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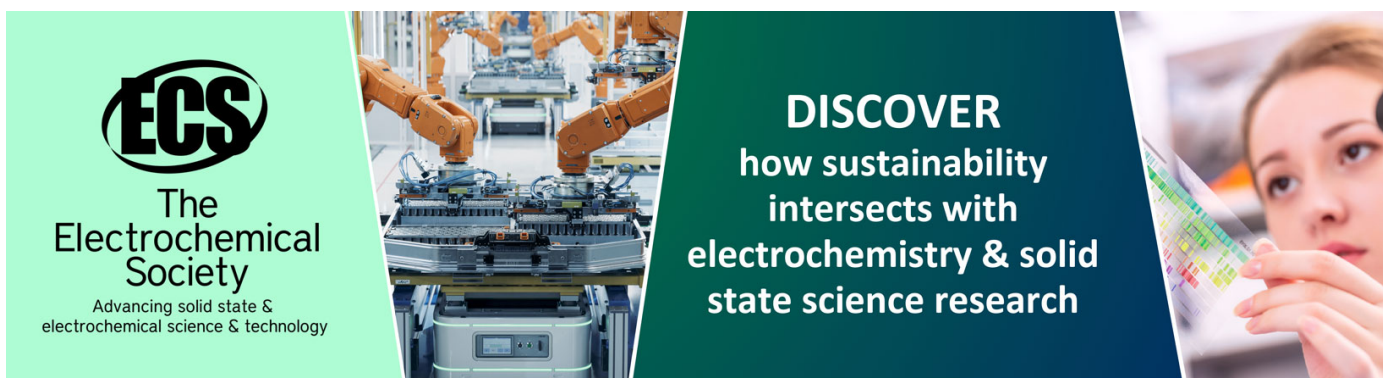
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Investigation of gas fuel combustion efficiency at magnetic field treatment

A Sinitsyn^{1*}, D Rusakov¹, V V Izrantsev², S A Kravchenko² and G A Konrashkova²

¹Vologda State University, Lenina Street 15, Vologda, 160000, Russia

²Peter the Great St. Petersburg Polytechnic University,
Polytechnicheskaya 29, Saint Petersburg, 195251 Russia

* Corresponding author: sinitsyn.science@mail.ru

Abstract. This paper presents an investigation of gas fuel combustion efficiency at magnetic field treatment. Equipment used for magnetic fuel activation is analyzed. Basing on the conducted analysis, the authors developed a laboratory setup and special technique for investigation of magnetic field impact on gas fuel characteristics during its combustion. The obtained experimental results are presented.

Keywords: magnetic activation, gas fuel, ortho-modifier, neodymium-iron-boron.

1. Introduction

Nowadays decreasing of oil and gas fuel consumption is of urgent market and scientific interest, due to its cost growth and decreasing of world reserves. Studying of regularities and mechanism of various types of fuel combustion, including ecological aspects, are presented in a vast number of paper, but a lot of problems still remain unsolved [1-17]. The surveys concerning efficiency increase for organic fuel combustion presented in [18,19] are dealing only with the problem of initial air-fuel mixture treatment. Magnetic fuel activation is one of the new technologies in this research area, whereas it is extensively used in other science fields [20-22].

In 1950s S. Raskin found that there was a special construction of fuel activators, which resulted in improvement of internal combustion engine characteristics. In order to increase intensity of hydrocarbon chain breakage in fuel, he used a special magnetic-neodymium alloy. This alloy is used at magnetic water treatment device described in [23, 24]. Further, a number of scientists [25-27] improved his results for magnetic resonance theory. They used the special neodymium composition as a catalytic material for hydrocarbon chain breakage in fuel. They have proved that magnetic fuel treatment might change the molecular fuel structure. While addressing the issue concerning pollution abatement and hazardous emission decreasing for fuel combustion at car engines, a SMF product was invented. According to scientific classification, SMF is a magnetic-frequency resonance device. These devices are widely used in various scientific areas, but magnetic resonance principles used in SMF for hydrocarbons ionization are unique.

Scientific group of Kherson State Marine Academy carried out some tests of magnetic fuel activators for 6ChN25/34 engine. The tests were carried out using operating process monitoring and diagnostic system D4.0H (DEPAS). The object under test was steady-state operating mode ($n=411 \text{ min}^{-1}$)



with constant cyclic fuel supply, with various magnetic activators. In addition, the magnetic activators were placed in various parts of engine fuel system in order to achieve maximum efficiency. The maximum effect was achieved when the five activators were placed before fuel pump of high pressure [28]. The similar principle of discrete-gradient fuel treatment is described in the Ukrainian patent [29].

The known devices are "Powermag", "Soyuzintellect", inventions are "Ecomag-10G", "Stat-7", "Pomazkin Apparatus". However, all patents for these devices became expired and are not supported now. These devices are based on medium changes which occur during its movement in magnetic field. According to the manufacturer's data, the total engine cleaning from soot and coke takes place, carbon formation on the valves, piston rings, cylinder walls is avoided, toxic exhaust emission to the atmosphere reduces, noise and vibration levels decrease. However, despite the deceptive simplicity of device design and treatment availability, the announced positive effect of exploitation is difficult to obtain.

Ortho-modifier OMT-5 developed by LLC "Innova-Orto" (Russia) is one of the modern devices for magnetic fuel treatment. A number of Russian companies have tested this device. According to test reports, the following results were obtained: the engine start and warm-up time in winter period was decreased; the accumulator launch-load became less; engine operation at low temperature and high humidity was improved; fuel consumption was decreased for 15%, oil consumption was decreased for 12%; engine smoking was decreased; operating productivity was increased for 7%.

Magnetic modifier "ortho-modifier OMT-5" by LLC "Innova-Orto" satisfies the requirements of Russian Specifications 4591-005-90449293-2011 and is classified as fit for exploitation. However during the Specifications review the general guidelines and standards for the magnetic activator were not revealed. This says that nowadays there are no existing normative documents, which standardize the device and its operation. Thus, the further investigations and development of the similar devices should be aimed at formation of general specifications.

2. Materials and methods

We investigated impact of magnetic field on gas characteristics during its combustion through the example of fuel activator ortho-modifier OMT-5.

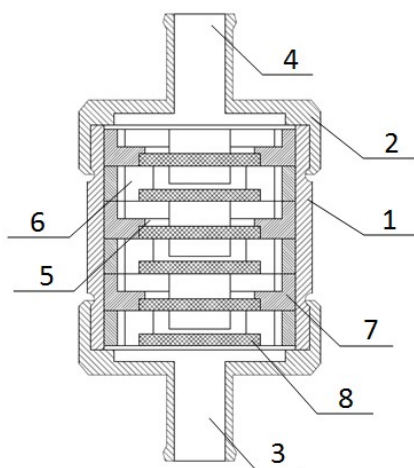


Figure 1. A device for magnetic medium treatment ortho-modifier OMT-5:

- 1 - casing,
- 2 - cap,
- 3 - gas input connection,
- 4 - gas output connection,
- 5 - magnet module,
- 6 - zigzag flow channel,
- 7 - washer,
- 8 - magnet.

According to Figure 1, the device consists of casing 1, caps 2 are connected from both sides of the casing, each of them having gas input 3 and output connections 4 from modifier of 8 mm diameter. Magnet modules 5 located in the casing are sources for magnetic field. Due to specific modules location, a zigzag flow channel 6 is formed. Magnet module 5 consists of washer 7 and magnet disk 8.

We investigated impact of magnetic field on gas characteristics during its combustion at a designed laboratory setup.

Gas cylinder for portable gas devices is used as a fuel source. One cylinder is intended for tests of neodymium-iron-boron magnetic disks, the other one is for testing of copper-nickel non-magnetic disks. Gas composition was the following: propane, isobutane, butane.

It corresponds to Russian State Standard GOST 20448-90 "Hydrocarbon liquid fuel gases for domestic consumption", European Standard EN 417, meets the requirements ISO 9001, ISO 14001.

Figure 2 presents laboratory setup for investigation of magnetic field impact on gas characteristics during its combustion.

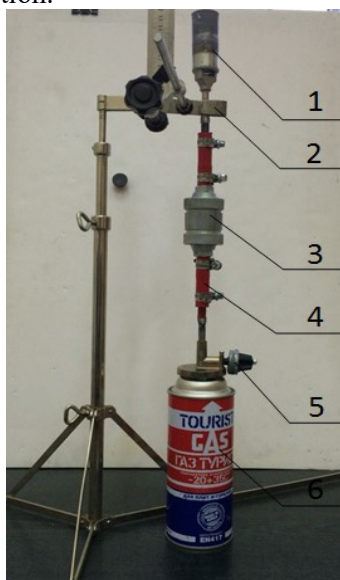


Figure 2. The laboratory setup for investigation of magnetic field impact on gas characteristics:

- 1 - gas torch,
- 2 - mount pillar,
- 3 - ortho-modifier OMT-5,
- 4 - gas hose,
- 5 - tap with a clamp,
- 6 - gas cylinder.

According to Figure 2, ortho-modifier 3 is connected using hose 4 to the gas cylinder 6 from one side, and to the gas torch 1 from the other side. Mount pillar 2 serves as a support for the setup as a whole.

The setup operates in the following way: The flow of the treated gas from gas cylinder enters the casing through the input connection. In the casing the initial flow is divided into two. The flows move towards each other and intensively collide with each other. Further, the flow turns at a set angle α . Consequently, the treated gas moves in a zigzag way along the flow channel perpendicularly to magnetic field force lines. Further, the flow is turbulized by force of hydrodynamic resistance, caused by the shape of the flow channel. In a turbulent flow the groups of molecules are rubbed and collide with each other. This results in breakage of several groups, viscosity reduction, gas volume ratio increase and, finally, the fuel activity in oxidation reactions increases. Magnetic field-treated gas comes out of the casing through the output connection and enters the torch [25].

Work sequence at the laboratory setup for investigation of magnetic field impact on gas characteristics is as follows:

1. Installation of neodymium-iron-boron magnetic disks (copper-nickel non-magnetic disks) at washers of the ortho-modifier OMT-5.
2. Formation of modules with flow channel and their fixation at the modifier.
3. Caps connection to the modifier casing.
4. Tap with a clamp connection to the modifier with the help of two clamps and a hose segment.
5. Gas torch connection to the modifier with the help of two clamps and a hose segment.
6. Weighting of the gas cylinder using electronic balance.
7. Writing the obtained data in Table.
8. Gas cylinder connection.
9. Gas torch mounting on the mount pillar with target height.
10. Opening of valve with fixing unit.
11. Simultaneous ignition and timer turn on.
12. Combustion time is three minutes.
13. Valve closing.
14. Gas cylinder dismounting and weighting.
15. Writing the obtained data in Table.

The tests are performed several times. Further, the magnetic disks at modifier modules are replaced by the non-magnetic ones, the tests are repeated.

3. Results and discussion

Figure 3 presents a chart for gas cylinder mass change when using neodymium-iron-boron magnetic disks, and copper-nickel-non-magnetic disks at washers of the ortho-modifier OMT-5.

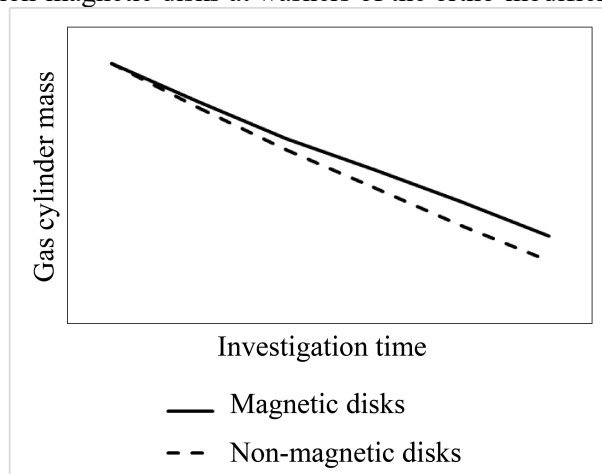


Figure 3. Gas cylinder mass change chart.

The performed tests showed that the examined ortho-modifier OMT-5 is more efficient for gas combustion when using neodymium-iron-boron magnetic disks, at this gas consumption reduces for 12%.

We used the following free torch schemes for describing the shape and character of the flame: laminar and turbulent [25]. Figure 4a presents laminar flare in comparison to torch flare. The torch flare is from modifier with neodymium-iron-boron magnetic disks.

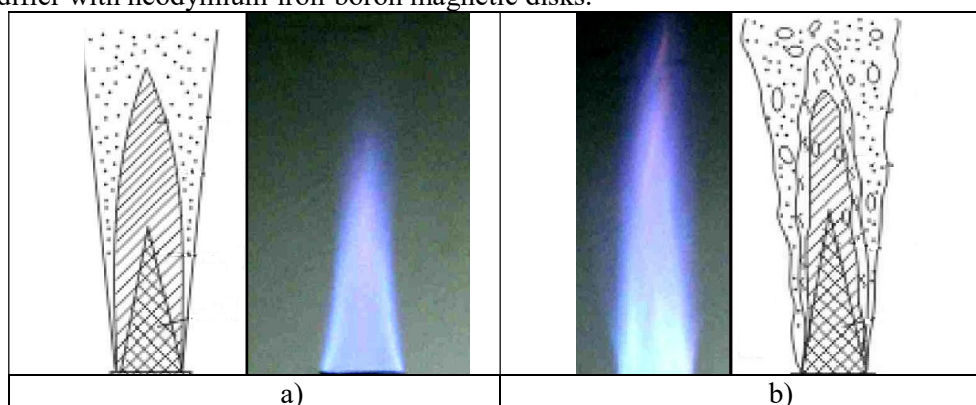


Figure 4. Comparison between flame shapes:

- a) laminar flare with non-magnetic disks
- b) turbulent flare with magnetic disks.

According to Figure 4a, the flame has an increased brightness and noticeable conic front. Also the flame has distinct boundaries which are common for laminar shape.

Figure 4b presents turbulent flare in comparison to torch flare. The torch flare is from modifier with neodymium-iron-boron magnetic disks. According to Figure 4b, there is no noticeable conic front of flame, at this separate flare particles are observed, divided by flame impulses. The combustion process occurs throughout the volume, an increased intensity of flame is observed, by analogy to results from [26, 27]. Figure 5 presents comparison between torch flames when using magnetic and non-magnetic disks.

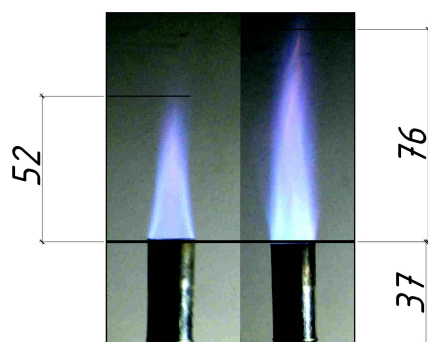


Figure 5. Comparison between torch flames when using magnetic and non-magnetic disks.

4. Conclusions

It was experimentally shown that usage of neodymium-iron-boron magnetic disks in the ortho-modifier cassette reduces gas consumption for 12%, at this the magnetic field has an impact on flame character.

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