

Note: It's important to note that if the flow rate is higher than that indicated in the table, this suggests that your power supply system is more than sufficient to power your motor. In this case, nothing needs to be done.

Chapter 3 – Fuels

3.1 Introduction

Fuels can be classified in several ways. But for our purposes, I'll separate them into two types as follows:

OXYGENATED – are all fuels that have oxygen in their molecules. Examples include ethanol, methanol, and nitromethane.

NON-OXYGENATED – these are all those that do not have oxygen in their molecules. Gasoline is an example of this.

The presence of oxygen in the molecule explains the stoichiometric ratio of each fuel. This refers to the amount of air required to burn 100% of the fuel. Fuels that contain oxygen require less air to burn, as they contain oxygen itself. This oxygen is removed from the molecule by the pressure and heat of combustion.

In the table below, we can see the AF (air / fuel) ratio, or air/fuel ratio, for each fuel. This means that, for gasoline, for example, we need 14.7 parts of air for 1

equivalent part of fuel. Realistically, we need 14.7 kg of air to burn 1 kg of gasoline. We can see that ethanol and methanol require even less air to burn. This is because they are oxygenated and already carry part of the oxygen they need for combustion within them.

Fuel	AF relationship	Percentage more
Gasoline	14.7	-
Ethanol	9	~50%
Methanol	6.47	~100%

Gasoline molecule: C_8H_{18} - does not contain oxygen in the molecule

Ethanol molecule: C_2H_6O - 34.73% of the composition is oxygen

Methanol molecule: CH_4O - 49.93% of the composition is oxygen

The availability of oxygen in ethanol and methanol is what explains the greater efficiency of these fuels, despite both having a lower calorific value than gasoline.

CALORIFIC VALUE:

- ▶ Gasoline (ethanol-free): 45,000 KJ/kg
- ▶ Ethanol: 28,000 KJ/kg
- ▶ Methanol: 22,600 KJ/kg

Calorific value is, in practical terms, the fuel's ability to heat the combustion chamber. We know that gases expand with heat, and therefore, the higher the fuel's calorific value, the greater its ability to expand the gases. This, in theory, results in greater thermal efficiency and engine power.

However, although ethanol and methanol have a lower calorific value, their property of being oxygenated and another property that we will see later, surpasses the calorific value of gasoline.

Let's imagine that we can put more oxygenated fuel inside the combustion chamber and this partly explains their better performance.

But what really makes oxygenated fuels outperform gasoline is a property called enthalpy of evaporation.

3.2 Enthalpy of evaporation

This is where the magic of ethanol and especially methanol happens.

Enthalpy of evaporation, or latent heat of vaporization, is the fuel's ability to absorb heat. In other words, it's the condition the fuel needs to evaporate, removing heat from the air or whatever it's in contact with. This is why we feel the chill when we rub alcohol on our skin. Alcohol needs to absorb heat from somewhere to evaporate. This condition is even greater in methanol.

Who hasn't seen manifolds and carburetors sweating when switching from gasoline to ethanol? This occurs because the manifold is at a lower temperature than the air, causing moisture in the air to condense on the surface. The same thing happens when we take something out of the refrigerator and immediately notice water forming on the surface.

The magic happens when air passes through the carburetor's venturi and mixes with the fuel. What happens is vaporization, and, as we saw above, the fuel needs to remove heat from somewhere. What's in contact with the fuel? The air! Therefore, the heat from the air is removed, causing its temperature to drop. Here we return to the topic of thermal expansion.

If the air cools, it reduces in volume, increasing the engine's volumetric efficiency. In other words, we can "push" more air into the engine, since its volume has shrunk. If the volume has shrunk and we can increase the amount of air, we consequently have more oxygen available for combustion. More oxygen requires more fuel, which is why ethanol and methanol are better fuels than gasoline when it comes to performance.

Below is a table with all the data we need for various fuels. Note the enthalpy of vaporization of methanol and ethanol relative to gasoline.

Property	GASOLINE	METHANOL	ETHANOL	NITRO METHANE	HYDRAZINE
Higher Calorific Value (PCS)	48000	29700	29700	11300	19400
Lower Calorific Value (LCV)	45000	22600	28000	11300	19400
Enthalpy of Vaporization (hLV)	496	1045	919	563	1404
Specific Heat (cTL)	2.1	2.53	2.44	1.74	3.12
Octane Rating (RON)	94	106	107		
Octane Index (MON)	83	92	89		
Antiknock Index (IAD - AKI)	89	99	98		
Sensitivity (RON - MON)	11	14	18		
Air/Fuel Ratio (AFR)	14.26	6.44	8.95	1.69	
Fuel/Air Ratio (F/A)	0.07	0.155	0.112	0.592	

The octane rating of fuels can be referenced by the acronyms RON and MON. The difference between the two is that the MON method is more rigorous when testing to determine a fuel's octane rating. So much so that the table shows lower levels. However, the RON method is more commonly used in the literature, and that's what we'll use here. The octane rating is a fuel's ability to resist detonation. In other words, it tells us how

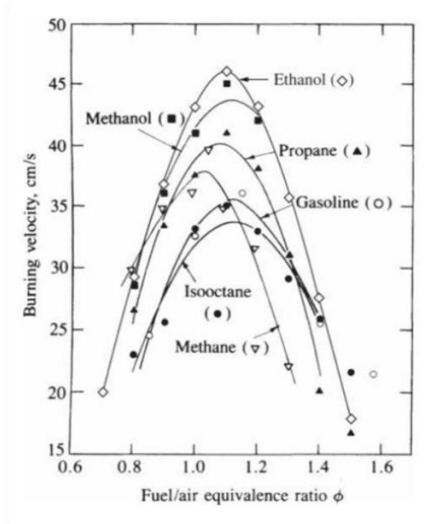
much heat and temperature we can expose this fuel to without it self-igniting. Here's another explanation for the greater efficiency of ethanol and methanol compared to gasoline. These fuels can be used at a higher compression ratio due to their high octane rating.

3.3 Laminar flame velocity

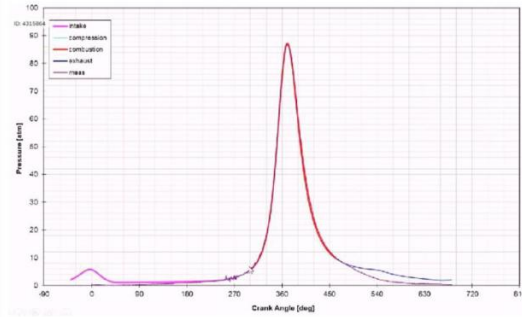
The laminar flame velocity is a very important point to analyze. It tells us how long it takes the mixture to burn. We're not talking about the time it takes for the mixture to ignite after the spark, but rather the speed at which the flame burns and fills the combustion chamber. We'll address this when we talk about ignition timing. Flame velocity is important for determining which fuels are faster and can increase combustion chamber pressure more quickly, since at high RPMs, the piston is traveling very fast, and the time we have to increase combustion chamber pressure is limited. Some fuels can burn slowly, and even before the entire mixture is burned inside the chamber, the piston will be moving down. This results in a loss of efficiency.

The graph on the side shows the flame speed of various fuels. From ignition to complete combustion, methanol takes about 43 cm/s compared to 36 cm/s for gasoline, under the same temperature and pressure conditions. However, it's important to remember that methanol requires twice as much combustion in the combustion chamber, and although it's faster, it takes

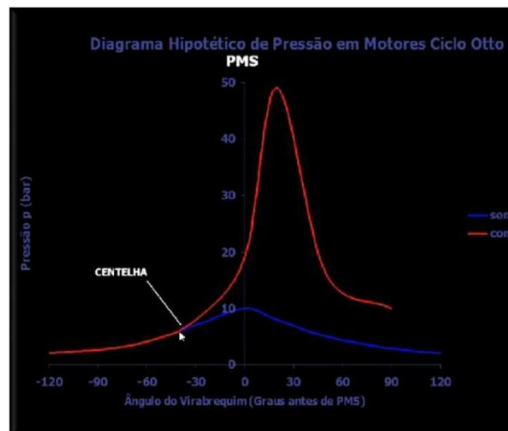
longer to burn due to the larger physical volume inside the combustion chamber.



In the graph below, we can see the pressure inside the cylinder of an F1 car. We can see that after the spark, the pressure rises very quickly. We can see that fuel is being consumed very quickly, which is extremely necessary in engines like this that rotate at over 15,000 RPM.



The graph below is from a standard engine. The difference is notable, including in pressure. Compare the time it takes for the fuel to reach maximum pressure and the pressure range in bar, which is much lower than that of a Formula 1 car.



3.4 Final considerations

Each fuel has its advantages and disadvantages. Gasoline is practical and easy to use, but has limited cooling properties and is susceptible to quality fluctuations. Ethanol is cheap, readily available, and offers excellent cooling, but requires higher fuel consumption and compression. Methanol provides maximum performance and cooling, but is corrosive, difficult to maintain, and impractical for everyday use.

Tuners should always consider the engine's intended purpose before choosing a fuel. There's no universally best option: it all depends on the balance between performance, durability, cost, and availability. The real benefit lies in understanding the characteristics of each fuel and properly tuning the engine to extract its maximum potential.

3.5 Mixtures with oil

3.5.1 Introduction

In two-stroke engines, lubrication is essential for proper operation and durability. Unlike four-stroke engines, which have a separate oil system in the crankcase, two-stroke engines rely on a mixture of oil and fuel to ensure all moving parts receive the necessary protection.

This lubrication can occur in two ways: through an automatic system, known as Autolube , or by directly mixing oil with fuel, called Premix . The most important thing is not choosing one system over the other, but using it correctly. Oil in a two-stroke engine fulfills three main functions:

1. Lubricate bearings and cages.
2. Reduce friction between piston, rings and cylinder.
3. Help transmit heat from the piston to the cylinder.

Therefore, the correct proportion and the appropriate type of oil are decisive for the performance and service life of the engine.

3.5.2 Mixing forms

Automatic System (Autolube)

Autolube system, the motorcycle or kart has a separate oil reservoir. A metering pump injects the oil directly into strategic points, such as the intake or, in some more modern cases, directly into the crankcase. The main advantage is convenience: the rider simply fills up with fuel, and the system automatically measures the oil, eliminating the need for manual calculations.

Pre -mix

In premix, the oil must be manually mixed with the fuel before refueling. This practice requires care and discipline from the driver or tuner, as any error in the proportions can damage the engine. Although more laborious, it ensures complete control over the amount of oil used, something especially important in tuned engines or under specific racing conditions.

3.5.3 Types of oil

Mineral Oils

They are petroleum-based, have the lowest cost, but also offer the least protection. Therefore, they should only be used in low-power engines and light-duty applications, such as gardening equipment or mini-motorcycles. They are recommended exclusively for gasoline-powered engines. Examples include Lubrax Essential, Stihl 8017H, and Castrol Motor Oil. Among these, Stihl is preferred.

Vegetable Oils (Castor)

Extracted from the castor bean, they are known as castor oils. They have excellent protective properties and are particularly suitable for engines that use ethanol or methanol as fuel. They are widely used in racing, regardless of engine type.

Examples include Dimethyl and Raid, with a personal preference for Dimethyl.

Semi-synthetic oils

These are a blend of mineral and synthetic oils. They offer intermediate protection and are cost-effective, making them suitable for both original equipment and light-duty engines. They should only be used in gasoline-powered engines. Examples include Motul 510 and Yamalube 2-S.

Synthetic Oils

These are fully synthetic base oils, offering the highest level of protection and lubrication. Recommended for high-performance engines and extreme use, they are also miscible only with gasoline. Example: Motul 800, considered ideal for highly tuned engines.

3.5.4 Mixing proportions

Mineral Oils

Due to its low lubrication efficiency, it is recommended to use 30 to 50 ml of oil per liter of gasoline, depending on the application.

Vegetable Oils (Castor)

Special care is needed here. Since ethanol requires about 50% more volume than gasoline, and

methanol can require up to 100% more, the oil ratio must also be adjusted.

- If the manufacturer recommends 40 to 50 ml per liter of gasoline, in the case of ethanol this proportion should be reduced by 50%, reaching approximately 30 ml per liter.
- With methanol, the reduction should be 100%, resulting in approximately 20 ml per liter.

In highly tuned engines, it is recommended to add around 5% more oil.

Semi-synthetic oils

When used with an autolube system, dosing is done automatically. In the case of premix, the recommended dosage is 30 ml per liter of gasoline.

Synthetic Oils

Motul 800, for example, recommends 15 to 20 ml per liter, depending on the application. However, it is recommended not to use less than 15 ml per liter. For light to medium tune-ups, 15 ml per liter is adequate; for highly tuned engines and competitions, 20 ml per liter is the best option.

3.5.5 Important considerations

The recommendations presented should not be interpreted as absolute rules, but rather as practical

guidelines based on experience. Engine performance and durability vary depending on the application, type of setup, fuel, climate, and riding style.

Most manufacturers avoid specifying exact oil quantities, precisely to avoid assuming liability for potential failures. Therefore, it's up to the preparer to assess the conditions and adjust the mixture as needed.

Another relevant point is the formation of residues: mineral and vegetable oils tend to generate more smoke and carbon in the combustion chamber, while synthetic oils produce fewer deposits and keep the engine cleaner.

Whenever possible, choose synthetic oil, as long as it's compatible with the system you're using. It's also crucial to check the label to see if the oil is suitable for autolube systems to avoid lubrication failures.

3.6 Fuel applications

Introduction

Choosing the right fuel should always take into account the engine's application and the driver's needs. There is no universally best fuel: each option has characteristics that can benefit or hinder performance depending on the type of fuel, intended use, and cost involved.

Therefore, it is essential to understand how each fuel behaves in different contexts, from everyday use to high-performance competitions.

Regular gasoline (up to 97 octane)

Regular gasoline should preferably not be used in tuned engines. The reason is simple: its formulation doesn't follow a uniform standard. From manufacturer to manufacturer, and even from gas station to gas station, the composition can vary greatly.

This means there's always a risk of fueling with adulterated or low-quality gasoline. To minimize the risk of detonation or failure, it would be necessary to reduce both the compression ratio and the ignition timing. However, doing so results in a loss of efficiency and power, which defeats the purpose of tuning.

Therefore, although it is possible to run on regular gasoline in tuned engines, it should be avoided when seeking high performance and reliability.

Premium Gasoline (over 97 octane)

Premium gasoline offers greater standardization and quality compared to regular gasoline. This makes it a reliable option for tuned engines, especially in situations where range is important—i.e., when the engine needs to run long distances without refueling.

Despite the high cost, its use in everyday motorcycles can be interesting for those looking for efficiency and not concerned about the price per liter.

Another advantage of premium fuel is its higher octane rating, which allows for a higher compression ratio compared to regular gasoline. This results in better fuel efficiency, with increased performance without compromising reliability. Therefore, premium fuel is primarily recommended for light to medium fuel consumption.

Ethanol

Ethanol is an extremely versatile fuel. It allows for the same compression ratio as premium gasoline, but offers better performance in preparations and, at the same time, a lower cost per liter.

However, three points need to be noted:

1. Autonomy – compared to gasoline, ethanol reduces autonomy by around 50%.
2. Cold starting – in colder regions, starting may become more difficult.
3. Internal oxidation – ethanol accelerates the oxidation of the engine's internal components, requiring greater care.

To avoid corrosion problems in engines that will be idle for long periods, it is recommended to run the engine on gasoline or kerosene mixed with 2T oil before storing it.

In practical terms, ethanol can be used in engines with light to heavy preparations, as long as the aforementioned precautions are observed.

Methanol

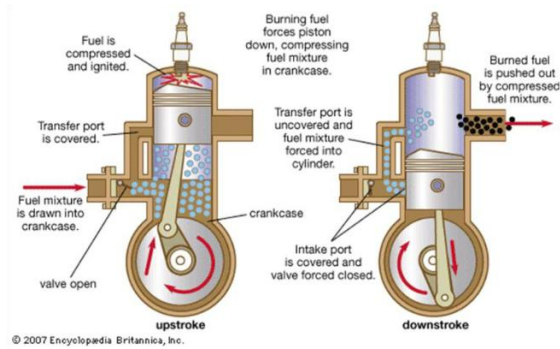
Methanol is a fuel designed for highly tuned engines. Its use is practically exclusive to short-duration competitions, such as drag racing, where range isn't a concern and high fuel consumption is no longer relevant in the pursuit of maximum performance. One of the advantages is its relatively affordable cost, considering its use is restricted to short races. However, the biggest challenge lies once again in oxidation. Just like ethanol, methanol accelerates corrosion, but even more aggressively. Methanol should never be left standing in the carburetor or engine. The oxidation it causes can create micro-holes in the crankshaft pins and cages, drastically reducing engine life.

Therefore, methanol should only be used in extreme competition contexts, accompanied by frequent maintenance and strict conservation procedures.

Chapter 4 – Reed Valve

4.1 Introduction

Early two-stroke engines didn't use reed torques. Intake was controlled by the opening and closing of the piston. However, despite there being no restriction on incoming flow, which would have been ideal, the engine only performed well near the peak torque zone. Starting and idling were unstable, as the opening also allows some of the pressure created by the piston as it descends to pass through, causing the flow to reverse and the mixture to exit through the carburetor. If the mixture passes through the carburetor twice, it draws twice as much fuel, which explains the uneven idle.



Over time, it was discovered that using a bypass between the engine and the carburetor could improve flow control, preventing some of the pressure from escaping through the carburetor. The first reed torques