The effect of bioethanol on pollutants and engine fuel consumption
Sadegh Mohammadi, Hekmat Rabani, Saeed Jalali Honarmand

ABSTRACT
With increasing growth of population, air pollutants are increased mostly. Among human activities, vehicles have the highest share in air pollution. This study investigates the effect of various ratios of bioethanol fuel with gasoline (0, 5, 10, 15, 20, 25%) in different engine cycles (1000, 2000, 3000 rpm) on amount of pollutants, suspended particles and fuel consumption in gasoline engine of Pride with Siemens fuel system. The results showed that by adding 25% bioethanol to consumption fuel, the mean of UHC pollutant reduced as 104.53 from 55.22ppm to 27ppm, CO2 was reduced as 3.45 from 12.51% to 12.1%, CO reduced as 34.57% from 0.081% to 0.060%, NOx increased as 163.41% from 241.44ppm to 636ppm, fuel consumption increased as 15.75% from 0.43ml/s to 0.50ml/s, the number of fine suspended particles reduced as 41.42% from 337015 to 238307 and number of big suspended particles reduced as 96.09% from 4009 to 2044. Also, the increase of engine cycle increased CO2, NOx, suspended particles and fuel consumption and reduced UHC and CO pollutants. Adding bioethanol due to extra oxygen in chemical structure leads to full combustion. The effect of bioethanol on increasing fuel consumption is due to the reduction of thermal value and increasing fuel density. Based on considerable reduction of suspended particles and UHC and CO pollutants and bioethanol-gasoline combustion combination with various percent is a suitable method to reduce pollutants. In this method, fuel consumption is increased a little. UHC and CO pollutants and suspended particles are reduced. In addition, Bioethanol is generated of renewable resources and using bioethanol instead of MTBE is economical.

KEY WORDS: Air pollution, Bioethanol, Suspended particles, Fuel consumption, Gasoline engine

INTRODUCTION
Emitting pollutants of combustion engines play important role in air pollution as in advanced countries, it is one of the most important problems (Koç, M., et al., 2009). High consumption of fossil fuels has adverse effect on environment and we can refer to greenhouse gas, acid rain, and ozone layer depletion and weather changes (Agarwal, A.K., 2007). Thus, by combustion in spark ignition, four main pollutants as carbon monoxide (CO), carbon dioxide (CO2), Unburned hydrocarbons (UHC) and nitrogen oxides (NOx), and suspended particles. The highest share of suspended particles generation among internal combustion engines is referred to compression ignition engines. Although spark ignition engines generated a few suspended particles, due to great number of vehicles with these engines in urban regions, their generated particles play important role in air pollution and endangering human health. Generally, existing suspended particles in environment are divided into followings based on particles cumulative size as: 1- Thoracic Particles, particles with aerodynamic diameter less than 10 μ (PM10), Fine Particles, particles with aerodynamic diameter less than 2.5 μ (PM2.5), Coarse Particles, particles with diameter between 2.5 to 10 μ (PM2.5-10) and Ultrafine Particles, particles with aerodynamic diameter less than 0.1 μ (Schlesinger, R B., et al., 2006). Due to their small size, suspended particles penetrate respiratory system and lung and lead to heart and respiratory diseases as asthma and lung cancer. The tests show that the effect of fine particles is much dangerous than the effect of coarse particles (Europe, 2014). Internal combustion engines play important role in generation of suspended particles of urban areas. These particles are generated due to incomplete combustion in internal combustion engines. Many particles are oxidized during combustion process but the residuals exit as compressed particles. These particles are complex and compressive compound called black carbon and mostly consists of volatile organic particles. The chemical nature of particles depends upon the combination of fuels
and combustion conditions. The particles of diesel engines mostly are Agglomerated Carbonaceous Primary Particles absorbed on volatile organic matters but gasoline particles consist of organic matters (Arsie, I., et al., 2013), the formation of suspended particles in gasoline engine mostly depends upon work conditions (Piök, W., et al., 2011). The mass of suspended particles of diesel engines is more than that of gasoline engines. Thus, environmental rules emphasize on reduction of particles of diesel engines (Lv, G., et al., 2014). Average size of particles from gasoline engines is smaller under similar conditions compared to suspended particles of diesel engines (Gupta, T., et al., 2010). The distribution of Number Size Distribution of gasoline engine particles compared to similar diesel engine shows that gasoline engine generates particles with small sizes (Piök, W., et al., 2011). By considering the multiplication of number of suspended particles of gasoline engines by the number of existing vehicles in urban regions, gasoline vehicles are the main source of suspended particles namely fine particles in highly populated urban areas. According to the report of World Health Organization, the effect of fine and ultrafine particles is much dangerous than the effect of coarse particles (Europe, 2014). Recently, European commission considered mostly the Number–Weighted Particle of gasoline engine pollutant and some rules are approved regarding the limit of number of emitted particles of gasoline engines. This commission introduced $6 \times 10^{12}$ p/km and for direct injection gasoline engines produced after September 2017, the limit $6 \times 10^{12}$ p/km for engines with EURO 6 criterion in September 2014 (Lv, G., et al., 2014).

The applied energy sources in the world are achieved more than fossil fuels (Yücesu, H.S., et al., 2006). In recent years, some reasons as sudden increase of using energy, shortage of crude oil storage, increase of crude oil price and air and environment pollution of transportation tended into alternative fuels namely alcoholic fuels (Bayraktar, H., 2005; Park, S.H., et al., 2010). Now, using MTBE (methyl tertiary-butyl ether) as additive to lead-free gasoline contaminates underground water and human health is threatened (Wu, C.W., et al., 2004). Among various types of alcohol, ethanol is recognized as the suitable fuel for spark ignition engines (Bayraktar, H., 2005). Ethanol is provided of renewable resources as cane, corn, barley and many wastes of agriculture (Topgül, T., et al., 2006). Ethanol has many advantages as good anti-knock due to high octane value, thermal return and better engine exit power, high speed of combustion, lower CO, UHC pollutants compared to petrol (Bayraktar, H., 2005; Wu, C.W., et al., 2004; Hsieh, W.D., et al., 2002). Ethanol is used in two forms of net or gasoline blend in spark ignition engines. Using net ethanol in engine requires some changes in design of engine and fuel system. Its combination with gasoline has no need to the changes in engine design (Bayraktar, H., 2005). Now, in most countries, Ethanol is used as an alternative of total or part of gasoline (Ghazikhani, M., et al., 2013).

Koç et al., (2009) replaced the single-cylinder gasoline engine fuel with a combination of ethanol-unleaded gasoline blends on engine performance and exhaust emissions at different compression ratios. In this study, at the engine speed range from 1,500 to 5,000 rpm was analyzed. The results showed that new fuel replacement increased engine torque, power and fuel consumption and reduction of CO, NOX and UHC pollutants.

Srinivasan and Saravanani (Srinivasan, C.A. and C.G. Saravanani, 2010) studied the combustion features of spark ignition engine with bioethanol and oxygenated fuel Blends. The results showed that fuel compounds increase UHC, O2 slowly. CO2 and NOx pollutants were reduced considerably. CO pollutant was reduced a little. The results of tests on a four cylinder diesel engine with direct injection with compression ratio 19 with ratios 6.1, 12.2, 18.2 and 24.2% bioethanol percent in two engine speeds 1800 and 2400 rpm showed that in both engine speeds, by adding ethanol in fuel compound, suspended particles were reduced in terms of size and mass. Also, the number and mass of particles at speed 2400 rpm were more than 1800 rpm (Di, Y., et al., 2009). In a study Fumigation effect of ethanol on pollutant gases and suspended particles on a four-cylinder engine (Ford 2701C) was investigated. The results showed that by adding fumigated ethanol to entrance manifold, NOx and PM_{2.5} were reduced but the number of suspended particles and UHC, CO pollutants were increased. Adding fumigated ethanol in input air reduced it and UHC and CO pollutants were increased but NOx was reduced (Surawski, N.C., et al., 2012). A study evaluated the suspended particles of single cylinder diesel engine working with diesel, biodiesel and blend of biodiesel and ethanol. The results showed that by biodiesel, suspended particles were reduced and particles reduction in using biodiesel blend with 20% of ethanol was high (Su, J., et al., 2013). The turbo effect of emitting gases of direct injection gasoline engine was investigated in three speeds and four times of engines on the number of suspended particles at Nano scale. The results showed the reduction of suspended particles in low loads and increase of suspended particles in high loads (Cucchi, M., and S. Samuel, 2015).

As it was said, air pollution and suspended particles had harmful effect on human health and environment. In recent years, population increase and industrialization of countries was effective in consumption of fossil fuels. The shortage of fossil fuels and air pollution caused that researchers replace fossil fuels with renewable fuels as bioethanol. In many countries, due to environmental problems, MTBE as gasoline additive is banned but it is used in Iran. Bioethanol fuel has plant origin and it produces a few pollutants. Thus, it can be used as an alternative to MTBE. The highest share of suspended particles is dedicated to compression ignition engines but spark ignition engines namely Pride car have the highest shares in urban transportation of country and they have considerable suspended particles. Thus, the investigation of their suspended particles is necessary. No study has
been performed regarding the effect of bioethanol on suspended particles of Pride engine. This study evaluates the effect of bioethanol on generated suspended particles of Pride engine with pollution and fuel consumption.

**MATERIALS AND METHODS**

This study is performed in pollution lab and application of biofuels of mechanic department of bio system of Razi University of Kermanshah in Mordad 2014. A gasoline engine M13NI (Pride engine) with Siemens fuel supply with written technical features is shown in Table 1.

**Table 1**: The features of investigated engine (Mohammadi Busari, M.)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine type</td>
<td>Four cylinder</td>
</tr>
<tr>
<td>Combustion order</td>
<td>1342</td>
</tr>
<tr>
<td>Diameter x Piston course length(mm)</td>
<td>71 × 83.6</td>
</tr>
<tr>
<td>Cylinder capacity (cc)</td>
<td>1323</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>9.7</td>
</tr>
<tr>
<td>Maximum torque</td>
<td>N·m 103.3 at rpm 2800</td>
</tr>
<tr>
<td>Maximum speed (rpm)</td>
<td>5500</td>
</tr>
</tbody>
</table>

To analyze engine emission gases, Airrex, HG-550 five gases in Korea is applied. The technical properties of device are shown in Table 2.

**Table 2**: Technical properties of Airrex test

<table>
<thead>
<tr>
<th>Pollutant and measurement unit</th>
<th>Measurement range</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHC (ppm)</td>
<td>1-15000</td>
<td>1</td>
</tr>
<tr>
<td>CO (%)</td>
<td>0-10</td>
<td>0.001</td>
</tr>
<tr>
<td>CO₂ (%)</td>
<td>0-20</td>
<td>0.01</td>
</tr>
<tr>
<td>O₂ (%)</td>
<td>0-25</td>
<td>0.01</td>
</tr>
<tr>
<td>NOX (ppm)</td>
<td>0-5000</td>
<td>1</td>
</tr>
</tbody>
</table>

To measure suspended particles, Particle Counter of LIGHTHOUSE company, 3016-IAQ in USA was applied (Figure 1-4) and the number of particles are measured by diameters 0.3, 0.5, 1, 3, 5, 10 micron. By suctioning the suspended particles, the device measures them at specific time and volume. The device is located in 50cm of exhaust exit along it. The number of particles was measured at 30s and volume 2lit of suctioned exhaust gas. The particles were divided into fine (sum of particles with diameter 0.3, 0.5, 1 micron) and coarse (sum of particles with diameter 3, 5, 10 micron). To provide tested fuels, basic gasoline (blend of platform at e and light gasoline) from oil refinery of Kermanshah and absolute bioethanol with purity degree 99.6% of Jahan Teb company of Arak alcohol. By combining bioethanol and basic gasoline, some fuels with ratios 5, 10, 15, 20, 25% bioethanol were provided and hold in definite containers. Before relevant tests of each type of fuel, 4-liter fuel container of engine was emptied completely and after assurance of emptiness, it is filled with next fuel. General schematic of test tools is shown in Figure 1.

![Fig. 1: General schematic of test tools, 1) Engine, 2) Exhaust, 3) Five gas test, 4) Particle counter, 5) Fuel consumption measurement system](image)

Fuel injection pressure in Pride injectors is 2.4 bars and gasoline pumping pressure is 5 bar (Mohammadi Busari, M.). We can observe similar fuel injection in a separate fuel system as located in parallel with main fuel system. Thus, we can use a separate fuel system, 4 graded cylinders made in LAB GLASS TECHNICAL with volume 10mL and precision 0.2mL, cylinder box and two inflow and outflow valves for fuel consumption measurement (Figure 2). In the test, inflow and outflow valves were opened for 30s and consumption amount was added with fuel reading in cylinders in mL/s.
Fig. 2: The system of fuel consumption, (1) fuel reservoir, (2) gasoline pump, (3) high pressure filter, (4) main injectors, (5), (9) inflow and outflow valves to consumption measurement injectors, (6) consumption measurement injectors, (7) graded cylinders and holding box, (8) Air Manifold

After the engine reached stable conditions (10-15 min after starting), the tests are performed. After each test, engine worked for some minutes to be adaptable with next test conditions and reach stable state. In this study, the effect of fuel type (gasoline with 0% bioethanol (basic gasoline or E0), gasoline with 5% bioethanol (E5), gasoline with 10% bioethanol (E10), gasoline with 15% bioethanol (E15), gasoline with 20% bioethanol (E20) and gasoline with 25% bioethanol (E25) and engine cycle (1000, 2000, 3000 rpm) on pollution (unburned hydrocarbon (UHC), carbon monoxide (CO), Carbon dioxide (CO2) and Nitrogen oxides (NOx), Suspending particles (particles with the sum of diameters 0.3, 0.5, 1micrometer (fine particles) an particles with the sum of diameters 3, 5, 10 micrometer (coarse particles) and fuel consumption. Each test was replicated three times and the replications were averaged to plot the charts.

RESULTS AND DISCUSSION

Unburned hydrocarbons:

Unburned hydrocarbons in emission gas is associated to three mechanisms: a) Misfiring or Incomplete Combustion as occurred in rich fuel (no air) or when fuel-air blend is with much amount of burnt gas (exhaust gas) or nitrogen to diffuse combustion flame in combustion box, b) Flame Quenching Effect as occurred in the proximity of combustion box area or Clearance (Wu, C.W., et al., 2004). In piston engines, a blend of fuel and air is trapped in rings holes and no flame reaches it. It is possible that some areas in the combustion box have very weak flame with low combustion temperature (Ghazikhani, M., et al., 2013). c) Deposits or Oil Membrane as attaching to fuel or being absorbed (Wu, C.W., et al., 2004). Also, unburned hydrocarbon pollutants of engine are due to form, fuel structure, combustion temperature, available oxygen and combustion process time (Sayin, C., 2010).

Fig. 3: The chart of unburned hydrocarbon pollutant-Fuel type
As shown in Figure 3, by increasing bioethanol percent in compounds and increasing engine cycle, UHC pollutant is reduced. Ethanol due to an oxygen atom in its structure is an oxygenate fuel and has high air to fuel. The ethanol added to gasoline increases volume return and the combustion can be complete. Thus, flame temperature and pressure inside cylinder can be increased (Bayraktar, H., 2005). The slow speed of flame in ethanol is higher than that of gasoline. The increase of flame speed can reduce combustion time but combustion temperature is increased. High combustion temperature leads to complete combustion (Sayin, C., 2010). Also, ethanol due to lack of lead in its chemical structure avoids porous sediments. In addition, ethanol molecules are polar and are not absorbed easily by non-polar molecules of lubricating oil (Wu, C.W., et al., 2004). Thus, increasing ethanol reduces UHC pollutant production. The amount of unburned hydrocarbons for E5, E10, E15, E20 and E25 to E0 reduced as 17.49%, 12.19%, 51.06%, 58.79%, and 104.53%. By increasing cycle of engine, combustion temperature and exhaust are increased making UHC oxidized. Thus, UHC concentration is reduced in engine exhaust gas (He, C., et al., 2011). If engine speed is increased, fuel to air ratio is reduced. Thus, oxygen amount in the blend is increased and hydrocarbon pollutant is reduced by increasing exhaust temperature (Ghazikhani, M., et al., 2014). In high cycles of engine, UHC pollutant is reduced by adding ethanol and due to improvement of air and fuel blend is due to high disturbance of blend and by improving blend process, combustion is complete and UHC is reduced (Koç, M., et al., 2009).

By increasing engine cycle, combustion temperature and exhaust are increased (He, C., et al., 2011). If engine speed is increased, fuel to air ratio is reduced. Improvement of air and fuel blend is due to high disturbance of blend. By 25% increase of bioethanol to fuel from E0 to E25, UHC pollutant for engine cycle 1000 from 84.67ppm to 51.67ppm, for engine cycle 2000 from 59.67ppm to 23ppm and for engine cycle 3000 from 21.33ppm to 6.33ppm are reduced.

**Carbon dioxide:**

CO2 pollutant is formed by carbon fuel combustion in the proximity or above stoichiometry conditions. According to the studies, CO2 pollutant is greenhouse gas and leads to global warming (Alsayed, M.F.M., 2008). Like other fuels, if Ethanol is burned, CO2 is generated but CO2 gas by burning ethanol in plant growth can be turned into organic tissues. The origin of ethanol is plants and it has the lowest life cycle of greenhouse gas. Thus, CO2 enters the atmosphere by burning ethanol as it is obtained of renewable carbon resources and it doesn’t increase greenhouse gas (Agarwal, A.K., 2007).

Figure 4 shows CO2 pollutant chart in various ratios of bioethanol-gasoline. In this chart, despite irregular jumps, a decreasing trend with the increase of percent of bioethanol in fuel is observed. When extra bioethanol is emerged in gasoline fuel, due to rapid evaporation and better mixture of air and fuel and better combustion, carbon dioxide is reduced (Ghazikhani, M., et al., 2014).

Carbon dioxide for E5, E10, E15, E20 and E25 to E0 is 1.15%, 0.45%, 2.63%, 1.16% and 3.45% were reduced. If engine cycle is increased, CO gas oxidation reaction to CO2 is increased and this increases the concentration of CO2 gas (Rajkumar, K., and P. Govindarajan, 2011). By 25% increase of bioethanol to fuel from E0 to E25, CO2 pollutant for engine cycle 1000 is reduced from 12.37% to 11.80% for engine cycle 2000 from 12.57% to 12.28% and for engine cycle 3000 from 12.60% to 12.20%.

![Fig. 4: The chart of carbon dioxide pollutant-Fuel type](image-url)
Carbon monoxide:

If there is no adequate oxygen to produce CO2, when an internal combustion engine or stove works at closed area, carbon monoxide is formed by partial oxidation of carbon compound (Ghazikhani, M., et al., 2013). CO pollutant is dependent mostly to air-stoichiometry fuel ratio. Combustion of rich fuels generates CO and by deviation from stoichiometry is increased linearly (Park, S.H., et al., 2010). Carbon to hydrogen ratio is another factor affecting CO formation and the higher the ratio, CO value is increased (Pourkhesalian, A.M., et al., 2010).

Nitrogen oxides:

Nitrogen oxides are formed from the existing nitrogen in fuel, extra oxygen; very high combustion temperature and gases stay time in reaction area. Nitrogen monoxide (NO) is the first nitrogen oxide generated of engines. This oxide is based on nitrogen oxidation in atmosphere based on Zeldovich mechanism of thermal nitrogen and as equivalence ratio of fuel to air approaches stoichiometry ratio, NOX pollutant is increased (Lin, C.Y., and K.H. Wang, 2004).

As shown in Figure 6, by increasing bioethanol percent in gasoline and bioethanol blend and increase of engine cycle, NOX is increased. Regarding NOx pollutant formation in ethanol, some mechanisms are effective. First, oxygen in fuel increases NOx, second, alcohol cooling effect due to high hidden heat can reduce combustion temperature and NOX is reduced. Third, due to high octane value of alcohol, combustion temperature is increased in pre-mixed blend. The effect of octane value and oxygen in alcohol in increasing the temperature inside cylinder is higher than the effect of hidden heat of evaporation in temperature reduction. Thus, concentration of nitrogen oxides pollutant is increased by increasing alcohol (Sayin, C., 2010).
The amount of nitrogen oxides for E5, E10, E15, E20 and E25 blends to E0 is 12.61%, 46.20%, 53.20%, 88.54%, 163.41% was increased. The important factor affecting nitrogen oxides is increasing temperature as by increasing engine cycle NOX concentration is increased. By 25% increase of bioethanol to fuel from E0 to E25, NOx pollutant for each engine cycle 1000 is increased from 211 ppm to 515ppm, for engine 2000, from 250ppm to 589.33ppm and for engine 3000 from 263.33ppm to 803.67ppm.

**Fuel consumption:**

Fuel consumption is a function of thermal value of fuel, sparking time, air to fuel ratio, load and engine speed. If combustion thermal value is higher and air to fuel is high, its fuel consumption is lower (Pourkhesalian, A.M., et al., 2010).

As shown in Figure 7, by adding bioethanol in fuel and increase of engine cycle, fuel consumption is increased. The ratio of air to gasoline theory fuel is 1.6 times more than Ethanol (Hsieh, W.D., et al., 2002). It means that Ethanol with low air consumption can consume high fuel. Ethanol due to having oxygen atom in its chemical structure reduces the thermal value of ethanol-gasoline compound and when gasoline combustion compound with ethanol is used instead of pure gasoline, to achieve the same output power, much fuel is required (Bayraktar, H., 2005). Also, high density of bioethanol fuel to gasoline leads to high fuel consumption and increase of blend density increases the mass of fuel blend (Sundarapandian, S., and G. Devaradjane, 2007).
Fuel consumption for E5, E10, E15, E20, E25 to E0 is 3.08%, 5.83%, 11.30%, 10.96%, 15.75%, respectively. By increase of engine cycle, friction power of engine is increased. This is due to high work cycles in a specific time at high engine speeds (Pourkhesalian, A.M., et al., 2010; Lin, C.Y., and K.H. Wang, 2004). Thus, fuel consumption is increased. By 25% increase of bioethanol to fuel from E0 to E25, fuel consumption for engine cycle 1000 is increased from 0.24ml/s to 0.3ml/s, for engine 2000 from 0.46ml/s to 0.51ml/s and for engine 3000, from 0.59ml/s to 0.69ml/s.

Suspended particles:
Black carbon or suspended particles are formed if adequate air is not for reaction with all existing carbon atoms in fuel or combustion process is occurred in rich area of fuel (Amirshekari, M., 2012). In areas with fuel ratio to rich air at high temperature of unburned fuel of gas state, can be turned into solid nucleus (Park, S.H., et al., 2010). If Aromatic polynuclear hydrocarbons are big enough, they can create initial nucleus of black carbon and fine particles (Topgül, T., et al., 2006). The researchers have found that black carbon or suspended particles are associated highly with stoichiometry, temperature, pressure and blend mixture (Liang, Y., et al., 2013). Reduction of suspended particles to high oxygen content in fuel and reduction of air stoichiometry to fuel and reduced aromatic content (Su, J., et al., 2013).

Fig. 8: The chart of number of fine suspended particles-Fuel type

Fig. 9: The chart of number of coarse suspended particles-Fuel type
Figures 8, 9 show fine and coarse suspended particles of engine in various percent of bioethanol fuel. As shown, by increase of bioethanol % in combustion combination and increase of engine cycle, number of particles are reduced and increased. One of the particles generation sources is generated black carbon in combustion. The fuels with high mass ratio of carbon to hydrogen generated high black carbon than fuels with low ratios (Alsayed, M.F.M., 2008). Bioethanol has low carbon to hydrogen ratio to gasoline. By increase of bioethanol ratio in compound compared to basic gasoline, low black carbon is generated and it reduces suspended particles. Ultrafine particles with high fuel splashing and homogenous blend can be reduced (Wu, C.W., et al., 2004; Cucchi, M., and S. Samuel, 2015). Chen et al. showed that bioethanol fuel under rich conditions due to existence of oxygen in fuel molecules, concentration of mediatory types to form initial mater of black carbon is reduced more than stoichiometry conditions (Chen, L., et al., 2012). The oxygen in fuel reduces the formation of areas rich with fuel and oxidation of black carbon nucleus is improved (Sayin, C., 2010).

Song et al., in a study achieved similar results and reported that by increase much oxygen to inflow air and using oxygenated fuels as bioethanol, generated black carbon is reduced and it leads to reduction of suspended particles (Song, J., et al., 2002). Oxygenated compound in fuel reduces the formation of primary nucleus of black carbon and carbon is reduced. This is done by reducing the number of carbon-carbon chains. Free radicals of existing oxygen in fuel avoid aromatic cycle and black carbon and carbon oxidation (converting CO to CO2) is improved (Park, S.H., et al., 2010). The number of fine suspended particles for E5, E15, E20 and E25 blends to E0 is 8.88%, 11.45%, 15.84%, 26.66%, 41.42% is reduced. The number of coarse suspended particles for E5, E15, E20 and E25 to E0 is reduced as 13.71%, 52.09%, 64.79%, 89.60% and 96.09%. The increase of engine cycle increased temperature and oxidized suspended particles but due to high cycles, the number of particles is increased. By 25% increase of bioethanol to fuel from E0 to E25, the number of fine and coarse suspended particles for engine cycle 1000 is reduced from 304340 to 163318 and from 3147 to 1839 for engine 2000, from 325968 to 265349 and from 4142 to 2061 and for engine 3000, from 380736 to 286256 and from 4739 to 2234.

**Conclusion and Summary:**

This study evaluates the effect of gasoline-bioethanol combustion compound on pollutants and fuel consumption in various cycles of gasoline engine. The general results are achieved.

By increasing bioethanol percent in fuel combination with gasoline, unburned hydrocarbon, carbon monoxide and carbon dioxide and fine and coarse suspended particles are reduced but nitrogen oxides are increased and fuel consumption is also increased.

By adding engine cycle, carbon monoxide and unburned hydrocarbon are reduced but carbon dioxide and nitrogen oxides and fine and coarse suspended particles and fuel consumption are increased.

Based on considerable reduction of suspended particles and unburned hydrocarbon and carbon monoxide pollutants, using bioethanol-gasoline combination with various percent is a good method to reduce pollutants. Although, fuel consumption is increased a little in this method, reduction of pollutants and suspended particles and the elimination of their adverse effect on environment and human require high costs and using bioethanol instead of MTBE is economical.

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