DECLARATION

I, Trinesh Chanka, declare that the content of this report is my own unaided work, unless otherwise stated, and that I own copyright in this. This research report is being submitted for the Degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Signed:_____

Trinesh Chanka

Date: _____ day of _____ 200_____

ABSTRACT

This report entails the research undertaken into the use of hydrogen, as generated by an on-demand production system, as an alternate fuel to the conventional spark ignition engine. The objectives were to develop a hydrogen generator capable of supplementing the petrol intake to the engine and to determine the engine performance and emissions for both conventional fuelling and hydrogen-enhanced fuelling. Comparisons of engine torque, BMEP and NO_x, CO and CO_2 concentrations were drawn. The use of hydrogen within the automotive industry, as well as current hydrogen-powered vehicles, was researched and described. A study into the effects of hydrogen fuelling was carried out and methods of hydrogen production were discussed. The detailed design of the hydrogen generator and its controlling electronic circuitry was undertaken and the generator was built and commissioned. The tests were performed on a 338 cm^3 Acme Motori engine coupled to a water-cooled dynamometer, complete with automatic control equipment. A detailed discussion of the preliminary testing was then presented whereafter, the final experimental procedure was described. Tests were performed at one-half throttle and at two-thirds throttle respectively for each fuelling scenario. Engine performance parameters and emissions concentrations were plotted for each fuel and direct comparisons between the two fuelling scenarios were drawn. Average BMEP output for hydrogen-enhanced fuelling was 15% higher. Average torque for hydrogen-enhanced fuelling was 9% higher. Average NO_x concentrations for hydrogen were 19% lower, while average CO emissions were 22% lower. Average CO_2 concentrations were 6% higher for hydrogen-enhanced fuelling.

ACKNOWLEDGEMENTS

The author wishes to acknowledge Dr. D. Cipolat for his guidance, assistance and mentorship throughout the duration of this project. The skills and knowledge that he has imparted, technical and otherwise, are, and will continue to be, of great benefit. Thanks and gratitude are also extended to Prof. Sheer for the financial assistance received from his department. To Mr. and Mrs. Eder, a debt of gratitude is owed for their assistance in the construction of the electronic circuitry. Acknowledgements must also be expressed to the staff of the mechanical workshops for their patience and practical advice. Lastly, to my parents, for affording me this opportunity and so many others, I am eternally grateful.

TABLE OF CONTENTS

Table of Contents

LIST OF FIGURES

List of Figures

LIST OF TABLES

List of Tables

NOMENCLATURE

Symbol	Description	Unit
A_{cap}	End cap area	[m^2]
A_{hole}	Hole surface area	[m^2]
ATDC	After top dead centre	[°crank angle]
b	Breadth of cross section	[m]
BMEP	Brake mean effective pressure	[kPa]
BTDC	Before top dead centre	[°crank angle]
C	Capacitance	[F]
C_d	Coefficient of discharge	
CO	Carbon monoxide	[ppm]
CO_2	Carbon dioxide	[ppm]
D_{major}	Major diameter	[m]
D_{thread}	Thread depth	[m]
EGR	Exhaust gas recirculation	
e^-	electron	
F	Force	[N]
f	Frequency	[Hz]
$F_{end\ cap}$	Force on end cap	[N]
F_{thread}	Thread force	[N]
f.o.s	Factor of safety	
g	Gravitational constant	[$m.s^{-2}$]
h	Height of cross section	[m]
H^+	Hydrogen ion	
I	Second moment of inertia	[m^4]
imep	Indicated mean effective pressure	[kPa]
m	Mass	[kg]
M	Bending moment	[Nm]

Symbol	Description	Unit
m	Carbon atom index	
m_w	Mass of water	[kg]
MBT	Maximum brake torque	[Nm]
n	Hydrogen atom index	
N	Engine speed	[rps]
NO_X	Nitrogen Oxides	[ppm]
P	Power	[kW]
p_a	Ambient pressure	[Pa]
p_{int}	Internal pressure	[Pa]
R	Universal gas constant	[$J.kg^{-1}.K^{-1}$]
$R_{1,2}$	Resistance	[Ω]
$Ratio_{thread}$	Thread depth / diameter ratio	
r_i	Inner radius	[m]
SA	Spark angle	[°crank angle]
sCO	Specific carbon monoxide	[$ppm.W^{-1}$]
sCO_2	Specific carbon dioxide	[$ppm.W^{-1}$]
sNO_x	Specific Nitrogen oxides	[$ppm.W^{-1}$]
$S_{y, PVC}$	Yield Strength of PVC	[MPa]
T	Temperature	[K]
T	Torque	[Nm]
t	Thickness	[m]
t	Time	[s]
T_a	Ambient temperature	[K]
T_{off}	Space time period	[s]
T_{on}	Mark time period	[s]
V	Voltage	[V]
$w_{generator}$	Weight of generator	[N]
wwmp	World wide mapping point	
y	Distance from neutral axis, bending	[m]

Symbol	Description	Unit
(aq)	Aqueous	
(g)	Gaseous	
(*l*)	Liquid	
$\dot{m}_h$	Mass rate of hydrogen	[kg.s^{-1}]
$\dot{m}_w$	Mass rate of water	[kg.s^{-1}]
V_w	Volume rate of water	[m^3.s^{-1}]
$\sigma_{bending}$	Bending stress	[MPa]
σ_{hoop}	Hoop stress	[MPa]
$\sigma_{hoop,max}$	Maximum hoop stress	[MPa]
λ	Relative equivalence ratio	
Δp	Differential pressure	[Pa]