A

DISSERTATION REPORT

ON

PERFORMANCE AND COMBUSTION ANALYSIS OF VARIABLE COMPRESSION RATIO DIESEL ENGINE FUELLED WITH HYDROGEN

Submitted in partial fulfillment of the requirements for the award of degree of

MASTER OF TECHNOLOGY
IN
ENERGY ENGINEERING

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June 2015

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CERTIFICATE

Thisistocertifythatthedissertationreportentitled**"Performance and Combustion analysis of Variable Compression Ratio (VCR) Diesel Engine fuelled with Hydrogen**"submitted by**Ms. DebasmitaBal**(IDNo.2013PME5119)totheMalaviyaNationalInstituteofTechnologyJaipurfortheawardofthedegreeof**MasterofTechnologyinEnergy Engineering**isabonafiderecordoforiginalworkcarriedoutbyher. Shehasworkedundermyguidanceandsupervisionandhasfulfilledtherequirement for the submissionofthisthesis, whichhasreachedtherequisitestandard.

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This is to certify that the dissertation entitled**"Performance and Combustion analysis of Variable Compression Ratio (VCR) Diesel Engine fuelled with Hydrogen** "submitted by **DebasmitaBal**towards the partial fulfilment of requirement for the degree of Masters of Technology (M.Tech.) in the field of Energy Engineering of Malaviya National Institute of Technology Jaipur is a work carried out by me under the supervision of**Prof.S.L.Soni**and has not been submitted anywhere else. The thesis has been checked for plagiarism and I will be solely responsible if any kind of plagiarism is detected.

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled **"Performance and Combustion analysis of Variable Compression Ratio (VCR) Diesel Engine fuelled with Hydrogen"**in partial fulfillment of the requirements for the award of the degree of **Master of Technology (M.Tech.)** in **Energy Engineering**, and submitted to the **Department of Mechanical Engineering, Malaviya National Institute of Technology,Jaipur** is an authentic record of my own work carried out by me during a period of one year from July 2014 to June 2015 under the guidance and supervision of **Prof. S. L. Soni,**Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the results of my own work and has not been submitted anywhere else for award of any other degree or diploma.

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ACKNOWLEDGEMENT

Firstandforemost, I expressmy deepsenseofgratitude andrespect tomy supervisor**Prof. S.L. Soni,**DepartmentofMechanicalEngineering, forhisinvaluableguidanceandsuggestionsduringmyresearchstudy. I considermyselfextremelyfortunatetohavehad theopportunity ofassociatingmyselfwithhimforoneyear. This thesiswasmadepossiblefor his kindpatienceandpersistence.

I express my sincere thanks to **Prof. DilipSharma,**Department of Mechanical Engineering, for his constant supportand elucidating my doubts during my research work.

Iwouldliketothankthetechnicalstaffspecially**Mr.RameshChandraMeena**,**Mr.BabuLalSainiandMr.KolahalPrasad**forprovidingmethesupportandequipment I neededtocompletemyexperiment.

I convey my heartfelt thanks to **Mr. Deepesh Sonar** and **Anmesh KumarSrivastava**, who helped me while conductingexperiments and all those who helped me in completion of this work.

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ABSTRACT

Alternative fuels are fetching attention among the researchers due to growing environmental concerns all over the globe. One most prominent candidate of alternative fuels is hydrogen due to its higher calorific value per unit mass basis, lower fuel consumption and clean burning properties. Using hydrogen as an energy source has opened up a new direction for its highest calorific value based on its mass basis. This research work focuses on the utilization of hydrogen in diesel engine in gaseous form along with air at a fixed mass flow rate of 40gm/hr at a fixed injection timing and fixed injection pressure while operating the engine at varied loads and different compression ratios (16-22) in Variable Compression Ratio Engine set up 240PE. Compression ratio 21 is found to be the optimum compression ratio in terms of maximum brake thermal efficiency when the engine is run with diesel only. Performance parameters and combustion analysis of hydrogen enriched diesel has been discussed and it has been observed the brake thermal efficiency decreases and BSEC increases when hydrogen enriched diesel fuel is used, but sustainable reduction in diesel mass flow rate has been observed as hydrogen takes part in reaction, which is desirable. However, the exhaust gas temperature and cylinder pressure and temperature is found to be higher during hydrogen enriched fuel as compared to the results obtained when the engine is run with diesel only. For appraisal any source of energy in a large scale basis, generates the need of determining its viability. This research study will assist the researchers to carry out their researches further on hydrogen at various compression ratios and will aid them with an outlook in its implementations.

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NOMENCLATURE

A	*Area*
C_d	Coefficient of discharge
D	Piston diameter, m
f	Coefficient of friction,
FF	Friction Factor
FC	Coefficient Of Friction
L	Length of the stroke, m
A	Area of the piston, m^2
N	Rotational speed of engine, RPM
P_m	Mean Effective Pressure (in bar)
ppm	Parts per million
R_e	Reynold's number
S	Sommerfeld number (dimensionless)
T	Torque, Nm
μ	Dynamic viscosity of fluid, Pa-s.
U	Linear velocity, m/s
V	Total Volume, m^3
V_a	Volume flow rate of air, m^3 /s
V_S	Swept Volume, m^3
V_c	Clearance Volume, m^3
kW	KiloWatt

Greek symbols

η_{bth}	Brake Thermal Efficiency
η_{it}	Indicated Thermal Efficiency
η_m	Mechanical efficiency
η_v	Volumetric Efficiency
θ	Crank Angle
ρ_w	Density of water, kg/m^3
ρ_a	Density of air, kg/m^3

Abbreviations

A/F	Air-Fuel Ratio
BDC	Bottom Dead Center
BMEP	Brake Mean Effective Pressure
BP	Brake Power
BSEC	Brake Specific Energy Consumption
BSFC	Brake Specific Fuel Consumption
BSN	Bosch Smoke Number
BTDC	Before Top Dead Centre
BTE	Brake Thermal Efficiency
CAE	Computer Aided Engineering
CFD	Computational Fluid Dynamics
CI	Compression Ignition
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CNG	Compressed Natural Gas
CR	Compression Ratio
CV	Calorific Value
DI	Direct Injection
EGT	Exhaust gas Temperature
EGR	Exhaust Gas Recirculation
FCV	Fuel Cell Vehicle
FDM	Finite Difference Method
FEA	Finite Element Analysis
FMEP	Frictional Mean Effective Pressure
FP	Frictional Power
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
ICE	Internal Combustion Engine
IDC	Inner Dead Center
IMEP	Indicated Mean Effective Pressure

IP	Indicated Power
LPG	Liquefied Petroleum Gas
LPM	LitrePer Minute
NO_X	Nitrogen Oxides
ODC	Outer Dead Center
PBDF	Petroleum Based Diesel Fuel
PM	Particulate Matter
P-V	Pressure Volume
SCR	Selective Catalytic Reduction
SI	Spark Ignition
TMI	Timed Manifold Injection
TDC	Top Dead Center
UHC	Unburned Hydrocarbon
VCR	Variable Compression Ratio