stroke with 26 mm intake valve diameter	5-32
5.8	Crank angle Vs. Horizontal velocity component of intake air in suction stroke with 29 mm intake valve diameter	5-32
5.9	Crank angle Vs. Horizontal velocity component of intake air in suction stroke with 32 mm intake valve diameter	5-33
5.10	Comparison of horizontal velocity components of different intake valve diameters	5-33
5.11	Crank angle Vs. Vertical velocity component of intake air in suction stroke with 14 mm intake valve diameter	5-34
5.12	Crank angle Vs. Vertical velocity component of intake air in suction stroke with 17 mm intake valve diameter	5-34
5.13	Crank angle Vs. Vertical velocity component of intake air in suction stroke with 20 mm intake valve diameter	5-34
5.14	Crank angle Vs. Vertical velocity component of intake air in suction stroke with 23 mm intake valve diameter	5-35
5.15	Crank angle Vs. Vertical velocity component of intake air in suction stroke with 26 mm intake valve diameter	5-35
5.16	Crank angle Vs. Vertical velocity component of intake air in suction stroke with 29 mm intake valve diameter	5-35
5.17	Crank angle Vs. Vertical velocity component of intake air in suction stroke with 32 mm intake valve diameter	5-36
5.18	Comparison of vertical velocity components of different intake valve diameters	5-36
5.19	Crank angle Vs. Cylinder pressure of intake air in suction and exhaust stroke with 14 mm intake valve diameter	5-37
5.20	Crank angle Vs. Cylinder pressure in suction and exhaust stroke with 17 mm intake valve diameter	5-37
5.21	Crank angle Vs. Cylinder pressure in suction and exhaust stroke with 20 mm intake valve diameter	5-37
5.22	Crank angle Vs. Cylinder pressure in suction and exhaust stroke with 23 mm intake valve diameter	5-38



5.23	Crank angle Vs. Cylinder pressure in suction and exhaust stroke with 26 mm intake valve diameter	5-38
5.24	Crank angle Vs. Cylinder pressure in suction and exhaust stroke with 29 mm intake valve diameter	5-38
5.25	Crank angle Vs. Cylinder pressure in suction and exhaust stroke with 32 mm intake valve diameter	5-39
5.26	Comparison of the cylinder pressures in suction stroke with different intake valve diameters	5-39
5.27	Crank angle Vs. Temperature in suction and exhaust stroke with 14 mm intake valve diameter	5-40
5.28	Crank angle Vs. Temperature in suction and exhaust stroke with 17 mm intake valve diameter	5-40
5.29	Crank angle Vs. Temperature in suction and exhaust stroke with 20 mm intake valve diameter	5-40
5.30	Crank angle Vs. Temperature in suction and exhaust stroke with 23 mm intake valve diameter	5-41
5.31	Crank angle Vs. Temperature in suction and exhaust stroke with 26 mm intake valve diameter	5-41
5.32	Crank angle Vs. Temperature in suction and exhaust stroke with 29 mm intake valve diameter	5-41
5.33	Crank angle Vs. Temperature in suction and exhaust stroke with 32 mm intake valve diameter	5-42
5.34	Comparison of the effects of intake valve diameter on the temperature in suction and exhaust stroke with different intake valve diameters	5-42
5.35	Turbulence kinetic energy in suction stroke at different crank angle with 14 mm inlet valve	5-43
5.36	Turbulence kinetic energy in suction stroke at different crank angle with 17 mm inlet valve	5-43
5.37	Turbulence kinetic energy in suction stroke at different crank angle with 20 mm inlet valve	5-43
5.38	Turbulence kinetic energy in suction stroke at different crank angle with 23 mm inlet valve	5-44
5.39	Turbulence kinetic energy in suction stroke at different crank angle with 26 mm inlet valve	5-44
5.40	Turbulence kinetic energy in suction stroke at different crank angle with 29 mm inlet valve	5-44
5.41	Turbulence kinetic energy in suction stroke at different crank angle with 32 mm inlet valve	5-45
5.42	Comparison of the effects of intake valve diameters on the turbulence kinetic energy	5-45
5.43	Dissipation-rate in suction stroke at different crank angle with 14 mm inlet valve	5-46
5.44	Dissipation-rate in suction stroke at different crank angle with 17 mm inlet valve	5-46



5.45	Dissipation-rate in suction stroke at different crank angle with 20 mm inlet valve	5-46
5.46	Dissipation-rate in suction stroke at different crank angle with 23 mm inlet valve	5-47
5.47	Dissipation-rate in suction stroke at different crank angle with 26 mm inlet valve	5-47
5.48	Dissipation-rate in suction stroke at different crank angle with 29 mm inlet valve	5-47
5.49	Dissipation-rate in suction stroke at different crank angle with 32 mm inlet valve	5-48
5.50	Comparison of the effects of intake valve diameter on the dissipation-rate	5-48
5.51	Horizontal velocity component in suction stroke with 33° intake valve angle	5-49
5.52	Horizontal velocity component in suction stroke with 38° intake valve angle	5-49
5.53	Horizontal velocity component in suction stroke with 43° intake valve angle	5-49
5.54	Horizontal velocity component in suction stroke with 48° intake valve angle	5-50
5.55	Horizontal velocity component in suction stroke with 53° intake valve angle	5-50
5.56	Horizontal velocity component in suction stroke with 58° intake valve angle	5-50
5.57	Horizontal velocity component in suction stroke with 63° intake valve angle	5-51
5.58	Comparison of the effects of intake valve angle on horizontal velocity component	5-51
5.59	Vertical velocity component in suction stroke with 33° intake valve angle.	5-52
5.60	Vertical velocity component in suction stroke with 38° intake valve angle	5-52
5.61	Vertical velocity component in suction stroke with 43° intake valve angle	5-52
5.62	Vertical velocity component in suction stroke with 48° intake valve angle	5-53
5.63	Vertical velocity component in suction stroke with 53° intake valve angle	5-53
5.64	Vertical velocity component in suction stroke with 58° intake valve angle	5-53
5.65	Vertical velocity component in suction stroke with 63° intake valve angle	5-54
5.66	Comparison of the vertical velocity components in suction stroke with different intake valve angles	5-54
5.67	Cylinder pressure at different crank angles in suction and exhaust stroke with intake valve angle 33°	5-55



5.68	Cylinder pressure at different crank angles in suction stroke with intake valve angle 38°	5-55
5.69	Cylinder pressure at different crank angles in suction and exhaust stroke with intake valve angle 43°	5-55
5.70	Cylinder pressure at different crank angles in suction and exhaust stroke with intake valve angle 48°	5-56
5.71	Cylinder pressure at different crank angles in suction and exhaust stroke with intake valve angle 53°	5-56
5.72	Cylinder pressure at different crank angles in suction and exhaust stroke with intake valve angle 58°	5-56
5.73	Cylinder pressure at different crank angles in suction and exhaust stroke with intake valve angle 63°	5-57
5.74	Comparison of in cylinder pressures at different crank in suction and exhaust stroke with different intake valve angles	5-57
5.75	Crank angle Vs. Temperature in suction and exhaust stroke with 33° intake valve angle	5-58
5.76	Crank angle Vs. Temperature in suction and exhaust stroke with 38° intake valve angle	5-58
5.77	Crank angle Vs. Temperature in suction and exhaust stroke with 43° intake valve angle	5-58
5.78	Crank angle Vs. Temperature in suction and exhaust stroke with 48° intake valve angle	5-59
5.79	Crank angle Vs. Temperature in suction and exhaust stroke with 53° intake valve angle	5-59
5.80	Crank angle Vs. Temperature in suction and exhaust stroke with 58° intake valve angle	5-59
5.81	Crank angle Vs. Temperature in suction and exhaust stroke with 63° intake valve angle	5-60
5.82	Comparison of temperature in suction and exhaust stroke with different intake valve angles	5-60
5.83	Turbulence kinetic energy of intake air at different crank angles in suction stroke with 33° intake valve angle	5-61
5.84	Turbulence kinetic energy of intake air at different crank angles in suction stroke with 38° intake valve angle	5-61
5.85	Turbulence kinetic energy of intake air at different crank angles in suction stroke with 43° intake valve angle	5-61
5.86	Turbulence kinetic energy of intake air at different crank angles in suction stroke with 48° intake valve angle	5-62
5.87	Turbulence kinetic energy of intake air at different crank angles in suction stroke with 53° intake valve angle	5-62
5.88	Turbulence kinetic energy of intake air at different crank angles in suction stroke with 58° intake valve angle	5-62
5.89	Turbulence kinetic energy of intake air at different crank angles in suction stroke with 63° intake valve angle	5-63
5.90	Comparison of turbulence kinetic energy of intake air in suction stroke with different intake valve angles	5-63

5.91	Dissipation rate of intake air at different crank angles in suction stroke with 33° intake valve angle.	5-64
5.92	Dissipation rate of intake air at different angles in suction stroke with 38° intake valve angle.	5-64
5.93	Dissipation rate of intake air at different crank angles in suction stroke with 43° intake valve angle	5-64
5.94	Dissipation rate at different crank angles in suction stroke with 48° intake valve angle.	5-65
5.95	Dissipation rate at different crank angles in suction stroke with 53° intake valve angle.	5-65
5.96	Dissipation rate at different crank angles in suction stroke with 58° intake valve angle.	5-65
5.97	Dissipation rate at different crank angles in suction stroke with 63° intake valve angle.	5-66
5.98	Comparison of dissipation rates in suction stroke with different intake valve angles.	5-66
5.99	Vector plot of horizontal velocity component at 180° in suction stroke with 14 mm intake valve diameter	5-67
5.100	Vector plot of horizontal velocity component at 180° in suction stroke with 23 mm intake valve diameter	5-67
5.101	Vector plot of horizontal velocity component at 240° in suction stroke with 14 mm intake valve diameter	5-68
5.102	Vector plot of horizontal velocity component at 240° in suction stroke with 23 mm intake valve diameter	5-68
5.103	Vector plot of horizontal velocity component at 300° in suction stroke with 14 mm intake valve diameter	5-69
5.104	Vector plot of horizontal velocity component at 300° in suction stroke with 23 mm intake valve diameter	5-69
5.105	Vector plot of horizontal velocity component at 360° in suction stroke with 14 mm intake valve diameter	5-70
5.106	Vector plot of horizontal velocity component at 360° in suction stroke with 23 mm intake valve diameter	5-70
5.107	Vector plot of vertical velocity component at 180° in suction stroke with 14 mm intake valve	5-71
5.108	Vector plot of vertical velocity component at 180° in suction stroke with 23 mm intake valve	5-71
5.109	Vector plot of vertical velocity component at 240° in suction stroke with 14 mm intake valve	5-72
5.110	Vector plot of vertical velocity component at 240° in suction stroke with 23 mm intake valve	5-72
5.111	Vector plot of vertical velocity component at 300° in suction stroke with 14 mm intake valve	5-73
5.112	Vector plot of vertical velocity component at 300° in suction stroke with 23 mm intake valve	5-73
5.113	Vector plot of vertical velocity component at 360° in suction stroke with 14 mm intake valve	5-74



5.114	Vector plot of vertical velocity component at 360° in suction stroke with 23 mm intake valve	5-74
5.115	Contour of cylinder pressure at 180° in suction stroke with 14 mm intake valve	5-75
5.116	Contour of cylinder pressure at 180° in suction stroke with intake valve	5-75
5.117	Contour of cylinder pressure at 240° in suction strokes with 14 mm intake valve	5-76
5.118	Contour of cylinder pressure at 240° in suction stroke with 23 mm intake valve	5-76
5.119	Contour of cylinder pressure at 300° in suction stroke with 14 mm intake valve	5-77
5.120	Contour of cylinder pressure at 300° in suction stroke with 23 mm intake valve	5-77
5.121	Contour of cylinder pressure at 360° in suction stroke with 14 mm intake valve	5-78
5.122	Contour of cylinder pressure at 360° in suction stroke with 23 mm intake valve	5-78
5.123	Contour of turbulence kinetic energy in suction stroke at 180° with 14 mm intake valve	5-79
5.124	Contour of turbulence kinetic energy in suction stroke at 180° with 23 mm intake valve	5-79
5.125	Contour of turbulence kinetic energy in suction stroke at 240° with 14 mm intake valve	5-80
5.126	Contour of turbulence kinetic energy in suction stroke at 240° with 23 mm intake valve at 240°	5-80
5.127	Contour of turbulence kinetic energy in suction stroke at 300° with 14 mm intake valve	5-81
5.128	Contour of turbulence kinetic energy in suction stroke valve at 300° with 23 mm intake	5-81
5.129	Contour of turbulence kinetic energy in suction stroke at 360° with 14 mm intake valve	5-82
5.130	Contour of turbulence kinetic energy in suction stroke at 360° with 23 mm intake valve	5-82
5.131	Contour of dissipation-rate in suction stroke at 180° with 14 mm intake valve at 180°	5-83
5.132	Contour of dissipation-rate in suction stroke at 180° with 23 mm intake valve	5-83
5.133	Contour of dissipation-rate in suction stroke at 240° with 14 mm intake valve	5-84
5.134	Contour of dissipation-rate in suction stroke at 240° with 23 mm intake valve	5-84
5.135	Contour of dissipation-rate in suction stroke at 300° with 14 mm intake valve	5-85
5.136	Contour of dissipation-rate in suction stroke at 300° with 23 mm intake valve at 300°	5-85

5.137	Contour of dissipation-rate in suction stroke at 360° crank angle with 14 mm intake valve	5-86
5.138	Contour of dissipation-rate in suction stroke at 360° angle with 23 mm intake valve	5-86
5.139	Vector plot of horizontal velocity component in suction stroke at 180° with intake valve angle 33°	5-87
5.140	Vector plot of horizontal velocity component in suction stroke at 180° with intake valve angle 63°	5-87
5.141	Vector plot of horizontal velocity component in suction stroke at 240° with intake valve angle 33°	5-88
5.142	Vector plot of horizontal velocity component in suction stroke at 240° with intake valve angle 63°	5-88
5.143	Vector plot of horizontal velocity component in suction stroke at 360° with intake valve angle 33°	5-89
5.144	Vector plot of horizontal velocity component in suction stroke at 360° with intake valve angle 63°	5-89
5.145	Vector plot of vertical velocity component in suction stroke at 170° with intake valve angle at 33°	5-90
5.146	Vector plot of vertical velocity component in suction stroke at 170° with intake valve angle 63°	5-90
5.147	Vector plot of vertical velocity component in suction stroke at 240° with intake valve angle at 33°	5-91
5.148	Vector plot of vertical velocity component in suction stroke at 240° with intake valve angle 63°	5-91
5.149	Vector plot of vertical velocity component in suction stroke at 320° with intake valve angle at 33°	5-92
5.150	Vector plot of vertical velocity component in suction stroke at 320° with intake valve angle 63°	5-92
5.151	Contour of cylinder pressure in suction stroke at 180° with intake valve angle 33°	5-93
5.152	Contour of cylinder pressure in suction stroke at 180° with intake valve angle 63°	5-93
5.153	Contour of cylinder pressure in suction stroke at 240° with intake valve angle 33°	5-94
5.154	Contour of cylinder pressure in suction stroke at 240° with intake valve angle 63°	5-94
5.155	Contour of cylinder pressure in suction stroke at 300° with intake valve angle 33°	5-95
5.156	Contour of cylinder pressure in suction stroke at 300° with intake valve angle 63°	5-95
5.157	Contour of turbulence kinetic energy in suction stroke at 170° with intake valve angle 33°	5-96
5.158	Contour of turbulence kinetic energy in suction stroke at 170° with intake valve angle 63°	5-96



5.159	Contour of turbulence kinetic energy in suction stroke at 220° with intake valve angle 33°	5-97
5.160	Contour of turbulence kinetic energy in suction stroke at 220° with intake valve angle 63°	5-97
5.161	Contour of turbulence kinetic energy in suction stroke at 240° with intake valve angle 33°	5-98
5.162	Contour of turbulence kinetic energy in suction stroke at 240° with intake valve angle 63°	5-98
5.163	Contour of turbulence kinetic energy in suction stroke at 300° with intake valve angle 33°	5-99
5.164	Contour of turbulence kinetic energy in suction stroke at 300° with intake valve angle 63°	5-99
5.165	Contour of dissipation-rate in suction stroke at 180° with intake valve angle 33°	5-100
5.166	Contour of dissipation-rate in suction stroke at 180° with intake valve angle 63°	5-100
5.167	Contour of dissipation-rate in suction stroke at 240° with intake valve angle 33°	5-101
5.168	Contour of dissipation-rate in suction stroke at 240° with intake valve angle 63°	5-101
5.169	Contour of dissipation-rate in suction stroke at 300° with intake valve angle 33°	5-102
5.170	Contour of dissipation-rate in suction stroke at 300° with intake valve angle 63°	5-102
5.171	Contour of dissipation-rate in suction stroke at 360° with intake valve angle 33°	5-103
5.172	Contour of dissipation-rate in suction stroke at 360° with intake valve angle 63°	5-103



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 = $p_s - \rho_0 g_m x_m$
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
P_{sg}	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	Absolute 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 (U_1, U_2, U_3, \dots)
U_j	Mean vertical velocity of u_j (V_1, V_2, V_3, \dots)
V	Average vertical velocity (U_j)
V^o	Old (previous) volume
V^n	New volume
x_m	Coordinates from a datum where ρ_0 is defined

