# An Experimental Study on feasibility of using Methanol as a fuel blended with diesel in Motorized Boat for passenger transport

**A THESIS SUBMITTED TOWARDS PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE**
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**IN**
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**SUBMITTED BY**
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**UNDER THE GUIDANCE OF**
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**M. TECH IN ENERGY SCIENCE AND TECHNOLOGY**
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# CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitled "**An Experimental Study on feasibility of using Methanol as a fuel blended with diesel in Motorized Boat for passenger transport"** is a bonafide work carried out by **Mr. HIMALAYA DEBNATH** under our supervision and guidance for partial fulfilment of the requirements for the Post Graduate Degree of Master of Technology in Energy Science and Technology, during the academic session 2022-2024.

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## CERTIFICATE OF APPROVAL

This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactorily to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted**.**

**Committee of** --------------------------------------

**Final examination for** --------------------------------------

**Evaluation of Thesis** --------------------------------------

# DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his Master of Technology in Energy Science and Technology studies during academic session 2022-2024.

All information in this document has been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by these rules and conduct, I have fully cited and referred all materials and results that are not original to this work.

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***Dedicated to***

***My beloved family members***

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# Chapter 1

# Introduction

# 1. Introduction

Energy, the lifeblood of our modern world, fuels our homes, industries, and transportation. However, our ever-growing demand for energy is putting immense strain on our planet's resources and environment. Fossil fuels, the dominant energy source, are finite and their continued use contributes significantly to climate change. Compression ignition (CI) engines are widely used for transportation, automotive, agricultural applications and industrial sectors because of their high fuel conversion efficiencies and relative easy of operation. These wide fields of usage lead to increasing requirements of petroleum-derived fuels. The depletion of petroleum reserves and increasing demand also contribute to a steep rise in fuel prices. On the other hand, their exhaust emissions, such as soot and nitrogen oxide (NOx) are harmful to natural environment and living beings (Yao et al., 2008). Lot of studies are being conducted worldwide to reduce the soot, carbon monoxide (CO), hydro-carbon (HC) and NOx emissions from diesel engines. (Canakci et al., 2009). At the same time, depletion of fossil fuels and environmental considerations has led to investigations on the alternative fuels such as methanol, ethanol, hydrogen, and biodiesel. Particularly, methanol can be obtained from many fossil and renewable sources. These include coal, petroleum, natural gas, biomass, wood, landfills and even the ocean (Sayin et al., 2009). Dual fuel operation with methanol and diesel fuel brings following advantages and disadvantages; The relative advantages of methanol as compared with conventional diesel fuel include: 1) High stoichiometric fuel to air ratio 2) High oxygen content, high hydrogen to carbon ratio and low sulfur content 3) Higher latent heat of vaporization 4) Improving the combustion and reducing the soot and smoke 5) Higher cooling by evaporation of methanol blended diesel fuel relative to single diesel fuel. Thus, required work input in the compression stroke is reduced. The disadvantages are: 1) Poor ignition behavior due to its low cetane number, high ignition temperature, thereby causing probably longer ignition delay 2) More corrosive than diesel fuel on copper, brass, aluminum, rubber, and many plastics 3) Methanol has lower energy content and much lower flash point as compared to with diesel engine (Bayraktar, 2008). The most important problem encountered in this case is the separation of phases. This problem can be prevented by adding some solvent into mixture. Moreover, an ignition improver like diethyl ether can be added into the blended fuel to increase the cetane number. This application doesn't require modification on engine design and fuel system if concentrations of methanol in the blends are at low levels (Bayraktar, 2008). Therefore, in the 1$^{st}$ phase of study, methanol was blended with diesel fuel at rates of 0, 5, 10,15,20, and 25% diesel fuel volume and their effects on the engine performance and exhaust emissions were experimentally investigated using a single cylinder, direct injection diesel engine. **In the 2nd phase** we have some specific data regarding the study and as we know that the engine was ran smoothly up to 20% of methanol mixing with the diesel and in 5% of methanol, the engine also ran smoothly. For this reason, we did only the blended percentage 10%,15%,20%and 25%. we conducted this experiment in real world scenario at Sundarbans area where, we took a boat engine for set up. Here we choose the methanol, because one of the cheapest chemicals in market also accessed easily.

This study consists of all total 7 chapter,

Chapter 1 – A brief Introduction of the experiment and also the aims and objective of the experiment has been carried out in this chapter.

Chapter 2 – The literature review in the thesis establishes the context for the research by summarizing and analyzing existing work gape.

Chapter 3 – This chapter aims to elaborate about the diesel engine with consist of history, various cycles, efficiency and as well as emissions of diesel engine.

Chapter 4 – This chapter consist of various parameters of methanol and their properties, and how much methanol is capable to mixed with diesel.

Chapter 5 – This chapter aims to elaborate about the laboratory scale study on using of methanol blended with diesel and the exhaust gas temperature variation.

Chapter 6 – This chapter delivered the concept about the survey data , field experiment, consumption of fuel and energy and a briefly cost analysis of field experiment.

Chapter 7 – This chapter conclude that whether the study fulfill our aims and objective or not.

**The main objective of our experimental study is** – to investigate the effect of Methanol as a fuel blended with diesel in Motorized Boat for passenger transport.

1) This study aims to obtained the percentage of the mixing capability of methanol with diesel, up to when the engine can run perfectly without any abnormal vibration and noise.

2) This study aims to know that whether the methanol diesel blend is perfectly working or not in fields boat.

3) This study aims to know the fuel consumption / km, Energy consumption / Km and the specific energy consumption of boat.

4) This study aims to investigate a suitable cost analysis for the percentage of blending compared to the diesel fuel in the boat.

# Chapter 2
# Review of Earlier Work

## 2.1 Introduction

In the last chapter, we talked about the current situation of the world. Current world conditions have increased the need for alternative energy sources due to the environmental damage caused by the use of renewable energy sources to generate power from fossil fuels. The world is facing an unprecedented climate crisis, with global carbon dioxide emissions reaching unprecedented levels Here, we embark on a comprehensive exploration of existing research, discreet examining scholarly works, articles, and studies relevant to this field. Our objective is to paint a clear picture of the current state of knowledge on feasibility of using Methanol as a fuel blended with diesel in Motorized Boat for passenger transport.

## 2.2 Review of Earlier Work

**Yasin M.H. Mat et al. (2013)** are mentions that biodiesel has been a lucrative commodity in the current global economic trade as there is mounting concern for issues relating to the environment and oil depletion. Biodiesel has been proven to be the next alternative renewable fuel as it is environmentally friendly, sustainable and possesses similar combustion characteristics to petroleum diesel. However, due to the higher density and viscosity of biodiesel, pure biodiesel is not widely used in diesel engines. Therefore, the purpose of alcohol as a fuel additive is to improve the viscosity and density in the biodiesel blend. The focus of this study is to evaluate the performance and emissions of a small proportion of methanol (5% by volume) in a B20 blend and mineral diesel separately. A compression ignition (CI) Mitsubishi 4D68 multi-cylinder DI diesel engine was used in this work. Engine performance, combustion and exhaust emission characteristics were evaluated at two specific conditions. The first condition was an increase in engine speed from 1500 rpm to 3500 rpm at partial engine load and the second condition involved maintaining a constant speed of 2500 rpm at three different engine loads (0.05 MPa, 0.4 MPa and 0.7 MPa). Lower brake power was noticed when operating with B20 and B20 M5 blend. However, an increase in brake specific fuel consumption (BSFC) of 4–6% was observed when the engine was fueled with B20 and B20 M5. The results indicate that NOx emissions increase (up to 13%) while lower carbon monoxide (CO) and Carbon dioxide (CO2) (up to 17–18%) are observed in contrast with the mineral diesel.

**Yasina Mohd Hafizil Mat et al. (2015)** in this study, biodiesel (20%)-methanol (5%)-diesel (75%), biodiesel (20%)-methanol (10%)- diesel (70%), biodiesel (20%)- diesel (80%), and standard mineral diesel as a baseline fuel are tested in a multi-cylinder diesel engine. Those biodiesel-alcohol low proportion blends are investigated under the same operating conditions at 20%, 40% and 60% of engine loads to determine the engine performance and emission of the diesel engine. Overall, biodiesel methanol diesel blends show higher brake specific fuel consumption than mineral diesel. As methanol proportions in blends increase, NO emissions increase, while CO emissions are reduced. Also, biodiesel-diesel blend with 5% of methanol is more effective than biodiesel blend with 20% for reducing CO emissions.

**Ambarish Datta et al. (2014)** in this study there have some particular method are used. Transport sector banks mainly on diesel engines and combustion of diesel generates plenty of toxic pollutants. In this study, a numerical simulation is being carried out by the authors to investigate the performance and emission characteristics of an unmodified single cylinder, naturally aspirated, water cooled, direct injection, four stroke diesel engine fuelled with diesel and dieselmethanol blends. The simulation has been conducted at a constant engine speed of 1500 rpm and static injection timing of 23°bTDC at different brake power of the engine. The methanol percentage has been varied in the blends up to 15%. The results have been presented in terms of different performance and emission parameter

**Murat Ciniviz et al. (2011)** in this study, considering strict restrictions on exhaust emissions of newly produced diesel engines, in this study, the effects of methanol and diesel fuel blends on compression ignition engine performance and exhaust emissions of a four cylinder, four stroke, direct injection, turbocharged diesel engine were experimentally investigated. Methanol-blended diesel fuels were ranged from 0 to 15% volumetric methanol content with an increment of 5%. The tests were performed by varying engine speed between 1000 min-1 to 2700 min-1 by an engine testing dynamometer. Results indicated that brake specific fuel consumption and nitrogen oxide emissions increased while brake thermal efficiency, carbon monoxide and hydrocarbons decreased relative to single diesel fuel operation with increasing amount of methanol in the fuel mixture. Effects can be visualized by data which were 49 and 47.5 kW for power, 169 and 190 g/kWh for brake specific fuel consumption, 33 and 30% for brake specific thermal efficiency, 0.21 and 0.18% for carbon monoxide, 7.15 and 8.1% for carbon dioxide, 8.02 and 6.1 ppm for hydrocarbons, 385 and 418 ppm for nitrogen oxides at 1600 min-1 in order of standard diesel fuel operation and fuel blend with 10% methanol content.

**Qais Hussein Hassan et al. (2021)** in this study, The impact of blending diesel fuel with different ratios of methanol was investigated in a TD 212 laboratory internal combustion diesel engine which is a single-cylinder, four-strokes, and pneumatic cooling. The tested engine was fuelled by a diesel fuel blending with methanol in a volume percentage of 7, 14 and 21, and the results were compared with pure diesel fuel. To avoid a phase separation issue, 1% of 1- dodecanol was added into each blend. The engine was operated within a constant speed of 2000 rpm under three levels of torques 2, 4 and 6 N.m. The brake-specific fuel consumption (BSFC), engine effective power (Ne), brake-specific energy consumption (BSEC), brake thermal efficiency (BTE), and noise level of the tested engine as well as the exhaust temperature were evaluated. The results showed that blending diesel with methanol up to 14% improves the performance of the fuel through improving BSFC, Ne, BSEC, BTE, noise level, and decrease the exhaust temperature due to increase the oxygen content of the fuel resulted from adding methanol which also lowers the fuel density and viscosity. This lowering in the fuel density and viscosity decrease the noise level and improve the combustion rate of the fuel. Improving the combustion with lowering the exhaust temperature lead to decrease the formation of NOx components which are serious pollutants for the environment.

**Ahmed I. EL-Seesy1 et al. (2022)** this research endeavored to boost the applicability of methanol in CI engines utilizing n  decanol as cosolvents. The work was split into binary phases. Firstly, the stabilities of pure methanol (M100) and hydrous-methanol (MH10), with diesel as a reference fuel, were examined applying various temperatures: 10 °C, 20 °C, and 30 °C. The fndings showed that the M100-diesel and MH10-diesel combinations were unstable. Thus, n-decanol was utilized as a cosolvent. Following by the engine combustion and emissions characteristics were evaluated by manipulating three proportions of M100-diesel mixtures with n-decanol. Three mixtures comprised of 5, 10, and 15% M100 with 20% n-decanol, which are denoted as M5, M10, and M15, correspondingly. These combinations were assessed via thermogravimetric assessment, and their physicochemical properties were assessed corresponding to the ASTM. The maximum in-cylinder pressure, heat release rate, and pressure rise rate diminished by 10, 11, and 10%, respectively, for the M100/diesel/n-decanol combinations compared with the diesel oil. The brake thermal efciency lowered by 10%, whereas the brake specifc fuel consumption enlarged by 10% for the combinations compared with the diesel. NOx and smoke opacity levels diminished by about 30 and 50%, respectively, whereas the CO and UHC enlarged by about 50 and 60% for the blends compared with the diesel oil.

**Chandan Kumar et al. (2018)** this research states that the consumption of diesel fuel is increasing day by day due to its wide application in agriculture and transportation sectors which is also responsible for deteriorating condition of environment due to emissions i.e., smoke, CO, HC, NOx, etc. These emissions may be reduced by adding methanol in diesel fuel. As compared to diesel, lower value of viscosity and density of methanol-diesel blends helps in easy pumping. The lower boiling point of methanol helps in reducing the ignition delay and thereby avoiding knocking. Methanol with higher oxygen content also helps in easy availability of more oxygen in the vicinity of the diesel for its quick and better combustion. To improve the working of diesel engine and control its emission level, blend diesel version definitely plays a very important role.

**Sridhar Sahoo et al. (2021)** this research states that compressed natural gas (CNG) is considered one of the most promising alternative fuel used in the transport sector. CNG has high octane number, wide flammability limit, and high H/C ratio, brings in important aspects regarding its feasibility as a fuel for internal combustion engines. It is necessary to have a dedicated engine rather than retrofitted, bi-fuels or dual-fuel ones to exploit the full potential of CNG properties. Most vehicles use the CNG in bi-fuel mode, where the fuel system is modified to operate either on gasoline or CNG. Therefore, the engine's compression ratio (CR) needs to be determined according to gasoline fuel requirement. However, CNG can be used at a higher CR, and the performance of the engine can be improved. The aim of this study is to investigate the effect of CR on knock intensity, performance, combustion, and emissions of a spark ignition (SI) engine fuelled with gasoline and CNG. Gasoline and CNG engine's performance were compared at different CRs and stoichiometric air-fuel ratio. The results show that the knock intensity was high at CR 12 and 7 bar indicated mean effective pressure (IMEP) for the gasoline-fueled engine. The maximum CR was limited to 12 for the gasoline engine. However, Knock was not observed even at CR 16 for the CNG engine. The engine was successfully operated at CR 16 with CNG. The performance and emission of the engine were also compared and presented. Fuel consumption and thermal efficiency were improved for CNG at higher CR compared to the gasoline engine.

**T. Yusaf et al. (2013)** in the current work, a comprehensive study on the possibility of using methanol as an alternative fuel for diesel engines was carried out. Methanol was mixed at different ratios with diesel fuel. The mixing ratios of methanol to diesel were 0:100, 10:90, 20:80 and 30:70. The effects of methanol fraction on engine power, torque, brake specific fuel consumption (BSFC), brake thermal efficiency and exhaust temperature were experimentally investigated at variant engine speeds. The engine used to carry out these experiments is a four-stroke four-cylinder diesel engine. The results showed that mixing methanol at different fractions with diesel fuel has a significant effect on the engine performance. The methanol to diesel ratio of 10:90 exhibited the lowest exhaust temperature and achieved an improvement in the output power of approximately 70% compared to the other ratios. Also, the brake thermal efficiency improved at all the mixing ratios used. Furthermore, the BSFC of pure diesel fuel registered a lower value than any other mixing ratio. It has been shown in this research that the addition of 10% methanol to the diesel fuel may have a great impact on the engine performance and the environment

**Zhiqing Zhang et al.  (2022)** in this work, the diesel engine fueled with diesel/methanol/n-butanol blended fuel was employed to investigate the effects of different fuel blending ratios on the spray, combustion, and emission characteristics of diesel engine in term of cylinder pressure, cylinder temperature, heat release rate, brake specific fuel consumption, brake power, brake thermal efficiency, NOx emission, soot emission, CO emission, and HC emission. The model was developed by a three-dimensional CFD model in CONVERGE and was verified by the experiment results. In addition, an improved chemical kinetic mechanism including 359 reactions and 77 species was employed to simulation the combustion processes. The results showed that diesel/methanol/n-butanol blends played an essential role in the fuel spray and combustion processes. The blended fuel had longer ignition delay, higher cylinder pressure, and higher peak heat release rate compared with diesel. Moreover, the occurrence of microexplosion improves the blending of fuel and air. More specifically, the diesel/methanol/n-butanol blends could reduce NOx, CO, soot, and HC emissions. It can be found that the best blending ratio of blended fuel is 70%diesel + 20%methanol + 10%n butanol. Therefore, the diesel/methanol/n-butanol blended fuel can improve the combustion and emission characteristics of the engine.

**Gholamhassan Najafi et al. (2022)** a comprehensive study on the methanol as an alternative fuel has been carried out. A four stroke four cylinder diesel engine was adopted to study engine power, torque, break specific fuel consumption, break thermal efficiency and exhaust temperature with the fuel of fraction methanol in diesel. In this study, the diesel engine was tested using methanol blended with diesel at certain mixing ratio of 10:90, 20:80 and 30:70 of methanol to diesel respectively. The performance of the engine using blended fuel compared to the performance of engine with diesel fuel. Experimental results showed that the output power and torque for diesel fuel is lower compared to methanol-diesel blended fuel at any ratio. The best mixing ratio that produced the lowest exhaust temperature was at 10% of Methanol in 90% of Diesel fuel. The exhaust temperature for diesel fuel was higher compared to any mixing of the blended fuel. The brake specific fuel consumption for the three mixing ratios was not varying significantly but the lowest was for 30% Methanol and 70% Diesel. The specific fuel consumption for diesel fuel was much lower compared to any mixing ratio. It was noticed that brake thermal efficiency was thus improved in almost all operation conditions with the methanol and diesel blended fuels.

**Dayadi Nageswara et al. (2023)** the present investigation of utilizing biodiesel as an alternative additive for diesel and 22 ethanol for diesel engines. Biodiesel blended with diesel or ethanol using 50 vols biodiesel and by varying 04 vols, 08 volt, 12 vols and 16 vols ethanol with 46 vo1$, 42 vols, 3gm vol and 34a vol diesel blend on 4-stroke 4- Cylinder, Common Rail Direct Injection (CRDI) Diesel engine. The experimental results showed that the ruel properties of the blend met the requirements of a diesel engine, although a trend towards more car- bon residue was observed with increasing proportion of biodiesel. Studies have shown that with increas- ing alcohol content in the mixture, brake thermal efficiency decreases, BSFC increases, CO and HC emissions increase while NOx emissions decrease. As the engine speed increased from 1200 to 1800 rpm, BTE continued to increase, but CO and HC emissions decreased. while NOx emissions increased significantly. Copyright 2023 Elsevier Ltd. All rights reserved. Selection and peer-review under responsibility of the scientific committee of the International Confer- ence on Materials Innovation and Sustainable Manufacturing

**R. Hussain Vali, M. Marouf Wani (2021)** this research explores using mixed nanoadditives (aluminum oxide and titanium dioxide) to improve diesel engines fueled with ethanol blends. While ethanol reduces emissions, it can also hurt engine performance.The study added these nanoparticles at 50 ppm and 100 ppm concentrations to a diesel-ethanol blend with a surfactant for better mixing. They observed significant improvements in engine performance

(BTE and BFSC) and reductions in harmful emissions (NOx, CO, UBHC) with the nanoadditives. However, CO2 emissions did increase.

**Dayadi Nageswara Rao et al. (2023)** this study explored using biodiesel and ethanol as alternatives for diesel fuel in a 4-stroke, 4-cylinder diesel engine. The researchers blended biodiesel with diesel and ethanol in various ratios. The blended fuels met the engine's requirements, but higher biodiesel content increased carbon residue. Adding ethanol lowered efficiency (BTE) and increased fuel consumption (BSFC), but reduced harmful NOx emissions. It also raised CO and HC emissions. Engine speed had an opposite effect on emissions. As speed increased, BTE improved, while CO and HC decreased. However, NOx emissions rose significantly with higher engine speed.

**Ziye Zhang et al. (2023)** this passage discusses Coal-to-Liquid (CTL) fuels as a possible replacement for petroleum-based fuels, particularly beneficial for regions rich in coal but lacking oil. It explores two types of CTL diesel: Direct Coal Liquefaction (DDCL) and Indirect Coal Liquefaction (DICL).The paper compares these CTL fuels with regular diesel, highlighting their advantages - lower sulfur, cleaner burning (less soot), and better cold weather performance. However, they also have lower lubricity (slickness), requiring adjustments. The study then analyzes engine tests from various countries, comparing CTL fuels to traditional diesel. Interestingly, DICL shows the best fuel efficiency and cleanest emissions, while DDCL offers superior engine power and a smoother burning process.Finally, the paper emphasizes the importance of ongoing research and development in CTL technology to improve fuel quality and efficiency. This can provide valuable insights for the future of chemical liquefaction processes.

**Avinash Kumar Agarwal et al. (2023)** this study investigated DME (dimethyl ether) as a fuel to reduce pollution in agriculture. They compared emissions from a customized DME engine and a regular diesel engine on a tractor. The DME engine had slightly higher carbon monoxide and hydrocarbon emissions at low power, but these became similar to diesel at higher power. Importantly, DME produced significantly lower nitrogen oxides, virtually no smoke, and far fewer particulate matters across most test conditions. These particulates were also much smaller and less harmful than those from diesel. Overall, the study suggests DME fuel can significantly reduce harmful emissions from agricultural engines, making it a promising option for cleaner farming practices.

**Kumarasubramanian Ramar et al. (2024)** this study explores ammonia as a potential secondary fuel for diesel engines, addressing the need for sustainable alternatives. Compared to hydrogen's safety concerns, ammonia is a viable option. Researchers tested a diesel engine with ammonia-biogas blends. Ammonia's corrosive nature and lower energy content were balanced by biogas. The study found a strong correlation between ammonia content and heat release, leading to improved engine efficiency and lower fuel consumption. Ammonia blends also reduced hydrocarbon and carbon monoxide emissions. However, the high flammability of biogas in the highest ammonia blend (B30B3) increased nitrogen oxide formation. Overall, the study highlights the potential of ammonia-biogas blends to improve combustion and reduce greenhouse gas emissions in diesel engines, offering a balance between performance and environmental impact.

**Ravikumar Jayabal (2024)** this research explores a dual-fuel mode for diesel engines using a blend of sapota seed biodiesel (SSB) and hydrogen gas. Hydrogen is seen as a way to improve engine efficiency and reduce emissions, while SSB offers a renewable biodiesel source from waste seeds.The study analyzes the impact of hydrogen on engine performance with SSB as the main fuel. They found that adding hydrogen (3 or 6 liters per minute) significantly increased engine performance (pressure, heat release, efficiency) and reduced most emissions (CO2, CO, HC, smoke) compared to pure diesel. However, there was a slight increase in nitrogen oxide (NOx) emissions with hydrogen. Overall, the research suggests that combining SSB with hydrogen can be a viable alternative to diesel fuel, offering improved engine performance and reduced emissions, except for NOx.

**Ayush Tripathi et al. (2024)** the study explores dimethyl ether (DME) as a low-carbon alternative to diesel for generators (gensets). DME offers lower emissions but requires modified fuel injection equipment due to its properties. Researchers built a customized system and optimized injection timing for DME. Results showed DME performance comparable to diesel with lower emissions and good potential for cleaner, more efficient gensets.

**Mansoor Alruqi et al. (2022)** this research examined a small diesel engine fueled by mixtures of algal biodiesel, regular diesel, and diethyl ether (a fuel additive). The study found that adding diethyl ether improved engine performance (efficiency, pressure, heat release) due to its better oxygen content, higher cetane number, and easier vaporization. However, it also increased nitrogen oxide (NOX) emissions.The researchers created a computer model to predict engine performance and emissions based on engine load, fuel mix ratio, and injection pressure. This model, built using a machine learning technique called Gaussian Process Regression, was fine-tuned with a Bayesian optimization method. The model predicted engine data very accurately, with correlation coefficients between 0.97 and 1 and minimal errors.Overall, the study suggests that diethyl ether can enhance engine performance but increases NOX emissions. The machine learning model developed shows promise for simulating and predicting engine behavior under different fuel and operating conditions.

**Taemin Kim et al. (2023)** DME is a clean burning fuel, but its low viscosity damages engine parts. This study addresses this issue by blending DME with glycerol to increase viscosity to diesel levels. To prevent the blend from separating, researchers identified propylene glycol and di-propylene glycol as suitable co-solvents based on factors like safety and renewability. They created two final blends (Michigan DME I & II) with these co-solvents and glycerol. They found the minimum amount of co-solvent needed to prevent separation depends on the specific blend. Importantly, these blends achieved diesel-like viscosity at a higher DME content (40-43%) compared to previous studies.The article focuses on the blend development process. A companion article explores the life-cycle greenhouse gas emissions of one of the final blends.

**S. Vinodraj et ai (2022)** this research investigates a biofuel alternative (P.Juliflora biodiesel) to regular diesel fuel for combustion engines. Biodiesel offers environmental benefits by reducing carbon footprint. The study examines the performance, efficiency, and emissions of this biodiesel in a controlled engine setting. Results show promising potential: the biodiesel performs similarly to diesel fuel at partial and moderate engine loads, with slightly higher fuel consumption at full load. Importantly, it also produces lower emissions of pollutants like hydrocarbons, smoke, and carbon monoxide. These findings suggest P.Juliflora biodiesel as a viable option for sustainable engine operation.

**Prakash Chandra Mishra et al. (2022)** the author acknowledges errors in a published paper on a fuel blend and apologizes for any inconvenience. Corrections include typos ("pie-chart" instead of "π-chart", "unburned" instead of "unborn") and additional details (manufacturer of the engine tested, measuring instruments). The paper also incorporates feedback from peer reviewers. References are reordered due to the addition of new ones, and a list of abbreviations is included. The rest of the paragraph discusses previous research on alternative fuels and emissions. It mentions positive environmental impacts of using blended fuels and compares the performance of different fuel types (gasoline with varying octane rating, biodiesel blends).

**Bichitra Nanda Behera, Tapano Kumar Hotta. (2023)** the passage discusses using biofuels to address energy issues and environmental concerns. Diesel engines are important but have high emissions. The study explores using palm biodiesel with n-butanol additive as a cleaner alternative. Experiments test different blends in a four-stroke engine: pure diesel, palm biodiesel (10%, 15%, 20% with diesel), and the same biodiesel blends with 10% n-butanol added.The research examines how these blends affect engine performance (fuel consumption, efficiency, temperature) and emissions (smoke, NOx, CO, CO2, hydrocarbons) at various loads.The findings suggest that adding 10% n-butanol to biodiesel significantly reduces harmful emissions and offers better efficiency than pure diesel. A specific blend (10% palm biodiesel, 10% n-butanol, 80% diesel) shows a 2% efficiency increase and 1.33% lower fuel consumption compared to regular diesel.Overall, the study highlights the potential of biofuels with n-butanol additives as a promising alternative for diesel engines.

**Harikrishna Nagwan et al. (2023)** in this study a vital resource for any nation's development is fossil fuel. Increasing consumption is the cause of the quick depletion of fossil fuels. Furthermore, the burning of fossil fuels releases greenhouse gases into the atmosphere, which exacerbates climate change. Generating substitute renewable fuels can improve energy security.The present This study evaluates the potential use of hemp oil (cannabis sativa) in combination with diesel and ethanol (C2H5OH) as a substitute fuel for diesel engines. The conversion of hemp oil to biodiesel is known as transesterification. Different ratios of hemp biodiesel, such as B10, B10E10, B10E20, B20, B20E10, and B20E20, are combined with base diesel and ethanol (C2H5OH). These mixtures are then tested in a single-cylinder, four-stroke diesel engine under varied loading conditions. due to braking power

**B. Musthafa et al. (2023)** in the study explored using biofuels and alcohols as substitutes for fossil diesel in a single-cylinder engine. They tested blends of regular diesel, biodiesel, coconut oil, sunflower oil, and various alcohols (ethanol, propanol, n-butanol). The results showed that a specific blend (diesel, biodiesel, coconut oil, sunflower oil, and propanol) increased engine efficiency by 9.2%, while another blend (diesel, biodiesel, coconut oil, sunflower oil, and ethanol) significantly reduced hydrocarbon and carbon monoxide emissions.

**Ümit Agbulut et al. (2023)** this research explores using waste soybean oil from food processing as an alternative fuel for diesel engines. Disposing of this used oil harms the environment, so the study aims to create biodiesel through a process called transesterification. The researchers tested different catalysts and reaction times to find the most efficient method for biodiesel production. The best results came from catalysts Iron Oxide (IO-II) and Alkyl-celite (AC).Using this biodiesel, they created blends with diesel fuel (25% and 50% biodiesel). The 25% biodiesel blend with IO-II catalyst showed the closest performance to pure diesel in terms of efficiency (BTE) and produced significantly less smoke. Therefore, the study recommends using a blend of 25% diesel fuel with 75% biodiesel from IO-II treated waste soybean oil. This blend offers a promising alternative fuel for diesel engines without needing engine modifications.

## 2.3 Chapter Summary

In this chapter we reviewed various type of literature and observed there has a huge requirement of energy in the marine sector in terms of commercial fuel (diesel). Most of the experiments has been carried out in the road transport and electrical DG (Digital Generator) sets. We already know through the literature review that there has a good scope of improvement in CI engine parameters to addition of some others chemical like (methanol, ethanol, butanol, diethyl ether etc.).So we are try to explore the research opportunity, addition of methanol in CI engine in marine transport in a rural part of Sundarbans area and try to get the better parameters and make suitable cost analysis.

# Chapter 3

# Diesel Engine and its working

## 3.1 Introduction

Diesel engines work by compressing air or air plus residual combustion gases from the nature, resulting in a heterogeneous air-fuel mixture. The torque produced is controlled by manipulating the air-fuel ratio, which is usually high. Diesel engines have the highest thermal efficiency due to their high expansion ratio and lean burn, allowing heat dissipation by the excess air. Low-speed diesel engines can reach effective efficiencies of up to 55%. The world's largest diesel engines are 14-cylinder, two-stroke marine diesel engines, producing a peak power of almost 100 MW each. Diesel engines have been used since the 1910s in submarines, ships, locomotives, buses, trucks, heavy equipment, agricultural equipment, and electricity generation plants. However, air pollution emissions are harder to control in diesel engines than in gasoline engines.

## 3.2 History

The concept of the internal combustion engine was initially explored in the 18th century. In 1893, a patent for a new engine design was filed by Rudolf Diesel. This design, later known as the diesel engine, was developed with the goal of achieving greater efficiency than gasoline engines.  Following several years of refinement, the first functional diesel engine was successfully run in 1897.Over the 20th century, diesel engines underwent continuous improvement, with advancements made in fuel injection, combustion processes, and materials. This development led to their widespread adoption in various applications, including transportation, power generation, and industrial machinery. Today, diesel engines remain a crucial technology, although ongoing research focuses on improving their efficiency and reducing emissions. An old diesel engine is shown in figure 1.

**Figure 1: Old diesel engine**

## 3.3 The characteristics of diesel engine are

A diesel engine uses compression ignition instead of a spark plug, forming an internal mixture of air and fuel only within the combustion chamber. It has quality torque control, maximizing air intake volume and controlling the amount of injected fuel. Diesel engines have a high air-fuel ratio, significantly lower than the stoichiometric ratio. The combustion process begins at the end of the injection phase, resulting in a heterogeneous air-fuel mixture.

## 3.4 Thermodynamic cycle

The diesel internal combustion engine uses compressed hot air to ignite fuel, unlike the gasoline-powered Otto cycle. The engine introduces only air into the combustion chamber, which is compressed with a compression ratio between 15:1 and 23:1. This high compression causes the air temperature to rise, and fuel is injected directly into the compressed air. The fuel injector breaks down the fuel into small droplets, which are then ignited by the heat from the compressed air. Combustion occurs at a constant pressure during the initial part of the power stroke, with the start of vaporization causing a delay before ignition and the characteristic diesel knocking sound. When combustion is complete, combustion gases expand, and the high pressure drives the piston downward, supplying power to the crankshaft. A high compression ratio increases engine efficiency, unlike a spark-ignition engine where fuel and air are mixed before entry to the cylinder. In a diesel engine, premature detonation is not a problem, and compression ratios are much higher.

## 3.5 Working Cycle:

The diesel engine, thrives on a precise choreography of compression, ignition, and expansion. Unlike its gasoline counterpart, which relies on a spark plug to ignite the fuel mixture, the diesel engine takes a different approach. The four strokes that drive its operation shown in figure 2:

1. **Intake Stroke**: The piston moves downward, creating a vacuum that draws fresh air through the open intake valve. This fresh air, the lifeblood of the combustion process, fills the cylinder, preparing for the next crucial step.
2. **Compression** Stroke: With the intake valve closed, the piston forcefully moves upward, dramatically compressing the trapped air. This compression not only heats the air to a high temperature but also creates the high pressure needed for ignition.
3. **Power Stroke**: Just before the piston reaches the top of its stroke, a precisely timed spray of atomized diesel fuel is injected into the hot, compressed air. The intense heat

and pressure cause the fuel to spontaneously ignite, resulting in a controlled explosion that drives the piston back down with immense force. This is the stroke that generates the power that propels vehicles, machinery, and more.

4. **Exhaust Stroke**: With the piston moving back up, the exhaust valve opens, and the spent gases, a byproduct of the combustion process, are forcefully expelled out of the cylinder through the exhaust valve. This clears the chamber for the next intake stroke, completing the cycle.

This process of intake, compression, power, and exhaust repeats continuously, transforming the chemical energy stored in diesel fuel into the mechanical energy that powers countless applications.

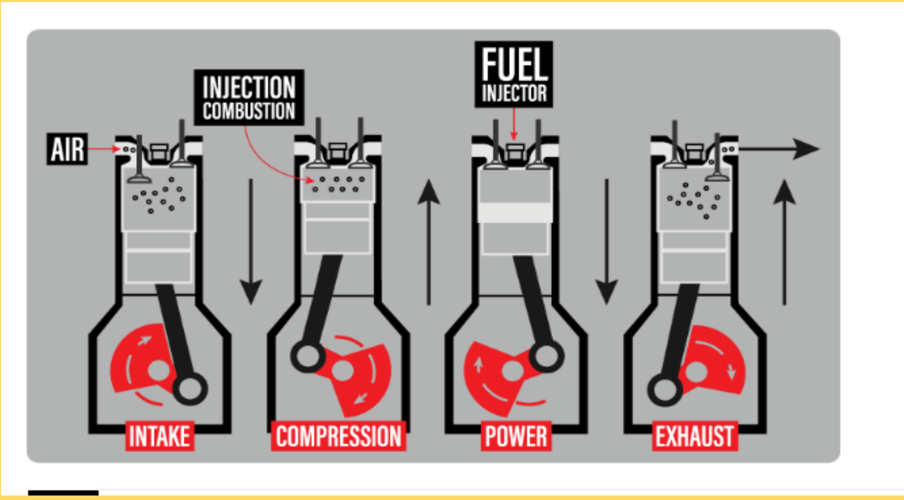


**Figure 2:** Working cycle of diesel engine

## 3.7 Efficiency

Diesel engines have superior fuel efficiency due to their high compression ratio, high air-fuel equivalence ratio, and lack of intake air restrictions. The theoretical maximum efficiency is 75%, but in practice, it can be up to 43% for passenger cars, 45% for large trucks and buses, and 55% for large two-stroke marine engines. [U.S. Department of Energy: Fuel Econom]. The average efficiency over a vehicle driving cycle is lower than the peak efficiency, as diesel engines' fuel efficiency drops at lower loads.

### 3.8 Emission

Diesel engines are combustion engines and, therefore, emit combustion products in their exhaust gas. Due to incomplete combustion, diesel engine exhaust gases include carbon monoxide, hydrocarbons, particulate matter, and nitrogen oxides pollutants. About 90 per cent of the pollutants can be removed from the exhaust gas using exhaust gas treatment technology. Road vehicle diesel engines have no sulfur dioxide emissions, because motor vehicle diesel fuel has been sulfur-free since 2003.Particulate matter emitted from motor vehicles has negative impacts on human health.

The particulate matter in diesel exhaust emissions is sometimes classified as a carcinogen or "probable carcinogen" and is known to increase the risk of heart and respiratory diseases. The emission of four stroke diesel engine illustrates in figure 3.

**Figure 3:** Emission from truck (diesel engine)

# Chapter 4
# Methanol as Supplementary fuel in CI Engine

## 4.1 Introduction:

While diesel engines reign supreme in terms of power and torque, they also face the challenge of pollutant emissions. Methanol emerges as a potential alternative fuel to address this. Although not a direct drop-in replacement for diesel, methanol offers several advantages. It burns cleaner, emitting fewer harmful pollutants like particulate matter. Additionally, methanol can be produced from renewable sources like biomass, reducing dependence on fossil fuels. [NITI AAYOG] However, challenges exist. Methanol has lower energy density than diesel, requiring more fuel for the same range. Modifications to the engine or dual-fuel systems with diesel may be necessary for proper combustion. Despite these hurdles, research on using methanol in diesel engines continues, aiming to harness its environmental benefits while addressing its limitations.

## 4.2 Different name of methanol used in industry:

Methanol boasts a diverse vocabulary depending on the context. The scientific term is "methyl alcohol," while "carbinol" is a historical name for this simple alcohol. "Anhydrous methanol" emphasizes its purity. Industry has its own terms: "wood alcohol" reflects its past production method, while "methylated spirit" refers to a denatured version used for cleaning and fuel. For fuel applications, we have "methanol fuel" and for sustainability, "bio-methanol" is produced from renewable sources. "Syn methanol" comes from syngas. In technical contexts, "MeOH" is a common abbreviation. Beyond fuel, methanol serves as a "formaldehyde precursor," a solvent, and an antifreeze component in windshield washer fluid and coolants. It is also a valuable "feedstock" for various chemical syntheses. Ultimately, the chosen name depends on the situation and people being interacted with.

## 4.3 Opportunities of methanol as a fuel

Methanol is a promising alternative fuel with environmental and economic advantages. It burns cleaner than gasoline, reduces reliance on fossil fuels, and can be produced from renewable sources like biomass or even captured $CO_2$. This translates to cleaner air, reduced greenhouse gas emissions, and increased energy security. Furthermore, methanol's versatility extends to various applications in transportation and power generation. While challenges like infrastructure development and cost competitiveness exist, ongoing advancements and responsible implementation position methanol as a key player in a sustainable energy future.

## 4.4 Methanol in internal combustion engines

Using methanol in diesel engines presents a fascinating possibility for cleaner burning. While not a perfect replacement, it offers environmental benefits and the potential for renewable fuel sources. On the positive side, methanol burns cleaner, emitting less harmful pollutants like NOx and particulates. Additionally, it can be produced from renewable sources like biomass, reducing reliance on fossil fuels. Its high-octane rating even allows for increased engine power. However, challenges remain. Starting a diesel engine on methanol in cold weather is difficult due to its higher ignition temperature. Engine components may also need modifications to handle methanol's corrosive nature. While overall cleaner, methanol does emit some formaldehyde, requiring advanced emission controls. Additionally, its lower heat of vaporization can lead to slightly lower fuel efficiency in some cases. Finally, widespread adoption hinges on significant investment in infrastructure for storage, distribution, and refuelling. Despite these hurdles, research on using methanol in diesel engines is ongoing. Advancements in areas like catalyst development and injection technology are promising. The future of methanol as a diesel fuel option depends on overcoming cost competitiveness and infrastructure challenges.

## 4.5 Methanol-diesel blend properties

Methanol-diesel blends hold promise for cleaner diesel engines. They can reduce emissions, offer renewable fuel options, and even improve performance in some cases. However, challenges exist. Blending requires careful consideration of miscibility, cold start issues, material compatibility, and potential for increased wear. Additionally, infrastructure limitations and performance trade-offs need to be addressed. Research is ongoing to overcome these hurdles, making methanol-diesel blends a potentially significant player in the future of sustainable diesel technology. Properties of Methanol and Diesel which are used in this study are mentioned in the Table No-1

**Table 1:** Comparison of thermo-physical properties of methanol and diesel

| Properties | Methanol | Diesel |
|---|---|---|
| Chemical Formula | CH3OH | C10~H15 |
| Molecular weight (g mol−1) | 32 | 190-220 |
| Density @ 20ºC (g cm−3) | 0.790 | 0.840 |
| Viscosity @ 20ºC (m Pa S) | 0.59 | 2.8 |
| Carbon Content (%wt) | 37.5 | 86 |
| Hydrogen Content (%wt) | 12.5 | 14 |
| Oxygen Content (%wt) | 50 | 0 |
| Sulfur content (ppm wt) | 0 | <350 |
| Cetane number | | 51 |
| Auto ignition temperature (ºC) | 464 | 316 |
| Heat of evaporization (kJ/kg) | 1178 | 260 |
| Stoichiometric fuel/air ratio | 0.15393 | 0.06924 |
| Lower heating value (MJ/kg) | 19.7 | 42.5 |
| Flash Point (ºC) | 11 | 52 |

## 4.6 Emission factor of methanol

Methanol's "emission factor," the amount of pollutant per unit of fuel burned, isn't a simple number. It depends on what pollutant you are interested in (CO2, NOx, PM, etc.), how the engine burns the fuel (temperature, air-fuel ratio, etc.), how the methanol is produced (fossil fuels or renewable sources), and even the entire life cycle from production to combustion. While methanol offers lower greenhouse gas emissions than gasoline, some pollutants like nitrogen oxides can be higher depending on conditions. For a complete picture, considering all these factors along with life cycle assessments is crucial.

## 4.7 Challenges of methanol

Methanol, a potential cleaner alternative fuel for diesel engines, faces a complex road to widespread adoption. While it burns cleaner, challenges include production costs, infrastructure needs, and engine modifications. Technically, methanol presents cold start issues and requires adjustments for its corrosive nature. Even with cleaner burning, it still emits pollutants, necessitating advanced emission control. Sustainability concerns involve sourcing renewable feedstock and verifying true environmental benefits. Additionally, safety considerations due to its toxicity demand robust protocols throughout the fuel chain. Regulations, public education on safety and environmental impact, and competition from other alternatives like hydrogen and electric vehicles are further hurdles. Overcoming these challenges requires collaboration – researchers, policymakers, industry, and the public must work together to focus on cost-competitiveness, technical solutions, sustainability, and safety to unlock methanol's potential as a viable and sustainable fuel option.

## 4.8 Blending process

The blending process of methanol and diesel is a relatively simple procedure that can be achieved through two main methods: inline blending and terminal blending. Chemical laboratory apparatus is shown in the below figure 4.

**Inline Blending** Involves mixing methanol and diesel directly at the fuel station, typically at the pump itself. This method is less common due to the additional equipment required at each station and the need for precise metering of both fuels.

**Terminal Blending** is the most common method for blending methanol and diesel. In this process, the two fuels are mixed in large storage tanks at a central terminal before being distributed to fuel stations. This method is more efficient and cost-effective, as it requires less specialized equipment at individual stations.

Here is a simplified overview of the terminal blending process described below

Transportation: Methanol and diesel are transported to the blending terminal via separate pipelines or tanker trucks.

Storage: The fuels are stored in separate tanks at the terminal.

Blending: The desired ratio of methanol and diesel is precisely measured and blended in a dedicated mixing tank. The proper blending process is described in the next page named (standard method).

Quality Control: The blended fuel is then rigorously tested to ensure it meets the required specifications before being distributed to fuel stations.

Distribution: The blended fuel is transported to fuel stations via pipelines or tanker trucks.

**Figure 4:** Chemical lab apparatus

## 4.8.2 Standard Method

Blending methanol and diesel is a process of mixing these two fuels in specific proportions to create a new fuel blend. This blended fuel can then be used in diesel engines, potentially offering some advantages over using pure diesel. However, it is important to note that this is a complex process with certain challenges and limitations.

**Preparation:** Both methanol and diesel need to be free of impurities and meet specific quality standards before blending. This ensures that the resulting blend is stable and functions correctly in the engine.

**Mixing:** The measured quantities of methanol and diesel are then transferred to a mixing tank. This can be done using various methods, such as pumps and pipes, ensuring proper control over the blending ratio.

**Agitation:** The mixture is continuously stirred or agitated to promote uniform blending and prevent separation. This is crucial because methanol and diesel are not naturally miscible, meaning they tend to form separate layers if left undisturbed.

**Additives:** In some cases, specific additives might be introduced during the blending process. These additives can serve various purposes.

**Improving miscibility:** Certain additives can help enhance the compatibility between methanol and diesel, promoting better blending and preventing separation.

**Corrosion protection:** Additives can be used to safeguard the engine components from potential corrosion issues that methanol might introduce.

**Lubricity enhancement:** As methanol has lower lubricity compared to diesel, additives can help improve the lubricating properties of the blend to minimize engine wear.

**Storage and transportation:** The blended fuel is then stored and transported in appropriate containers following specific guidelines. This is essential to maintain the blend's quality and prevent potential safety hazards.

In this method the direct inline method is followed in which there have a limitation on mixing time (as less as possible) and the mixing have been done in the ambient temperature varying between 23$^{o}$c – 26$^{o}$c. Also, no additive is added during the mixing process. In this process, the results are same like the standard method. The measuring and blending process are shown in figure no 5and 6

**Figure 5:** Measuring Cylinder full of methanol for measuring


**Figure 6:** Magnetic starrer with methanol diesel blend

## 4.8.3 Comparison between the Methanol and Carbinol

In this study we are trying to save our expenses to collect the methanol. As per our findings the lab grade methanol is too expensive (INR 756/liter) to buy, so behalf of lab grade methanol low grade methanol had used which cost at about (INR 20/liter). The commercial carbinol used in our study illustrate below figure 7and 8.

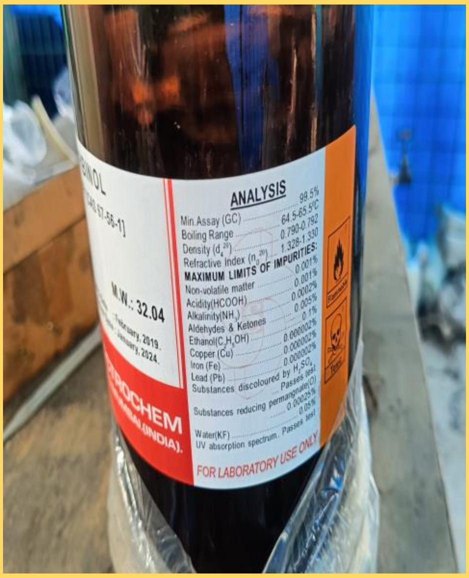


**Figure 7:** Carbinol specification


**Figure 8:** Methanol as Carnbinol

For the validation of carbinol as it is also similar as methanol, a little experiment had been done. In this experiment 45 ml of diesel and 5 (10%) ml of methanol, 45 ml of diesel and 5 (10%) ml of carbinol had been taken in two separate glass bottles. Then both mixtures are starred out by the magnetic starrer in 400 rpm for 1 hour. As per the results there have no difference between the two mixtures. Based on this experiment we can easily define that using carbinol behalf of methanol in IC engine does not make any big differences. After Blending results are shown in figure 9. And the comparison table are shown in table no -2


**Figure 9:** Carbinol (C10%) & Methanol (M10%) mixer with diesel after blending

**Table 2 The comparison between methanol and carbinol**

| **Specification** | **Methanol** | **carbinol** |
|---|---|---|
| Chemical Formula | $CH_3OH$ | $CH_3OH$ |
| IUPAC Name | Methanol | Methanol |
| CAS Number | 67-56-1 | 67-56-1 |
| Appearance | Clear, colorless, volatile liquid | Clear, colorless, volatile liquid (same as methanol) |
| Odor | Distinctive alcoholic odor | Distinctive alcoholic odor (same as methanol) |
| Solubility | Miscible with water and most organic solvents | Miscible with water and most organic solvents (same as methanol) |
| Toxicity | Highly toxic, can be fatal if ingested or inhaled | Highly toxic, can be fatal if ingested or inhaled (same as methanol) |
| Flammability | Flammable liquid | Flammable liquid (same as methanol) |
| Applications | Fuel, solvent, antifreeze, precursor to many chemicals | Same as methanol (carbinol is a less common synonym |

# Chapter 5

# Laboratory scale study on using of Methanol blended with Diesel fuel in CI engine

## 5.1 Introduction

The blending prepared in pilot scale was fed into the specific diesel engine with varying methanol concentration; D100%, M5, M10, M15, M20, and M25 respectively. The performance was compared with the results of CI engine run by normal Diesel.

## 5.2 Laboratory scale study engine specification

The laboratory scale study engine specification which we have used in this study are mentioned in Table no 2.

**Table 3:** Laboratory scale study engine specification

| | |
|---|---|
| Model | CDZ170F |
| Type | Single cylinder, horizontal, 4-stroke |
| Combustion | Swirl combustion chamber |
| Bore*Bore(mm) | 70*70 |
| Rated power | 2.94kw/4hp |
| Rated speed(r/min) | 2600 |
| Max Power | 3.23kw/4hp |
| Cooling method | Air-cooled |
| Lubrication Method | Centrifugal splashing |
| Starting method | Hand-cranking |
| Net weight(kg) | 44kg |
| Series | 6065 |

The laboratory scale study engine specification which we have used in this study are showed in Figure no 10


**Figure 10:** Laboratory scale study engine specification

## 5.3 Laboratory scale study engine setup

The test setup (figure 11) for engine performance with methanol diesel mixture was conducted on a single cylinder, four stroke, air cooled direct injection engine (figure 15) coupled to a generator (figure 14). Loads have been applied in the form of tungsten filament lamps (500W, 200W and 100W) through a multi socket switch board connected with the generator (figure 16). The fuel tanks of the compression ignition engine were re-placed by a graduated glass burette (figure 12). The fuel supply to the injector of the engine was monitored with the help of the burette. Silencer (figure 13) and the air filter (figure 13) are attached with the engine.


**Figure 11:** Laboratory study setup (Bioenergy laboratory)

The engine components in the laboratory scale study which we have used are mentioned in Figure No - 16 to 20.

**Figure 12:** Measuring cylinder used as fuel tank

**Figure 13:** Air filter and Silencer

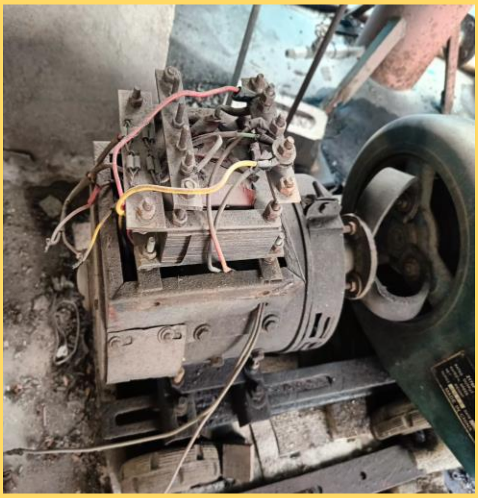

**Figure 14:** Alternator with Transformer

**Figure 15:** Laboratory Engine

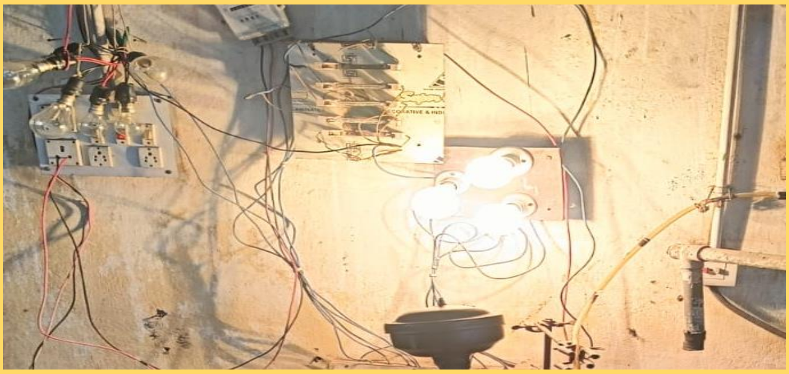

**Figure 16** filament load

## 5.4 Procedure

This study was conducted by varying the proportions of methanol blended with diesel. The total volume of mixture was kept constant 200 ml. Here in this study D100% stands for the pure diesel (200 ml) and zero methanol M5% stands for 5% methanol by volume 190 ml of diesel and 10 ml of methanol, similarly M10%, M15%, M 20%, M25% stands for 180 ml of diesel and 20 ml of methanol, 170 ml of diesel and 30 ml of methanol 160 ml 0f diesel and 40 ml of methanol, 150 ml of diesel and 50 ml of methanol respectively. By using this combination of blend the whole lab study was drawn out. The graduate glass burette was used to maintain the continuity of fuel supply for the engine, Air filter was used for the purification of the inlet air and the silencer was used for the purpose of reduction of the engine noise and as well as to bring the flue exhaust gas out. There was a transformer to maintain the proper power output form the alternator. Before starting new test, the engine was allowed to run for a sufficient time to consume the residual fuel from the earlier operation.

The experimental data of the laboratory scale study which we have observed are mentioned in Table no 4.

**Table 4** Laboratory scale study experiment data

| | D100% | M5% | M10% | M15% | M20% | M25% |
|---|---|---|---|---|---|---|
| Diesel | 200 ml | 190 ml | 180 ml | 170 ml | 160 ml | 150 ml |
| Methanol | 0ml | 10 ml | 20 ml | 30 ml | 40 ml | 50 ml |
| Ambiant Temperature | 28°C | 25.8°C | 26.5°C | 24°C | 23°C | 25°C |
| Exhust Temperature Max | 144°C | 109.4°C | 105.8°C | 113.6°C | 117.6°C | 112.1°C |
| Vibration | Normal | Normal | Normal | Normal | Normal | Not normal |
| Noise | 155 -158 DB | 155 - 158 DB | 155 - 159 DB | 155 -159 DB | 156 - 158 DB | 158 - 162 DB |
| Exhust Colour | lightly black | lightly white | lightly white | lightly white | semi white | White+Black |
| RPM | 2570 | 2570 | 2570 | 2570 | 2570 | 2570 |
| Engine Start Time | 3:04 PM | 3:04 PM | 4:44 PM | 2:40 PM | 3:33 PM | 3:20 PM |
| Engine Stop Time | 3:24 PM | 3:27 PM | 5:12 PM | 3:08 PM | 4:07 PM | 3:44 PM |
| Time Duration | 20 min | 23 min | 28 min | 28 min | 34 min | 24 min |
| Humidity | 48% | 45% | 46% | 44% | 43% | 44% |
| Knocking | NA | NA | NA | NA | NA | Knocking |
| Residue Mixture | 0 ml | 1.3 ml | 2 ml | 3.12 ml | 4 ml | 5.1 ml |

Form this above data sheet it can easily say that with the addition of methanol in a particular percentage like 5%,10%,15%,20% and 25% can achieve some improvement on parameters. The exhaust gas temperature was much lower (109.4*c) compared to the diesel(144*c) fuel. Also, the data table shows that the running time duration was increased, whereas the D100% runs 20 minute and the M20% runs the 34 minutes. The knocking and noise were under control up to 20%. After the engine stopped there was some residues of mixture are there in the fuel tank and their level of percentage are increasing respectively increasing of methanol.

# Chapter 6
# Field study on operation of using Methanol blended with Diesel fuel in CI engine

## 6.1 Introduction

In this chapter the various parameters have been observed, which are used widely in marine transportation services in Sundarban area. we conducted this survey in real world scenario at Sundarban area. There are three different types of survey data in terms of case study are collected, given bellow.

## 6.2 Survey Data

**<u>Case Study 1</u>**

### Widely Used Marine Transport Details (Field Visit), lot no 8, HP coastal 743374 to kachuberia ghat 743373, Sundarban west part.

Boat (Local name - vessel) (people transport as well as goods also)

Engine Specification - 4 cylinder, 105 HP,

Fuel - Diesel

Average Distance -Lot 8 to kochubariya (3023 meter)

Time required - 30 minute downstream (DS) 38 minutes upstream (US).

The collected survey data is given here in table format

| | |
|---|---|
| 1. Engine rating / specification | 4 cylinder, 105 HP |
| 2. Fuel used | Diesel |
| 3. Boat type / name of the boat | vessel |
| 4. Total distance cover in one trip DS | 3380 meters |
| 5. Total distance cover in one trip US | 3510 meters |
| 6. Starting fairy ghat name | Lot no 8, Harwood point |
| 7. Destination fairy ghat name | Kachubariya |
| 8. Average passenger count in one ferry | 150 persons |
| 9. Average goods carried / passenger/ trip | 2 kg |
| 10. Ticket price /trip/ passenger | Rs 9 |
| 11. Fuel price | INR 93.18/litre |
| 12. Source of fuel | Govt petrol pump |
| 13. Fuel consumed in one trip US | 7600 ml |
| 14. Fuel consumed in one trip DS | 6000 ml |
| 15. Average count of trip / day | 20 |
| 16. Propeller type | single screw 4 bladed, Fixed pitch |
| 17. Fuel consumption | 12000 ml /hour |

According to the google map the distance between Lot 8 to kochubariya are shown the figure 21

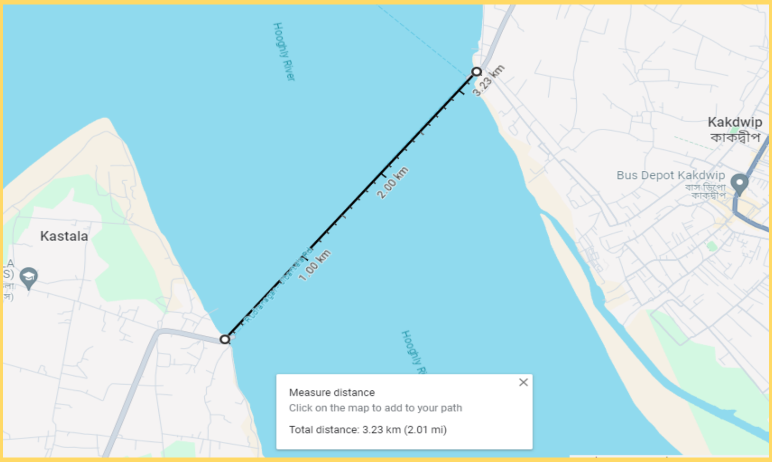


**Figure 17** Lot 8 to kochubariya distance by google map

According to the (software name map my walk) the actual path of the boat vessel between Lot 8 to kochubariya are shown the figure 22 and 23


**Figure 18** actual path of the boat vessel between Lot 8 to kochubariya.

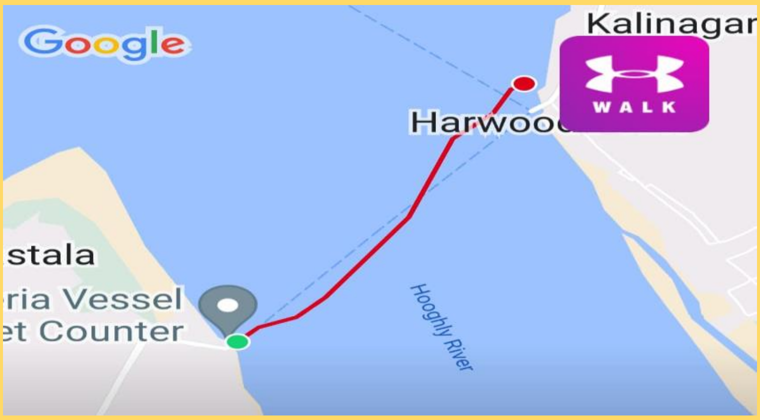


**Figure 19** actual path of the boat vessel between kochubariya to Lot 8.

# Case Study 2

## Widely Used Marine Transport Details (Field Visit),1NO coastal 743374 to Agnimarir char 743373, Sundarban west part

Boat (Local name - vutvuti) (people transport as well as goods also)

Engine Specification - 1 cylinder, 7.5 HP,

Fuel - Diesel

Average Distance -1 no to agnimarir char (7350 Meters)

Time required – 90 minute hour downstream (DS) 99 minute hour upstream (US).

Milledge-1200 ml/hour.

**The collected survey data is given here in table format**

| | |
|---|---|
| 1. Engine rating / specification | 1 cylinder, 7.5 HP Kirloskar |
| 2. Fuel used | Diesel |
| 3. Boat type / name of the boat | vutvuti |
| 4. Total distance cover in one trip DS | 7500 meters |
| 5. Total distance cover in one trip US | 8100 meters |
| 6. Starting fairy ghat name | 1 no jetty |
| 7. Destination fairy ghat name | Agnimarir char |
| 8. Average passenger count in one ferry | 15 persons |
| 9. Average goods carried / passenger/ trip | 2 kg |
| 10. Ticket price /trip/ passenger | Rs 20 |
| 11. Fuel price | INR 100/liter |
| 12. Source of fuel | Local seller |
| 13. Fuel consumed in one trip US | 2000 ml |
| 14. Fuel consumed in one trip DS | 1800 ml |
| 15. Average count of trip / day | 8 |
| 16. Propeller type | single screw 3 bladed, Fixed pitch |
| 17. Fuel Consumption | 1200 ml/hour |

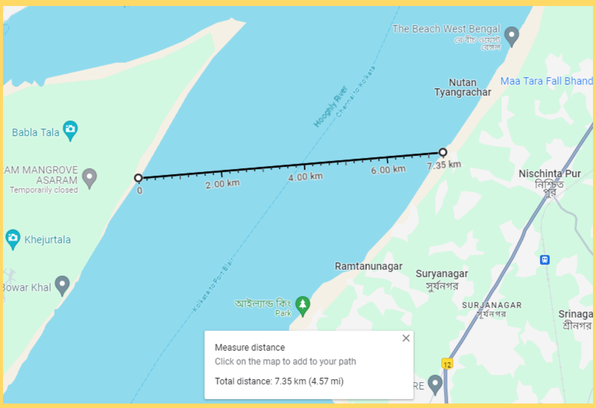


**Figure 20** 1 no to agnimarir char distance by google map

# Case Study 3

## Widely Used Marine Transport Details (Field Visit),15 no Bot-tala 743347 to Gondokata ghat,743347, Sundarban south part

Boat (Local name - vutvuti) (people transport as well as goods also)

Engine Specification - 1 cylinder, 7.5 HP,

Fuel - Diesel

Average Distance -15 no bot-tala ghat to 14 no gondokata ghat (337.09 meter)

Time required – 4.27 minute downstream (DS) 4.43 munite upstream (US).

Milledge-1200 ml/hour.

The collected survey data is given here in table format

| | |
|---|---|
| 1. Engine rating / specification | 1 cylinder, 7.5 HP Kirloskar |
| 2. Fuel used | Diesel |
| 3. Boat type / name of the boat | vutvuti |
| 4. Total distance cover in one trip DS | .345 km |
| 5. Total distance cover in one trip US | .360 km |
| 6. Starting fairy ghat name | 15 no bot-tala |
| 7. Destination fairy ghat name | 14 no gondokata ghat |
| 8. Average passenger count in one ferry | 10 persons |
| 9. Average goods carried / passenger/ trip | 2 kg |
| 10. Ticket price /trip/ passenger | Rs 5 |
| 11. Fuel price | INR 100/liter |
| 12. Source of fuel | Local seller |
| 13. Fuel consumed in one trip US | 82 ml |
| 14. Fuel consumed in one trip DS | 85 ml |
| 15. Average count of trip / day | 10 |
| 16. Propeller type | single screw 3 bladed, Fixed pitch |
| 17. Fuel Consumption | 1200 ml/hour |


**Figure 21 15 no bot-tala ghat to 14 no gondokata ghat distance by google map**

## 6.3 Field study boat Engine Specification

Specification of the engine which was used in this particular study have been mentioned in Table no 4.

**Table 5:** Boat Engine Specification used for field study

| | |
|---|---|
| Model | Kirloskar 102 |
| Type | Single cylinder, vertical, 4-stroke |
| Combustion | Swirl combustion chamber |
| Rated power | 7.5hp |
| Rated speed(r/min) | 2300 |
| Cooling method | Water-cooled |
| Starting method | Hand-cranking |
| Net weight(kg) | 105kg |

The side view, top view, and the total boat set-up, which have been used in field study is shown below in the below figure 22,23 and 24.


**Figure 22:** Side view of experimental boat engine 7.5HP

## 6.4 Field test boat engine test setup

The test setup for boat (also known as vutvuti) engine performance with methanol diesel mixture was conducted on a single cylinder, four stroke, air cooled direct injection engine coupled to a propeller. Loads have been applied in the form of persons (average weight 60 kg/person). The fuel tanks of the compression ignition engine were re-placed by a local plastic drum. The fuel supply to the injector of the engine was monitored with the help of the plastic drum. Silencer, air filter cooling pump were attached with the engine.

**Figure 23:** Top view of experimental boat engine 7.5HP

**Figure 24:** Used boat for the experiment

The engine components in the field study which we have used are mentioned in Figure 25 and 26.


**Figure 25**: fuel tank used for the boat engine


**Figure 26:** Single screw 3 bladed, Fixed pitch

## 6.5 Procedure

This study was happened using the variations in addition of methanol with diesel. The quantity of diesel and methanol was taken in the forms of volume total 500 ml. Here in this study D100% stands for the quantity of diesel is 500 ml and the M10%, M15%, M 20%, are stands for 450 ml of diesel and 50 ml of methanol, 425 ml of diesel and 75 ml of methanol 400 ml of diesel and 100 ml of methanol, respectively. By using this combination of blend the whole field study was drawn out. The plastic drum (figure 29) was used to maintain the continuity of fuel supply for the engine, other hand the air filter was used for the purification of the inlet and the silencer was used for the purpose of reduction of the engine noise and as well as to bring the flue exhaust gas out. A propeller (figure 30) was coupled with the shaft of the engine to maintain the proper power output form the engine. During this study the up stream and the down stream was considered for the proper result output. 3 different data were taken and make the average value from them to obtain the results.

## 6.6 Experimental Data Sets

Table 6 shows the experimental data on field study, where the engine rating is 7.5 HP.

**Table 6:** Field study experimental data sheet

| | D100% | M10% | M15% | M20% |
|---|---|---|---|---|
| Diesel | 500ml | 450ml | 425ml | 400ml |
| Methanol | 0ml | 50ml | 75ml | 100ml |
| Distance | 2.1km | 2.4km | 2.7km | 2.8km |
| Duration | 26min | 29min | 33min | 35min |

Base on the above data which is mentioned in the table 6, average consumption of boat is shown in the below Figure 27.

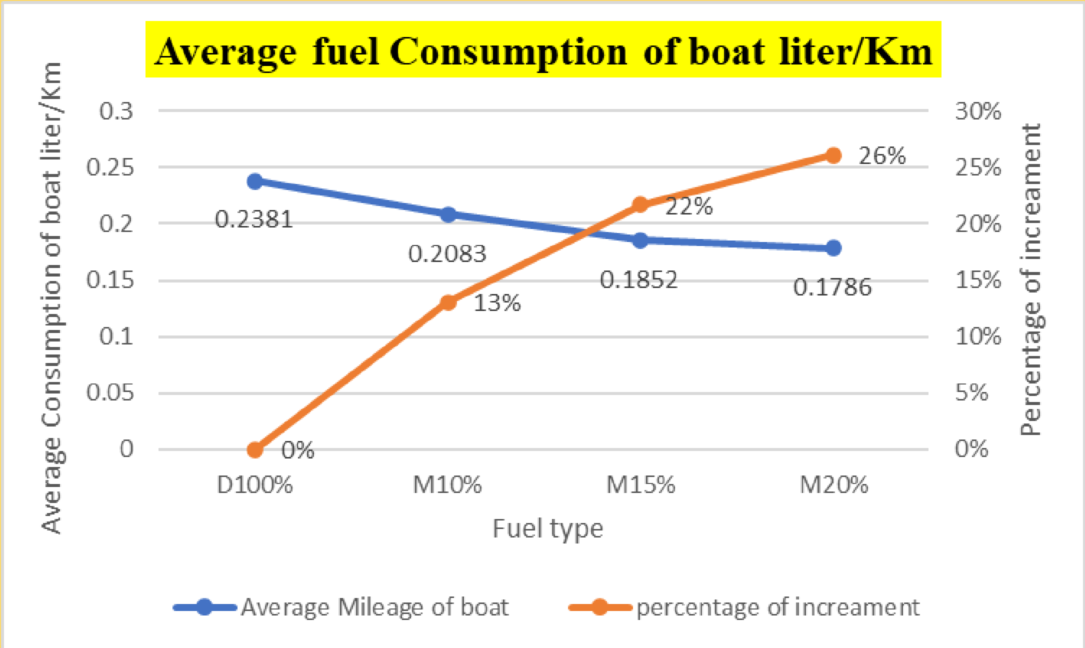


**Figure 27:** Average consumption of boat (liter/km)

## 6.6 Energy consumption

Energy content of diesel 35MJ / liter

For case study 2- Oil required = 3.8 liter / trip, Total Distance covered per trip boat = 15.6km

Energy content used for 1 trip in diesel=3.8*35=133 MJ

From the above data it can calculate the energy consumed /km for boat =133/15.6=8.5MJ / Km.

Using the same method, energy consumed per km for different fuel blends have been calculated and shown in table 6

M10%=8.05MJ /Km M20%=7.55MJ /Km

M15%=7.81MJ / Km

**Table 7:** Energy consumption MJ/Km for various blend

| Fuel Type | Energy consumption MJ/Km |
|---|---|
| D100% | 8.5MJ / Km |
| M10% | 8.05MJ /Km |
| M15% | 7.81MJ / Km |
| M20% | 7.55MJ /Km |

Base on the above data which is mentioned in the table 7, average energy consumption of boat is shown in the below Figure 28.

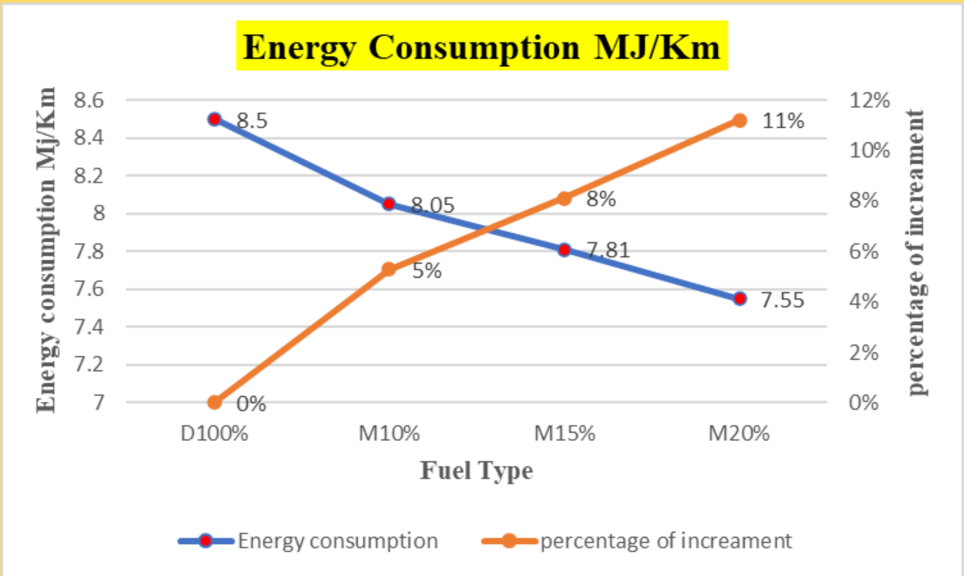


**Figure 28:** Energy consumption in terms of MJ/Km case study 2

### 6.6.1 Specific Energy consumption

For case study 2-Total average passenger on boat is 30 person / trip

D100%=8.5/30=0.283MJ/passenger/Km

M10% =0.268MJ/passenger/Km

M15% =0.260MJ/ passenger/Km

M20%= 0.251MJ/ passenger/Km

**Table 8:** Specific energy consumption MJ/ passenger/Km for various blend

| Fuel type | Specific energy consumption MJ/ passenger/Km |
|---|---|
| D100% | 0.283MJ/passenger/Km |
| M10% | 0.268MJ/passenger/Km |
| M15% | 0.260MJ/ passenger/Km |
| M20% | 0.251MJ/ passenger/Km |

Base on the data mentioned in the table 8, specific energy consumption of boat is shown in the below Figure 29.

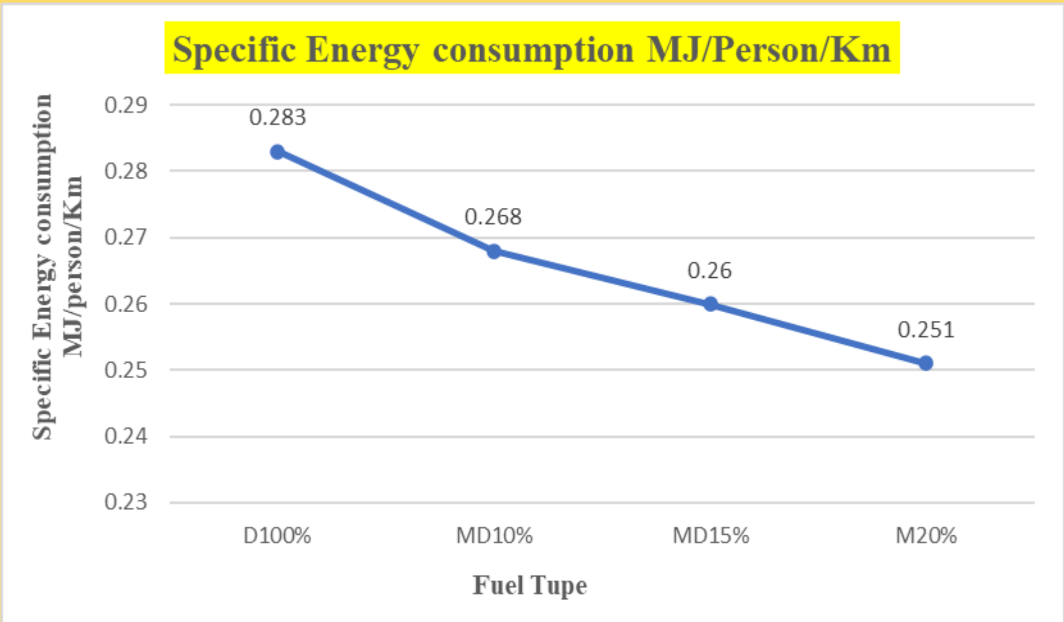


**Figure 29:** Specific Energy consumption in terms of MJ/Passenger /Km

## 6.7 Cost analysis for case study 2

**For case study 2**

Total Distance covered /day 124.8 km and (45552 km / year)

Labour value 450/day=164250/year

| Fuel consumption liter /km | Price of fuel INR/ km | Fuel consumption cost INR / year |
|---|---|---|
| D100%=0.2381 lit/km | D100%=23.81/km | D100%=1084593.12/ year |
| M10%=0.2083 lit/km | M10%=19.16/km | M10%=872776.32/year |
| M15%=0,1852 lit/km | M15%=16.29/km | M15%=742042.08/year |
| M20%=0.1786 lit/km | M20%=15/km | M20%=683280/year |

Total earning from tickets/year= (4,800*365) = INR 1,752,000

**Profit = ticket selling in – (fuel consumption cost /year +maintenance cost+labour value)**

**D100%=** 1,752,000-(1084593.12+10000+164250) =493156.88 INR/YEAR

**M10%=**1,752,000-(872776.32+10000+164250) =704973.68 INR/YEAR

**M15%=**1,752,000-(742042.08+10000+164250) =835707.92 INR/YEAR

**M20%=**1,752,000-(683280+10000+164250) =894470 INR/YEAR

**Table 9:** Yearly profit in INR for various fuel case study 2

| Fuel type | Yearly profit in INR |
|---|---|
| D100% | 493156.88 INR/YEAR |
| M10% | 704973.68 INR/YEAR |
| M15% | 835707.92 INR/YEAR |
| M20% | 894470.00 INR/YEAR |

Base on the above data which is mentioned in the table 8, yearly profit for the case study 2 of boat is shown in the below Figure 30.

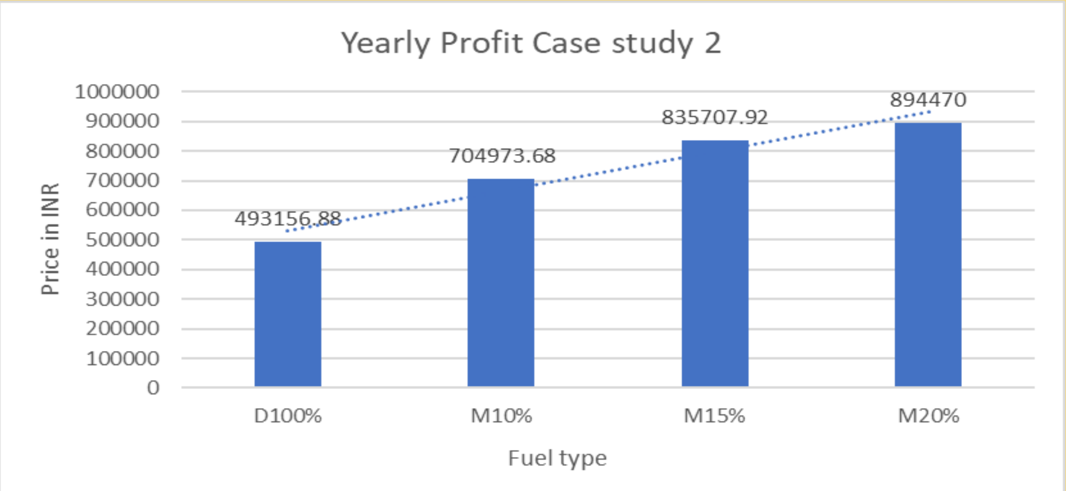


**Figure 30:** Yearly profit from the boat (vutvuti) case study 2

## 6.7.1 Cost analysis for case study 3

**For case study 3**

**Total Distance covered /day .705 km and (2573.25 km / year)**

**Labour value 400/day=164000/year**

**Fuel consumption liter /km**
D100%=0.2381 lit/km
M10%=0.2083 lit/km
M15%=0.1852 lit/km
M20%=0.1786 lit/km

**Price of fuel INR/ km**
D100%=23.81/km
M10%=19.16/km
M15%=16.29/km
M20%=15/km

**Fuel consumption cost INR / year**
D100%=61269.08/ year
M10%=49303.47/year
M15%=41918.24/year
M20%=38598.75/year

Total earning from tickets/year= (1000*365) = INR 3,65,000

**Profit = ticket selling in – (fuel consumption cost /year +maintenance cost+labour value)**

**D100%=** 3,65,000-(61269.08+8000+1,46,000) =149730.92 INR/YEAR

**M10%**=3,65,000-(49303.47+8000+1,46,000) =161696.53 INR/YEAR

**M15%**=3,65,000-(41918.24+8000+1,46,000) =169081.76 INR/YEAR

**M20%**=3,65,000-(38598.75+8000+1,46,000) =172401.25 INR/YEAR

**Table 10 Yearly profit in INR for various fuel case study 3**

| Fuel type | Yearly profit in INR |
|---|---|
| D100% | 149730.92 INR /YEAR |
| M10% | 161696.53 INR/YEAR |
| M15% | 169081.76 INR/YEAR |
| M20% | 172401.25 INR/YEAR |

Base on the above data which is mentioned in the table 10, yearly profit for the case study 3 of boat is shown in the below Figure 31.

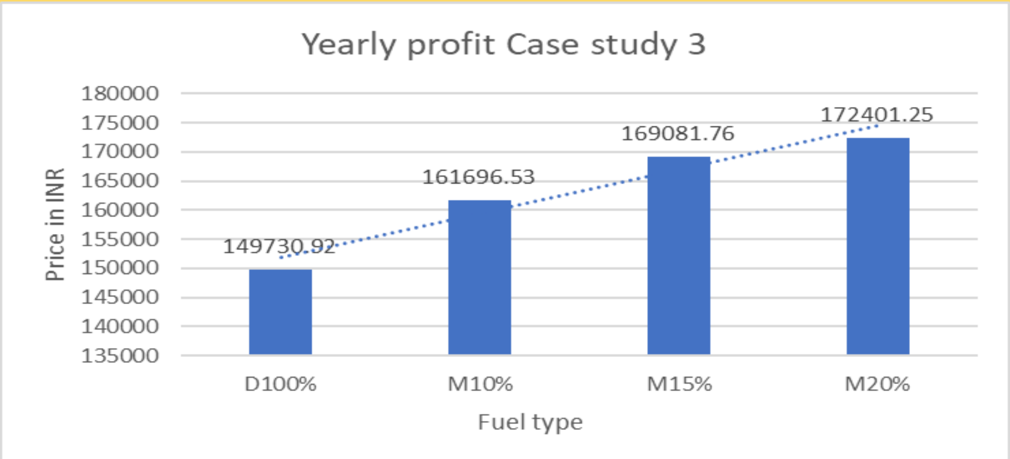


**Figure 31:** Yearly profit from the boat (vutvuti) case study 3

## 6.7.2 Cost analysis for case study 1

**For case study 1**

**Total Distance covered /day 137 km and (50297 km / year)**

**Fuel consumption liter /km**
D100%=1.9738 lit/km
M10%=1.7172 lit/km
M15%=1.5395 lit/km
M20%=1.4606 lit/km

**Price of fuel INR/ km**
D100%=183.92/km
M10%=147.44/km
M15%=126.55/km
M20%=114.72/km

**Fuel consumption cost INR / year**
D100%=9250624.24/ year
M10%=.7415900.33/year
M15%=6365160.79/year
M20%=5770137.22/year

Total earning from tickets/year= (30,600*365) = INR 11,169,000

**Profit = ticket selling in – (fuel consumption cost /year +maintenance cost + labor value)**

**D100%**= 11,169,000-(9250624.24+0+0) =1918375.76 INR/YEAR

**M10%**=11,169,000-(7415900.33+0+0) =3753099.67 INR/YEAR

**M15%**=11,169,000-(6365160.79+0+0) =4803839.21 INR/YEAR

**M20%**=11,169,000-(5770137.22+0+0) =5398862.78 INR/YEAR

**Table 11 Yearly profit in INR for various fuel case study 1**

| Fuel type | Yearly profit in INR |
|---|---|
| D100% | 1918375.76 INR /YEAR |
| M10% | 3753099.67 INR/YEAR |
| M15% | 4803839.21 INR/YEAR |
| M20% | 5398862.78 INR/YEAR |

Base on the above data which is mentioned in the table 11, yearly profit for the case study 2 of boat is shown in the below Figure 32.

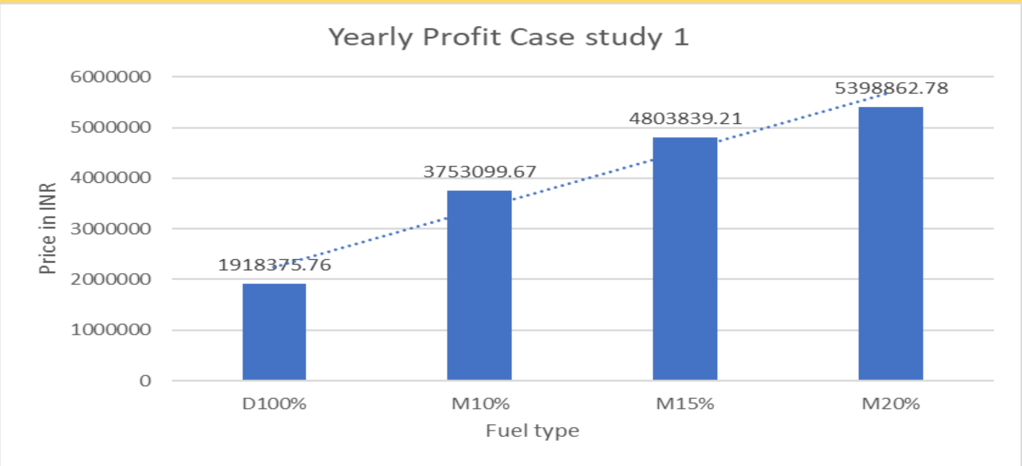


**Figure 32:** Yearly profit from the boat (vutvuti) case study 1

## 6.8 Discussion

In this section, a cost analysis of the proposed solution have been outlined.A detailed breakdown of the associated costs has been presented. This includes, material costs in terms of fuel consumption, labor costs in terms of labor used to do that work, operational costs in terms of maintenance costs. The costs of materials required for the development and implementation of the solution has been analyzed. Here, it can be stated that material costs were identified and categorized in case study 2 & 3. From this study it has been found that the material costs for the blended oil (m10%, M15% and M20%) compared to the commercial diesel fuel is much lower. The labor costs associated with the project will be examined. This might involve mentioning that "an estimation of labor costs was undertaken, considering factors like personnel required and their daily wages. From this study it have been found that the labor costs for the blended oil (m10%, M15% and M20%) compared to the commercial diesel fuels are same but they vary with respect with location. The ongoing costs associated with running and maintaining the system has been discussed. An analysis of operational costs was performed, including factors such as energy consumption and maintenance requirements. From this study it has been founded by us that the maintenance costs for the blended oil (m10%, M15% and M20%) compared to the commercial diesel fuel is same as of now but as per our point of view if the blended fuel will be commercialized for the diesel engine, Increasing the maintenance cost respectively increasing the methanol percentage with diesel. After the engine stopped there was no residue of mixture are there in the fuel tank. Also in the case study 1, data regarding proper maintenance cost as well as labor cost available.

# Chapter 7
# Conclusion

## 7.1 conclusion

This study was conduct in two phases. In the 1st phase, an engine was setup in the lab and the experiment was conducted on it. Upon performing the experiment, the parameter obtained by mixing capability of methanol with diesel, up to when the engine can run perfectly without any abnormal vibration and noise. And we also observed how much the exhaust gas temperature is decreased.

In 2nd phase the experiment was conducted in real world scenario at Sundarban area where, a boat engine used for set up. There upon testing the mix-fuel with 20% mix of methanol we achieve the best results in terms of performance and cost-efficiency.

Form the above study it can be concluded that methanol can be a suitable supplementary fuel for CI engine. A marginal improvement in fuel consumption as well as energy consumption per kilometer was observed. This is due to more complete combustion in the fuel rich zone. This enhanced the combustion efficiency and decrease heat losses in the cylinder due to the lower flame temperature of methanol blended fuel. The results improved as percentage of methanol in methanol – diesel blend increased from 0%-20% with best results at 20% mix.

## 7.2 Scope of work in future

1) At 25% methanol blend, knocking of engine and high vibration were observed. On a safe side 20% methanol blend was kept as upper limit for field study. Further studies may be conducted to find out the actual limits before which the engine starts malfunctioning.
2) This study was conducted for a limited set of engines. This study may be extended to different types of engines to better evaluate the fuel blend performance.
3) Similarly, this study may be extended in other location, with varying geographic and demographic conditions to test the performance of the fuel blends.

If we encountered all the problems which were mentioned in the above text we can achieve a better output means, we can increase the percentage of methanol more than 25% and the mileage also increased.

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