

# **Biodiesel Production of WCO by Hydrodynamic Cavitation and Its Performance Testing on a CI Engine**

A Major project report

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

of

**MASTER OF TECHNOLOGY**

**IN**

**THERMAL ENGINEERING**

Submitted By

**MANISHA RANI**

**(Roll No. 2K12/THR/14)**

Under the esteemed guidance

of

**DR. AMIT PAL**



**Department of Mechanical Engineering**

**Delhi Technological University,**

**Main Bawana Road, Delhi-110042.**

**Department of Mechanical Engineering  
Delhi Technological University ,Delhi  
Main Bawana Road , Delhi-110042**

---

**Certificate**

This is to certify that the thesis entitled " **Biodiesel Production of WCO by Hydrodynamic Cavitation and Its Performance Testing on a CI Engine**", which is being submitted by Ms. Manisha Rani to the Department of Mechanical Engineering , Delhi Technological University, Delhi for the award of Master of Technology in Thermal Engineering, is a record of bonafide research work carried out by her under my guidance and has fulfilled the requirements for the submission of thesis, which is to my knowledge has reached requisite standard.

To the best of my knowledge, the results contained in this dissertation have not been submitted in part or in full to any university or institute for the award or any degree.

**Dr. Amit Pal**

**Department of Mechanical Engineering**

**Delhi Technological University, Delhi**

## **STUDENT DECLARATION**

I hereby certify that the work which is being presented in the dissertation entitled **“Biodiesel Production of WCO by Hydrodynamic Cavitation and Its Performance Testing on a CI Engine”** submitted to the Department of Mechanical Engineering, is an authentic record of my own work carried under the supervision of **Dr. Amit Pal, Associate professor** Mechanical Engineering Department, Delhi Technological University, Delhi.

I have not submitted the matter embodied in this major project as whole or in part to any university or institute for the award of any other degree.

Manisha Rani

Roll no. 2K12/THR/14

## **ACKNOWLEDGEMENT**

I wish to express my deep sense of gratitude and veneration to my project guide, Prof. B.D. Pathak and Dr. Amit Pal, Department of Mechanical Engineering, Delhi Technological University, Delhi for their perpetual encouragement constant guidance, valuable suggestions and continued motivation which has enabled me to complete this work.

I also give my heartily thanks to Prof. Naveen Kumar, Head of Department of Mechanical Engineering, DTU and all the concerned faculty members of Department of Mechanical Engineering, Delhi Technological university for their kind help and valuable suggestions during the entire project.

I am also thankful to Shri Vijay Kumar (Research Lab), Shri Lalit Kumar and Shri Harjeet Singh (I.C. Engine Lab) for their constant support to carry out my project work.

I am thankful to all my colleagues for their co-operation and encouragement to complete this work.

Manisha Rani

Roll No.2K12/THR/14

## **ABSTRACT**

Rapid depletion in petroleum reserves, and increasing cost of fuels and increasing pollution in the environment due to these fossil fuels have stimulated the search for the alternatives to petroleum based fuels. Biomass derived vegetable oils are quite promising alternative fuels for agriculture and transport diesel engines. Different type of vegetable oils like jatropha oil, waste cooking oil, linseed oil, sunflower oil, coconut oil, karanja oil etc. can be converted into biodiesel to be used as a bio-fuel. Only problem with Waste Cooking Oil is its high viscosity and low volatility. To overcome these problems esterification is done. Transesterification is the process in which Vegetable oil is treated with ethyl/methyl alcohol in presence of as a catalyst.

In this experimental investigation we have prepared the biodiesel from waste cooking oil by conventional and advanced methods (e.g. mechanical stirring method, ultrasonic cavitation method and hydrodynamic cavitation methods) and studied the effect of different parameters like reaction time, change in catalyst percentage and change in molar ratio on the yield of biodiesel produced.

Max yield is obtained for catalyst-0.5% and molar ratio 6:1 for 60 min reaction time. Yield obtain is higher for Hydrodynamic Cavitation than Ultrasonic Cavitation and conventional Mechanical Stirring method.

Further experimental work is conducted on a single cylinder four-stroke water-cooled direct injection, constant speed diesel engine that was operated on different blends of waste cooking oil based bio-diesel and diesel. Load on the engine was varied to study their influence on performance, emission and combustion. It is observed that with increase in biodiesel in the blend brake thermal efficiency increases and a decrease in CO and hydrocarbon (HC) and smoke emission is also observed.

## LIST OF FIGURES

	CONTENT	PAGE No.
Fig.1	A mechanical stirrer	23
Fig.2	Yield Vs reaction time for different molar ratios for mechanical stirring method for catalyst percentage 0.5 %	27
Fig.3	Yield Vs reaction time for different molar ratios for mechanical stirring method for catalyst percentage 0.75 %	27
Fig.4	Yield Vs reaction time for different molar ratios for mechanical stirring method for catalyst percentage 1.0 %	28
Fig.5	Yield Vs reaction time for different catalyst percentage for mechanical stirring method for molar ratio 3:1	28
Fig.6	Yield Vs reaction time for different catalyst percentage for mechanical stirring method for molar ratio 4.5:1	29
Fig.7	Yield Vs reaction time for different catalyst percentage for mechanical stirring method for molar ratio 6:1	29
Fig.8	An ultrasonic horn type processor	31
Fig.9	Yield Vs reaction time for different molar ratios for ultrasonic cavitation method for catalyst percentage 0.5 %	35
Fig.10	Yield Vs reaction time for different molar ratios for ultrasonic cavitation method for catalyst percentage 0.75 %	35
Fig.11	Yield Vs reaction time for different molar ratios for ultrasonic cavitation method for catalyst percentage 1.0 %	36
Fig.12	Yield Vs reaction time for different catalyst percentage for ultrasonic cavitation method for molar ratio 3:1	36
Fig.13	Yield Vs reaction time for different catalyst percentage for	37

ultrasonic cavitation method for molar ratio 4.5:1

Fig.14	Yield Vs reaction time for different catalyst percentage for ultrasonic cavitation method for molar ratio 6:1	37
Fig.15	A hydrodynamic cavitation setup	40
Fig.16	Yield Vs reaction time for different molar ratios for hydrodynamic cavitation method for catalyst percentage- 0.5 %	44
Fig.17	Yield Vs reaction time for different molar ratios for hydrodynamic cavitation method for catalyst percentage- 0.75 %	44
Fig.18	Yield Vs reaction time for different molar ratios for hydrodynamic cavitation method for catalyst percentage- 1.0 %	45
Fig.19	Yield Vs reaction time for different catalyst percentage for hydrodynamic cavitation method for molar ratio 3 :1	45
Fig.20	Yield Vs reaction time for different catalyst percentage for hydrodynamic cavitation method for molar ratio 4.5 :1	46
Fig.21	Yield Vs reaction time for different catalyst percentage for hydrodynamic cavitation method for molar ratio 6 :1	46
Fig.22	A comparison of methods yield Vs reaction time for molar ratio 3:1 and KOH-0.5%	48
Fig.23	A comparison of methods yield Vs reaction time for molar ratio 4.5:1 and KOH-0.5%	48
Fig.24	A comparison of methods yield Vs reaction time for molar ratio 6:1 and KOH-0.5%	49
Fig.25	A comparison of methods yield Vs reaction time for molar ratio 3:1 and KOH-0.75%	50

Fig.26	A comparison of methods yield Vs reaction time for molar ratio 4.5:1 and KOH-0.75%	50
Fig.27	A comparison of methods yield Vs reaction time for molar ratio 6:1 and KOH-0.75%	51
Fig.28	A comparison of methods yield Vs reaction time for molar ratio 3:1 and KOH-1.0%	52
Fig.29	A comparison of methods yield Vs reaction time for molar ratio 4.5:1 and KOH-1.0%	52
Fig.30	A comparison of methods yield Vs reaction time for molar ratio 6:1 and KOH-1.0%	53
Fig.31	Experimental set-up of Kirloskar diesel engine	55
Fig.32	Rear view of the Kirloskar diesel engine	55
Fig.33	Brake thermal efficiency Vs Brake Power for diesel and WCOME blends	62
Fig.34	Exhaust Gas Temperature Vs Brake Power for diesel and WCOME blends	63
Fig.35	Brake Specific Fuel Consumption Vs Brake Power for diesel and WCOME blends	64
Fig.36	Brake Specific Energy Consumption Vs Brake Power for diesel and WCOME blends	65
Fig.37	CO emissions Vs Brake Power for diesel and WCOME blends	68
Fig.38	HC emissions Vs Brake Power for diesel and WCOME blends	69
Fig.39	NO <sub>x</sub> emission Vs Brake Power for diesel and WCOME blends	70
Fig.40	Opacity Vs Brake Power for diesel and WCOME blends	71



## LIST OF TABLES

	CONTENT	PAGE No.
Table.1	Production of Biodiesel Worldwide	6
Table 2	Physical Properties of Biodiesel	8-9
Table.3	Oil, alcohol and catalyst during the experimentation	25
Table.4	Conventional mechanical stirring method (molar ratio 3:1)	26
Table.5	Conventional mechanical stirring method (molar ratio 4.5:1)	26
Table.6	Conventional mechanical stirring method (molar ratio 6:1)	26
Table.7	Oil, alcohol and catalyst during the experimentation	33
Table.8	Ultrasonic cavitation method (molar ratio 3:1)	34
Table.9	Ultrasonic cavitation method (molar ratio 4.5:1)	34
Table.10	Ultrasonic cavitation method (molar ratio 6:1)	34
Table.11	Oil, alcohol and catalyst during the experimentation	42
Table.12	Hydrodynamic cavitation method (molar ratio 3:1)	43
Table.13	Hydrodynamic cavitation method (molar ratio 4.5:1)	43
Table.14	Hydrodynamic cavitation method (molar ratio 6:1)	43
Table.15	Specifications of engine test rig.	56
Table.16	Description of different blends of biodiesel	57
Table.17	Performance parameters for pure diesel Vs brake power	59
Table.18	Performance parameters for B-10 WCOME Vs brake power	60
Table.19	Performance parameters for B-20 WCOME Vs brake power	60
Table.20	Performance parameters for B-30 WCOME Vs brake power	61
Table.21	Emission parameters Vs Brake Power for pure diesel	66

Table.22	Emission parameters Vs Brake Power for B10 WCOME blend	66
Table.23	Emission parameters Vs Brake Power for B20 WCOME blend	67
Table.24	Emission parameters Vs Brake Power for B30 WCOME blend	67

## LIST OF ABBREVIATIONS

BTHE	Brake thermal efficiency
BHP	Brake Horse power
BSFC	Brake specific fuel consumption
BSEC	Brake specific energy consumption
BP	Brake power
WCOME	Waste Cooking Oil Methyl Ester
WCO	Waste cooking oil
FP	Frictional power
IP	Indicated power
IThE	Indicated thermal efficiency
MechE	Mechanical efficiency
A/F	Air fuel ratio
BMEP	Brake mean effective pressure
PPM	Parts Per Million
PM	Particulate Matter
FFA	Free fatty acid
UCME	Used cooking oil methyl ester
WFO	Waste frying oil
CN	Cetane Number
FAME	Fatty acid methyl ester
WCO-BXX	Waste cooking oil Blend with XX% of bio-diesel
THC	Total hydrocarbon emission
HC	Hydrocarbon
UHBC	Unburnt hydrocarbon
B-XX	Blend with XX % of bio-diesel