International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 1, December 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

# Study on the Investigation of the Effect of Additive Methanol on Performance and Exhaust Emission of a si Engine – A Review

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**ABSTRACT**

Internal combustion engines have become recently in attention due the strict regulations regarding the environmental protection, emissions and to reduce the dependency of the fossil fuels. One choice is the use of methanol as it can be produce from renewable sources and blended with gasoline in any proportion. The aim of this study is to compare the effects of methanol – gasoline blends regarding engine performance and exhaust emissions. The gasoline is fossil fuel which is limited in reserving causes varieties of study in search of alternative fuel for SI engine, where ethanol promises best alternative fuel. Five different blends M5, M10, M15, M20 and M25 were tested in a single cylinder spark ignition engine. The experimental results in engine performance show a decrease of torque and power up to 10 % and in emissions characteristics a CO, CO2, HC. It can be concluded that methanol-gasoline blends are viable option to be used in gasoline engines to replace partially the fossil fuel.

***KEYWORDS:*** *Methanol, Methanol -gasoline blends, Alternative fuel, Engine Performance, Emissions*

***How to cite this paper**:* Win Ko Ko Htike | Sandar Aung "Study on the Investigation of the Effect of Additive Methanol on Performance and Exhaust Emission of a SI Engine – A Review" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-1, December 2019, pp.249-254, URL: https://www.ijtsrd.com/papers/ijtsrd29505.pdf

IJTSRD29505



## I. INRODUCTION

Methanol is a clean burning, high octane blending component made from alternative non-petroleum energy sources such as natural gas, coal and biomass. Although methanol has been widely manufactured for use in chemical production, methanol has also been successfully used for extending gasoline supplies in many gasoline markets around the world. Unlike some other alcohols, methanol blending in gasoline has been economical without government subsidies or fuel blending mandates. Besides providing non-petroleum alternative energy into gasoline supplies, blending methanol also delivers a clean burning high octane to the oil refiner's gasoline supplies that can be used reduce the refiner's energy consumption as well as improve gasoline yields from the crude oil. Methanol's high octane and oxygen content produce a cleaner burning gasoline which significantly lowers vehicle exhaust emissions. When produced from natural gas or biomass, methanol fuel has a lower carbon intensity (or carbon footprint) than gasoline produced from petroleum. Following the crude oil price shocks of the 1970's, methanol blending in gasoline was first introduced commercially in the early1980's. Because carbureted fuel systems were most prevalent in the vehicle fleets on the road at that time, and because those vehicles had limited ability to handle high oxygen levels in the fuel, methanol blends were generally limited to 3 to 5 volume percent of the gasoline blend. However, with today's modern pressurized fuel injector systems with computerized feedback control loops, current experience shows that methanol blends as high as 15 volume percent (M15) of the gasoline can now be successfully used in the more modern vehicles that are on the road today.

## II. EXPERIMENTAL SETUPS AND SOME EFFECTS OF PREVIOUS RESEARCHES

With ever increasing concerns on environmental pollution, energy security, and future oil supplies, the global community has been seeking nonpetroleum based environment friendly alternative fuels for the past decade. In global concerns have been rising to find solutions to the depletion of fossil fuels and to search for greener combustible fuels to be used in internal combustion engines. These problems have led to the research of several possible renewable fuels like bio alcohols, vegetable oils and biodiesel to reduce the air pollution [1,2]. Among a variety of alcohols methanol, ethanol and butanol present the highest potential for use in transportation sector mainly because are cheap and have properties similar to gasoline [3,4]. Alcohols have a higher octane rating, higher latent heat of vaporization and oxygen in their molecular structure leading to higher efficiency of combustion and low emissions [5]. In time researchers used M15 and M85 (USA in the early 1980s) while in China was used "low-content methanol gasoline" called gasohol with a methanol proportion under 50%.

Canakci et al. [7] found that methanol–gasoline fuel blends reduce the emissions of CO and HC at the vehicle speed of 80 km/h. Wai et al. [8] studied the effect of methanol blends in internal combustion engines and found for M85 a reduction of emissions of CO and NOx by 23% and 80%. Hu et al. [9] studied the methanol addition in gasoline and found that methanol reduces the phase of rapid burning and also advances the start of combustion. The maximum pressure of the blends was higher comparative with gasoline. Bardaie et al [10] found for pure methanol (M100) a loss of power of 4–5% comparative with gasoline. Bilging and Sezer [11] observed the emissions characteristics and performance for methanol blends and found a maximum brake mean effective pressure for M5. Dai et al. [12] found that for M15 the evaporative THC emissions increased by 63% and carbonyls increased by 19% comparative with gasoline. Palmer [13] found that 10% addition of alcohol to gasoline reduce the CO emissions by 30%. Yanju et al. [14] found the maximum pressure increase with methanol addition in the blend with the increase by 4-5° CA in ignition delay and by 5-6° CA in combustion duration for M85 compared to gasoline. Agarwal et al. [15] study the regulated and unregulated emissions on medium-duty transportation MPFI SI engine fuelled with M5 and M15 and found a reduction in emissions of benzene, butylene, acetaldehyde, formic acid and nitrogen dioxide. Abu-Zaid et al. [16] studied the performance of a M3, M6, M9, M12 and M15 and found a maximum power output for M15 fuel blend. Tie gang Hu et al. [17] investigated on a three-cylinder engine the combustion and emission characteristics of methanol blends. The engine combustion was found better with the methanol addition into gasoline. During cold start the emissions of HC are reduced with 40% at 5 °C and 30% at 15 °C, CO with 70% for M30. In this study the effects of blending methanol and gasoline in a mono cylindrical engine are analysed regarding emissions levels and performance.

## III. COMPARISONS OF PERFORMANCE CHARACTERISTICS ON REVIEW PAPERS AND REWORK FOR TEST SET-UP

Many practical experiments have been conducted to explain the effects of methanol-gasoline blended on engine performance. The effect of methanol-gasoline blended on the engine performance is analyzed and compared the obtained results. Some of the engine sets up and application methods are stated in above. The following sections are the performance characters of these methanol-gasoline blended researches. According to these researches, this paper will focus the effects of methanol-gasoline blended on the engine performances.

### A. Methanol Physical Properties

Methanol is a clear, low viscosity liquid with a faintly sweet alcohol odour at low concentrations in air. Chemically, methanol is an aliphatic alcohol containing about 50 wt.% oxygen with physical properties consistent with other alcohols used as gasoline blending components (see Table 1). As is common for most alcohols blended in gasoline, methanol is fully soluble in water and also miscible with gasoline-type hydrocarbons (HC).

**TABLE1. Methanol Physical Properties**

| Synonym | Methyl alcohol |
|---|---|
| Molecular Formula | CH3OH |
| Molecular Weight | 32 kg/mole |
| CAS Number | 67-56-1 |
| Density | 0.791 g/mL at 25C |
| Boiling Point | 64.7 C |
| Melting Point | -98 C |
| Flash Point | 11.1 C |
| Viscosity | 0.544 at 25 C |
| Vapour Pressure | 410 mmHg(50C) |
| Vapour Pressure | 97.68 mmHg(20C) |
| Dielectric Constant | 33.00 at 20C |
| Dipole Moment | 1.700 C-m(Coulomb-meter) |
| UV cut-off | 210 nm |
| Refractive Index | 1.329 at 20C |
| Vapour Density | 1.11 (vs. air)unit less |

As with most gasoline and alcohol fuel blends, inhibitors or additives are generally recommended with methanol blends to provide added protection against metal corrosion. Methanol-gasoline blends have been successfully shipped commercially in barges, pipelines, and tanker trucks similar to those used to transport gasoline. As discussed later, because of methanol's affinity for water, some precautions are necessary when shipping and storing methanol-blended gasoline, such as mitigating water addition and using fire extinguishing foam approved for alcohol fires. Extensive product research, as well as years of commercial experience, indicate that properly blended methanol in gasoline has no adverse effect on vehicle performance. In fact, methanol-gasoline blends have cleaner burning properties that generally reduce CO, HC, PM and air toxics from most gasoline engine vehicles.

### B. Effect of Methanol –Gasoline Blended on Engine Performance

LIU SHIUGHUN [17] investigated the engine with cylinder pressure diagram. It shows that, under the same engine speed and throttle opening, see 50% WOT (Wide Open throttle) operation in figure 3, when the engine fuelled with M20, the maximum pressure is higher than that of pure gasoline operation. The IMEP (Indicated Mean Effective Pressure) are 0.91 MPa for M20 and 0.88 MPa for pure gasoline. Engine thermal efficiencies are 0.284 and 0.262, respectively.

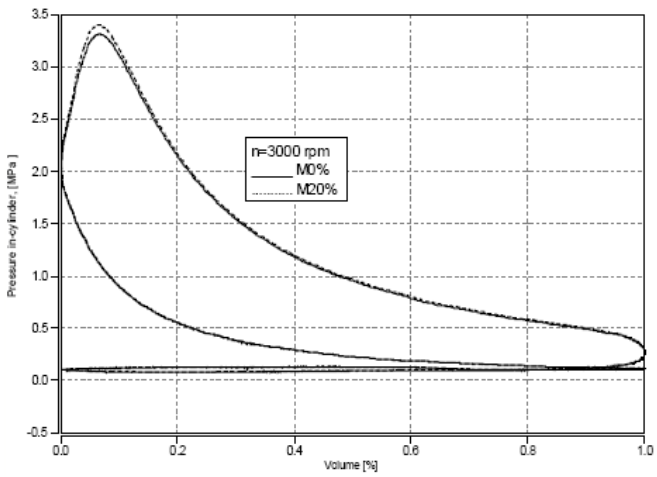


**Figure 1 p-V diagram comparisons**

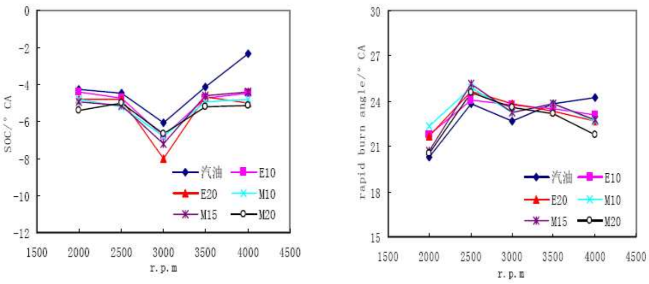


**Figure 2 Engine combustion phases analyses under 30N·m operating conditions [17]**

In most cases, the start of combustion is delayed due to the methanol addition, while the rapid burning phase becomes shorter at high speed operating conditions. Figure 2 indicates the changes of SOC (Secondary Organic Carbon) under constant torque of 30 Nm operating conditions. Therefore, if spark ignition time is advanced 2 or 3-degree CA (Conditions Access), engine combustion will be centralized near TDC (Top Dead Centre), so engine power and thermal efficiency will be improved. The energy performance of the engine concerning the torque and power are summarized in Fig. 3 and Fig. 4 The variation of engine torque and power is dependent by the quantity of methanol in the gasoline mixture. Increasing the fraction of methanol results in a decrease of performance, meaning lower value for the parameters examined previous at different speeds and loads of the engine. S. Liu et al. [18] and Figure 3 and Figure 6 show apparatus of experiment with Schematic diagram and Engine Stand. [18,20]

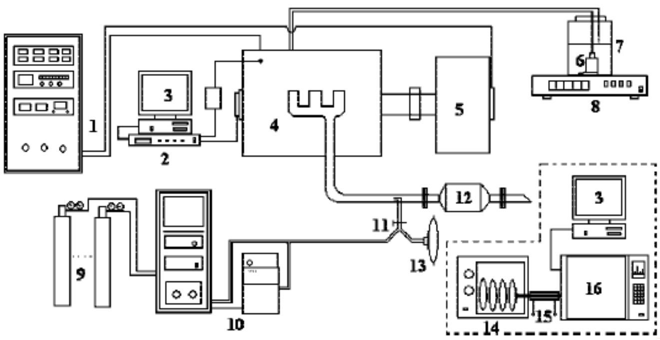

**Fig.3 Schematic diagram of the SI engine test bench: (1) dynamometer controller; (2) combustion analyser; (3) computer; (4) SI engine; (5) dynamometer; (6) fuel pump; (7) fuel bottle; (8) electronic balance; (9) standard gas bottles; (10) Horiba emission analyser; (11) Y valve; (12) TWC; (13) sampling bag; (14) gas heater; (15) sampling pipe heater; (16) gas chromatograph. [18]**

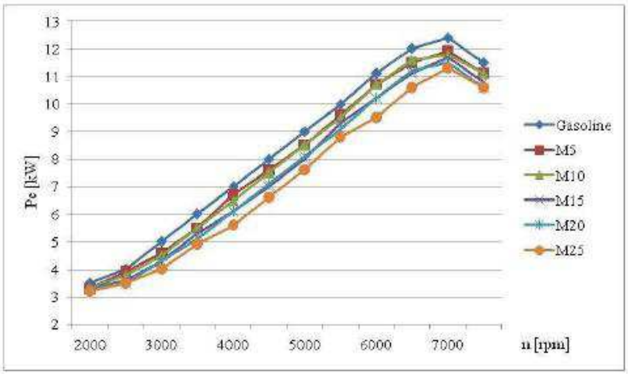


**Fig. 4 Evolution of engine power for gasoline variation related to engine speed and methanol blends [18]**

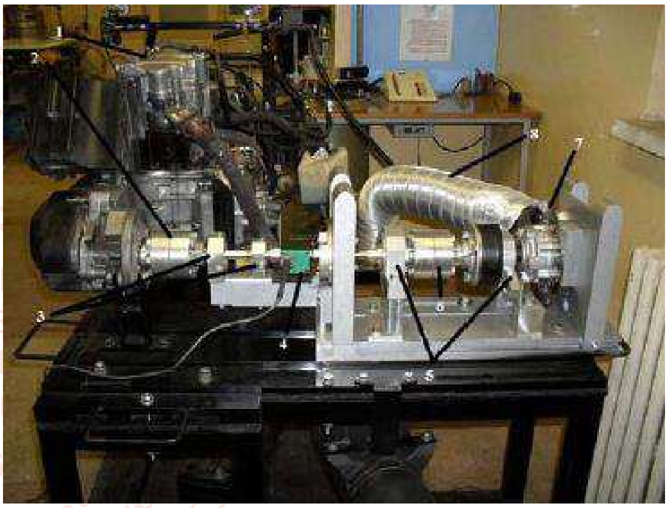

**Fig.5 Engine Stand**
**1 – engine; 2 – soft coupling; 3 – bearings; 4 – torque transducer; 5 – bearings;6 – soft coupling; 7 - disc brake; 8 – brake disc cooler. [20]**

### C. Methanol-Gasoline Blended Effect on Emission

The exhaust gas analyser unit for special cases of internal combustion engines should record the values of Carbon Monoxide (CO), Carbon Dioxide (CO2), Oxygen (O2) and Hydrocarbons (HC). The following figures, Fig.6 and Fig.8, show the variation of pollutant emissions versus the load of the engine for different engine speeds of 3600 and 4600 rpm, starting from where the load will be applied. As it can be seen, the values of CO decrease once the percentage of methanol is increased. The effect is generated by the quantity of oxygen contained by the alcohol and by the carbon that is found in greater proportion in gasoline rather than in methanol composition, [19].

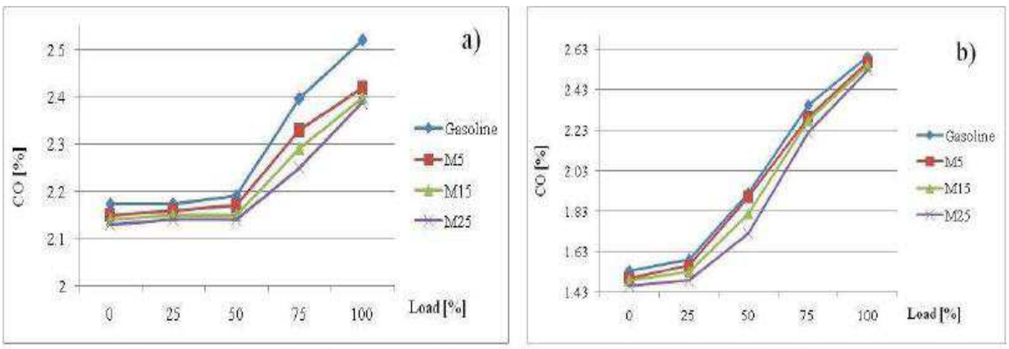


**Fig.6 Methanol influence on CO emissions, a) 3600 rpm, b) 4600 rpm [19]**

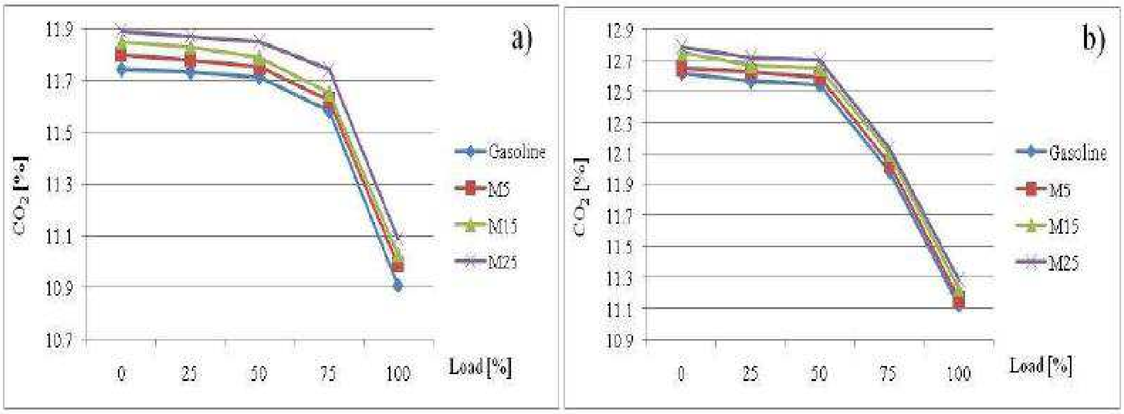


**Fig.7 Methanol influence on CO2 emissions, a) 3600 rpm, b) 4600 rpm [20]**

Fig. 7 indicates the evolution of CO2 emissions for two different engine speeds starting from 0 to 100 % load. It can be seen an increasing trend for the alcohol gasoline blends. At a high engine speed, the emission value has a great value do the quantity of air and fuel that increase the rate of complete combustion. Similar results were recorded with differences up to 13% higher CO2 emissions for methanol-gasoline blends [20].

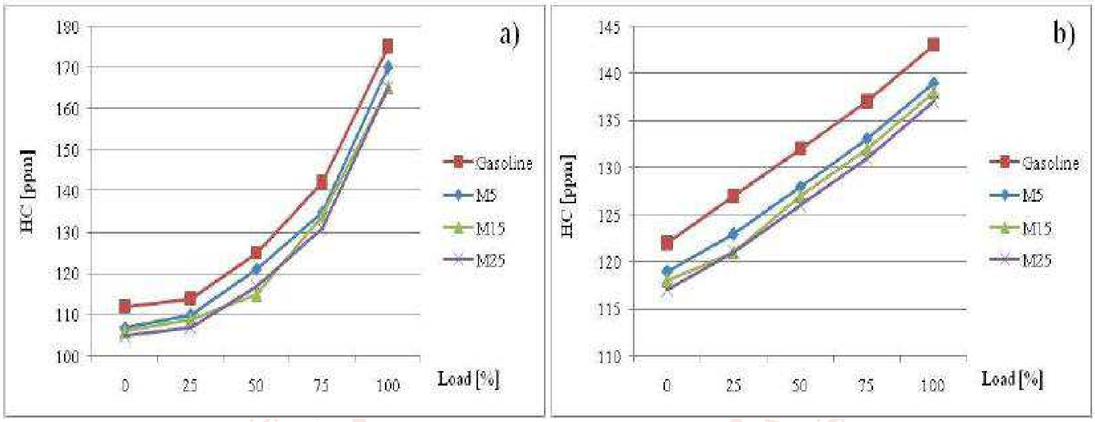


**Fig. 8 Methanol influence on HC emissions, a) 3600 rpm, b) 4600 rpm [21]**

Fig. 8 depicts the evolution of HC emissions, which can rise rapidly due to incomplete combustion or heat losses in the cylinder. Increase of the HC emissions can be caused also by the existence of regional lean and rich mixtures in the combustion chamber. Experiments show a decreased value of the emissions when the gasoline is mixed with methanol, influenced by the carbon to hydrogen fuel ratio which is lower than in the case of gasoline, [21].

**D. REWORK EXPERIMENTAL SETUP AND PROCEDURE** Multi-cylinder four stroke spark ignition engine was used. Tests were carried out at wide open throttle (WOT) condition. The specifications of the engine are given in Table 2.

**TABLE 2.TEST ENGINE SPECIFICATIONS**

| Sr. No. | Particulars | Data |
|---|---|---|
| 1. | Engine Type | Water Cooled Indirect Injection, SI |
| | | Engine |
| 2. | Engine Model | (Public a ) 4 k |
| 3. | No. of Cylinder | 4 Inline Engine |
| 4. | Cubic Capacity | 1.5 L (1486 cc) |
| 5. | Bore/Stroke | 75 mm(2.95 in)/ 73 mm (2.87 in) |
| 6. | Compression | 10:1 |
| | Ratio | |
| 7. | Displacement | 1290 cc(1.3 litres) |
| 8. | Maximum Torque | 97 Nm at 3600 rpm |

To get a good result for methanol-gasoline blended engine, some steps needed to satisfy step by step. The engine was started and allowed to warm up for a period of 10-15min. Before using the engine to a new fuel blend, it was allowed to sum for sufficient time to consume the remaining fuel from the previous experiment. It was exited the mixtures by weighing the appropriate amount of methanol on a sale and then added it to the gasoline. Engine test were performed at constant engine speed. The speed can be measured by digital tachometer. After all of the data collected, it was determined the air-fuel ratio by using the air flow reading and the fuel flow reading. Three runs were performed to obtain on overage value of the experimental data for each experiment.


**Fig. 9 Experimental test set-up**

Tests were performed at various loads as 200 watts, 400 watts, 600 watts, 800 watts, 1000 watts and 1200 watts at constant engine speed 1300 rpm. In this study the blends were prepared on volume basis. Methanol was blended in gasoline in concentration of 15% and 20% and their blends are known as M15 and M20. Their CV Values are 8950.10 Cal/g at M 15(Methanol and 92 Grade Petrol) and 7151.89 Cal/g at M 20(Methanol and 92 Grade Petrol) from the testing results of National Analytical Laboratory. The parameter such as brake power, fuel consumption rate, brake thermal efficiency was estimated by standard equations.

Brake power have 0.1159 kW (200-Watt load),0.3068 kW (400 Watt),0.4965 kW (600 Watt),0.75 kW (800 Watt) and 1.026 kW (1000 Watt) respectively at constant engine speed 1300 rpm. And then maximum current has 4.3 A and the maximum voltage has 210 Fuel consumption rate(bsfc) have 10.72 kg/kW-hr,4.83 kg/kW-hr,3.24 kg/kW-hr,2.21 kg /kW-hr and 1.67 kg/kW-hr. Brake thermal efficiency have 2.1 % ,4.8%,7.2%,10.6% and 14.03% respectively.

## IV. CONCLUSION

From this other researcher, it can be showed that low fraction methanol-gasoline blend can be used in SI engines without any modifications. The fuel blend has slightly lowered the engine power and torque, while increases engine breaks thermal efficiency. Methanol gasoline blended fuel may lower HC and CO emissions. The results also show a decrease of the CO and CO2 emissions and an equivalent variation of the HC emissions, which proves that the combination of these two could offer a viable solution.

Finally, it can be reviewed for this paper to show engine power and torque when using gasoline, a little increase than when using methanol gasoline blends nevertheless other benefits for emissions (such as CO2, CO and HC) when using methanol gasoline blends is higher than when using only gasoline. So, it can get better human's life and health and reduce global warming case when using methanol-gasoline blends.

## FUTURE WORK

There are many results demanding farther research and development work are as follows.

- It has been carried out studies on SI engine aiming to reduce mainly emissions and final testing with methanol gasoline blends to satisfy nearly theoretical and experiments results in SI Engine
- Analysing the engine exhaust emissions such as NOx, CO, CO2 and HC to reduce environmental warming problem.

## ACKNOWLEDGMENT

The author is sincerely thankful to Dr. Myint Thein, Rector, Yangon Technological University, for his suggestions and helps.

The author is also deeply thankful to Dr. Mi Sandar Mon, Professor and Head, Department of Mechanical Engineering, Yangon Technological University, for her generous guidance, instructions, suggestion and supervision for this paper.

The author is very grateful to Dr. Sandar Aung, Professor of Mechanical Engineering Department, Yangon Technological University, for her generous guidance, instruction, suggestion and supervision for this paper.

The author also would like to express grateful thanks to Teachers at National Analytical Laboratory (Department of Research and Innovation) and his parents and his family for their support, kindness, understanding and necessary assistance. Finally, the authors also thank all the teachers of Yangon Technological University.

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