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BORANG PENGESAHAN STATUS TESIS*

JUDUL: **DESIGN OF AUTOMATIC CONTROL SYSTEM TO CONTROL THE FLOW OF BIOGAS FUEL INTO INTERNAL COMBUSTION SYSTEM**

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**DESIGN OF AUTOMATIC CONTROL SYSTEM TO CONTROL THE
FLOW OF BIOGAS FUEL INTO INTERNAL COMBUSTION
SYSTEM**

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**BACHELOR OF ENGINEERING
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UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

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**DESIGN OF AUTOMATIC CONTROL SYSTEM TO CONTROL THE FLOW OF
BIOGAS FUEL INTO INTERNAL COMBUSTION SYSTEM**

MOHAMAD SAUFI BIN AYOB

Thesis submitted in fulfillment of the requirements
For the award of the degree of
Bachelor of Mechanical Engineering with Automotive Engineering

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Dedicated to my beloved family, for their helps and encouragement.

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ABSTRACT

This work is to analyze the parameter and variables that used to design an automatic control system to control biogas fuel in internal combustion engine. The objective of this thesis is to design the automatic control system. It shows that for governed engines, the governor maintains constant engine rpm by moving the throttle to control fuel supply to the engine and match power output to the engine load. The function of the mechanical governor is to adjust the fuel valve angle so the load on the engine will maintain the desired engine rpm at the horsepower setting selected. Performance of the designed automatic control system was investigated and the effect of the automatic control system to the internal combustion engine predicted. System analysis for the project were done by using manual calculation to set the displacement and force affected by the governor and the size opening of the valve and also using FORTRAN code to analyze the speed and position of the mechanical governor by using certain input speed that have been decided. In conclusion, this thesis aim to explain the significant of the automatic control system that have been designed and describe how the system can manage to maintain the optimum speed during steady state and transient condition.

ABSTRAK

Projek ini adalah tentang kajian parameter dan pembolehubah dalam sistem kawalan automatik untuk mengawal penghantaran bahan bakar biogas kepada enjin pembakaran dalaman. Objektif laporan ini adalah untuk menentukan parameter dan pembolehubah dalam merancang sistem kawalan automatik. Tesis ini menunjukkan bahawa pada proses telah ditetapkan, pengawal kelajuan mekanikal akan menetapkan kelajuan mesin malar dengan cara mengawal sudut bukaan pendikit supaya bekalan bahan bakar ke enjin dapat dikawal dan disesuaikan dengan kuasa pada beban. Fungsi pengawal kelajuan mekanikal adalah untuk menyesuaikan sudut injap sehingga beban pada enjin akan dapat ditetapkan pada kelajuan yang dikehendaki. Di dalam tesis ini, keupayaan sistem kawalan automatik yang telah dirancang akan dikaji dan kesan daripada sistem kawalan automatik pada enjin pembakaran dalaman diramal. Analisis sistem dilakukan dengan menggunakan perhitungan manual untuk mencari perubahan jarak dan saiz pembukaan injap yang dipengaruhi oleh pengawal kelajuan. Selain itu, tesis ini juga menggunakan kod FORTRAN untuk menganalisa kelajuan dan kedudukan pengawal kelajuan mekanikal dengan menggunakan input kelajuan tertentu yang telah ditetapkan. Kesimpulannya, laporan ni bertujuan untuk menjelaskan kepentingan sistem kawalan automatik dan menerangkan bagaimana ia dapat mengawal kelajuan untuk sentiasa pada keadaan terbaik.

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LIST OF SYMBOLS

A	Area of the fuel valve (m^2)
b	Small radius ellipse (m).
c	Constant of the system.
d	Ball arm finger length (mm)
D	Diameter of the fuel valve (m).
f	Friction coefficient (Ns/m)
F_R	Friction coefficient (Ns/m)
G	specific gravity relative to water
itr	Transmission ratio (-)
I_{GOV}	Transmission ratio between governor axis–crankshaft
k	Sensing element spring stiffness (N/m)
l	Ball arm length (mm)
L	Dimensions (mm)
N	Engine speed (rpm) or Force (N)
N_{FW}	Number of flyweights
N_{GOV}	Type of governor
m_c	Mass of center lever
M_{FW}	Mass of flyweights (kg)
M_{GOV}	Mass of governor clutch (kg)
SPEED0	Initial speed (rpm)
r_0	Initial radius of gyration of flyweights (mm)
T	Time (s)
Q	Design flow rate (gpm)

X _G	Governor displacement.
Y	Governor setting (prior spring strain) (mm)
z	Sensing element current position (mm)
ZMAX	Maximum spring deformation (mm)
ω	Angular velocity (rads ⁻¹)
ϕ	The angle of fuel valve.
ΔP	Allowable pressure drop across wide open valve.

LIST OF ABBREVIATIONS

0	Initial conditions rest
A _{ellipse}	Ellipse area
C.I. Engine	Compression ignition engine
CH ₄	Methane
CO ₂	Carbon monoxide
H ₂	Hydrogen
H ₂ S	Hydrogen Sulphide
I.C. Engines	Internal combustion engine
LPG	Liquefied petroleum gas
N ₂	Nitrogen
O ₂	Oxygen
rpm	Revolutions per minute
Se	Sensing element supporting
S.I. engine	Spark ignition engine

APPENDIX D

Table 5.1: Valve selection table

Flow characteristic	Valve size Maximum travel Port diameter				Design flow down					Design flow up					
					Valve opening (percent of total travel)					Valve opening (percent of total travel)					
	DIN	Inches	mm	mm		10	30	70	100	100	10	30	70	100	100
Equal percentage	DIN	Inches	mm	mm		C_V				F_L	C_V				F_L
	25	1.1	19	33.3	0.783	2.20	7.83	17.2	0.88	0.783	1.86	9.54	17.4	0.95	
	40	1.5	19	47.6	1.52	3.87	17.4	35.8	0.84	1.54	3.57	17.2	33.4	0.94	
	50	2	29	58.7	1.66	4.66	25.4	59.7	0.85	1.74	4.72	25.0	56.2	0.92	
	65	2.5	38	73.0	3.43	10.8	49.2	99.4	0.84	4.05	10.6	45.5	82.7	0.93	
	80	3	38	87.3	4.32	10.9	66.0	136	0.82	4.05	10.0	59.0	121	0.89	
	100	4	51	111.1	5.85	18.3	125	224	0.82	6.56	17.3	103	203	0.91	
	150	6	51	177.8	12.9	43.3	239	394	0.85	13.2	41.1	223	357	0.86	
Linear	200	8	76	203.2	105	105	605	818	0.96	25.9	97.8	618	808	0.85	
	DIN	Inches	mm	mm		X_r					X_r				
	25	1.1	19	33.3	0.766	0.587	0.743	0.667	0	0.754	0.763	0.630	0.721	0	
	40	1.5	19	47.6	0.788	0.716	0.690	0.679	0	0.674	0.694	0.698	0.793	0	
	50	2	29	58.7	0.827	0.774	0.702	0.687	0	0.863	0.849	0.792	0.848	0	
	65	2.5	38	73.0	0.778	0.678	0.661	0.660	0	0.747	0.745	0.783	0.878	0	
	80	3	38	87.3	0.774	0.682	0.663	0.675	0	0.768	0.761	0.754	0.754	0	
	100	4	51	111.1	0.731	0.643	0.672	0.716	0	0.722	0.739	0.718	0.718	0	
Semi-logarithmic	150	6	51	177.8	0.688	0.682	0.736	0.778	0	0.723	0.767	0.808	0.808	0	
	200	8	76	203.2	0.644	0.636	0.725	0.807	0	0.825	0.681	0.735	0.735	0	

APPENDIX E

Table 5.2: Program input transient condition

TCYCLE, cycle time,(s)	SPEED, revolution per minute, (Rpm)	Y, prior spring strain, (mm)
0	1500	0.5
15	1450	0.5
30	1400	0.5
45	1350	0.5
60	1300	0.5
75	1250	0.5
90	1200	0.5
105	1150	0.5

APPENDIX F

Table 5.3: Program output transient condition

TCYCLE	Z	SPEED	Y	AK1
0	5.1369	1500	0.50	7251.50
15	5.0324	1450	0.50	7103.95
30	4.7995	1400	0.50	6961.40
45	4.5132	1350	0.50	6823.85
60	4.2081	1300	0.50	6691.30
75	3.8999	1250	0.50	6563.75
90	3.5963	1200	0.50	6441.20
	3.3010	1150	0.50	6323.65