DESIGN AND PERFORMANCE STUDY OF A PERMANENT MAGNET FUEL SAVER

MOULAY YOUSSEF EL HAFIDI and MOHAMED EL HAFIDI*

Laboratoire «Modélisation & Instrumentation»'
Faculté des sciences Ben M'sik - Département de Physique
Université Hassan II Mohammedia-Casablanca
B.P: 7955 Sidi Othmane – 20740 Casablanca, Morocco

Abstract: A fuel saver consisting of two permanent magnets has been designed. The magnetic field is supplied by NdFeB permanent magnets and is about 1.3 Tesla. The quantum theory is based on the well known Zeeman diagram of the 1s level of the hydrogen atom. The fuel saver is tested in a diesel car and its performance is reported and analyzed. We also describe the benefits of our mechanism on environment and equipment life time and present its diverse applications.

Key words: Hydrogen, Fuel, design, simulation, combustion, energy saving, permanent magnets.
PACS : *87.15.ag,* 75.40.Mg, 75.50.Ww, 85.70.Ay, 87.14.Df, 88.05.Bc

*Corresponding author: Tel : +212 5 22 70 46 72 Fax : +212 5 22 70 46 75
E-mail address : elhafidimohamed@menara.ma (M. El Hafidi)

I. Introduction

Hydrogen, a major component of fuel, has two states: paramagnetic and diamagnetic [ref.1]. At 20 C, 75% of the H2 molecules are diamagnetic, whereas only 25% are paramagnetic. The predominant diamagnetic state is a stable state which is less energetic and less reactive, while the paramagnetic state is an unstable state with higher energy [ref.2 and ref.3] and thus promotes and catalyzes the combustion process. The objective of our paper is to design and test practically a magnetic fuel saver able to move hydrocarbon molecules from their steady state to their instable state. This stimulation is achieved through a strong magnetic field produced by permanent rare earth magnets. The outline of this paper is the following: In section 2, we present the design. In section 3, we do the numeric simulation. Then, in section 4, we test the fuel saver on a diesel car. Finally, in section 5, we present the benefits of our mechanism on environment and equipment life time.

II. Magnetic fuel saver design

The present design relates to a magnetic device used to reduce the consumption of hydrocarbons and reduce pollutant emissions. It includes a pair of NdFeB permanent magnets having a magnetic field of 1.3 Tesla. They are mounted symmetrically around the fuel pipeline regardless of its nature (diesel, gasoline or butane). The assembly should take place just before the combustion to allow a optimal performance.

Fig.1 shows the magnetic fuel saver assembly. The two permanent magnets are embedded in two special packaging (2) and (3) and are then bonded symmetrically to the fuel pipeline (4) using fasteners (1).

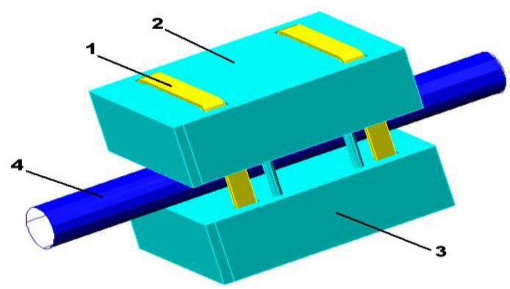

Figure1: Magnetic fuel saver design.

III. Numerical simulation

3.1 Quantum approach

Each dynamic state of the hydrogen atom is splitted into four energy levels. The decomposition is due to hyperfine interaction of the magnetic moments of the electron and proton, which creates a slight difference

in magnetic energy for each spin state. In this part, we aim to calculate the energy difference between these four states of spin in presence of an external magnetic field.
Based on the well known chapter of books devoted to the ``Quantum mechanics" [ref.4], the Hamiltonian writes in the standard $\{|m_e, m_p\rangle\}$ basis:

$$\hat{\mathrm{H}} = \mathrm{A}\overrightarrow{\sigma_e}.\overrightarrow{\sigma_p} + \hat{\mathrm{H}}_z \quad (1)$$

where the first term represents the exchange magnetic interaction between electron and proton in absence of magnetic field. The second one corresponds to the Zeeman Hamiltonian $\hat{H}_z$, for both electron and proton spins. If we assume that the field is applied in the z direction, we can write $\hat{H}_z$ as

$$\hat{H}_z = -\mu_e\sigma_z^e.B - \mu_p\sigma_z^p.B \quad (2)$$

Thus, H matrix of the Hamiltonian writes:

$$H = \begin{pmatrix} A-(\mu_e+\mu_p)B & 0 & 0 & 0 \\ 0 & -A-(\mu_e-\mu_p)B & 2A & 0 \\ 0 & 2A & -A-(-\mu_e+\mu_p)B & 0 \\ 0 & 0 & 0 & A+(\mu_e+\mu_p)B \end{pmatrix}$$

Since the magnetic field B does not vary with time, we obtain:

$$E.a_1 = A-(\mu_e+\mu_p)B.a_1 \quad (3)$$

$$E.a_2 = -A+(\mu_e-\mu_p)B.a_2 + 2A.a_3 \quad (4)$$

$$E.a_3 = 2A.a_2 - -A-(\mu_e-\mu_p)B.a_3 \quad (5)$$

$$E.a_4 = A+(\mu_e+\mu_p)B.a_4 \quad (6)$$

Let's note:

$$\mu = -(\mu_e+\mu_p)$$

and

$$\mu' = -(\mu_e-\mu_p)$$

μ and μ' are both positive and can be approximated to the *Bohr Magneton*.
By solving the previous set of equations (3, 4, 5 and 6), we get the following solutions:

- $|I\rangle = |{+}{+}\rangle$ and $E_I = A + \mu B$
- $|II\rangle = |{-}{-}\rangle$ and $E_{II} = A - \mu B$
- $|III\rangle = \frac{1}{\sqrt{2}}(|{+}{-}\rangle + |{-}{+}\rangle)$ with

$$E_{III} = A\{-1 + 2\sqrt{1+\frac{\mu'^2B^2}{4A^2}}\}$$

- $|IV\rangle = \frac{1}{\sqrt{2}}(|{+}{-}\rangle - |{-}{+}\rangle)$ with

$$E_{IV} = -A\{1 + 2\sqrt{1+\frac{\mu'^2B^2}{4A^2}}\}$$

E_I energy starts from A and goes up linearly with B (μ factor). E_{II} energy starts also from A but goes down linearly with B ($-\mu$ factor).
Zeeman energy curves are represented in fig.2.

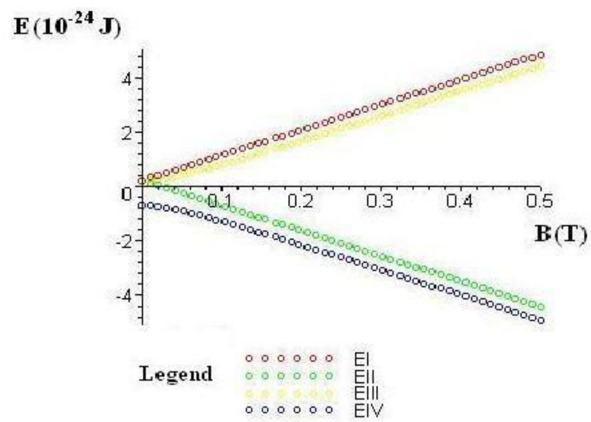

Figure 2: Zeeman diagrams

3.2 Theoretical calculation

The para state mentioned in the introduction corresponds to opposed spins of electron and proton which is precisely the state: $|III\rangle = \frac{1}{\sqrt{2}}(|{+}{-}\rangle + |{-}{+}\rangle)$ with E_{III} energy.
While for the ortho state, spins of electron and proton have the same direction of the permanent magnetic field B. Thus, it is the state $|I\rangle = |{+}{+}\rangle$ having E_I energy.
Therefore, the produced field by permanent magnets allows hydrogen atoms to transit from $|III\rangle$ state to $|I\rangle$ state and provides additional energy of:

$$\Delta E = E_I - E_{III} = 2A + \mu B - \sqrt{4A^2 + \mu'^2B^2} \quad (7)$$

Using the numeric values of A ($A = 2.317\times10^{-25}\,J$), μ and μ'

($\mu_e = -9.28\times10^{-24}\, J/T$; $\mu_p = 1.41061\times10^{-26}\, J/T$) [ref.5], one can draw the curve of ΔE as a function of B field. For a magnetic field between 0 and $2T$, results are shown in fig.3.

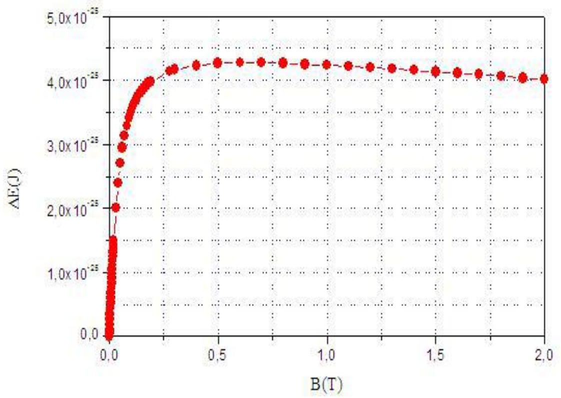

Figure 3: Magnetic field impact on atom energy

As seen, ΔE attains a large maximum and then declines gradually.

Table (1) shows precisely values of B field which improve ΔE value (the difference between E_1 and E_3). ΔE attains its maximum for a magnetic field of $0.6T$.

$B(Tesla)$	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
$E_1(10^{-24}J)$	30.11	39.38	48.65	57.91	67.18	76.44	85.71	94.98	104.24	113.51
$E_3(10^{-24}J)$	25.95	35.15	44.38	53.64	62.91	72.18	81.46	90.74	100.02	109.31
$\Delta E(10^{-24}J)$	4.17	4.23	4.26	4.27	4.27	4.26	4.25	4.24	4.22	4.20

Table 1: $\Delta E = f(B)$

3.3 Visual simulation

We will look at the effect of permanent magnets on the molecular structure of fuel using a $2D$ simulation software that takes into account the magnets shape and dimensions and simulates the magnetic field [ref.6]. The pipeline and the two permanent magnets have the following characteristics which are summarized in Table (2).

	μ	Dimensions (mm)	Depth (mm)	B(Tesla)
Permanent magnet	1.1	40*10	20	1.3
Circular pipeline	1.0	99*8	8	0.0

Table 2: Magnets and pipeline parameters

Thus, fig.4 describes clearly our application device.

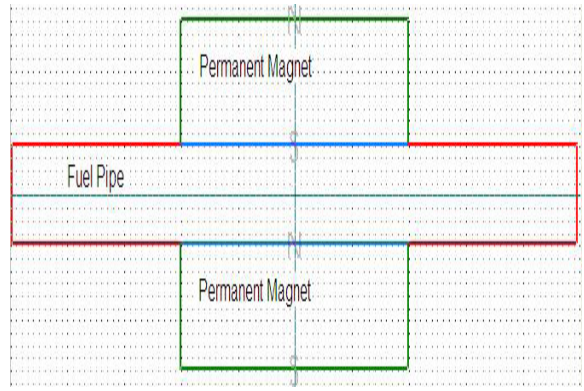

Figure 4: Fuel pipe surrounded by two permanent magnets

In order to enhance the magnetic field in the pipeline, the two magnets must be oriented in the same direction $(NS - NS)$. Fig.5 shows the magnetic flux density for the model. Drawing of the horizontal line passing through the center of the fuel pipe and the measurement of the magnetic field inside the line give the curve represented in fig.6.

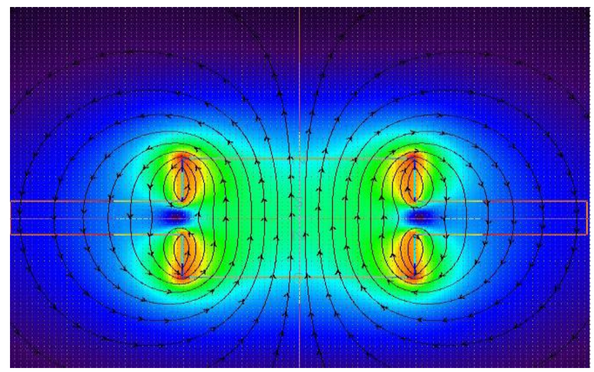

Figure 5: (Color online) Magnetic flux density

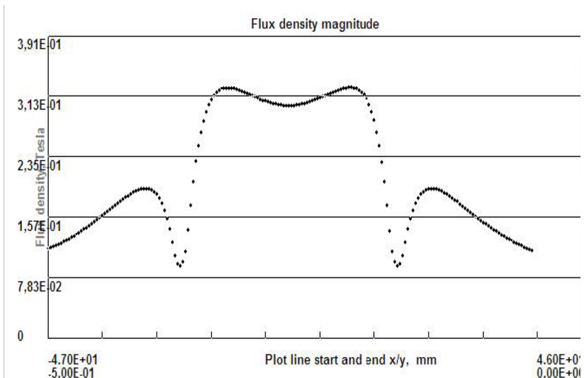

Figure 6: Magnetic field homogeneity in the pipeline

As observed, with two permanent magnets generating a field of $1.3T$, the effective field inside the pipe is only about $0.3T$. This is due to the magnets shape and demagnetization fields.

IV. Performance test

The magnetic fuel saver is tested in a $50ppm$ diesel vehicle. The device has been easily installed [see fig.7].

Figure 7: Fuel device installation on a diesel car

Different measurements were taken before and after installation including car speed, milage, fuel consumption.

Fig.8 shows fuel consumption curves before and after installation.

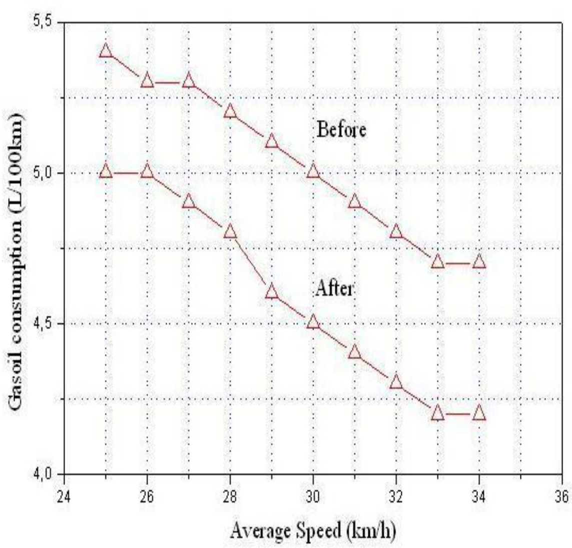

Figure 8: Fuel consumption before and after magnetic saver installation

The results prove a real energy saving of 10% over a period of six months [see fig.9]. No secondary effects of the field has been detected since the magnetic field extent does not exceed few centimeters.

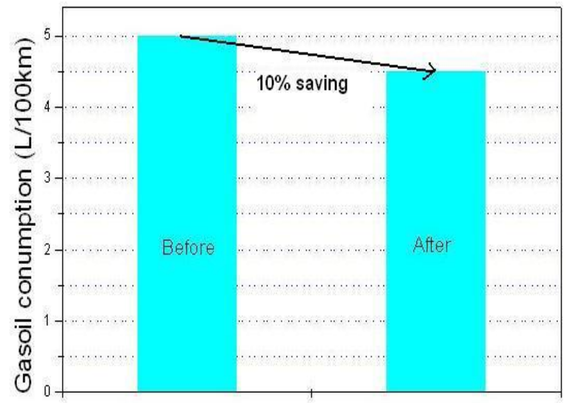

Figure 9: Fuel saving

V. Magnetic treatment benefits on hydrocarbons

Conceivably, the transformation of hydrogen from its para state to its ortho state might play a crucial role in separating and ordering hydrocarbon molecules. The magnetic field reduces the inter-molecular stress by increasing the molecules vibration frequency. Indeed, in the absence of external magnetic field, hydrocarbons combine in groups to form complex structures. This prevents oxygen atoms to attain carbon atoms in the center, making the oxidation very difficult. Whereas, in the presence of a strong magnetic field, the molecules become more energetic, start to vibrate and thus break bonds of hydrocarbon structures making them uniform and independent. As a result, the molecules of fuel are organized, ordered and become distant from each other (see fig.10).

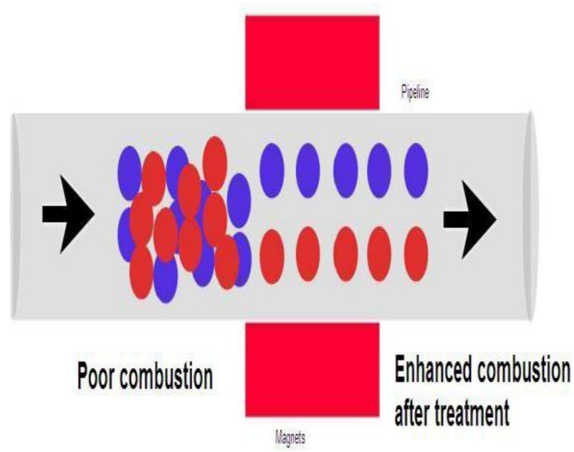

Figure 10: Schematic presentation of magnetic field impact on hydrocarbons

As known, combustion is none other than the redox

reaction that occurs between oxygen and hydrocarbons [ref.7]. In the normal state (ie in the absence of magnetic field), the oxygen atom/molecule attack primarily the hydrogen atoms/molecules. But they access partially to carbon molecules that are trapped at the center of molecule cages. Combustion is, therefore, incomplete and inefficient. Under the magnetic field, hydrocarbons are ordered and distant from one another. They are more accessible to oxygen atoms/molecules. Thus, the redox reaction has perfect conditions to take place and makes the combustion more efficient. This efficiency is automatically translated as energy improvement and therefore as economic savings.
In parallel, because the magnetic field makes the combustion more complete, the combustion reaction occurs more than before. The amount of CO_2 produced increases significantly. Maximizing CO_2 is equivalent to the minimization of the quantity of unburned hydrocarbons HC and CO_2 which can be considered as an additional reserve of fuel. If the right conditions are present, HC and CO can also oxidize which improves the combustion energy. This helps reducing pollutant emissions. In parallel, if all the molecules of oxygen react with hydrocarbons, there will be no more available oxygen to form nitrogen gas.
At the end, the magnetic field transforms hydrocarbons and remove unburned deposits from fuel injectors. Therefore, life time of burners increases and nozzles do not require clean up and maintenance.

VI. Conclusions and perspectives

The present study permits to elucidate the magnetic field role in the fuel combustion. Exploitation of these results could be improved especially if we work more on the shape and geometry of magnets to further increase the magnetic field.
The permanent magnet fuel saver has many benefits both in terms of economy and ecology. It makes energy savings because it increases combustion efficiency. Also, it reduces pollutant emissions and avoids harmful gas. Last but not least, it prevents fuel buildups, increases equipment life time and reduces maintenance cost.
To summarize, we have established that the magnetic fuel saver transforms the hydrogen molecule from its para form (diamagnetic) to ortho form (paramagnetic). the fuel saver was tested and performance results were proven. Further studies on hydrocarbons are needed to test the hypothesis regarding the transformation of these molecules from their para state to their ortho state.
At the end, the scope of this magnetic treatment can be very broad. It can be used everywhere, where there is combustion of any type of fuel. It can be applied in all kind of vehicles, in burners (e.g. heating, bathroom, bakery, industrial) and home appliances (e.g. gas cookers, oil heaters, boilers), as well as the industrial ones equipped with engines. It can also work in other industrial furnaces (glass, ceramic, iron and color metallurgy).

References

[1] *Physics of magnetism and magnetic materials*, K.H.J Buschow and F.R. De Boer, Editions Kluwer Academic Publishers, publication 2004.

[2] *Magnétisme I- Fondements*, Etienne du Trémolet de Lacheisserie, Editions EDP Sciences, publication 2000.

[3] *Magnétisme II- Matériaux et Applications*, Etienne du Trémolet de Lacheisserie, Editions EDP Sciences, publication 2000.

[4] *Feynman Lectures on Physics* Vol I, Richard P. Feynman, American Journal of Physics, Volume 33, Issue 9, pp. 750, 1965.

[5] *Introduction to Quantum Mechanics* (2nd ed.), David J.Griffiths, Published by Benjamin Cummings, April 10, 2004.

[6] *www.vizimag.com*, Modeling software.

[7] *Combustion Fourth edition*, Irvin Glassman - Richard A. Yetter, Editions Elsevier, publication 2008.

