`

EFFECT OF SUPERCHARGING AND TURBOCHARGING IN A MULTI CYLINDER LOW SPEED SPARK IGNITION ENGINE FUELLED BY PRODUCER GAS

by

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In the name of The God The Most Gracious The Most Merciful

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LIST OF ABBREVIATIONS

3D	Three dimension
30^o (1:1)	30^o angle mixer, 1" PG and air inlet diameter
60^o (1:1)	60^o angle mixer, 1" PG and air inlet diameter
90^o (1:1)	90^o angle mixer, 1" PG and air inlet diameter
90^o (2:1)	90^o angle mixer, 1" PG inlet, 2" air inlet diameter
AFR	Air-fuel ratio
BTE	Brake thermal efficiency
BTC	Before Top Center
CFD	Computational fluid dynamic
CH_4	Methane
CI	Compression ignition
CO	Carbon monoxide
CO_2	Carbon dioxide
CPG	Compressed Producer Gas
CR	Compression ratio
FAD	Free Air Delivery
GHG	Green house gas
GI	Galvanized iron
H_2	Hydrogen
H_2O	Water vapour
HC	Hydrocarbon
HHV	High heating value
IC	Internal combustion

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IISc	Indian Institute of Science
k-ε	k-epsilon
LHV_{pg}	Low heating value of producer gas
LHV_b	Low heating value of biomass material
LPG	Liquefied Petroleum Gas
N_2	Nitrogen
NA	Naturally aspirated
NEP	National Energy Policy
NO_x	Nitrogen oxide
O_2	Oxygen
OPEC	Organization of Petroleum Exporting Countries
PDF	Probability Density Function
PG	Producer gas
R/P	Reserves-to-production ratio
RON	Research Octane Number
SEC	Specific energy consumption
SC	Supercharged
SERI	Solar Energy Research Institute
SI	Spark ignition
TC	Turbocharged
TDC	Top Dead Center
U.S.A	United States of America

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LIST OF SYMBOLS

ΔP	Pressure difference
A	Area (m^2)
C_f	Flow coefficient
L	Stroke
N	Engine speed (RPM)
n	No. of cylinder
β	Beta ratio
η_{gas}	Gasification efficiency (%)
η_v	Volumetric efficiency (%)
M_b	Biomass fuel consumption
λ	Excess air coefficient
π	pi
$P_{a,0}$	Density of air at atmospheric (kg/m^3)
ρ_{pg}	Density of producer gas (kg/m^3)
Q_{pg}	Volume flow rate of producer gas
Φ	Equivalence ratio
V	Volume (m^3)

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KESAN CAS LAMPAU DAN CAS TURBO PADA ENJIN PENYALAAN PERCIKAN BERBILANG SILINDER BERKELAJUAN RENDAH MENGGUNAKAN GAS PENGELUAR

ABSTRAK

Gas pengeluar telah berjaya digunakan dalam enjin diesel dengan penggantian diesel sebanyak 60 - 70% tetapi mengalami 20 - 30% nyahkadaran kuasa. Sebaliknya, penggunaan gas pengeluar sepenuhnya di dalam enjin penyalaan percikan (SI) menyebabkan enjin mengalami nyahkadaran kuasa yang ketara sebanyak 40 - 70% yang menjadikan ia tidak diminati. Kajian ini dilakukan untuk menambah baik operasi enjin penyalaan percikan menggunakan gas pengeluar dari segi kuasa brek, kecekapan haba brek, penggunaan tenaga tertentu, suhu gas ekzos, pelepasan gas ekzos dan analisis ekonomi dengan kaedah cas lampau dan cas turbo kedua-dua gas pengeluar dan udara. Penyelidikan ini telah dijalankan pada enjin Perodua Kancil 660cc. Gas pengeluar telah dijana daripada proses penggasan di dalam penggasan aliran bawah lengkap dengan sistem penyejukan dan pembersihan. Kelajuan enjin dorongan gas pengeluar dalam mod enjin sedutan tabii (NA) dan cas lampau (SC) telah ditetapkan pada 1500 rpm, manakala operasi mod enjin cas turbo (TC) ditetapkan pada 3000 rpm. Beban yang dikenakan pada enjin telah dimanipulasi sehingga 20 Nm iaitu had beban maksimum dinamometer yang digunakan.

Mod SC menghasilkan kuasa brek yang serupa dengan operasi petrol iaitu 3.14 kW, manakala mod NA dan TC merekodkan nyahkadaran kuasa masing-masing

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sebanyak 70% dan 30%. Kecekapan brek haba dan penggunaan tenaga tertentu dalam mod SC didapati setanding dengan operasi petrol. Cas lampau kedua-dua gas pengeluar dan udara juga mengurangkan emisi CO sebanyak 40% berbanding operasi enjin sedutan tabii menggunakan gas pengeluar. Walau bagaimanapun ia tetap lebih tinggi sedikit berbanding operasi petrol sebanyak 30%. Tenaga masukan yang tinggi dalam mod SC yang disumbangkan oleh dua pemampat udara membuatkan ia tidak menguntungkan dari segi kewangan. Di antara semua mod operasi enjin menggunakan gas pengeluar, adalah dipercayai bahawa mod TC mampu menghasilkan prestasi enjin yang optimum dan kos efektif, sekiranya sistem turbocharger yang sesuai digunakan untuk mengurangkan nyahkadaran kuasa dan menambahbaik pelepasan gas ekzos.

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ABSTRACT

Producer gas has been used successfully in diesel engine with diesel replacement of 60 – 70% but suffers 20 – 30% power de-rating. On the other hand, fully fuelled producer gas in spark ignition (SI) engine suffered significantly high power de-rating about 40 – 70% which makes it undesirable. This research was done to improve producer gas fuelled SI engine in term of brake power, brake thermal efficiency, specific energy consumption, exhaust gas temperature, exhaust gas emissions and economic analysis by means of supercharging and turbocharging both producer gas and air. Research was done on a Perodua Kancil's 660cc engine. Producer gas was generated from gasification process inside downdraft gasifier with a complete cooling and cleaning system. Speed of producer gas fuelled engine in naturally aspirated (NA) and supercharged (SC) mode was maintained at 1500 rpm, while operation of turbocharged (TC) mode was fixed at 3000 rpm. Load applied to the engine was varied up to 20 Nm which is the maximum load limitation of the utilized dynamometer.

SC mode produced similar brake power with gasoline operation at 3.14 kW, while NA and TC mode recorded power de-rating of 70% and 30% respectively. Brake thermal efficiency and specific energy consumption of SC mode was found to be comparable with gasoline operation. Supercharging of both producer gas and air also

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improved 40% of CO emission compared to naturally aspirated producer gas fuelled engine operation. However the value was still slightly higher than gasoline operation by 30%. High energy input of SC mode contributed mainly by two air compressors make it not financially beneficial. Among all producer gas fuelled engine operation modes, it was believed that TC mode capable of producing optimum engine performance and cost effective, provided that suitable turbocharger system was used to further reduce its power de-rating and improved exhaust gas emission.

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