PAPER NAME
10. Jurnal IARAS_2017.pdf

AUTHOR
Mar 6

WORD COUNT
6489 Words

CHARACTER COUNT
33839 Characters

PAGE COUNT
12 Pages

FILE SIZE
473.3KB

SUBMISSION DATE
May 5, 2023 9:11 AM GMT+8

REPORT DATE
May 5, 2023 9:11 AM GMT+8

8% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 8% Internet database
- 0% Publications database

Excluded from Similarity Report

- Crossref database
- Crossref Posted Content database
- Submitted Works database
- Bibliographic material
- Quoted material
- Cited material
- Small Matches (Less then 10 words)
- Manually excluded sources

Suitable of High Compression Ratio, Injection Duration and Ignition Timing on CB150R Engine for High Performance and Low Emissions with Pure Bioethanol Fuelled

MARTH EN PALOBORAN[1)], GAYUH AGUNG PAMUJI[2)], BAMBANG SUDARMANTA[3)], I NYOMAN SUTANTRA[4)], DARMAWANG[5)]

1) Doctoral Student of Sepuluh Nopember Institute of Technology, Kampus ITS Sukolilo Surabaya, Indonesia 60111 (marth.me.unm@gmail.com)

2) Head of Automotive Laboratory, Mechanical Engineering Department, Sepuluh Nopember Institute of Technology, Kampus ITS Sukolilo Surabaya, Indonesia 60111 (tantra@me.its.ac.id)

3) Fuel and Combustion Engineering Laboratory, Sepuluh Nopember Institute of Technology, Kampus ITS Sukolilo Surabaya, Indonesia 60111 (sudarmanta@me.its.ac.id)

4) Automotive Engineering Department, Faculty of Engineering, Universitas Negeri Makassar, Kampus UNM Parangtambung Makassar, Indonesia 90242 (mawangunm707@gmail.com)

5) Undergraduate of Mechanical Engineering, Sepuluh Nopember Institute of Technology, Kampus ITS Sukolilo Surabaya, Indonesia 60111 (gayuh_meits@gmail.com)

6) Lecturer at Automotive Engineering Department, Faculty of Engineering, Universitas Negeri Makassar, Kampus UNM Parangtambung Makassar, Indonesia 90242 (marthen.paloboran@unm.ac.id)

Abstract: - Usage of bioethanol as a oxygenate fuel in spark ignition engine have been an effect on reducing hydrocarbon emissions, even it can be minimize products of NO_x emission if bioethanol applied in high concentration, as well as it have a significant impact on decreases greenhouse gas (GHG) effect. It's just that the generated power is lower than gasoline, so the suitable on bioethanol injection is required to get the equivalent power with gasoline. Grade octane of bioethanol is higher than gasoline, so the high compression ratio can be employed to increasing the torque and power as a compensation in low of heating value of bioethanol. Re-adjustment on ignition timing is needed during the injection duration and compression ratio is changed so that the high engine performance and low emissions can be reached. This study will exploit the compression ratio at 12:1, 12.5:1 and 13:1 with the injection duration by 100%, 125%, 150%, 175% and 200% that based on injection standard at 24cc/s as well as the ignition timing is advanced at 10°, 14°, 18°, 22° and 26° BTDC, while standard spark timing of engine is 7° BTDC. Usage of pure bioethanol at the maximum compression ratio (13:1) have been resulting brake torque, brake power and BMEP is increases by 16.1%, 18.10% and 18.12%, while the CO and HC emissions were decreases by 75.5% and 17.24% in average respectively compared with gasoline. Nevertheless, the specific fuel consumption is increased by 115.8% at 2000-4000 rpm, 57.2% at 5000-6000 rpm and 23.5% at 7000-8000 rpm in average respectively.

Key-words: - injection duration, ignition timing, compression ratio, advance, pure bioethanol.

1. Introduction

Indonesia as an agrarian country have been redundant natural resources, especially in agriculture sector. It position was on equator region so all type of plants could be thrive. In this fact, development of vehicle fuel that it's the raw material from plant (biofuel) is potential. Replace fossil fuel as a main feeds to vehicles have been a major issue in the last decade because its availability has been limited year by year. It is caused by exploration activities have not found yet the new oil wells until recently. Moreover, it is needed high technology and costly to exploitation existing reserve [1]. As known that the use of fossil fuel led to increases CO, HC, NO_x and CO_2 emissions are harmful to human and environment [2].

Application of bioethanol as a fuel is a solution toward increases of greenhouse gas (GHG) and global warming. Experimentally, the oxygen content of bioethanol was predicted influence to reducing hydrocarbon emission significantly, even though its exhaust gas is less toxic [3]. Bioethanol was used as fuel by Henry Ford on vehicle Model T design, even Nicholas Otto was popularizing the bioethanol in transportation engine is very long time before used of fossil fuel widely [4]. Indonesia's fossil fuel stockpile will be vanished for 12 – 15 years from now, so the alternative energy should be prepare [5], while the government of Indonesia was allocate 20% of bioethanol in all of energy consumption up to 2050 years [6].

The main objectives of this study are to find suitable the injection duration and ignition timing on variation of high compression ratio and evaluate the performance and emissions of engine when pure bioethanol (E100) is applied. Paloboran et al [7] has reviewed that application of gasoline-bioethanol blend up to 20% (E0-E20) in spark ignition engine is not needed any adjustment on engine. Meanwhile, the setting on compression ratio is required to accommodate the increases octane rating in mixture when 25-40% (E25-E40) of bioethanol with gasoline is used. The last one, simultaneous adjustment on prime combustion parameters namely; compression ratio, injection duration, ignition timing and air-fuel ratio should be re-arrangement when percentage 50-100% (E50-E100) of bioethanol with gasoline is applied for high engine performance and low emissions.

This work is one of experimental series that conducted for investigate effect of the high concentration gasoline-bioethanol blending (E50-E100) on performance and emissions of mini spark ignition engine as a popular motorcycle in Indonesia. The reason is to existing research infrastructure as a supporting to government when the legislation about application of bioethanol is implemented.

2. Literature Review

Bioethanol as a fuel has been mostly applicable in spark ignition engine than compression engine because the properties of bioethanol is close to gasoline rather than diesel. The advantageous properties of bioethanol in spark engine are latent heat of vaporization that could be increasing volumetric efficiency, reducing the over cylinder temperature to minimize product of NO_x emission [8]. Oxygen content of bioethanol led to speed of firing is increases and complete combustion is faster so the variation of cycle is low. It's also reducing CO and HC emissions and improve fuel efficiency [9]. The high laminar flame speed of bioethanol will shorten of combustion process to keep the stability of combustion so the heat loss will reduces to covering high of thermal efficiency [10]. Meanwhile, the high grade of octane bioethanol allowed to improving the compression ratio to increasing power, torque, cylinder pressure and thermal efficiency [11].

In contrast, there are some drawback of bioethanol when applied in spark ignition engine. Reid vapour pressure of bioethanol cause the engine difficult to start in cold weather and aldehyde emissions tend to increases as well [12-14]. Aldehydes emission of bioethanol are also caused by presence of the hydroxyl (OH) compound in bioethanol that forming formaldehydes (HCHO) and acetaldehyde (CH_3CHO) emissions. Amount of the aldehydes emissions in exhaust gas depend on concentration of bioethanol in the fuel, load of engine and percentage of oxygen in the fuel [15-18]. Aldehydes emissions by pure bioethanol fuel is higher than gasoline-bioethanol blend, but blending gasoline-bioethanol will produce higher NOx gas than pure bioethanol [19].

There were two strategies to overcome the cold start problems. Firstly, the temperature of air intake or fuels is increased before flowing into the combustion chamber. The second is using two fuel tanks which the gasoline fuel is used at the initial start to increases engine temperature before bioethanol fuel is applied [20]. Solubility of bioethanol in the water or otherwise are hundred percent so the engine material is damaged easily, particularly that made from metal and rubber [20]. Blending bioethanol and gasoline at various concentrations would be experience separation on the certain pressure and temperature. This problems could be attack with using isopropanol as co-solvent [21]. Heating value of bioethanol is lower than gasoline so produce of power and torque is low at equivalent injection volume. Therefore to increase the torque and engine power will be required higher injection volume by enlarging the hole of injector or times of the duration of injection is extended when the bioethanol is used.

The study about usage of bioethanol as a fuel have been investigated by many researchers with various aspect. Therefore, this study will try to revealing effect of application pure bioethanol on Indonesia's motorcycle at various high compression ratio. As mentioned earlier that the high octane number of bioethanol than gasoline is may to employing high compression ratio to generate high thermal efficiency as stated in the formula [22]:

$$\eta_{th} = 1 - \frac{1}{\gamma^{k-1}} \quad \text{....(1)}$$

Balki et al. [23] was studying combustion effect of methanol (M100), bioethanol (E100) and gasoline (E0) on characteristic of performance and emissions with various compression ratio, wide open throttle and constant engine speed. The maximum of combustion efficiency was stand at 8.5:1 of compression ratio by value 97.57%, 99.26% and 99.45% for gasoline, bioethanol and methanol respectively. While the combustion efficiency tend to decrease when the compression ratio is increased. Therefore, the BMEP and BTE of bioethanol and methanol are increases as increase of compression ratio, but it is decrease for gasoline. This is caused by octane rating of alcohol fuel is higher than gasoline. Meanwhile, the CO and HC emissions decreases as increase the compression ratio, but at the maximum compression ratio (9.5:1) the emissions is increases. The reason is the ratio of surface of combustion chamber and cylinder volume is increases as increases of compression ratio so a part of hydrocarbon is unburnt.

Chelik MB [22] has showed power and torque of E50 is higher than those E25, E75 and E100 at 6:1 of compression ratio and 2000 RPM. The average of power of E50 will increases by 23% when the compression ratio setting at 10:1, and 29% higher than the gasoline on standard condition in range 1500-4000 RPM of engine speed. The CO emissions of E50 is decreases significantly as increases of the compression ratio, but CO_2, HC and NO_x emissions was increases slightly at the same condition. It is influenced by the ignition timing of engine standard is too advance so the fire is easy to extinct when the compression ratio is increases [24]. This study was supported by experiments of Farha et al [25-26] and Sudarmanta et al [27], but their subjects was presenting that the CO and HC emissions is decreases as increases both bioethanol percentage in gasoline and the compression ratio. It is because the ignition timing has been setting on the maximum brake torque condition.

Heating value of bioethanol only two-thirds compared with gasoline so specific fuel consumption of bioethanol is higher than gasoline at same power. Turkoz et al [28] have proved that the power and torque is higher when injection duration was extended with widening the hole of injector two times from the standard. Paloboran et al [29] has explained that the injection duration is required by 150-200% to obtain the maximum torque. In his study was also revealed that 200% of injection duration is needed at 2000-4000 rpm, 175% at 5000-6000 rpm and 150% at 7000-8000 rpm. Furthermore, the average power was sitting at the point by 12.62kW, 12.97kW and 13.28kW on 12, 12.5 and 13 of the compression ratio respectively, while the gasoline only was at 11.44kW. Then, CO and HC emission was significantly decrease when the compression ratio is increasing from 12 to 13 compared with gasoline. Those are 50-85% of CO and 13-19% of HC along the increasing engine speed.

Ignition timing have a dominant impact on the performance and emissions of internal combustion engines, so it is should be re-adjusted when the compression ratio is changed [12]. Yucesu at al [30] studied effect of various ignition timing, relative air fuel ratio and compression ratio toward torque and BSFC on constant speed for E10, E20, E40 and E60. The study showed that the maximum torque and BSFC was on 26 BTDC at 8:1 of compression ratio, while at 10:1 of compression ratio was on 22 BTDC. It is proven that the ignition timing is retard as an increases of the compression ratio at the constant speed. The different subject has identified by Wannatong et al [31] that has investigated the ignition timing for each of percentage of gasoline-bioethanol blend at 10.5 of compression ratio and 5000 rpm. The result presenting that the ignition timing is advance as the percentage of bioethanol in the gasoline is increases. The methods to determine the maximum torque for various engine speed, fuel composition and compression ratio could be done by minimum spark ignition for maximum brake torque. This strategy has been done successfully by several researchers, that are; Sudarmanta et al [27], Costa R et al [24], Alexandru et al [32] and Yoon SH et al [33]. Their conclusion were stated that the ignition timing should be advance as an increases of engine speed, compression ratio and percentage of bioethanol. In addition, the studies that conducted by Binjuwair S [34] and Sayin C [35] showing that advanced of the ignition timing will increasing thermal efficiency and power as well as reducing the BSFC, HC and CO emissions.

3. Experimental Section

In the experimental study, a single cylinder 4-stroke, 150cc, port fuel injection and spark ignition engine was used. The general specification of the test engine are shown in table.1

An increase in the compression ratio can be done by installing a dome on top of cylinder, but to reduce in the compression ratio any suitable gasket can be applied. Effect of usage unleaded gasoline (E0) and pure bioethanol (E100) on performance and engine emissions have been investigated experimentally. The gasoline have RON by 92, while the bioethanol have specified with 120 of RON. The bioethanol was produced from cellulose by PT. Enero Mojokerto that is the biggest producer of bioethanol in Indonesia.

The experimental conditions are fully open throttle and in the range 2000-8000 rpm. The water brake dynamometer “DYNOmite Land Sea” was applied as a regulator of rpm and strobotester “CS SINCRO-type DG 85” to measure the engine speed. Furthermore, a digital gas analyser was assembled at exhaust manifold, while the relative air fuel ratio was calculated with formula [37]:

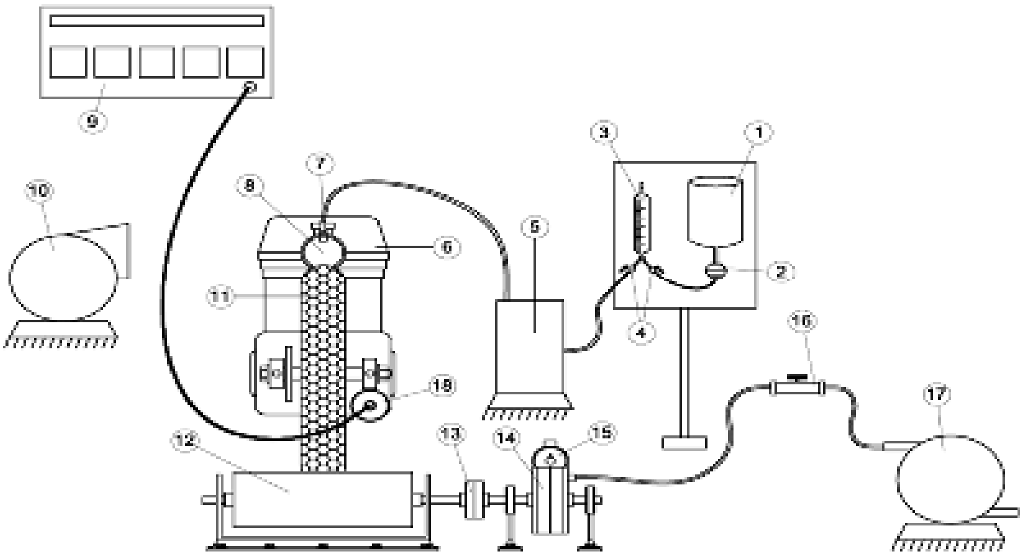
$$\lambda = \frac{AFR_{actusl}}{AFR_{stoic}} \qquad (2)$$

Table 1: Engine test

Parameters	Standard
Engine type	4 Stroke, 4 Valve, 1 cyl
Bore	63,5 mm
Stroke	47,2 mm
Displacement vol.	149,5 mm
Compression ratio	11,0 : 1
Ignition system	Full transistorized
Maximum power	12,5kW/10000RPM
Maximum torque	13,1Nm/8000RPM
Intake valve open	5^o BTDC, lifting 1 mm
Intake valve close	35^o ABDC, lifting 1 mm
Exhaust valve open	35^o BBDC, lifting 1 mm
Exhaust valve close	5^o ATDC, lifting 1 mm
Valve Train	Chain, DOHC

The digital thermocouples have been installed to measure the local temperature, i.e. air intake and exhaust gas, engine temperature, cooler and water coolant temperature, as well as oil lubrication temperature. The electronic control unit (ECU) has been developed to accommodate all of parameter in the experiment. In initial of engine operation, unleaded gasoline was used firstly to overcome the cold start when bioethanol is applied. The gasoline has operated only on engine standard, i.e. 7^o BTDC and at 11:1 of compression ratio, while the bioethanol has used on various ignition timing, duration injection and compression ratio.

Data retrieval is done in three stages, the firstly is mapping the injection duration in interval 25% in volume 100%-200%, the second is mapping the ignition timing on 10, 14, 18, 22 and 26 BTDC where the maximum torque of injection duration is already applied. Both of maximum torque of ignition timing and injection duration have been recorded in ECU system and all of experiment were runs on 2000 – 8000 rpm. The engine is running once again to find the best performance and emission of engine as a last one step. In the final stage, the maximum value of brake torque when mapping process has been put in.



1. Fuel Tank
2. Filter fuel
3. Glass gauge
4. Valve
5. Fuel pump
6. Engine test
7. Injector
8. Throttle body
9. Gas analysers
10. Blower
11. Back train
12. Roller of back train
13. Clutch
14. Dynamometer
15. Torque gauge
16. Valve
17. Water pump
18. Exhaust manifold

Figure 1: The engine test

4. Result and Discussion

4.1 Mapping the duration injection

Fig. 2-3 showed the result of mapping injection duration on various rpm and compression ratio. In early of engine started (2000-4000 rpm) is needed 200% of bioethanol injection. Furthermore, 150% of injection duration is needed on 5000-6000 rpm and 150% on 7000-8000 rpm respectively at all compression ratio. The situation caused by the oxygen content of bioethanol could be help the complete combustion by substitute insufficient of air when the engine runs on low speed. The mass flow rate of bioethanol is decreases if the engine speed is increases. It is influenced by the evaporation process of bioethanol is better while the engine speed is faster, because the cylinder temperature has been increases. The maximum torque has been reach on 7000 rpm for all of fuel and compression ratio, i.e. 13.95Nm, 14.76Nm, 15.34Nm, 15.84Nm and 16.07Nm respectively.

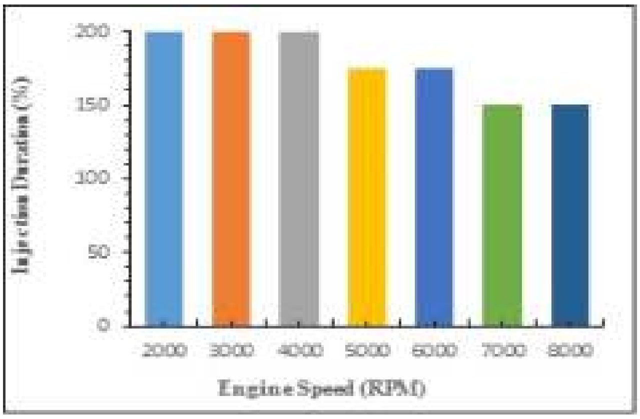


Figure 2. Maximum torque at varying injection duration

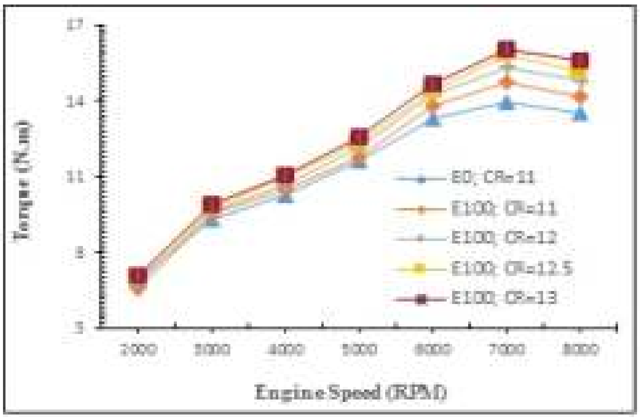


Figure 3. Mapping injection duration at varying RPM and CR

4.2 Mapping the ignition timing

Fig. 4-7 presented the mapping ignition timing process for all of compression ratio when pure bioethanol is used. The ignition timing was increases if the engine speed is increases to get the maximum torque, i.e. 10^o BTDC at 2000-3000 rpm, 14^o BTDC at 4000-5000 rpm and 18^o BTDC at 6000-8000 rpm, respectively. Meanwhile, at 22^o and 26^o BTDC is too advance, even its value is lower than gasoline, especially on high speed. The results has been confirmed to many previous studies that the ignition timing is advance when the compression ratio and engine speed is increases for usage of bioethanol. At the top of engine speed, the torque was decline because the combustion process was on lean mixture for all of CR. The average magnitude of increases of torque is 9.7%, 13.1% and 16.5% for 12, 12.5 and 13 of compression ratio respectively if compared with gasoline.

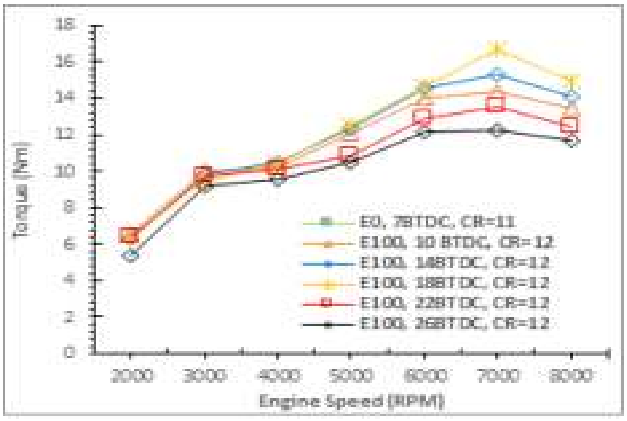


Figure 4. Mapping the ignition timing at CR=12 :1

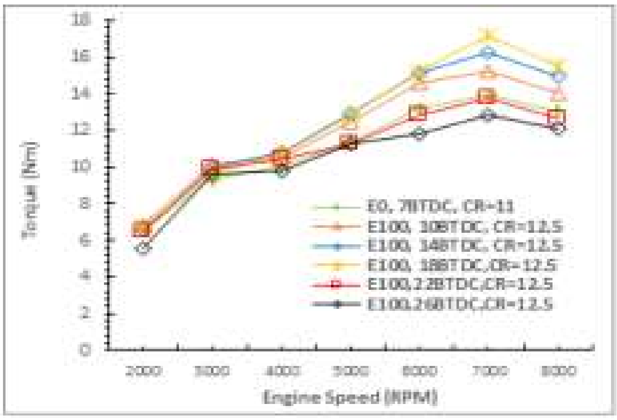


Figure 5. Mapping the ignition timing CR=12.5:1

4.3 Brake Power

Fig. 8-11 showed effect of various of speed and compression ratio on brake power for gasoline and bioethanol. The brake power have a correlation with torque directly, as shown in an equation [37]:

$$\text{BHP} = 2\pi NT\left[\frac{Nm}{s}\right] \quad \ldots\ldots \ (3)$$

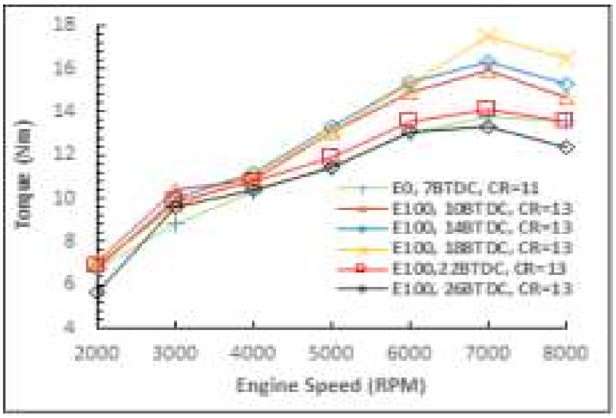


Figure 6. Mapping the ignition timing at CR=13:1

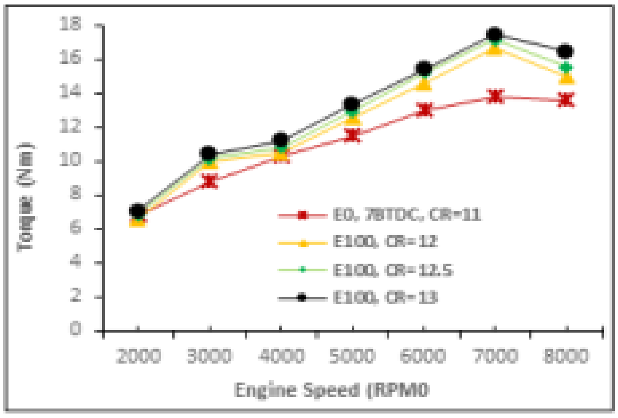


Figure 7: Torque on MBT at varying CR and engine speed

Where N is engine speed (revolution per second) and T is torque (Nm), so an increase of torque have direct impact on increase of brake power. Fig. 8-9 was explained that the brake power on 2000-4000 rpm is not significant among the fuel and ignition timing.

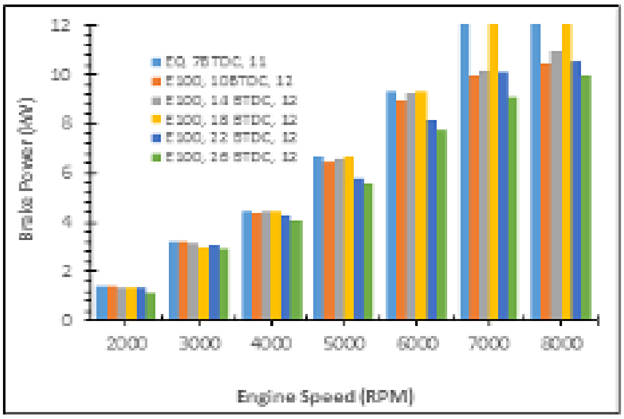


Figure 8. Brake power at various RPM and CR=12:1

The power started to different when speed of engine is above 5000 rpm, which in 18^{o} BTDC of the ignition timing is superior with others, except at12:1 of CR where the gasoline almost equal with bioethanol. This phenomena was affected by the high of heating value of gasoline so it power is higher than bioethanol, particularly at low speed and low compression ratio. Meanwhile, the high of latent heat of vaporization and octane rating of bioethanol was making the bioethanol is dominant at high speed and high compression ratio.

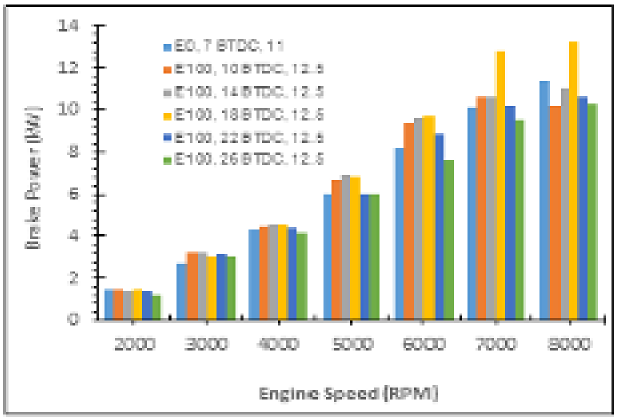


Figure 9. Brake power at various RPM and CR=12.5:1

Fig. 10 was presented similar trend with fig. 9, but they are different qualitatively, which there are brake power increases by 2.4% - 3% in average with increasing the compression ratio. Fig. 11 presents brake power on various compression ratio. The brake power would be increases as increases of speed by 5.7%, 20.2%, 10.5%, 18.02%, 20.5%, 28.8% and 23.2% for 13:1 of compression ratio if compared with gasoline. The maximum brake power of gasoline is 11.31kW, while 14.01kW by bioethanol.

4.4 Brake Mean Effective Pressure

Fig. 12-14 were provided effect of various ignition timing and speed of engine on brake mean effective pressure at 12, 12.5 and 13 of compression ratio. In general, the BMEP have a differences slightly when the engine is runs up to 4000 rpm for all of ignition timing. The BMEP will increases with increasing the engine speed, but it was on culmination point at 6000 rpm before going down continuously, except the 18 BTDC that increase consistently until 7000 rpm. A formula that expressing this condition is [38]:

$$\text{BMEP} = \frac{\text{BHP x z}}{\text{A x L x N x i}} \left[\frac{N}{m^2}\right] \qquad \text{... (4)}$$

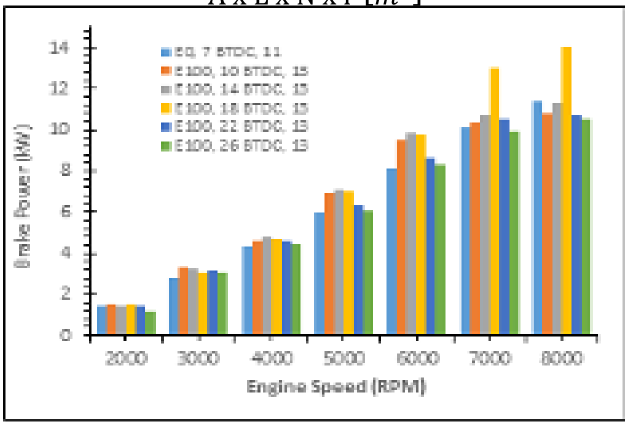


Figure 10. Brake power versus RPM at CR=13

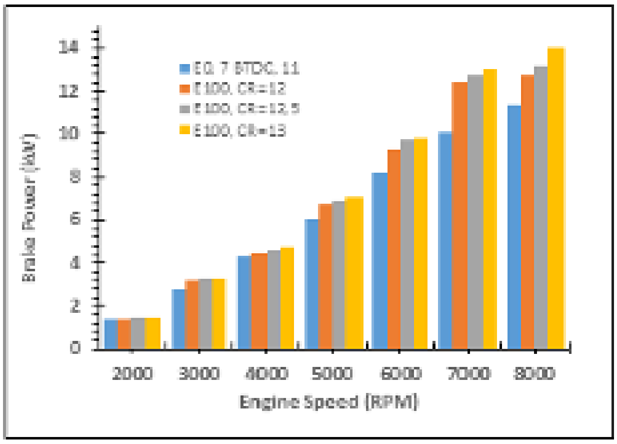


Figure 11. Brake power on MBT versus RPM and CR

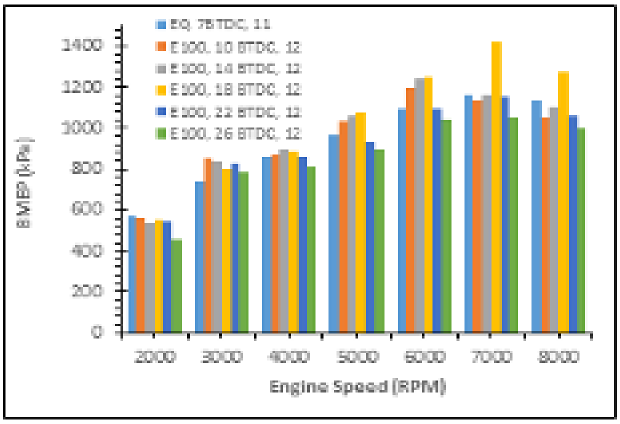


Figure 12. BMEP versus RPM at CR=12:1

Where z is a coefficient of motor, *A* is area of combustion chamber, *L* is lenght of stroke and *i* is amount of cylinder. The BMEP is a function of engine speed in reverse, so the BMEP would be decreases when the engine speed is too high. Unbalances of combustion process was the cause it, due to the lack of air intake into the combustion chamber, while the injection duration of fuel is steady. Furthermore, frictional losses was also triggered the reduction in value of BMEP that it happened in high speed. Noted that the 22 and 26 BTDC of ignition timing is inferior to others, so it does effectiveness to apply at 12:1, 12.5:1 and 13:1 of CR when E100 is used.

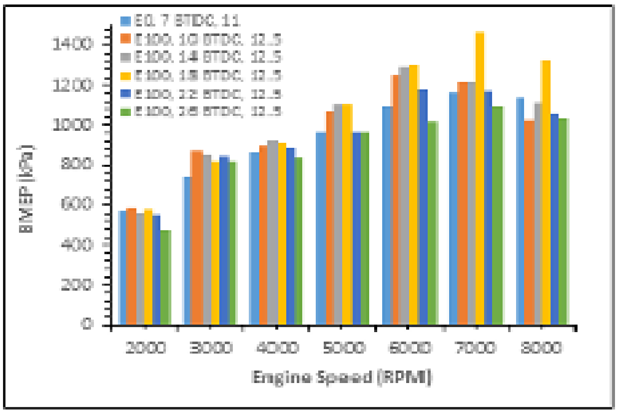


Figure 13. BMEP versus RPM at CR=12.5:1

Fig. 15 was explained the maximum value of BMEP distribution at each compression ratio and rpm for any ignition timing is 2000-3000 at 10° BTDC, 4000 at 14° BTDC and 5000-8000 at 18° BTDC for 12:1 of CR. Then, 2000-3000 at 10° BTDC, 4000-5000 at 14° BTDC and 6000-8000 at

18° BTDC for 12.5:1 of CR, Finally, 2000-3000 at 10° BTDC, 4000-6000 at 14° BTDC and 7000-8000 at 18° for 13 of CR. The average increases of maximum BMEP from engine standard to 13:1 of compression ratio is 19.4% when E100 is used.

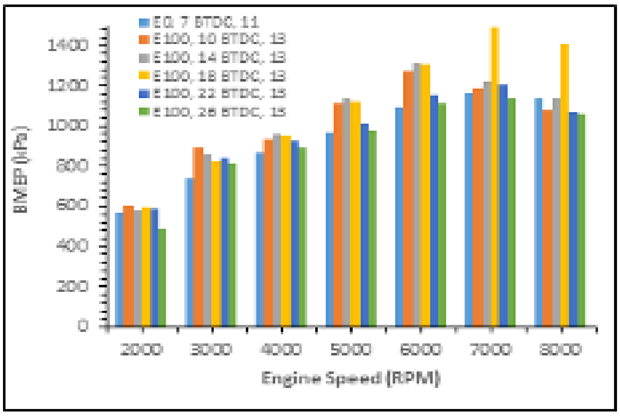


Figure 14. BMEP versus RPM at CR=13:1

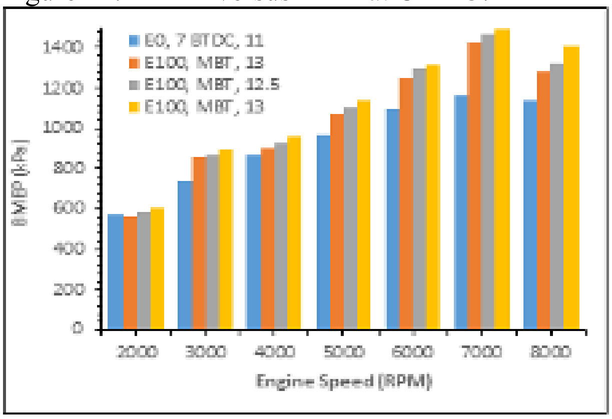


Figure 15. BMEP on MBT versus RPM and CR

4.5 SFC and Thermal Efficiency

Addition of bioethanol into gasoline will reducing the heating value of fuels, therefore, high of mass flow rate of gasoline-bioethanol blend is required to obtain the same power instead of pure gasoline. Moreover, the low favour pressure of bioethanol has been lighters toward the increases of fuel consumption, especially at low engine speed when E100 is applied. Therefore, this situation would be better gradually with increase of engine speed. It is due to the cylinder temperature will increase as increase of speed, so the bioethanol fuel in combustion chamber will evaporate completely. Nevertheless, the torque and engine power will increases significantly when E100 is used as mentioned previously. The SFC were showing the same trend line at all compression ratio, except at compression ratio 13:1 is less fuel consumption particularly when the engine runs close to maximum speed.

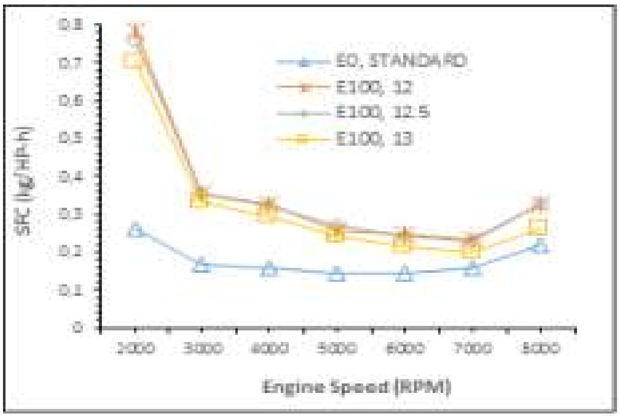


Figure 16. SFC on MBT versus RPM

As shown in fig. 16, the SFC decrease as the compression ratio increases, due to in the narrow combustion chamber will promote the combustion process [39]. When the speed of engine was on 7000 rpm, the SFC started to increases because the volumetric efficiency is decrease with increase of temperature and cylinder pressure so the combustion process are in rich mixture condition. At the optimum point (7000 rpm), the specific fuel consumption of E100 at 12:1, 12.5:1 and 13:1 of compression ratio were 0.231 kg/HP-h, 0.229 kg/HP-h and 0.201 kg/HP-h respectively. Meanwhile, at the engine standard the SFC is 0.145 kg/HP-h at the 5000-6000 rpm when the gasoline was burned.

Brake thermal efficiency expressed the ability of combustion system to optimize potential energy of fuel and it converted become mechanic output. Commonly, the BTE is stated in formulation [40]:

$$\text{BTE} = \frac{3600 \text{ x BHP}}{\text{Fuel Consumption x LHV}} \quad \text{... (5)}$$

Fig. 17 display the BTE values of various compression ratio in the MBT, which is BTE increased with engine speed until 7000 rpm for E100 and 5000 rpm for E0 in all the compression ratio. In this position, the maximum BTE was on 39.6%, 43.10%, 43.41% and 49.53% when 11:1, 12:1, 12.5:1 and 13:1 of CR were applied for E0 and E100 respectively. Neat gasoline have higher BTE value than pure bioethanol at engine speed less than 7000 rpm. It is caused by heating value of gasoline is higher than bioethanol. Meanwhile, above 7000 rpm, the BTE of gasoline is lower than bioethanol. It is influenced by; the first is oxygen content of bioethanol cause the oxidation process of the fuel increases at high rpm.

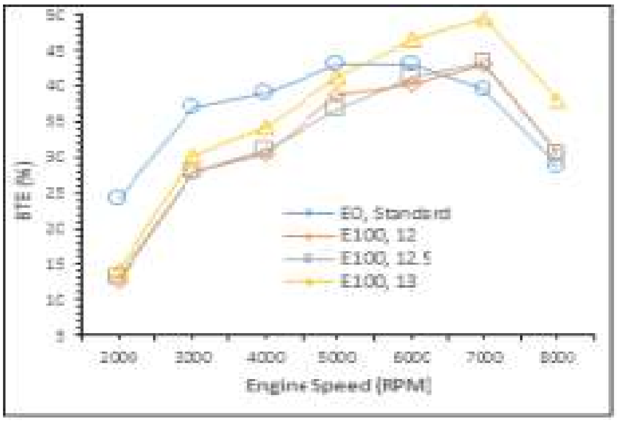


Figure 17. BTE on MBT versus RPM

The second is the favour pressure of bioethanol will increases at high engine speed so the fuel is evaporate easily. The third is latent heat of vaporization will absorb a partial heat in cylinder during the evaporating process so the charge could be compressed easily when the speed of engine is high. In average, increases of BTE as increase the compression ratio is 0.31% and 6.44% respectively, when E100 is used.

4.6 The CO and HC Emission

Fig. 18 showed effect of compression ratio and speed of engine on carbon monoxide emission. Usage of bioethanol as a fuel would be reducing CO emission significantly. It is due to the high oxygen content of bioethanol will making the process was in the stoichiometric condition, so the CO emission is low with complete combustion in the chamber. Moreover, existence of oxygen in the mixture is effective to handle increases of CO especially at high engine speed. In this situation, the pressure and temperature of cylinders will increases so the mass flow rate of air is less. In this study, the CO emission is gradually increased at above 6000 rpm, but it was sharply increased at the same speed when the neat gasoline is applied. In addition, suitable on ignition timing has been also contributed in reducing the CO toxics. As known, the CO and HC emission is also low at high compression ratio because value of cylinder temperature and turbulence effect of charge is increases if combustion chamber is narrow. In average, the reduction of CO emissions that based on standard condition (E0, 11:1) with increases of compression ratio are 52.8%, 63.1% and 75.4% respectively.

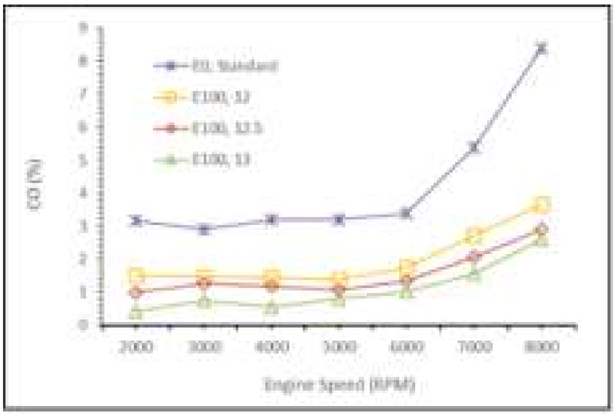


Figure 18. CO on MBT versus RPM

Fig. 19 explained effect of various compression ratio and speed of engine on HC emission. In general, increase of HC emission caused by insufficient of air in the combustion process, so consideration to usage of bioethanol as a oxygenate fuel has been a solution to overcome the problems. Besides that the advances of ignition timing when increases of octane number have impact on ignition delay which is longer so intake of air into cylinder is increases. The minimum HC emission with increasing the compression ratio are 70 ppm, 67 ppm and 63ppm respectively. Meanwhile, decreasing the HC emission that started on engine standard to maximum compression ratio are 10.9%, 29.9% and 41.2%, in average.

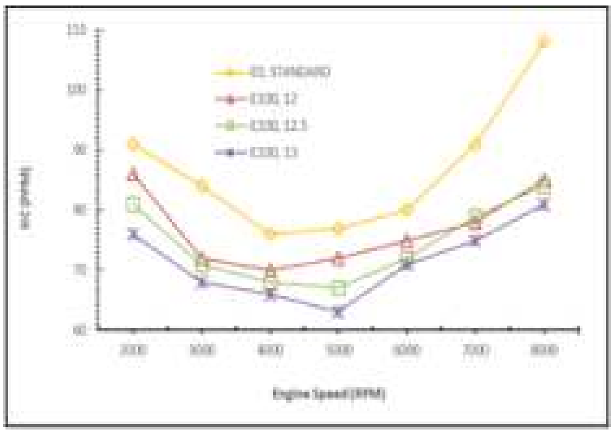


Figure 19. HC on MBT versus RPM

5. Conclusion

The increases of power and torque on spark ignition engine is not significant when E100 is used if compared with gasoline fuel on engine standard. In average, the power of engine standard with gasoline fuels is 6.31kW, while on engine that have advances is 7.65kW when E100 is burned at compression ratio by 13:1 or increases about 21.30% from the standard. Meanwhile, the average increase of power with increase of each of compression ratio are 0.238kW and 0.233kW respectively when E100 is applied.

In opposite, the usage of ethanol both as pure fuel and blending with gasoline is reducing CO and HC emissions effectively. Products of CO and HC emission is 1.10% and 71.43ppm when the engine is runs at 13:1 of compression ratio. While, the CO and HC emission on standard engine is 4.23% and 86.71ppm or decreases about 74% and 17.62%, in average if compared with bioethanol.

In this study, mapping process of the injection duration and ignition timing has conducted with combination methods i.e. minimum advance for maximum brake torque and move or re-arrangements the point of ignition timing to any point that have fixed before (advanced). This methods is effective to increase performance of engine until on top of engine speed. On mapping of injection duration have found that the best of injection duration is 150%-175% among the engine speed at all of compression ratio. Meanwhile, on the ignition timing mapping process known that the best of ignition timing was on 10^o, 14^o and 18^o BTDC at all of compression ratio when E100 is used. The best of ignition timing tend to increase as increases of engine speed which is 10^o BTDC at 2000-4000 rpm, 14^o BTDC at 5000-6000 rpm and 18^o BTDC at 7000-8000 rpm, respectively.

The result of this study has proved that CO and HC emission is decreases significantly when ethanol is applied in small spark ignition engine with varying high of compression ratio. As a research series, usage of bioethanol with high concentration in gasoline (E50, E70 and E85) has been a target on the next study, to finding the best of each of bioethanol percentage. Then, all of the result will proposed to Indonesia government for application of bioethanol widely.

References

1. Havard Devold, *An introduction to oil and gas production, transport, refining and petrochemical industry,* Oil and gas production handbook, ISBN 978-82-997886-3-2, Oslo, 2013
2. Mustafa Balat, Havva Balat, *"Recent trends in global production and utilization of bio-ethanol fuel"*, Elsevier, Applied Energy, Vol. **86**, 2009, pp. 2273-2282
3. Alvydas Pikūnas, Saugirdas Pukalskas, and Juozas Grabys, *"Influence of composition of gasoline-ethanol blends on parameters of internal combustion engines"*, Journal of KONES Internal Combustion Engines, Vol. 10, n.3-4, 2003, pp. -
4. Mustafa Balat, Havva Balata and Cahide OZ , *"Progress in bioethanol processing"*, Elsevier, Progress in Energy and Combustion Science, Vol. 34, 2007, pp. 551-573
5. Dewan Energi Nasional, *Outlook energy Indonesia 2014"*, Jakarta-Indonesia, 2014
6. Saleh Abdulrahman, *Outlook energy Indonesia 2015"*, Sekretaris Jenderal Dewan Energi Nasional, ISSN: 2503-1597, Jakarta-Indonesia, 2016
7. Marth EN Paloboran, Bambang Sudarmanta, I Nyoman Sutantra, "*Performances and emissions characteristics of three main types composition of gasoline–ethanol blended in spark ignition engines*", Prise Worthy Prize, International Review of Mechanical Engineering, Vol. 7, n. 7, 2016, pp. 432-442
8. BM Masum, H.H.Masjuki, M.A.Kalam, I.M.Rizwanul Fattah, S.M. Palash and M.J.Abedin, *"Effect ofethanol–gasoline blend on NOx emission in SI engine*", Elsevier, Renewable and Sustainable Energy Reviews, Vol. 24, 2013, pp. 209-222
9. Karl Erick Egaback-AVL MTC, *Blending of ethanol in gasoline for spark ignition engines*, Problem Inventory and Evaporative Measurements, Stockholm University, Sweden, 2005
10. Yuan Zhuang, Guang Hong and Jianguo Wang, *"Preliminary investigation to combustion in a SI engine with direct ethanol injection and port gasoline injection (EDI+GPI)"*, 18th Australasian Fluid Mechanics Conference, Launceston, Australia, 3-7 December 2012
11. Cenk Sayin and Mustafa Kemal Balki, *"Effect of compression ratio on the emission, performance and combustion characteristics of a gasoline engine fueled with iso-buthanol/gasoline blends"*, Elsevier, Energy, Vol. 82, 2015, pp. 550-555
12. Amit Kumar Thakur, Ajay Kumar, Kaviti, Roopesh Mehra and K.K.S. Mer, *"Progress in performance analysis of ethanol-gasoline*

blends on SI engine", Elsevier, Renewable and Sustainable Energy Reviews, Vol. 69, 2016, pp. 324-340
13. Rong-Horng Chen, Li-Bin Chiang, Chung-Nan Chen and Ta-Hui Lin, *"Cold-start emissions of an SI engine using ethanol gasoline blended fuel"*, Elsevier, Applied Thermal Engineering, Vol. 31, 2011, pp. 1463-1467
14. M. Clairotte, T.W. Adam, A.A. Zardini, U. Manfredi, G. Martini, A. Krasenbrink, A. Vicet, E. Tournié and C. Astorga, *"Effects of low temperature on the cold start gaseous emissions from light duty vehicles fuelled by ethanol-blended gasoline"*, Elsevier, Applied Energy, Vol. 102, 2012, pp. 44-54
15. Musaab O. El-Faroug, Fuwu Yan, Maji Luo and Richard Fiifi Turkson, *"Spark ignition engine combustion, performance and emission products from hydrous ethanol and its blends with gasoline"*, Energies, Vol. 9, n. 984, 2016, pp. 1-24
16. AVL MTC, Investigation on emission effects of alternative fuels, the Norwegian Environment Agency, Sweden, 2015
17. S.G. Poulopoulos, D.P. Samaras and C.J. Philippopoulos, *"Regulated and unregulated emissions from an internal combustion engine operating on ethanol-containing fuels"*, Elsevier, Atmospheric Environment, Vol. 35, 2001, pp. 4399-4406
18. Sergio Manzetti and Otto Andersen, *"A review of emission products from bioethanol and its blends with gasoline. Background for new guidelines for emission control"*, Elsevier, Fuel, Vol. 140, 2014, pp. 293-301
19. Larry G.Anderson, *"Effects of using renewable fuels on vehicle emissions"*, Elsevier, Renewable and Sustainable Energy Reviews, Vol. 47, 2015, pp. 162-172
20. N. Jeuland, X. Montagne1 and X. Gautrotet, *"Potentiality of ethanol as a fuel for dedicated engine"*, Oil & Gas Science and Technology – Rev. IFP, Vol. 59, No. 6, 2004, pp. 559-570
21. C. Ananda Srinivasan and C.G. Saravanan, *"Study of combustion characteristics of an SI engine fuelled with ethanol and oxygenated fuel additives"*, Journal of Sustainable Energy & Environment, Vol. 1, 2010, pp. 85-91
22. M. Bahattin Celik, *"Experimental determination of suitable ethanol–gasoline blend rate at high compression ratio for gasoline engine"*, Elsevier, Applied Thermal Engineering, Vol. 28, 2007, pp. 396–404
23. Mustafa Kemal Balki and Cenk Sayin, *"The effect of compression ratio on the performance, emissions and combustion of an SI (spark ignition) engine fuelled with pure ethanol, methanol and unleaded gasoline"*, Elsevier, Energy, Vol. 71, 2014, pp. 194-201
24. Rodrigo C. Costa and José R. Sodré, *"Compression ratio effects on an ethanol/gasoline fuelled engine performance"*, Elsevier, Applied Thermal Engineering, Vol. 3, 2010, pp. 278-283
25. Farha Tabassum Ansari, Abhishek Prakash Verma and Alok Chaube, *"Effect on Performance and Emissions of SI Engine Using Ethanol as Blend Fuel Under Varying Compression Ratio"*, International Journal of Engineering Research & Technology (IJERT), Vol. 2, n. 12, 2013, pp. 848-864
26. Farha Tabassum Ansari1 and Abhishek Prakash Verma, *"Experimental determination of suitable ethanol–gasoline blend for Spark ignition engine"*, International Journal of Engineering Research & Technology (IJERT), Vol. 1, n. 5, 2012, pp. 1-10
27. Bambang Sudarmanta, Bambang Junipitoyo, Ary Bachtiar Krisna Putra and I Nyoman Sutantra, *"Influence of the compression ratio and ignition timing on sinjai engine performance with 50% bioethanol-gasoline blended fuel"*, ARPN Journal of Engineering and Applied Sciences, Vol. 11, n. 4, 2016, pp. 2768-2774
28. Necati Türköz, Barıs Erkus, M. Ihsan Karamangil, Ali Surmen and Nurullah Arslanog lu, *"Experimental investigation of the effect of E85 on engine performance and emissions under various ignition timings",* Elsevier, Fuel, Vol. 115, 2013, pp. 826–832
29. Marth EN Paloboran, Renno FD Dharmawan, Bambang Sudarmanta and I Nyoman Sutantra ,*"Effect of various of high compression ratio and injection duration on performance and emissions for Indonesian motorcycle with pure ethanol fuelled"*, Jounal DYNA Energia, 2017
30. H. Serdar Yu¨cesu, *"Comparative study of mathematical and experimental analysis of spark ignition engine performance used ethanol–gasoline blend fuel"*, Elsevier, Applied Thermal Engineering, Vol. 27, 2007, pp. 358–368
31. S. Phuangwongtrakul, K.Wannatong, T. Laungnarutai and W. Wechsatol, *"Suitable Ignition Timing and Fuel Injection Duration for Ethanol-Gasoline Blended Fuels in a Spark Ignition Internal Combustion Engine"*, Proc. of the Intl. Conf. on Future Trends in Structural,

Civil, Environmental and Mechanical Engineering – FTSCEM, 2013, pp. 39-42

32. Alexandru Radu, Constantin PANA and Niculae NEGURESCU, *"An experimental study on performance and emission characteristics of a bioethanol fuelled SI engine"*, U.P.B. Sci. Bull., Series D, Vol. 76, n. 1, 2014, pp. 193-200
33. Seung Hyun Yoon and Chang Sik Lee, *"Effect of undiluted bioethanol on combustion and emissions reduction in a SI engine at various charge air conditions"*, Elsevier, Fuel, Vol. 97, 2012, pp. 887–890,
34. Saud Binjuwair and Abdullah Alkudsi, *"The effects of varying spark timing on the performance and emission characteristics of a gasoline engine: A study on Saudi Arabian RON91 and RON95"*, Elsevier, Fuel, Vol. 180, 2016, pp. 558–564
35. Cenk Sayin, *"The impact of varying spark timing at different octane numbers on the performance and emission characteristics in a gasoline engine"*, Elsevier, Fuel, Vol. 97, 2012, pp. 856–861
36. Stephen R Turns, *An introduction to combustion*, Concept and application, second edition, McGraw-Hill, 2000
37. John B. Heywood, *Internal combustion engine fundamentals*, McGraw-Hill, 1998
38. Goering et al, *Engine Performance Measures", Off road vehicle engineering principles*, American Society of Agricultural Engineers, 2003, Ch 4
39. Gholamhassan Najafi, Barat Ghobadian, Talal Yusaf, Seyed Mohammad Safieddin Ardebili and Rizalman Mamat, *"Optimization of performance and exhaust emission parameters of a SI (spark ignition) engine with gasoline-ethanol blended fuels using response surface methodology"*, Elsevier, Energy, Vol. xxx, 2015, pp. 1-15
40. B.M. Masum, H.H. Masjuki, M.A. Kalam, S.M. Palash and M. Habibullah, *"Effect of alcohol-gasoline blends optimization on fuel properties, performance and emissions of a SI engine"*, Elsevier, Journal of Cleaner Production, Vol. 86, 2014, pp. 230-237

8% Overall Similarity

Top sources found in the following databases:

- 8% Internet database
- 0% Publications database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	researchgate.net Internet	3%
2	ijrat.org Internet	2%
3	semanticscholar.org Internet	1%
4	repository.its.ac.id Internet	1%
5	ia600703.us.archive.org Internet	<1%
6	vestniken.ru Internet	<1%
7	docplayer.net Internet	<1%

Excluded from Similarity Report

- Crossref database
- Submitted Works database
- Quoted material
- Small Matches (Less then 10 words)
- Crossref Posted Content database
- Bibliographic material
- Cited material
- Manually excluded sources

EXCLUDED SOURCES

iaras.org Internet	81%
iaras.org Internet	81%
autodocbox.com Internet	76%
wseas.org Internet	11%