

# **PERFORMANCE AND EMISSIONS TESTING OF GASOLINE AND CNG ON A SI ENGINE**

A Major Dissertation Submitted in partial fulfillment of the  
Requirements for the award of the degree of

**Master of Technology**  
In  
**Thermal Engineering**

By  
**SANDEEP KUMAR**  
**(2K11/THE/16)**

Session 2011-13

*Under the Guidance of*

**Prof. S.MAJI**  
Professor

**Dr. AMIT PAL**  
Associate Professor



**DEPARTMENT OF MECHANICAL ENGINEERING  
DELHI TECHNOLOGICAL UNIVERSITY  
DELHI-110042**

## **DECLARATION**

I, hereby declare that the dissertation entitled “**PERFORMANCE AND EMISSIONS TESTING OF GASOLINE AND CNG ON A SI ENGINE**” being presented here in the partial fulfillment for the award of the Degree of Master of Technology (Thermal Engineering), is an authentic record of own work carried out by me under the guidance and supervision of Prof. S.Maji, Professor Department of Mechanical Engineering and Dr. Amit Pal, Associate Professor, Department of Mechanical Engineering, Delhi Technological University, Delhi.

I, further declare that the dissertation has not been submitted to any other Institute/University for the award of any degree or diploma or any other purpose whatsoever.

**Sandeep Kumar**

2K11/THE/16

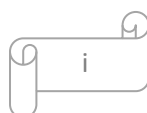
Master of Technology

(Thermal Engineering)

Department of Mechanical Engineering,

Delhi Technological University,

Delhi, India.



# **CERTIFICATE**

Date: \_\_\_\_\_

This is to certify that the dissertation entitled “**PERFORMANCE AND EMISSIONS TESTING OF GASOLINE AND CNG ON A SI ENGINE**” submitted by **Sandeep Kumar** (2K11/THE/16) in partial fulfillment of the requirements for the award of the Degree of Master of Technology in Thermal Engineering, is an authentic record of student’s own work carried out by him under our guidance and supervision.

This is also certified that this dissertation has not been submitted to any other Institute/University for the award of any degree or diploma.

**Prof. S. Maji**  
**Professor**

**Dr. Amit Pal**  
**Associate Professor**

**Department of Mechanical Engineering**  
**Delhi Technological University**  
**Delhi, India**



## **ACKNOWLEDGEMENT**

It gives me a great sense of pleasure to present the report of the M.Tech major dissertation undertaken during M.Tech Second Year. I am grateful to my learned project guide **Prof. S. Maji**, Professor and **Dr. Amit Pal**, Associate Professor in the Department of Mechanical Engineering, at Delhi Technological University for their expert guidance, meticulous efforts, constructive criticism, inspiring encouragement, unflinching supports and invaluable cooperation, which enabled me to enrich my knowledge and reproduce the same in the present form. Their continuous inspiration has only helped me to complete this project.

I would also like to thank **Head of Mechanical Department, Prof. Naveen Kumar & Prof. B. D. Pathak** for giving their kind support, sharing of valuable knowledge and approval of necessary infrastructure.

I would also like to thank **Sh. Lalit Kumar, Sh. Harjeet Singh and Sh. Vijay Hingorani** of I. C. Engine laboratory for extending their kind support and sharing their valuable time for the completion of this project on time.

I express my whole-hearted gratitude to all the faculty members who extended their cooperation in completing my project successfully.

**Sandeep Kumar**

(2K11/THE/16)

M.Tech (Thermal Engineering)

Department of Mechanical Engineering,

Delhi Technological University,

Delhi, India.

## ABSTRACT

Nowadays, increased attention has been focused on internal combustion engine fuels. Compressed natural gas has been introduced as an alternative to gasoline and diesel fuels in many applications. A high research octane number which allows combustion at higher compression ratios without knocking phenomenon and good emission characteristics of unburned hydrocarbons and carbon monoxide are major benefits of compressed natural gas as an engine fuel.

In Present work an experimental study is conducted using gasoline and compressed natural gas (CNG) as the main fuel in a 4-cylinder,4-stroke spark ignition Maruti wagon –R engine at different loading conditions. The engine was converted to computer integrated Bi-fueling system and operated separately either with gasoline or CNG. A personal computer (PC) based data acquisition and control system was used for controlling all the operation. A detailed comparative analysis of the Engine performance and exhaust emissions is performed.

The variation of performance parameters (BSFC, BTE, and BSEC) and emissions (CO, CO<sub>2</sub> and HC) for CNG is compared with gasoline for a wide range of Engine load. The results show that gasoline is having higher BSFC as compared to CNG. Whereas BTE or maximum BTE for gasoline and CNG are almost same. A CO and HC emission of CNG is lower but little more NO<sub>x</sub> which can controlled with catalytic convertor as compared to gasoline. CNG can be successfully used as an alternative gaseous fuel in SI engine.

# TABLE OF CONTENTS

	<b>Page No.</b>
<b>Students' Declaration</b>	i
<b>Certificate</b>	ii
<b>Acknowledgement</b>	iii
<b>Abstract</b>	iv
<b>Table of Contents</b>	v
<b>List of Figures</b>	viii
<b>List of Tables</b>	xi
<b>List of Abbreviations</b>	xiii
<b>Chapter 1 INTRODUCTION</b>	<b>1</b>
1.1 Overview	1
1.1.1 GASOLINE	5
1.1.2 CNG	7
1.2 Motivation	13
1.3 Objectives	13
1.4 Organisation of the report	14
<b>Chapter 2 LITERATURE REVIEW</b>	<b>15</b>
2.1 Performance and emission characteristics of spark ignition engine with alternative fuels	15
2.2 Important findings from the literature review	24

2.3	Objectives of the present work	25
<b>Chapter 3</b>	<b>EXPERIMENTAL SETUP</b>	<b>26</b>
3.1	Description of Experimental setup	26
3.2	Experimental setup specifications	31
3.3	Emission Gas Analyzer specifications	33
<b>Chapter 4</b>	<b>RESULTS AND DISCUSSION</b>	<b>34</b>
4.1	Collection of Experimental data	34
4.2	Combustion Parameters	35
4.2.1	Pressure Crank Angle Diagrams	35
4.3	Performance Parameters	40
4.3.1	Performance Parameters Experimental data	41
4.3.2	Brake Specific Fuel Consumption	44
4.3.3	Brake Specific Energy Consumption	46
4.3.4	Brake Thermal Efficiency	48
4.4	Emission Parameters	51
4.4.1	Emission Parameters Experimental data	51
4.4.2	CO emissions	55
4.4.3	HC emissions	57
4.4.4	NO <sub>x</sub> emissions	60
<b>Chapter 5</b>	<b>CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK</b>	<b>62</b>
5.1	Conclusion	62
5.2	Recommendations for future work	63



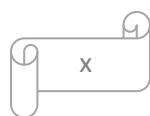


## LIST OF FIGURES

S.No.	Title	Page No.
Figure 3.1	Experimental setup	26
Figure 3.2	Schematic diagram of Engine Setup	27
Figure 3.3	Test Engine	27
Figure 3.4	Dynamometer Loading Unit	27
Figure 3.5	Data Acquisition System	27
Figure 3.6	CNG Conversion Kit	27
Figure 37	Cylinder Pressure sensor	28
Figure 3.8	Exhaust tailpipe & secondary outlet	28
Figure 3.9	Gas Analyser	33
Figure 4.1	Cylinder pressure variation V/s crank angle for Gasoline & CNG at speed 3000 rpm.	37
Figure 4.2	Cylinder pressure variation V/s crank angle for Gasoline & CNG at speed 3500 rpm.	37
Figure 4.3	Cylinder pressure variation V/s crank angle for Gasoline & CNG at speed 4000 rpm.	38
Figure 4.4	Cylinder pressure variation V/s crank angle for Gasoline & CNG at speed 4500 rpm.	38
Figure 4.5	Cylinder pressure variation V/s crank angle for gasoline at four different speeds.	39
Figure 4.6	Cylinder pressure variation V/s crank angle for CNG at four different speeds.	40

Figure 4.7	BSFC V/s Load at 3000 rpm	45
Figure 4.8	BSFC V/s Load at 3500 rpm	45
Figure 4.9	BSFC V/s Load at 4000 rpm	46
Figure 4.10	BSFC V/s Load at 4500 rpm	46
Figure 4.11	BSEC V/s Load at 3000 rpm	47
Figure 4.12	BSEC V/s Load at 3500 rpm	47
Figure 4.13	BSEC V/s Load at 4000 rpm	48
Figure 4.14	BSEC V/s Load at 4500 rpm	48
Figure 4.15	BTE V/s Load at 3000 rpm	49
Figure 4.16	BTE V/s Load at 3500 rpm	49
Figure 4.17	BTE V/s Load at 4000 rpm	50
Figure 4.18	BTE V/s Load at 4500 rpm	50
Figure 4.19	CO V/s Load at 3000 rpm	55
Figure 4.20	CO V/s Load at 3500 rpm	56
Figure 4.21	CO V/s Load at 4000 rpm	56
Figure 4.22	CO V/s Load at 4500 rpm	56
Figure 4.23	HC V/s Load at 3000 rpm	57
Figure 4.24	HC V/s Load at 3500 rpm	58
Figure 4.25	HC V/s Load at 4000 rpm	59
Figure 4.26	HC V/s Load at 4500 rpm	59
Figure 4.27	NO <sub>x</sub> V/s Load 3000 rpm	60
Figure 4.28	NO <sub>x</sub> V/s Load 3500 rpm	61

Figure 4.29	NO <sub>x</sub> V/s Load 4000 rpm	61
Figure 4.30	NO <sub>x</sub> V/s Load 4500 rpm	61



## LIST OF TABLES

S.No.	Title	Page No.
Table 1.1	Composition of CNG in India Supplied by GAIL	11
Table 1.2	Properties of Gasoline and CNG	12
Table 4.1	Test engine specifications	34
Table 4.2	Performance parameters for gasoline at 3000 rpm	41
Table 4.3	Performance parameters for CNG at 3000 rpm	41
Table 4.4	Percentage change of the performance parameters for CNG with respect to gasoline at 3000 rpm	41
Table 4.5	Performance parameters for gasoline at 3500 rpm	42
Table 4.6	Performance parameters for CNG at 3500 rpm	42
Table 4.7	Percentage change of the performance parameters for CNG with respect to gasoline at 3500 rpm	42
Table 4.8	Performance parameters for gasoline at 4000 rpm	43
Table 4.9	Performance parameters for CNG at 4000 rpm	43
<i>Table 4.10</i>	Percentage change of the performance parameters for CNG with respect to gasoline at 4000 rpm	43
Table 4.11	Performance parameters for gasoline at 4500 rpm	44
Table 4.12	Performance parameters for CNG at 4500 rpm	44
Table 4.13	Percentage change of the performance parameters for CNG with respect to gasoline at 4500 rpm	44
Table 4.14	Emissions for Gasoline at 3000rpm	51
Table 4.15	Emissions for CNG at 3000rpm	51
Table 4.16	Percentage change of the emissions parameters for CNG with respect to gasoline at 3000rpm	51

Table 4.17	Emissions for Gasoline at 3500rpm	52
Table 4.18	Emissions for CNG at 3500rpm	52
Table 4.19	Percentage change of the emissions parameters for CNG with respect to gasoline at 3500rpm	52
Table 4.20	Emissions for Gasoline at 4000rpm	53
Table 4.21	Emissions for CNG at 4000rpm	53
Table 4.22	Percentage change of the emissions parameters for CNG with respect to gasoline at 4000rpm	53
Table 4.23	Emissions for Gasoline at 4500rpm	54
Table 4.24	Emissions for CNG at 4500rpm	54
Table 4.25	Percentage change of the emissions parameters for CNG with respect to gasoline at 3000rpm	54

## **LIST OF ABBREVIATIONS**

A/F ratio	air fuel ratio
BMEP	brake mean effective pressure
BP	brake power
BS	bharat stage emission standards
BSEC	brake specific energy consumption
BSFC	brake specific fuel consumption
BTDC	before top dead center
BTE	brake thermal efficiency
CA	crank angle
CC	Cubic centimeter
CFX	Commercial computational fluid dynamics program
CR	Compression ratio
CNG	compressed natural gas
CNG/DI	direct injection compressed natural gas engine
CO	carbon mono oxide
CO <sub>2</sub>	carbon dioxide
D	diesel oil
ECU	engine control unit
EGR	exhaust gas recirculation
FCE	fuel conversion efficiency
HC	unburnt hydro carbons

IMEP	Indicated mean effective pressure
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MAP	manifold absolute pressure
MBT	maximum brake torque
NG	natural gas
NGV	natural gas vehicle
NMHC	non methane hydrocarbon
NO <sub>x</sub>	Oxides of nitrogen
PPM	particles per million
RPM	revolution per minute
SA	spark advance
SI	spark ignition
TWC	three way catalytic convertor
TDC	top dead center
Tsfc	trillion standard cubic feet
VOC	Volatile organic compound

