FUELS

Octane number

Octane ratings are measures of fuel stability. These ratings are based on the pressure at which a fuel will spontaneously combust (auto-ignite) in a testing engine. The octane number is actually the simple average of two different octane rating methods—*motor octane rating* (MOR) and *research octane rating* (RON)—that differ primarily in the specifics of the operating conditions. The higher an octane number, the more stable the fuel.

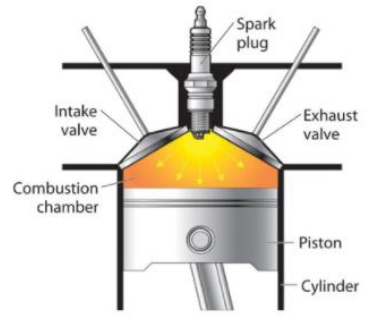
Some companies have different names for these grades of gasoline, such as unleaded, super, or super premium, but they all refer to the octane rating.

Of the 18 isomers of normal octane (C_8H_{18}), octane gets its name from the 2, 2 ,4-Trimethylpentane compound, which is highly resistant to auto-ignition. This iso-octane has been assigned the reference value of 100 for testing purposes. The extremely unstable normal heptane (C_7H_{16}) molecule is the 0 octane reference fuel.

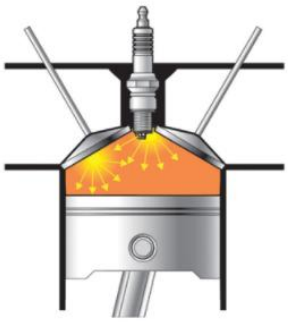
Effects of octane level

Engines are designed to burn fuel in a *controlled combustion*. A flame starts at the spark plug and burns throughout the cylinder until all of the fuel in the cylinder is burned. In comparison, *spontaneous combustion*, also called *auto-ignition*, *detonation*, or *knock*, happens when rising temperature and pressure from the primary combustion causes unburned fuel to ignite. This uncontrolled secondary combustion causes pressure in the cylinder to spike and causes the knock to occur.

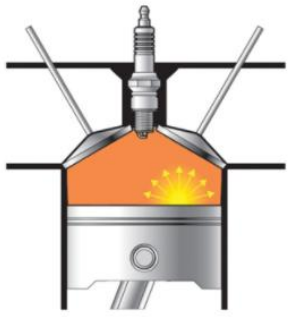
The competition between the intended (controlled) and unintended (spontaneous) combustion causes the energy from the burning fuel to disperse unevenly, which can cause damage and place high pressure on the engine's piston before it enters the power stroke (the part of the cycle when the piston's motion is generating power).



Normal combustion in a gasoline engine cylinder



Spontaneous combustion in a gasoline engine cylinder causing engine knock



Preignition in an engine cylinder

Before electric computerized ignition was widely used, this knocking commonly occurred and could cause significant engine damage. Most modern engines have sensors to detect knocking. When detected, the computer delays the initial spark, which causes the controlled combustion to take place at a point when compression is not at its highest point. Although this eliminates the knock, it can cause the engine to run less efficiently.

A similar undesirable condition is called pre-ignition, when the fuel ignites on its own before the spark ignites it. Modern engine computers minimize this condition by controlling the timing of valves and fuel injection; however, this control mechanism can also come with a fuel-efficiency or emissions penalty.

Octane number meassurment

This test is similar to the way the mass of an object can be determined by comparing it to objects (references) of known mass on a balance scale. Primary Reference Fuels (PRF) of precisely known octane are formed by combining iso-octane, heptane, and other well-known standards such as toluene. These PRFs are used to bracket a given fuel sample to determine the pressure at which similar knock intensities are observed. This measurement is taken by adjusting the octane engine's cylinder height, which changes the compression ratio/pressure in the engine until the knocking reaches a specific intensity level.

The (R+M)/2 you see on the label refers to the average of the research octane number (**R**ON) and the motor octane number (**M**ON) ratings. To determine the RON, the fuel is tested under engine idle conditions with a low air temperature and slow engine speed. To determine the MON the fuel is tested under the more stressful conditions of higher air temperature and engine speed.

Historically, RON and MON were determined on separate testing machines specifically configured for each test. Current designs (see image below) allow the same engine to perform both tests. Despite this flexibility, many testers still prefer to use more than one machine with each specifically set up and calibrated to perform either RON or MON tests.

https://www.youtube.com/watch?v=7sLqbkmUrrg&ab_channel=energyriot

Cetane number

Cetane rating, also known as cetane number is a measurement of the quality or performance of diesel fuel. The higher the number, the better the fuel burns within the engine of a vehicle. The cetane number is similar to the octane rating in that it is a rating assigned to a fuel to rate the quality of its combustion. The difference is that octane rating rates gasoline whereas cetane rates diesel. Just as higher performance gasoline vehicles require fuels with a higher octane rating, high performance diesel vehicles require fuel with a higher cetane rating.

The cetane rating of a specific diesel mixture is based off of how much cetane—a clear, colourless hydrocarbon that ignites under high pressures—is in some fuel. Pure cetane represents the highest purity of diesel fuel possible, and thus has a cetane rating of 100.

The main difference between cetane and octane ratings is that the octane rating represents how well a fuel can resist pre-ignition due to compression—ensuring the fuel ignites only from a spark from the spark plug. However, the cetane number measures the delay in the ignition time of the fuel. In other words, it is how *minimized* the delay is between when the fuel is injected into the chamber and when the combustion begins. Unlike gasoline engines which attempt to resist any ignition due to compression, diesel engines *rely* on this compression ignition and thus no spark is involved. A higher cetane number simply means the time between when the fuel is injected into the combustion chamber and when the fuel ignites is minimized. This means the fuel has the ability to ignite more easily and readily due to compression. This shorter delay time results in more complete fuel combustion.

Benefits of a High Cetane Rating

A higher cetane number resulting in quicker ignition of the fuel leads to less non-ignited fuels building up inside the combustion chamber, as well as more complete fuel combustion. Better fuel combustion and quick ignition leads to quicker starting for vehicles, as well as an engine that operates more quietly as only misted fuel is ignited and build up inside the engine is minimized. Moreover, fuel efficiency improves with more complete combustion and harmful emissions are reduced.

Generally, the owner's manual that comes with new vehicles has manufacturer's recommendations as to which cetane rating a vehicle should use to ensure the engine is operating at its peak.

https://www.youtube.com/watch?v=WdQ4J-NFoU8&ab_channel=LZDieselAdditives

Gasoline

Unleaded motor gasolines are mixtures of liquid hydrocarbons mainly of petroleum origin, which boil and evaporate in the temperature range of 30 - 210 ° C. Evaporation is one of the best carburetion properties of gasoline. Motor gasolines may contain antioxidant additives, detergent additives as well as other additives to improve performance. The oxygen components are included only in such an amount that the oxygen content of the gasoline does not exceed 2.7% by weight. To protect the exhaust gas catalysts, phosphorus-containing additives are not added to unleaded motor gasolines. Motor gasolines are a Class I hazard class of combustibility. They are volatile substances. Motor gasolines are high-quality and high-performance fuels for petrol engines designed for unleaded petrol and equipped with a catalytic converter, as well as for engines designed for fuel containing lead anti-knock agents.

Diesel

Diesel is a mixture of liquid hydrocarbons that boils in the temperature range of 150 - 370 ° C. It contains additives to improve the low-temperature properties of the fuel. It may also contain other proven additives to improve performance. It is also permitted to use dyes and markers. Diesel is produced in three types and differs in properties and use in different climatic conditions. They are Class III hazard of combustibility. From a hygienic point of view, diesel is a substance that can cause obvious irritation on repeated or prolonged skin contact. Diesel is used mainly as a fuel to drive diesel engines. It can also be used as a fuel for space heating in appliances designed for the purpose (diesel stoves, boilers). Different types of diesel are used according to different periods.

PROPANE-BUTANE (LPG)

Propane-butane is formed in refineries as a by-product of oil processing. It is a light gas fraction, which is liquefied by cooling while the so-called LPG (Liquid Petroleum Gas), which can be used as fuel in motor vehicles. The ratio of propane to butane in LPG varies in winter and summer, and there are also differences in composition between countries. LPG has been used as a fuel for motor vehicles for more than 60 years and there are more than 5 million such vehicles in the world. In OECD countries, this fuel accounts for five percent of total transport fuel consumption. The countries with the highest number of LPG vehicles are Italy, the USA and Canada, and the Netherlands.

PROPERTIES

LPG is a fuel with an octane number higher by 5 to 10% than gasoline and is suitable as a replacement for gasoline and diesel engines. The higher octane number allows for higher compression and thus higher efficiency.

Another advantage is that LPG does not require mixture enrichment during a cold engine start. One of the most important reasons why this fuel is used in the world is its low price.

The use of LPG in motor vehicles is technically proven and hassle-free. However, it requires some modifications to the vehicle. In diesel engines, minor modifications are necessary associated with the installation of a spark plug and electrical system. Today, there are also vehicles using the so-called a dual system in which a small amount of diesel is used to ignite a mixture of LPG and air.

ADVANTAGES

As LPG burns cleaner than petrol, the engine lasts longer and requires lower maintenance costs. The oil, oil filter, spark plugs and the engine itself last up to three times longer than when burning gasoline. It follows that the maintenance of such vehicles is almost negligible compared to diesel vehicles. Another advantage is that there is a developed propane supply network in Europe. Another advantage is that LPG combustion also results in a lower noise

level of about 5 decibels compared to diesel engines. The existing infrastructure and the fact that conventional vehicles can be adapted to run on LPG in one day make LPG an attractive fuel in the short term.

DISADVANTAGES

Handling LPG requires special safety measures. Another disadvantage is that in terms of production capacity of current refineries, only about 15% of vehicles could run on LPG. Larger quantities are possible in principle, but would require special modifications in refineries and therefore higher costs. Vehicles are also heavier due to the need for a larger fuel tank.

NATURAL GAS

The advantage of natural gas as an alternative fuel is that its world reserves are slightly larger than oil reserves and, moreover, they are more evenly distributed. Natural gas consists of 88% to 96% methane with small amounts of alkanes, propane and butane. Natural gas is a fuel with a high octane number and is suitable as a replacement for conventional fuels for motor vehicles. Natural gas vehicles are not new. In many countries, they were used 50 years ago. A large number of gas buses appeared in the world, especially after the Second World War, when there was a significant shortage of oil. Natural gas is used in motor vehicles in many countries around the world and, according to available data, there are currently more than one million such vehicles on the road. At present, compressed natural gas is used as a fuel mainly in city buses, as it is much easier to place a large pressure tank than in a car.

APPLICATION

Ignition of the air / gas mixture is controlled by an oxygen sensor. The use of natural gas requires its storage in a tank, either in gaseous - compressed (CNG) or liquid (LNG) form. The disadvantage is that it is necessary to reduce the gas temperature to minus 162 ° C for liquefaction. However, the advantage is that such a fuel has up to three times higher energy density than compressed gas. Therefore, a smaller fuel tank is sufficient to achieve the same range, but it must be insulated to keep the temperature very low. One of the disadvantages of natural gas is that it has a lower energy density in gaseous form, and therefore, in order for the vehicle to have an acceptable range, a compression of at least 200 bar (atmospheres) is required. It follows that such vehicles require special pressure tanks. The fuel tank with compressed natural gas also leads to an increase in the weight of the vehicle in the case of buses, for example. This means that to achieve the same range, a gas fuel tank is about 5 times heavier than a diesel tank and at the same time takes up about 7 times more volume. Upgrading a vehicle to compressed natural gas is usually more expensive than LPG. Higher costs are mainly related to the pressure tank. An additional carburetor is also needed because a conventional carburetor causes a pressure drop due to air intake. However, all technological elements for compressed natural gas vehicles are commonly available on the market. Compressed natural gas vehicles also require a different system of fuel supply and pumping,

because the gas pressure in the tank is higher than e.g. pressure in gas pipes. Fuel pumping takes place at compression stations, which in terms of their logistics in practice allow fast or slow pumping. Fast pumping takes about 10 to 15 minutes, in the case of slow pumping the whole process takes 6 to 8 hours.

BIOFUELS

Alcohol or vegetable oils that can be obtained from biomass (plants) are just such fuels. Biomass was a source of energy even before gasoline was used. The production of alcohol (methanol and ethanol) from biomass for technical purposes has been known since the 1930s. Currently, the most important fuels produced from biomass are methanol, ethanol and biodiesel. The use of biogas and wood gas, which were very popular during World War II, gave way to the background. From the global point of view, the most widespread so-called alcohol fuels - ethanol and methanol, which are produced in the world mainly from grain, corn and sugar cane. The advantage of biofuels is that they burn with fewer pollutants. This is due to the fact that these fuels have a simpler structure than petrol or diesel, burn better and the whole process leads to less unburned residues. From this point of view, methanol is a better fuel than ethanol. Biomass is characterized by a relatively good energy density.

Ethanol

Ethanol (other names: ethyl alcohol, alcohol, alcohol) is a colorless flammable liquid. Its chemical formula is CH3-CH2-OH, often referred to as C2H5OH, in general C2H6O.

The largest part of ethanol production is prepared from simple carbohydrates (sugars) by alcoholic fermentation by the action of different types of yeasts, especially different bred strains.

Ethanol is a substance that occurs only sporadically in nature and its consumption (in small amounts), unlike methanol, is not burdened to humans. Ethanol is now commonly used as a substitute for gasoline in engines, and it is only one of the oldest fuels.

A large number of vehicles have been running on this fuel since the 1990s. One of the reasons for the introduction of these programs was the effort to improve the environment.

METHANOL

The production of methanol (methyl alcohol) from wood has been known in the world for a very long time. However, methanol often acted only as a by-product in the production of charcoal. However, such production was characterized by very low yields. Charcoal gradually lost its importance and methanol remained an important fuel for motor vehicles. It is a pure, odorless liquid that occurs only sporadically in nature. The efficiency of the engine on such fuel is higher than in the case of gasoline (about 20%), which essentially increases the energy value of methanol. The methanol engine is characterized by quiet operation and low vibrations, because the combustion is very slow. This also results in reduced driver fatigue while driving. The advantage is that such fuel is very low. The methanol engine features a significant up to 65% reduction in NOx emissions compared to conventional diesel engines.

BIODIESEL

The importance of biodiesel is mainly that almost every diesel engine can in principle be adapted to burn biodiesel. In addition, there are a large number of diesel passenger cars that could also use biodiesel. However, the use of pure vegetable oil in engines brings several difficulties, and therefore this oil is modified by esterification to a methyl ester in Slovakia called MERO. Esterification of vegetable oil viscosity and brings many advantages. Engine operation, fuel production, transport and storage are not after esterification of production. Such oil can then be easily mixed into the diesel, which does not have a negative effect on the engine. This has a positive effect on reducing combustion emissions.

One of the main advantages of biodiesel is its positive energy balance, which is better than in the case of alcohol fuels.

The disadvantage of pure vegetable oils is that they have a high viscosity (up to 40 times higher than diesel) and during their storage the quality of fuels is reduced. They pollute the engine during combustion, are aggressive towards plastics and paints and have higher emissions of particulate matter and N2O. The problem of solid particles can be eliminated by the so-called esterification of vegetable oil (MERO production).

HYDROGEN

The water molecule consists of hydrogen and oxygen, which can be separated from each other, e.g. by the action of electric current (electrolysis). When hydrogen is obtained in this way, it burns (combines with the oxygen contained in the air) e.g. in the internal combustion engine - energy is released. In vehicles, it is possible to use hydrogen as a fuel either directly in the internal combustion engine or as a source of electricity in the so-called fuel cell. The biggest advantage is that the combustion of fuel is completely clean and the only waste generated in this process is clean water and a small amount of NOx. When hydrogen is used in fuel cells, NOx is not produced at all. If electrolysis water is produced, uses electricity produced from renewable sources, and then it is the cleanest fuel that currently exists. Disadvantage of this fuel is high cost of its production and the large weight of the fuel tank, which is needed to ensure the long run of the vehicle. Several methods are currently used to store hydrogen. In recent years, liquid storage has become the most common.

NITROGEN

Nitrogen has a very low boiling point and, in liquefied form, contains a large amount of potential energy. This energy can also be used to power vehicles. The physical principle of running on nitrogen is based on the evaporation of nitrogen in a heat exchanger. In this process, energy is generated in the form of mechanical pressure, which drives the air piston engine. The surrounding atmosphere is used as a source of thermal energy. Compared to a conventional internal combustion engine, such a system has the advantage that not only no heat is generated during this process, but the surrounding space is cooled. The big advantage is that nitrogen as a fuel is the most widespread gas in nature and no pollutants are formed during the reaction in the engine. The disadvantage is the relatively high cost of liquefaction

of nitrogen. The process for producing liquid nitrogen, which requires electricity, is very clean and, when electricity is produced from renewable sources, no pollutants are generated at all. The advantage over gasoline is that it could be produced directly at current filling stations equipped with small nitrogen liquefaction plants.

HYBRID DRIVE

Hybrid electric vehicle (HEV) vehicles combine the internal combustion engine of a conventional vehicle with the battery and electric motor of the electric vehicle, which brings up to a twofold increase in fuel savings compared to conventional vehicles (fully hybrid vehicles). Hybrids can save up to 15-20% of fuel. This combination offers the longer range and faster refuelling that consumers expect from conventional vehicles, along with the energy and environmental benefits of the electric car.

Batteries are an essential component of HEV, as they help accelerate and power the accessories in the vehicle. In hybrid vehicles, the batteries are recharged with the energy recovered during braking. They help to significantly reduce fuel consumption and emissions.

Sources

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