SCIENTIFIC PRINCIPLES OF LOGIKKO SYSTEMS

Basic Principle

Logikko has launched an Energy Saver system, which uses as a basic principle the advantages of adding hydrogen to improve the combustion of an engine.

The problem with hydrogen lies in its production, distribution and storage. The best way to obtain ($2H2_{(g)}$ **+ $O2_{(g))}$** without having to store it in a container connected to the engine is to generate it *in situ* using the <u>electrolysis of water.</u> In which case the only storage means to be provided is a small bottle of water.

PRINCIPLE OF WATER ELECTROLYSIS

Electricity passes between two metal plates immersed in water.

Electricity is supplied by a generator-type power source (car battery for example).

This reaction takes place in two simultaneous half-reactions:

At the anode, the oxidation of water releases electrons:

$2\ _{H2O(l)} \rightarrow 4\ H+_{(aq)} + O2(_{g}) + 4\ e-$

At the cathode, the reduction of H+ ions consumes electrons :

$4\ H+_{(aq)} + 4\ ^{e-} \rightarrow 2\ _{H2(g)}$

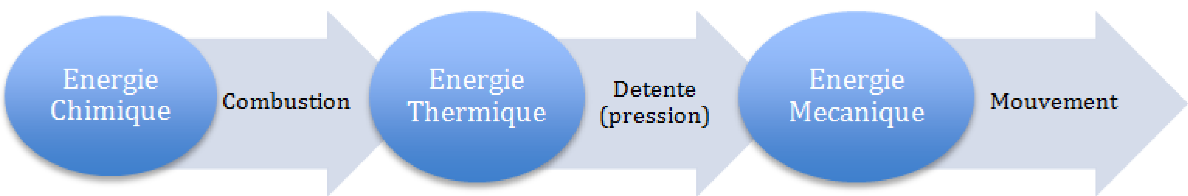
The H_2O molecule is broken down to become hydrogen H_2 and oxygen O_2 in gaseous form. Finally, we have the following reaction:

$2\ H_2O_{(l)} \rightarrow 2\ H_{2(g)} + O_{2(g)}$

It is these molecules that will improve combustion and reduce local and global pollution.

Now let's look at this in more detail:

Reminder of the principle of operation of an internal combustion engine



What is the ideal reaction during combustion?

Several elements are involved in combustion. According to the equation:

Fuel + Combustion → CO_2 +H_2O + energy ΔH

Fuel: fuel that powers a thermal machine. It consists of hydrocarbons with the chemical formula CnHmOr (fuel of petroleum origin, synthetic, bio-fuels, etc.).

Combustible: another reagent necessary for combustion. Often oxygen from the air (composition of the air 21% O_2 and 79% N_2).

Reaction enthalpy (ΔH): reaction quantity associated with the balance equation of a chemical reaction carried out at constant temperature T and pressure P. It provides direct access to the amount of energy released in the form of heat (thermal energy).

Efficient combustion includes :

- high-performance reagents (fuels and oxidants)
- good proportions of reagents
- an engine fuel injection designed for good molecular contact

Simple examples :

Perfect carbon combustion: C + O_2 → CO_2 + Heat
Perfect propane combustion: C_3H_8 + 5O_2 → 3CO_2 + 4H_2O + Heat
Perfect diesel combustion: 2$C_{16}H_{34}$ + 49O_2 → 32CO_2 + 34H_2O + Heat

BUT the chemical reaction in an engine is incomplete

We'd like to have:
Fuel + O_2 → CO_2+ H_2O + Heat

But in reality, we have:
Fuel + O_2 + N_2 + Ar + ... → HC + CO_2 + CO + NO + NO_2 + N_2O + SO_2 + ... + O_2 + N_2 + H_2O + ΔH

The combustion of fuel actually produces other compounds that are toxic pollutants (including HC, CO, NOx, SOx).

Moreover, in a conventional combustion engine the combustion efficiency does not exceed η_{comb}=0.5; there are therefore 50% energy losses, including unburned (HC). Thus, one of the main drawbacks of internal combustion engines is the high fuel consumption due to the incomplete nature of combustion.

(Source: IFP Energies Nouvelles)

Why is the reaction incomplete?

On the one hand, the reaction conditions in the combustion chamber are heterogeneous and therefore not ideal everywhere. On the other hand, the dosage of reagents is poor and leads to an incomplete reaction (formation of unwanted by-products, existence of residual reagents and non-optimal energy created).

Indeed, the quality of the combustion depends closely on the air/fuel ratio noted λ of the mixture admitted into the combustion chamber.

Here is a map of the origin of the pollutants discharged by a conventional combustion engine:

- CO2 Product of ideal combustion
  - - Decreases only if fuel consumption decreases
- CO From a bad dosage: Too little air (so-called rich mixture)
  - - Another reaction may occur: $CO_2 + H_2 \rightarrow CO + H_2O$
- HC From a bad dosage: Too little air (rich mixture)
  - - Another reaction may occur: Cracking or recombination
- Particles Wrong dosage: Too little air (rich mixture)
- NOx Reaction medium: Too high T°

(Source L. LE MOYNE, Moteurs thermiques, University of Burgundy)

It can be thought that if you place yourself in lean mixture conditions (add a lot of air so that the air/fuel ratio λ is greater than 1, you improve combustion. However, in reality, if we increase λ the engine loses power and stability: it stalls. Excess O_2 also causes additional NOx emissions.

How does hydrogen improve combustion?

The hydrogen produced by the LOGIKKO device acts on the 3 points that make combustion an efficient reaction. Thus, it improves the quality of the reagents (fuels), ensures that the stoichiometric proportions are always respected and ensures a good molecular contact in the reaction medium.

Reagent Improvement

In an internal combustion engine, the flame speed of a fuel is a property that determines its ability to undergo controlled combustion without detonation. It is a parameter used to determine engine efficiency. Indeed, according to NASA, *"Combustion processes with high flame velocities, which are similar to constant volume processes, should result in high efficiencies*. Therefore, the flame speed of hydrogen is about 10 times higher than that of fuel. When mixed with the fuel, hydrogen will increase the flame velocity of the mixture and thus increase the speed of combustion, which will then be more complete and, above all, more stable.

Caractéristiques d'inflammation de l'hydrogène et du propane

Propriétés	Unités	Hydrogène	Propane
Domaine d'inflammabilité dans l'air	*% vol*	4 - 75	2,1 – 9,5
Energie minimale d'inflammation	*mJ*	0,02	0,26
Température d'auto-inflammation	*°K*	858	760
Vitesse de combustion dans l'air (à P_{atm} et T_{amb})	*cm/s*	265-325	30-40
Energie d'explosion	*g TNT/g produit*	24	10
	kg TNT/cm^3 gaz (à PE)	2,02	20,3

__source__ : Commission of the European Communities and the Government of Québec, novembre 1993

<u>Stoichiometric proportions</u>

For combustion to be effective, the reagents must be introduced in stoichiometric proportions. There must therefore be enough oxygen in the air for fuel combustion to take place.

The question then arises: by adding hydrogen, is there not a risk of lowering the proportion of oxygen in the reaction mixture? And the answer to this question is obviously no since the gas produced is a mixture of O2 and H2 produced naturally in stoichiometric proportions by electrolysis.

However, even if only H_2 were to participate in the combustion; the quantity of hydrogen required to increase the flame speed of the mixture does not exceed 1% of the volume of air introduced, which will in no way upset the equilibrium of the reaction. It can be specified that for most engines the dilution is even rather close to 1/1000 since in practice about 1 l/min of hydrogen is produced for 1 to 2 $^{m3/min\ of}$ air absorbed by the engine intake.

<u>Molecular contact</u>

On the one hand, dihydrogen is the smallest molecule in the reaction mixture. It enters the combustion chamber with greater celerity, has a lower activation energy and engages in more intermolecular collisions than heavy molecules. On the other hand, the addition of hydrogen to the fuel increases the rate of molecular cracking during which long chains of hydrocarbons are broken into smaller fragments. This therefore contributes to increasing the contact surface of the hydrocarbons with the oxygen in the reaction mixture and allows for more complete combustion.

(Source : Dr. Gilbert GALLAHAR. The use of « the higher form of water » as a catalyst to increase flame velocity in an internal combustion engine. Ph.D.)

In short, the combustion conditions of the mixture with H_2 are improved so that combustion is as complete as possible.

What happens to the reaction with the integration of the LOGIKKO system?

Thanks to our device the reaction that takes place in the engine is:

Fuel + O_2 + (H+1/2O) → CO_2 + H_2O + Heat + Traces of pollutant releases

The reaction is more complete, there are fewer parasitic products and above all fewer unburned reagents. It is understandable that the combustion efficiency is improved:

Indeed. $\eta_{comb} = \dfrac{Q^{té} carburant\ utile}{Q^{té} carburant\ initiale}$ And there is a balance:

$$Q^{té}\ carburant\ initiale = Q^{té}\ carburant\ utile + Q^{té}\ carburant\ imbrulé$$

Because less fuel is thrown away without reacting, there is more useful fuel and the system's efficiency is better. In conclusion, **consumption is reduced**.

Thus, the admitted gas improves combustion by consuming the unburned. The **polluting emissions resulting from poor combustion are** therefore greatly **reduced** or even eliminated.

Indeed the reaction conditions are improved, so we see a decrease in emissions such as CO or HC. The reaction temperature decreases, so the NOx emissions also decrease. Finally, we consume less, so we emit less CO_2.

Moreover, the implementation of this complete combustion causes a progressive "deslagging" of the engine; the reduction of unburned hydrocarbons and other pollutants also corresponds to the reduction of soot and tars which usually line all the engine components where the burnt gases circulate. As a result, engine performance improves and economy is maximised. The engine is then in optimal operation, lubrication is improved, which has as a new consequence to preserve the engine potential (more accessible performances and longevity).

NB: This document is based on a lecture given in 2013 by engineering students from ENSAM Bordeaux.