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The Emitted Noise from a Spark Ignition Engine Fueled by Methanol Added to Gasoline

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Abstract— *Alcohols are added to gasoline fuel to improve octane and reduce hydrocarbon pollutants emitted from combustion. Methanol has high octane number and high oxygen content, so it is a suitable type of alcohols to be added to gasoline. Fuel from the addition of methanol to gasoline improves the resultant octane number and enables the blend to work at high compression ratios. In this study, a single-cylinder internal combustion engine was used to measure the effect of adding methanol alcohol in volume fractions of 10% and 20% to gasoline fuel on the noise of the engine. The results showed a significant reduction in the noise of the engine when adding methanol by 10% compared to the other two studied cases.*

Keywords— *Methanol alcohol, noise, total sound pressure level.*

I. Introduction

Today, energy is the measure of the development and progress of societies and is a measure of the welfare of the individual and the development of the services provided to him [1]. The energy produced today in all fields whether thermal, electrical or transport depends entirely on fossil fuels which began to vow with regard to its near maturity [2]. The burning of fossil fuels, in addition to energy, results in many pollutants, which have caused a significant increase in greenhouse gases since the industrial revolution and the most important is CO2 [3]. Air pollution from the gases released from combustion has become a real dilemma for global warming and climate change [4]. Also, the past two decades witnessed a clear fluctuation in the price of oil high and then a significant decline causing the paralyzing and striking economic security of both producing and importing countries of this article [5]. However, the number of diesel-powered and gasoline-powered cars is still increasing, causing severe environmental damage to humans and animals [6, 7].

Reciprocating internal combustion engines are the most common engines, and the aim of most engines is to obtain the highest output capacity, less fuel consumption and fewer pollutants [8]. The cars operating in these engines were very heavily deployed and the pollutants emitted were severely damaged [9-11]. These engines, whether operated at high or medium speeds or even at idle speed or at cold starting will cause the emission of large quantities of pollutants and harmful to public health [12, 13, 15]. These engines are also one of the most important sources of pollution, accounting for 50% of the total components of air pollution sources, especially those that operate with gasoline and their effect on humans, animals and plants [15].

Since the 1970s, studies have been continuing to find alternative fuels for fossil fuels for use in internal combustion engines. The researchers studied the use of gaseous fuels such as natural gas [16, 17], liquefied petroleum gas [18, 19], or hydrogen in ignition engines [20, 21]. The comparison between these gases shows that each has its negative and positive characteristics [22, 23]. Methane, for example, has a low flame speed [24], liquefied petroleum gas (LPG) with a transmission speed equal to that of gasoline [25, 26], and hydrogen has the faster flame speed than any other fuel known worldwide [27, 28]. This difference in the flame speed has prompted researchers to mix natural gas, liquefied petroleum gas, and even gasoline with hydrogen to take advantage of this characteristic [29-31]. These studies have shown that the work of the engine with gaseous fuels reduced the emitted exhaust pollutants [32-34]. Adding hydrogen to gaseous fuels or gasoline reduces hydrocarbon contaminants and increases NOx pollutants due to increased flame velocity because of hydrogen addition [35-37]. Also, the researchers found that increasing the cetane number of diesel fuel reduces pollutants and improves the engine's efficiency [38]. The use of new concepts for engine work, such as changing the valve timing [39], HCCI [40], and PCCI [41], all reduce the emissions from the engine.

Dual diesel fuel in the compression ignition engines with the addition of gaseous fuel to diesel also showed a marked improvement in brake power and relative reduction of pollutants [42, 43]. The addition of hydrogen to diesel increased the engine's brake power and reduced exhaust emissions emitted [44, 45]. As well as, it reduced the PM emitted and the good relationship between these emissions and NOx [46, 47]. These specifications of hydrogen encouraged the researchers to look after using diesel-water emulsion as fuel for CIE because water contains both hydrogen and oxygen [48].

The researchers also studied the use of oxygenates such as alcohols and biodiesel in internal combustion engines [49, 50]. The first step was to add these oxygenate to gasoline and diesel fuels. Studies on the addition of oxygenates to diesel have demonstrated a marked decrease in hydrocarbon contaminants and a slight increase in nitrogen oxides with a slight increase in fuel consumption [51, 52]. Biodiesel is characterized by a laminar burning velocity approaches to diesel [53]. However, the use of biodiesel added to diesel indicated a significant reduction in emitted PM [54]. Ethanol and methanol have speeds slightly higher than diesel [55]. Biodiesel is preferred in compression ignition engines because its specifications are close to diesel fuel, particularly the relatively high cetane number [56, 57]. Ethanol and methanol have very low cetane number and their octane numbers are very high, so it is better to add them to the gasoline as anti-

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knock agents and to raise the formed blend octane number [58, 59].

Studies with the addition of ethanol and methanol to gasoline have shown an increase in octane numbers, and decrease of hydrocarbon pollutants emitted from the engine because of the abundance of oxygen in the composition of these alcohols [60, 61]. This factor is the reason for the high NOx emissions emitted from such engines [62, 63]. However, the NOx emissions can be controlled using EGR techniques [64]. Methanol is characterized by a high octane number (up to 114) which gives the engine the possibility to operate at high compression rates [65]. This alcohol is also used to run race cars with high compression ratios. Methanol is either used alone or in combination with gasoline, which will cause a significant rise in the specific fuel consumption [66].

The researchers studied pollutants emitted from compression ignition engines and found that the most important are carbon dioxide, carbon monoxide, unburned hydrocarbons, nitrogen oxides, sulfur oxides, and smoke [67, 68]. The noise from diesel engines is considered high and has been considered as a pollutant to be reduced [46]. The spark ignition engines emit many pollutants including CO_2, CO, HC, NOx, lead compounds, PM, and noise [69, 70].

Noise is one of the most important pollutants that must be controlled to minimize its hazards [71]. Noise is divided into two main types: mechanical noise and fluid noise. Noise is defined as any unwanted sound heard and measured in decibels (dB). The following table shows noise levels for design purposes at 100 HZ [72].

TABLE I. Noise levels for design purposes.

Painful	120 dBA
Very annoying	100 dBA
Confused / annoying	70 dBA
Extent of speech	60 dBA
Levels of silence desirable	30 dBA
Barely heard	20 dBA

Many studies have been conducted on the noise resulting from internal combustion engines as a harmful environmental factor and have become environmental pollution problems due to their negative impact on the human at high noise levels that causes health risks [73, 74]. Some countries have used laws to limit and control these levels of emitted noise. The sources of noise in the engine are:

A. Noise of engine suction and exhaust.

B. Noise from the engine structure vibration.

Jones and Brown [75] studied noise from the exhaust system in a two-stroke engine and used a statistical technique for this study. It was assumed that the exhaust noise emitted was generated on the assumption that the source was one-dimensional. Staiano [76] has conducted a study to assess the environmental impact of vehicle noise and the impact of maintenance in reducing it.

Several researchers investigated the importance of a sound barrier consisting of soundproofed materials. Ref. [77] realized that the noise caused by the disturbance was caused by the speed of the engine and that the noise can be reduced by 5-8 dB with special designs proposed by the authors.

Ref. [78] examined the noise from the engine and the exhaust and the means to reduce it and reached the following results:

A- The acceptable level of noise for vehicles is (74 dB) and that this measurement should be taken into account in the design of cars, especially in narrow areas.

B- Reduce the noise level of the engines and exhaust through the following:

(1) The correct design and use of appropriate materials in terms of the use of ribs and materials in the engine structure, which reduced the vibrations of various engine parts causing noise.

(2) The use of hydraulic passages through which fluid passes through the design of flywheel and for different speeds.

(3) The use of electro-rheological fluids in motor supports that connect the motor to the body of the vehicle, and these fluids provide better damping at all the vibrations that appear to exist.

(4) Engine noise can be sensed by an accelerometer that sends its information to the engine management system.

This research work aims to study the noise generated by a single-cylinder petrol engine with a mixture of gasoline and methanol, which is added at 10% and 20% volume fractions. The use of methanol in addition to gasoline has been studied extensively in terms of the effect of this addition to the performance of the engine and the regular pollutants emitted but did not study the impact of such an addition to the noise emanating from the engine. Therefore, due to the importance of this factor on the public health it will be studied alone.

II. EXPERIMENTAL SETUP

Practical experiments were conducted on the Italian origin internal combustion engine made by Prodit Company. The engine is a single cylinder, four-stroke with a variable compression ratio. The engine is coupled to a hydraulic dynamometer to measure torque out of the engine. The engine is linked to a control panel through which the engine speed is controlled and measured in rpm. Figure 1 shows the engine and attached devices.

The measurements of the engine noise was conducted noise measuring device type (CS 171A) made in England, shown in Figure 2. This device was calibrated using a measuring device level sound pressure from the 4230 model made by Herg Estelltvon Company / Madebly B & K.

Iraqi gasoline was used as the primary fuel in the experiments. This fuel has an octane number of 81, and heating value of 44000 kJ/kg. Also, methanol with purity of 99.99% and heating value of 9800 kJ/kg was used as additive to gasoline in two volume fractions. Three fuel models were prepared for the experiments:

A) Single gasoline with no additive.

B - Mixture of gasoline and methanol by 90% Gasoline + 10% Methanol.

C - Mixture of gasoline and methanol by 80% Gasoline + 20% Methanol.

The experiments were conducted at variable engine speeds to demonstrate the effect of alcohol addition on emitted noise intensity.

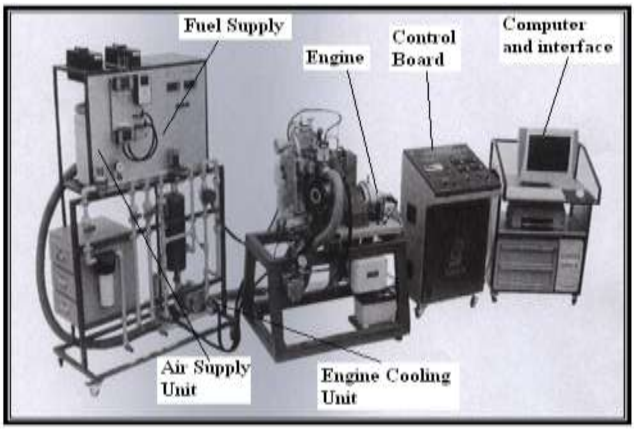

Fig. 1. Illustration of the engine kit and its accessories used in the study.

Fig. 2. Illustration of noise measurement device.

III. Results and Discussions

The addition of methanol to the gasoline reduces the heating value of the mixture because of the small heating value of methanol compared to gasoline. Thus reducing the resulting brake power and increasing the specific fuel consumption of the mixture. However, this addition increases the resistance of the mixture to knock. Thus increasing the compression ratio of the engine means compensating the decrease in the brake power and the reduction in the specific fuel consumption.

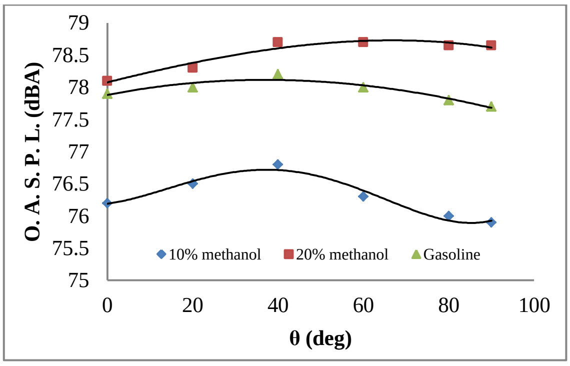

Fig. 3. The impact of adding methanol to gasoline on emitted noise at 1500 rpm.

Figures 3 shows that the magnitude of the change in noise intensity at the same speed, when the noise measuring device angle varied, is small and this is consistent with the theory of Ref. [79].

Figures 4, 5 and 6 indicate that noise intensity is increased with increasing engine speed, as the speed of the piston reciprocating increases and the flow rate of the air increase, as well as the flow of exhaust gases also, which increases the disturbance, i.e., the increase in the level of sound pressure. This result is identical to the basic aerodynamic theory of noise [80]. From these figure it can be concluded that the noise level is reduced by 3.3% when methanol is added by 10% and increased by 1.2% when it is added by 20% compared to the neat gasoline case. The study results reveal that in order to obtain a noise level within internationally permissible ranges, the engine must be serviced using acoustic insulation.

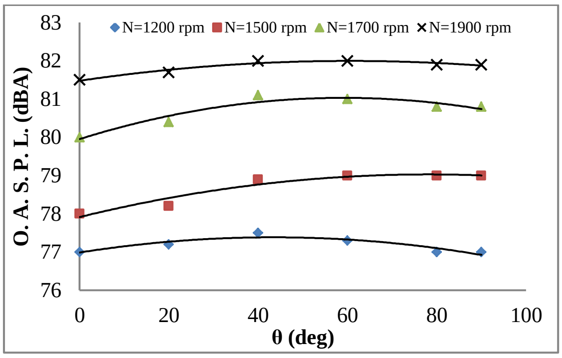

Fig. 4. The impact of engine's velocity variation on the emitted noise for gasoline.

IV. Conclussions

In this study, emphasis was placed on the effect of adding methanol alcohol to gasoline with specific ratios of 10% and 20%. The study foxed on the effect of this addition on the noise generated by the engine when the different engine speeds. The results of the study showed the following:

I- The results were identical with previous researchers regarding engine performance.
II- Increase the noise level by increasing the engine rpm.
III- Lower noise level was achieved when using 10% methan0l + 90% gasoline (3.3%).
IV- Insulators must be added to the engine to reduce noise and reach to the globally desired measurements.

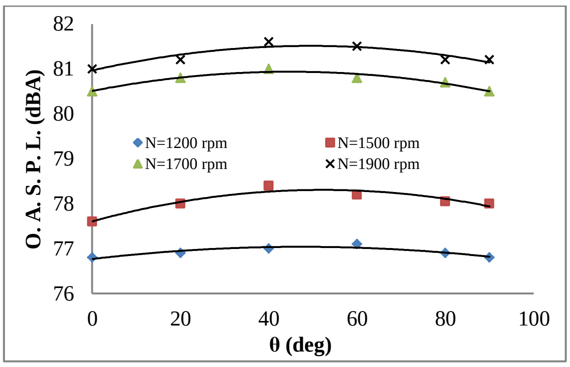

Fig. 5. The impact of engine's velocity variation on the emitted noise for 10% methanol added to gasoline.

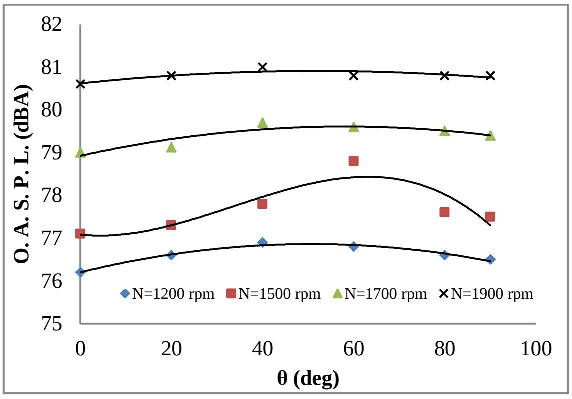

Fig. 6. The impact of engine's velocity variation on the emitted noise for 20% methanol added to gasoline.

REFERENCES

[1] H. M. S. Al-Maamary, H. A. Kazem, M. T. Chaichan, "Changing the energy profile of the GCC States: A review," *International Journal of Applied Engineering Research (IJAER)*, vol. 11, No. 3, pp. 1980-1988, 2016.

[2] H. M. S. Al-Maamary, H. A. Kazem, M. T. Chaichan, "Climate change: the game changer in the GCC region," *Renewable and Sustainable Energy Reviews*, vol. 76, pp. 555-576, 2017.

[3] M. T. Chaichan, A. H. Kadhum, A. A. Al-Amiery, "Novel technique for enhancement of diesel fuel: Impact of aqueous alumina nano-fluid on engine's performance and emissions," *Case Studies in Thermal Engineering*, vol. 10, pp. 611–620, 2017.

[4] M. T. Chaichan, K. I. Abaas & A. H. Naser, "Study of the effect of exhaust gas recirculation on performance and emitted noise of an engine fueled with diesel fuel," *Association of Arab Universities Journal of Engineering Science*, vol. 20, No. 1, pp. 43-59, 2013.

[5] H. M. S. Al-Maamary, H. A. Kazem, M. T. Chaichan, "The impact of the oil price fluctuations on common renewable energies in GCC countries," *Renewable and Sustainable Energy Reviews*, vol. 75, pp. 989-1007, 2017.

[6] M. T. Chaichan, H. A. Kazem, T. A. Abid, "Traffic and outdoor air pollution levels near highways in Baghdad, Iraq," *Environment, Development and Sustainability*, vol. 20, No. 2, pp. 589-603, 2018.

[7] M. T. Chaichan and K. A. H. Al-Asadi, "Environmental impact assessment of traffic in Oman," *International Journal of Scientific & Engineering Research*, vol. 6, No. 7, pp. 493-496, 2015.

[8] M. T. Chaichan and A. M. Saleh, "Practical investigation of single cylinder SI Engine performance operated with various hydrocarbon fuels and hydrogen," *Al Mostaseria Journal for engineering and development*, vol. 14, No. 2, pp. 183-197, 2010.

[9] A. A. Al-Waeely, S. D. Salman, W. K. Abdol-Reza, M. T. Chaichan, H. A. Kazem and H. S. S. Al-Jibori, "Evaluation of the spatial distribution of shared electrical generators and their environmental effects at Al-Sader City-Baghdad-Iraq," *International Journal of Engineering & Technology IJET-IJENS*, vol. 14, No. 2, pp. 16-23, 2014.

[10] M. T. Chaichan and Q. A. Abass, "Study of NOx emissions of SI engine fueled with different kinds of hydrocarbon fuels and hydrogen," *Al Khwarizmi Eng. Journal*, vol. 6, No. 2, pp. 11-20, 2010.

[11] M. T. Chaichan and K. I. Abass, "Experimental comparison of CO emissions emitted from single cylinder S I engine fueled with different kinds of hydrocarbon fuels and hydrogen," *Iraqi Journal for Mechanical and Material Eng.*, vol. 10, No. 3, pp. 397-405, 2010.

[12] M. T. Chaichan & S. S. Faris, "Practical investigation of the environmental hazards of idle time and speed of compression ignition engine fueled with Iraqi diesel fuel," *International J for Mechanical and Civil Eng.*, vol. 12, No. 1, pp. 29-34, 2015.

[13] M. T. Chaichan, O. K. Maroon, K. I. Abass, "The effect of diesel engine cold start period on the emitted emissions," International Journal of Scientific & Engineering Research, vol. 7, No. 3, pp. 749-753, 2016.

[14] M. T. Chaichan, O. K. Marhoon, B. A. Mohammed, "The effect of spark ignition engine cold starting period on the emitted emissions," *Scientific and Eng. Reports*, vol. 1, No.1, pp. 1-8, 2016.

[15] M. T. Chaichan, "Effect of injection timing and coolant temperatures of DI diesel engine on cold and hot engine startability and emissions," *IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE)*, vol. 13, No. 3-6, pp. 62-70, 2016.

[16] M. T. Chaichan & S. A. Al Sheikh, "Study of SIE performance fueled with methane," *Al-Jufra University Journal*, vol. 1, No. 1, pp. 15-27, 2001.

[17] A A Salim & M. T. Chaichan, "Study of SIE performance fueled with LPG," *Sabha University Journal*, vol. 4, No. 4, pp. 67-82, 2003.

[18] M. T. Chaichan, "Study of performance of SIE fueled with Supplementary methane to LPG," *The Iraqi Journal for Mechanical and Material Engineering*, vol.7, No.4, pp. 25-44, 2007.

[19] A. A. Salim & M. T. Chaichan, "Study of NOx and CO emissions for SIE fueled with LPG," *Sabha University Journal*, vol. 1, No. 1, pp. 106-125, 2002.

[20] A. A. Salim & M. T. Chaichan T, "Study of SIE performance fueled with hydrogen," *Sabha University Journal*, vol. 6, No. 3, pp. 32-57, 2004.

[21] M. T. Chaichan, "Practical study of compression ratio, spark timing and equivalence ratio effects on SIE fueled with hydrogen," *Proceeding to Industrial Applications of Energy Systems, Sohar University*, Oman, 2008.

[22] M. T. Chaichan, "Characterization of lean misfire limits of alternative gaseous fuels used for spark ignition engines," *Tikrit Journal of Engineering Sciences*, vol.19, No.1, pp. 50-61, 2012.

[23] M. T. Chaichan, "Study of performance of SIE fueled with different kinds of hydrocarbon fuels," *Association of Arab Universities Journal of Engineering Science*, vol. 14, No. 1, pp. 25-44, 2007.

[24] M. T. Chaichan, "The measurement of laminar burning velocities and Markstein numbers for hydrogen enriched natural gas," *International Journal of Mechanical Engineering & Technology (IJMET)*, vol. 4, No. 6, pp. 110-121, November- December, 2013.

[25] A. M. Salih, M. T. Chaichan, A. H. Naser, "Study of the effect of elevated temperatures on the laminar burning velocity of propane-air mixtures," *The 2nd Scientific Conference of Engineering Science, Diyala*, IRAQ, 2015.

[26] M. T. Chaichan, "Measurements of laminar burning velocities and Markstein length for LPG–hydrogen–air mixtures," *International Journal of Engineering Research and Development*, vol. 9, No. 3, 2013.

[27] M. T. Chaichan & A. M. Saleh, "Experimental measurements of laminar burning velocities and Markstein number of hydrogen–air mixtures," *The 3rd Scientific International Conference, Technical College, Najaf*, Iraq, 2013.

[28] M. T. Chaichan, "Practical measurements of laminar burning velocities for hydrogen-air mixtures using thermocouples," *Association of Arab Universities Journal of Engineering Science*, vol. 17, No. 2, 2010.

[29] M. T. Chaichan, "Study of performance of SIE fueled with Supplementary hydrogen to LPG," *Association of Arab Universities Journal of Engineering Science*, vol.16, No.1, pp. 125-145, 2009.

[30] M. T. Chaichan, "Study of performance of SIE fueled with Supplementary hydrogen to gasoline," *Baghdad Engineering Collage Journal*, vol.12, No.4, pp. 983-996, 2006.

[31] M. T. Chaichan, "Study of NOx and CO emissions for SIE fueled with Supplementary methane to LPG," *The Iraqi Journal for Mechanical and Material Engineering*, vol.6, No.2, pp. 85-97, 2006.

[32] M. T. Chaichan, "Study of NOx and CO emissions for SIE fueled with different kinds of hydrocarbon fuels," *Association of Arab Universities Journal of Engineering Science*, vol.13, No. 2, pp. 85-105, 2006.

[33] M. T. Chaichan, J. A. Kadhum, K. S. Riza, "Spark ignition engine performance when fueled with NG, LPG and Gasoline," *Saudi Journal of Engineering and Technology*, vol. 1, No. 3, pp. 105-116, 2016.

[34] M. T. Chaichan, "Evaluation of the effect of cooled EGR on knock of SI engine fueled with alternative gaseous fuels," *Sulaimani Journal for Engineering Science*, vol. 1, No. 1, pp. 7-15, 2014.

[35] M. T. Chaichan, "Study of NOx and CO emissions for SIE fueled with Supplementary hydrogen to LPG," *Association of Arab Universities Journal of Engineering Science*, vol. 16, No.2, pp. 32-47, 2009.

[36] M. T. Chaichan, "Study of NOx and CO emissions for SIE fueled with Supplementary hydrogen to gasoline," *Baghdad Engineering Collage Journal*, vol. 16, No. 1, pp. 4606-4617, 2010.

[37] M. T. Chaichan, "EGR effects on hydrogen engines performance and emissions," *International Journal of Scientific & Engineering Research*, vol. 7, No. 3, pp. 80-90, 2016.

[38] S. T. Ahmed & M. T. Chaichan, "Effect of fuel cetane number on multi-cylinders direct injection diesel engine performance and emissions," *Al-Khwarizmi Eng. Journal*, vol. 8, No.1, pp. 65-75, 2012.

[39] S. H. Khudhur, A. M. Saleh, M. T. Chaichan, "The effect of variable valve timing on SIE performance and emissions," *International Journal of Scientific & Engineering Research*, vol. 6, No. 8, pp. 173-179, 2015.

[40] M. T. Chaichan, K. I. Abass, "EGR and injection timing variation effects of an engine run in HCCI mode performance and emitted emissions," *International Journal of Engineering Trends and Technology (IJETT),* vol. 19, No. 3, pp. 120-130, 2015.

[41] M. T. Chaichan, "Combustion and emissions characteristics for DI diesel engine run by partially-premixed (PPCI) low temperature combustion (LTC) mode," *International Journal of Mechanical Engineering (IIJME)*, vol. 2, No. 10, pp. 7-16, 2014.

[42] M. T. Chaichan and A. M. Saleh, "Practical investigation of performance of single cylinder compression ignition engine fueled with duel fuel," *The Iraqi Journal for Mechanical and Material Engineering*, vol. 13, No. 2, pp. 198-211, 2013

[43] M. T. Chaichan, "Combustion of dual fuel type natural gas/liquid diesel fuel in compression ignition engine," *Journal of Mechanical and Civil Engineering (IOSR JMCE)*, vol. 11, No. 6, pp. 48-58, 2014.

[44] M. T. Chaichan, D. S. M. Al-Zubaidi, "A practical study of using hydrogen in dual – fuel compression ignition engine," *International Journal of Mechanical Engineering (IIJME)*, vol.2, No. 11, pp. 1-10, 2014.

[45] M. T. Chaichan, "The effects of hydrogen addition to diesel fuel on the emitted particulate matters," *International Journal of Scientific & Engineering Research*, vol. 6, No. 6, pp. 1081-1087, 2015.

[46] M. T. Chaichan, "Performance and emissions characteristics of CIE using hydrogen, biodiesel, and massive EGR," *International Journal of Hydrogen Energy*, vol. 43, pp. 5415-5435, 2018

[47] M. T. Chaichan, "The impact of equivalence ratio on performance and emissions of a hydrogen-diesel dual fuel engine with cooled exhaust gas recirculation," *International Journal of Scientific & Engineering Research*, vol. 6, No. 6, pp. 938-941, 2015.

[48] M. T. Chaichan, "Practical investigation of the performance and emission characteristics of DI compression ignition engine using water diesel emulsion as fuel," *Al-Rafidain Engineering Journal*, vol. 21, N0. 4, pp. 29-41, 2013.

[49] M. T. Chaichan, "EGR effect on performance of a spark ignition engine fueled with blend of methanol-gasoline," *Wassit Journal of Engineering Science*, vol. 1, No. 2, pp. 93-110, 2013.

[50] M. T. Chaichan, A. Q. Salam & S. A. Abdul-Aziz, "Impact of EGR on engine performance and emissions for CIE fueled with diesel-ethanol blends," *Arabic universities Union Journal*, vol. 27, No. 2, pp. 2014.

[51] M. T. Chaichan & A. M. Salih, "Study of compression ignition engine performance when fueled with mixtures of diesel fuel and alcohols," *Association of Arab Universities Journal of Engineering Science*, Vol. 17, No.1, pp. 1-22, 2010.

[52] M. T. Chaichan, "Emissions and performance characteristics of ethanol-diesel blends in CI engines," *Engineering and Technology J*, vol. 28, No. 21, pp. 6365-6383, 2010.

[53] M. T. Chaichan, "Evaluation of emitted particulate matters emissions in multi-cylinder diesel engine fuelled with biodiesel," *American Journal of Mechanical Engineering*, vol. 4, No. 1, pp. 1-6, 2016.

[54] M. T. Chaichan, "Practical measurements of laminar burning velocities and Markstein Numbers for Iraqi diesel-oxygenates blends," *The Iraqi Journal for Mechanical and Material Engineering*, vol. 13, No. 2, pp. 289-306, 2013.

[55] M. T. Chaichan, Q. A. Abass, "Effect of cool and hot EGR on performance of multi-cylinder CIE fueled with blends of diesel and methanol," *Al-Nahrain Collage of Engineering Journal*, vol. 19, No. 1, pp. 76-85, 2016.

[56] M. T. Chaichan & S. T. Ahmed, "Evaluation of performance and emissions characteristics for compression ignition engine operated with disposal yellow grease," *International Journal of Engineering and Science*, vol.2, No. 2, pp. 111-122, 2013.

[57] M. T. Chaichan, "Performance and emission study of diesel engine using sunflowers oil-based biodiesel fuels," *International Journal of Scientific and Engineering Research*, vol. 6, No. 4, pp. 260-269, 2015.

[58] M. T. Chaichan, D. S. M. Al-Zubaidi, "Operational parameters influence on resulted noise of multi-cylinders engine runs on dual fuels mode," *Journal of Al-Rafidain University Collage for Science*, vol. 35, pp. 186-204, 2014.

[59] M. T. Chaichan, "The impact of engine operating variables on emitted PM and Pb for an SIE fueled with variable ethanol-Iraqi gasoline blends," *IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE)*, vol. 12, N0. 6-1, pp. 72-79, 2015.

[60] M. T. Chaichan, "Exhaust gas recirculation (EGR) and injection timing effect on emitted emissions at idle period," *Al-Khwarizmi Engineering Journal*, Al-Khwarizmi Engineering Journal, vol.10, No. 4, pp. 33-44, 2014.

[61] M. T. Chaichan, "Combustion and emissions characteristics for DI diesel engine run by partially-premixed (PPCI) low temperature combustion (LTC) mode," *International Journal of Mechanical Engineering (IIJME)*, vol. 2, No. 10, pp. 7-16, 2014.

[62] M. T. Chaichan & K. I. Abass, "Emissions characteristics of methanol-diesel blends in CI engines," *Wassit Journal for Science & Medicine,* vol. 5, No.1, pp. 177-189, 2012.

[63] M. T. Chaichan, K. I. Abass, B. A. Mohammed, "Experimental study of the effect of fuel type on the emitted emissions from SIE at Idle Period," *Al-Khwarizmi Engineering Journal*, vol. 13, No.1, pp. 1-12, 2017.

[64] M. T. Chaichan & A. M. Saleh, "Practical investigation of the effect of EGR on DI multi cylinders diesel engine emissions," *Anbar Journal for Engineering Science (AJES)*, vol. 6, No. 3, pp. 401-410, 2013.

[65] M. T. Chaichan, N. M. Ali, "Experimental investigation of the effect of exhausts gas recirculation (EGR) on NOx-Smoke trade-off for SIE fueled with blends of gasoline/bioethanol," *Al-Rafidain Collage Journal*, Issue 39, pp. 388-404, 2016.

[66] M. T. Chaichan, "Improvement of NOx-PM trade-off in CIE though blends of ethanol or/ methanol and EGR," *International Advanced Research Journal in Science, Engineering and Technology,* vol. 2, No. 12, pp. 121-128, 2015.

[67] M. T. Chaichan, "Practical study of performance of compression ignition engine fueled with mixture of diesel fuel and ethanol," *Proceeding to the third International conference on modeling, simulation and applied optimization (ICMSAO'09), Al-Sharija*, UAE, 2009.

[68] K J Al-Khishali, A. M. Saleh, H. Mohammed, M. T. Chaichan, "Experimental and CFD simulation for Iraqi diesel fuel combustion," *1st International Babylon Conference, Babylon*, Iraq, 2015.

[69] M. T. Chaichan, "GEM Ternary Blends utilization as an alternative to conventional Iraqi gasoline to suppress emitted sulfur and lead components to environment," *Al-Khwarizmi Eng. Journal*, vol. 12, No. 3, pp. 38-51, 2016.

[70] M. T. Chaichan, "GEM Ternary blends: Testing emitted NOx-smoke trading off when EGR is applied to the engine," *International Journal of Applied Science*, vol. 13, No. 7, pp. 5014-5021, 2018.

[71] A. M. Saleh and M. T. Chaichan, "The effect of alcohol addition on the performance and emission of single cylinder spark ignition engine," *proceeding to Najaf Technical collage international scientific conference, Najaf,* Iraq, 2010.

[72] ER Fluid Engine Mounts, Automotive Engineering, vol. 101, No. 2, pp: 52-55, 1993.

[73] S. A. Al Sheikh & M. T. Chaichan, "The effect of number of nozzle sluices on released noise from free nozzles," *Al-Jufra University Journal*, vol. 1, No.1, pp. 55-66, 2001.

[74] E. S. Starkman & H. K. Newhall & R. D. Sutton, "Comparative performance of alcohol and hydrocarbon fuels", *Alcohol as Motor Fuel, S.A.E. Selected Papers Through*, 1980.

[75] A. D. Jones & G. L. Brown, "Determination of two stroke engine exhaust noise by the method of characteristics," *Journal of Sound & Vibration,* vol. 82, No. 3, 1982.

[76] M. A. Staiano, "Vehicle sound level reduction due to repair of defect exhaust system," *Noise Control Engineering Journal*, vol. 21, No. 2, 1983.

[77] M. T. Chaichan, "Exhaust analysis and performance of a single cylinder diesel engine run on dual fuels mode," *Baghdad Engineering Collage Journal*, vol. 17, No. 4, pp. 873-885, 2011.

Adel M Salih and Khaleel I Abass, "The emitted noise from a spark ignition engine fueled by methanol added to gasoline," *International Research Journal of Advanced Engineering and Science*, Volume 3, Issue 2, pp. 265-270, 2018.

[78] M. T. Chaichan & D. S. Al Zubaidi, "Practical study of performance and emissions of diesel engine using biodiesel fuels," *Association of Arab Universities Journal of Engineering Science*, vol. 18, No. 1, pp. 43-56, 2012.
[79] A. D. Jones and G. L. Brown, "Determination of two stroke engine exhaust noise by the method of characteristics," *Journal of Sound and Vibration*, vol. 90, No.4, 22 October 1983.
[80] Sound Transmission class, Science and engineering encyclopedia version 2.1, 2005, on line report www.direcdelta.co.uk

Notations

Symbol	Units	Meanings
bmep	bar	Mean brake effective pressure
bsfc	kg/ kW.hr	Brake specific fuel consumption
BP	kW	Brake power
CR		Compression ratio
f	N/m^3	The oscillation value of the power rate of the volume unit
i, j		Directions
N	rpm	Engine speed
OASP	dB	The overall sound pressure level
t	sec	Time
$\partial \bar{\rho}$		Volatility value of density