International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

Performance of Diesel Grade in Turbocharged Engine

Asrul Syaharani Yusof, Zulkifli Mohamed, Eida Nadirah Roslin

Abstract: The aim of this research is to investigate the effect of diesel fuel grade on engine performance thru experimental method. Three grades of diesel fuels are used in this study, which is pure diesel fuel, euro 2M diesel fuel and euro5 diesel fuel. These fuels are being tested on 3.2L diesel turbocharged engine on a engine dynamometer.

Keywords: diesel engine, euro 2M, Euro5; emission, opacity.

I. INTRODUCTION

Now days, mostly heavy transportation such as army truck, bus, rail transportation used diesel fuel to generate engine power for moving. Mixture with 8 to 21 carbon atoms per molecule obtain by crude oil distillation and addition contains an additive. The parameters to define the diesel fuel parameters is cetane number. Mostly the minimum cetane number is 51 [1]. For better fuel ignitability in the combustion chamber, higher cetane number as indicator to provide a power were the fuel is injected into combustion chamber with filled hot compressed air. Other than that, viscosity also main characteristic was by if the high viscosity will damage internal wear part for diesel pump due to higher pressure. Thus, if too low viscosity may lead to poor of lubrication in the fuel injection pump operation.

FAME (Fatty Acid Methyl Ester) or Biodiesel fuel that formulated from vegetable oil or animal fats. Term for pure Biodiesel is refers to B100 whereby the fuel is 100% of biodiesel. This fuel was designated as an alternative fuel for transportation and manufactured area. Advantage of biodiesel as fuel is renewability, greenhouse gases can be reduced and emission to environment will regulated. For the petroleum diesel also contain 7% biodiesel to meet the specific properties.

For the standard diesel engine, biodiesel can be used to convert the fuel on the standard engine. It can be used alone or be blended with any proportions and can be used as heating oil. Mostly, blends of biodiesel commonly distributed from used in retail marketplace. Biodiesel known as the "B" to state the quantity biodiesel blends in any fuel mix.

- B100 refers to 100% of Biodiesel
- B20 refers to 20% of Biodiesel and 80% of diesel
- B2 refers to 2% of Biodiesel and 98% of diesel

In 2010, a study that has been conducted to compare the performance of direct injection diesel engine operating with biodiesel and diesel fuel based on GT-Power simulation [2]. The simulation results showed that torque and power outputs for biodiesel fuel were generally lower than those for diesel fuel.

On the other hand, a study has been conducted to improve biodiesel properties by blending it with pure diesel and to measure the basic properties of waste palm oil biodiesel-diesel fuel blends according to the standard specifications of diesel fuels [3]. It is found out that optimum of volume ratio mixing in order to improve the cold flow properties if biodiesels are used under severe winter conditions.

II. METHODOLOGY

In this study, the experimental engine was performed on a Mitsubishi 4M4 2.8L diesel engine, 4 cylinders and Inline engine. A gas analyzer also is being used to collect the emission and opacity data during the testing and this series of experiment are being done on engine dynamometer as shown in Fig 1 and Fig 2. The engine specification is shown in Table 1 below.

Table. 1 Mitsubishi 4M4 3.2L engine specification

Mitsubishi 4M4 3.2L engine specification	
Engine type	Diesel engine DOCH 16 valve
Engine displacement	3200cc
No. of cylinder	4 inline
Total displacement	2835cm3
Cylinder bore x stroke	98x 105mm
Compression ratio	17:1
Maximum power	121kW (4000rpm)
Maximum torque	351N.m (2500rpm)

Manuscript published on November 30, 2019.
* Correspondence Author
Asrul Syaharani Yusof*, Automotive Engineering Section, University Kuala Lumpur Malaysia France Institute, Bangi, Selangor, Malaysia.
Zulkifli Mohamed, Automotive Engineering Section, University Kuala Lumpur Malaysia France Institute, Bangi, Selangor, Malaysia.
Eida Nadirah Roslin, Automotive Engineering Section, University Kuala Lumpur Malaysia France Institute, Bangi, Selangor, Malaysia.

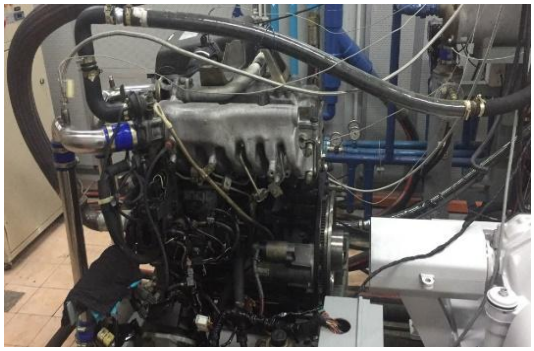

Fig. 1 4M4 engine testing on engine dynamometer

Fig. 2 Exhaust gas analyzer for diesel vehicle

III. RESULTS

Performance result has been obtained from the test performed on the engine that used compression ignition. This test was carried with two different throttle load which is 50% throttle opening and 100% throttle opening or wide-open throttle (WOT). The engine speed has been set from 1000, 1500, 2000, 2500, 3000, 3500, 4000 and until to 4300(RPM). This test will run for both throttle load respectively. At the same time, this test used three type diesel fuel such as Pure Diesel, Diesel 2M and Diesel Euro 5 which to carry out the engine performance. The engine performance that were analyzed is torque and power, fuel consumption and the smoke opacity that produce by different diesel fuel.

Power and Torque

Table. 2 Diesel Fuel Test on 50% engine load

RPM	Torque (Nm) Pure Diesel	Power (kW) Pure Diesel	Torque (Nm) 2M	Power (kW) 2M	Torque (Nm) EURO 5	Power (kW) Euro 5
1000	174.4	18.7	166.7	17.5	158.3	16.3
1500	235.6	36.8	244.9	38.5	242.3	38.6
2000	343.3	72.8	322.4	68.1	333.5	70.5
2500	338.8	88.6	329.8	87	329.8	86.3
3000	333.8	104.9	320.2	101.5	323.8	101.7
3500	292.7	107	277.9	102.6	283.2	103.5
4000	236.9	98.9	219.8	92.7	228.9	95.5
4300	173.9	78	118.7	53.9	164.1	73.5

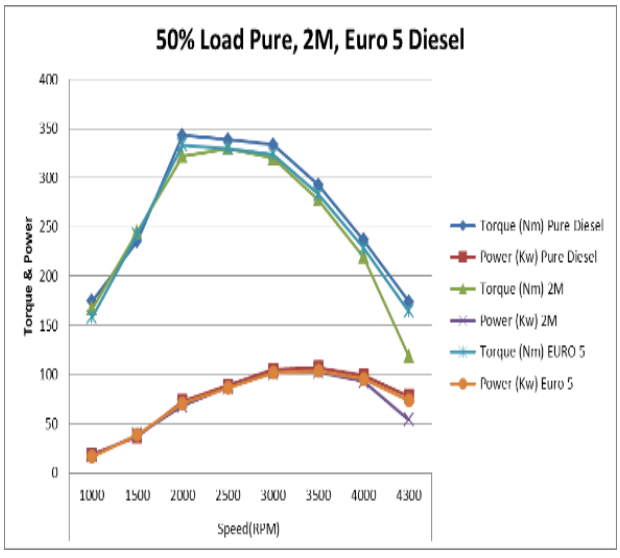

Fig. 3 Diesel Fuel Test on 50% engine load.

The graph in Fig.3 was given information about the combination of diesel fuel test at 50% throttle opening. At 50% throttle opening test three different fuel were used to get which give the best engine performance, that is Pure Diesel, Diesel 2M and Diesel Euro 5.

The line graph for engine torque shown Pure Diesel has reached peak point at 343.3(Nm) on 2000(RPM) compare to Diesel Euro 5 which is 333.5(Nlm) also on 2000(RPM) and increment at 2.3% of

engine torque for Pure Diesel. For the Diesel 2M, maximum torque produces at 329.8 on 2500(RPM). Thus, the optimum torque produce is by the Pure Diesel because has maximum reading compare others. Line graph for engine power shown Pure Diesel has reached peak point at 107(kW) on 3500(RPM) compare to Diesel 2M at 102.6(kW) and Diesel Euro5 at 103.5(kW) also on 3500(RPM) respectively. The engine power wasl increase to 3.3% between Pure Diesel and Diesel Euro 5 at engine speed 3500(RPM). Thus for 50% throttle opening, Pure diesel shown that improvement on engine power output at 3500(RPM).

Table. 3 Diesel Fuel Test on 100% engine load

RPM	Torque (Nm) Pure Diesel	Power (kW) Pure Diesel	Torque (Nm) 2M	Power (kW) 2M	Torque (Nm) EURO 5	Power (kW) Euro 5
1000	164.1	17	167.2	17.5	145.2	14.7
1500	248.8	38.5	251.8	39.6	252.6	40
2000	339.5	71.9	324	68	331.6	70.1
2500	340	89.1	328.7	86.2	328.7	86
3000	335.5	105.3	321	100.9	324.4	101.9
3500	294	107.4	279.2	102.4	283.7	103.7
4000	236	98.5	223.2	93.5	228.9	95.6
4300	173.5	77.7	139.8	63.1	165.1	73.9

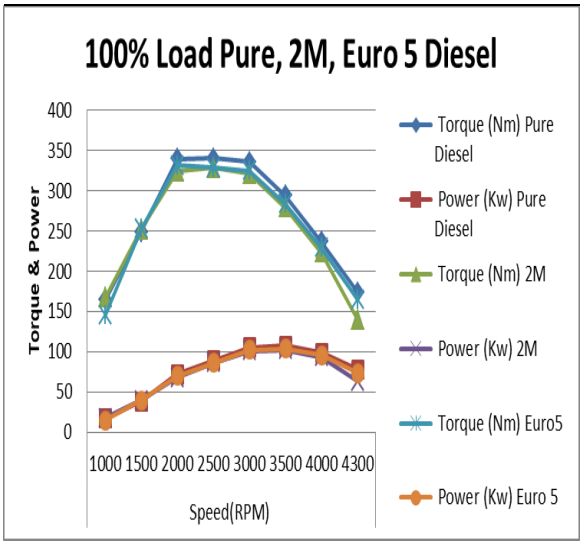

Fig. 4 Diesel Fuel Test on 100% engine load

The graph in Fig 4 was given information about the combination of diesel fuel test at 100% throttle opening. At 100% throttle opening test three different fuels were used to get which give the best engine performance that is Pure Diesel, Diesel 2M and Diesel Euro 5. Line graph for engine torque that produce maximum reading is from Pure Diesel which is 340(Nm) on 2500(RPM). Compare to Diesel 2M and Diesel Euro 5 which is 328.7(Nm) on 2500(RPM) and 331.6(Nm) on 2000(RPM). The engine torque increment between Pure Diesel and Diesel Euro 5 is 2.4%. Thus, at engine was wide open throttle Pure Diesel was best engine performance to meet with compression ignition engine compare to the Diesel Euro5 and Diesel 2M.

Line graph for engine power, peak reading showed at 107.4(kW) on 3500(RPM) which fuel from Pure Diesel. At 3500(RPM) engine produce two different power with different fuel which is 102.4(kW) for Diesel 2M and 103.7(kW) for Diesel Euro 5. This means at 3500(RPM) engine can produce variable power depending on the fuel based. However, engine will burn less fuel to produce more power output because power loss from crankshaft turning, movement of piston will increase the square of crankshaft speed.

Brake Specific Fuel Consumption

Table. 4 Brake Specific Fuel Consumption Test

RPM	Torque (Nm) Pure Diesel	Power (kW) Pure Diesel	Torque (Nm) 2M	Power (kW) 2M	Torque (Nm) EURO 5	Power (kW) Euro 5
1000	358.8	331.6	235.7	233.8	417.5	349.8
1500	202.3	196.8	229.1	225.62	261.34	217.1
2000	198.2	208.2	222.3	223.1	210.8	227.1
2500	218.3	210.1	228.9	235.4	220.2	230.1
3000	221.6	220.2	254.6	257.9	249.7	248.3
3500	221.6	253.7	269.6	274.2	259.7	263.3
4000	291.	279.2	304.3	311.2	303.3	280.2
4300	357.1	332.4	531.2	376.6	327.2	335.5

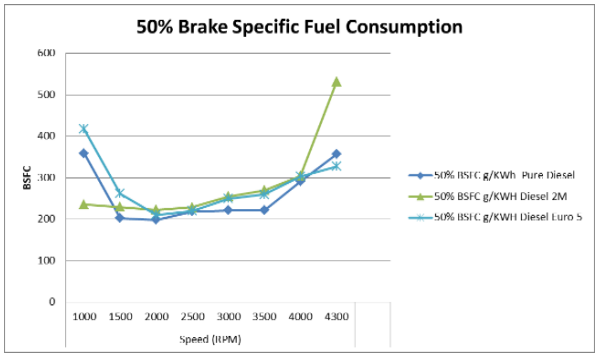

Fig. 5 Brake specific Fuel Consumption Test on 50% engine load

The line graph in Fig 5 was given an information about brake specific fuel consumption for the combination of diesel fuel test at 50% throttle opening. At 50% throttle opening test three different fuels were used to get which give the minimum and maximum fuel consumption that is Pure Diesel, Diesel 2M and Diesel Euro 5. In can be seen in this graph were when engine speed is increasing the amount of fuel consumption will increase. It was related to load torque by increasing the rotational speed the fuel consumption become more. The lowest specific fuel consumption that produce at 50% throttle load is 198.29 g/KWH by Pure Diesel and follow by Diesel Euro 5 is 210.87 g/KWH at 2000(RPM) respectively. Line graph for Diesel 2M shows that 50% throttle opening with 4300(RPM) it was most amount of fuel consumption was 531.23 g/KWH. Second was to Pure Diesel 357.17 g/KWH at 4300(RPM). Thus, for best fuel consumption at 50% throttle opening is Pure Diesel and Diesel Euro 5were the least amount of brake specific fuel consumption at minimum speed and load.

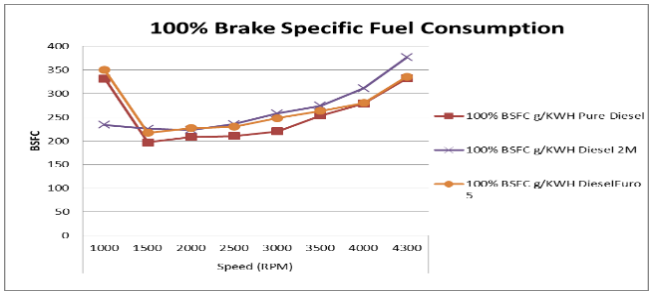

Fig. 6 Brake Specific Fuel Consumption Test on 100% engine load

The line graph in Fig 6 was given an information about brake specific fuel consumption for the combination of diesel fuel test at 100% throttle opening. At 100% throttle opening test three different fuel were used to get which give the minimum and maximum fuel consumption that is Pure Diesel, Diesel 2M and Diesel Euro 5. In can be seen in this graph were when engine speed is increasing the amount of fuel consumption will increase. It was related to load torque by increasing the rotational speed the fuel consumption become more. The lowest specific fuel consumption that produce at 100% throttle load is 196.86 g/KWH by Pure Diesel and follow by Diesel Euro 5 is 217.13 g/KWH at 1500(RPM) respectively. Line graph for Diesel 2M shows that 100% throttle opening with 4300(RPM) it was most amount of fuel consumption was 376.67 g/KWH. Second was to Diesel Euro 5 335.85 g/KWH at 4300(RPM). Thus, for best fuel consumption at 100% throttle opening is Pure Diesel and Diesel Euro 5were the least amount of brake specific fuel consumption at minimum speed and load.

Smoke Opacity

Table. 5 Smoke Opacity on 50% engine load

RPM	Opacity % 50% Pure Diesel	Opacity % 100% Pure Diesel	Opacity % 50% 2M	Opacity % 100% 2M	Opacity% 50% Euro 5	Opacity % 100% Euro 5
1000	2.5	16.5	2.7	3.1	3.1	11.9
1500	2.4	11.9	2.9	6.6	3.9	12.2
2000	1.5	13.4	2.9	5.3	9.6	6.6
2500	5.6	5.2	4.9	6.6	4.8	6.4
3000	7	5.8	8.4	10.2	7.1	6.1
3500	11	6.3	7.8	15.4	9.6	6.6
4000	15.2	15.5	14.9	22.3	12.1	13.6
4300	19.8	21.3	9.6	19.4	14.9	16.9

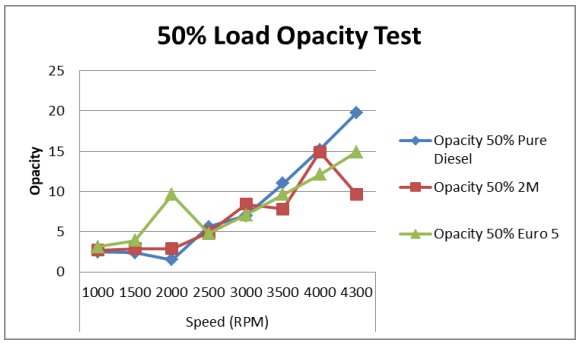

Fig. 7 Smoke Opacity at 50% engine load.

The graph in Fig. 7 was given information about smoke opacity percentage test for the combination of diesel fuel test at 50% throttle opening. At 50% throttle opening test three different fuels were used to get which give the minimum and maximum smoke opacity reading that is Pure Diesel, Diesel 2M and Diesel Euro 5. It can be observed that smoke opacity for Diesel Euro 5 and Pure Diesel was increase slightly consistence from 2500(RPM) until 4300(RPM) compared to

Diesel 2M. Line graph for Pure Diesel shown that peak reading at 4300(RPM) on 19.8% smoke opacity for 50% throttle opening compare the lowest reading is Diesel 2M which is 9.6%. At 2500(RPM) and above the smoke opacity is start increasing for each fuel because of increment on engine speed and air drawn into the combustion chamber. Smoke opacity percentage for diesel Euro 5 at 2000 (RPM) 9.6% and reduced to 4.8% at 2500 (RPM).

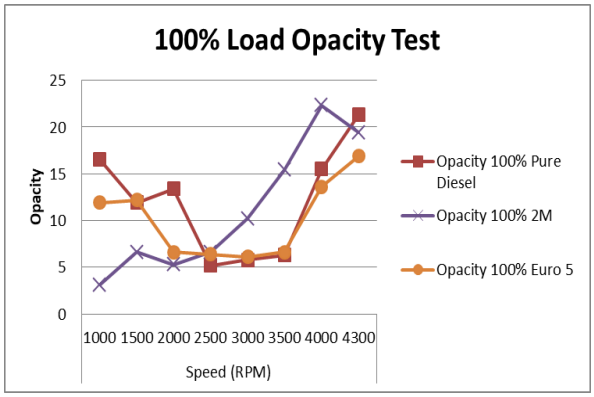

Fig. 8 Smoke Opacity on 100% engine load

The graph in Fig. 8 was given information about smoke opacity percentage test for the combination of diesel fuel test at 100% throttle opening. At 100% throttle opening test three different fuels were used to get which give the minimum and maximum smoke opacity reading that is Pure Diesel, Diesel 2M and Diesel Euro 5. It can be observed that at 1000(RPM) Pure Diesel and Diesel Euro5 was released high opacity which is 16.5% and 11.9% respectively. Pure Diesel line graph was slightly reduced to 5.2% at 2500(RPM). This is because of quantity of air in the combustion chamber is excessive when engine was travel from 50% throttle opening through wide open throttle (WOT) and start to increase at 3000(RPM) until 4300(RPM). Thus, for wide open throttle condition, Diesel 2M shown that most slightly increase excessively compare to others. From, 2000 (RPM) to 4000(RPM) the smoke opacity for Diesel 2M increase 5.3% to 22.3% opacity and dropto19.4% at 4300(RPM).

IV. CONCLUSION

This study has been executed to maximize diesel engine performance parameters when different diesel fuel has been used. Each fuel such as Pure Diesel, Diesel 2M and Diesel Euro 5 has different characteristic to the engine performance. Different throttle load will give different engine output. The main findings are summarized below.

Torque and Power

Based on the result obtain, found that Pure Diesel have produce best engine performance on torque and power for two throttle condition 50% and 100% opening at 1000(RPM) to 4300(RPM). Then, performance comparison between Diesel Euro 5 and Diesel 2M is slightly better for Diesel Euro 5.

Specific Fuel Consumption

For the specific fuel consumption result, it can be observed where Pure Diesel line graph give is least fuel consumption for each engine speed operation. There is linear trend on Pure Diesel test from 1500(RPM) to 3500(RPM) at 50% throttle opening. On the wide opening throttle at engine idle condition, Diesel Euro 5 and Pure Diesel reading is highest compare to the Diesel 2M and slightly reduce minimum specific fuel consumption for both fuels. When the engine speed is travel to high RPM, the fuel consumption will increase because of engine loads.

Smoke Opacity

Pure Diesel has proven that engine performance is better compare to the Diesel Euro 5and Diesel 2M. Meanwhile, for the smoke opacity reading that produce by exhaust smoke from Pure Diesel is highest. This mean exhaust smoke that produce by these fuels is not recommended to the diesel engine. Increasing engine speed will effects on smoke opacity reading if this fuel widely used in industries

REFERENCES

1. Clerc, J. C. "Cetane Number Requirements of Light-Duty Diesel Engines at Low Temperatures." SAE Transactions 95, 465-76. http://www.jstor.org/stable/44718137, 1986
2. Tziourtzioumis, D.N.; Stamatelos, A.M. Diesel-Injection Equipment Parts Deterioration after Prolonged Use of Biodiesel. Energies 2019
3. Hoekman, S.K.; Broch, A.; Robbins, C.; Ceniceros, E.; Natarajan, M. Review of biodiesel composition, properties, and specifications. Renew. Sustain. Energy Rev. 16, 143–169. 2012
4. Hong, Sung-Ho. Lubrication Characteristics in Fuel Injection Pump with Variation of Fuel Oils. Journal of the Korean Society of Tribologists and Lubrication Engineers. 31. 245-250. 10.9725/kstle.2015.31.6.245, 2015
5. Lacey, P.I. and Lestz, S.J., "Effect of Low-Lubricity Fuels on Diesel Injection Pumps-Part I: Field Performance, "SAE Paper 920823, Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA15096-0001, 1992
6. 6.European Biofuels Technology Platform, Fatty Acid Methyl Esters (FAME), http://www.etipbioenergy.eu/images/fame-fact-sheet.pdf, 2011.
7. Niculescu, R.A.; Clenci, A.; Iorga-Siman, V. Review on the use of diesel–Biodiesel–Alcohol blends in compression ignition engines. Energies 2019
8. Agarwal, A.K. Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. Prog. Energy Combust. Sci. 2007
9. Giakoumis, E.G.; Rakopoulos, C.D.; Dimaratos, A.M.; Rakopoulos, D.C. Exhaust emissions of diesel engines operating under transient conditions with biodiesel fuel blends. Prog. Energy Combust. Sci. 2012
10. A. Demirbas, Characterization of Biodiesel Fuels, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 31:11, 889-896, DOI: 10.1080/15567030801904202, 2009
11. F. Edition, "Biodiesel Handling and Use Guide," Natl. Renew. Energy Lab. Innov. Our Energy Futur., no. January, 2009
12. R.Rahim, R.Mamat and M.Y.Taib, Comparative study On diesel Engine Performance operating With biodiesel And Diesel Fuel, National Conference in Mechanical Engineering Research and Postgraduate Studies (2ndNCMER 2010), pp.863-870, 2010
13. Shahir, V.K. & Jawahar, C.P. & Suresh, P.R., "Comparative study of diesel and biodiesel on CI engine with emphasis to emissions—A review," Renewable and Sustainable Energy Reviews, Elsevier, vol. 45(C), pages 686-697. 2015
14. Özkan, Muammer. Comparative Study of the Effect of Biodiesel and Diesel Fuel on a Compression Ignition Engine's Performance, Emissions, and Its Cycle by Cycle Variations. Energy & Fuels - ENERG FUEL. 21. 10.1021/ef070013z. 2007
15. Florina, K. A Study On Blending Effect Of Biodiesel With Pure Diesel, 2008.

AUTHORS PROFILE

Asrul Syaharani Yusof is a Senior Lecturer at Universiti Kuala Lumpur, Malaysia France Institute. He obtained his Bachelor Of Engineering in Mechanical from University Sains Malaysia (USM) and Master of Science in Automotive Engineering from International Islamic University Malaysia (IIUM). His research interests include engine and powertrain performance, engine management system and vehicle chassis.

Zulkifli B. Mohammed @ Mohammed Nor is a Specialist at Universiti Kuala Lumpur, Malaysia France Institute. He obtained his Diploma Of Engineering Technology in Automotive Maintenance from University Kuala Lumpur Malaysia France Institute and Bachelor of Engineering (Mechanical-Automotive) from International Islamic University Malaysia (IIUM). His research interests include engine and powertrain performance and vehicle chassis.

Dr Eida Nadirah Roslin is a Senior Lecturer at Universiti Kuala Lumpur, Malaysia France Institute. She obtained her Bach. of Engineering in Manufacturing from International Islamic University Malaysia, Master of Engineering in Manufacturing System from Universiti Putra Malaysia and PhD in Engineering (Manufacturing System) from University of Malaya, Malaysia. She is currently a Research Principle for Advanced Manufacturing, Mechanical, and Innovation Research Lab. Her research interests include Manufacturing System, Operation Management, Lean System, Sustainable Engineering and Renewable System.