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HOMOGENIZED AVIATION BIOFUEL

Innovative modification of aviation homogenized fuel blends and biofuels based on the dynamic dissolution of combustible gases

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This book examines the development and implementation of innovative technical solutions aimed at the comprehensive optimization of fuel mixture preparation and delivery processes for thermodynamic equipment. Particular emphasis is placed on improving the efficiency of fuel preparation systems and associated fuel supply technologies used in combustion chambers of diesel engines, boilers, diesel generators, gas turbines, and other thermodynamic systems.

The article highlights the growing importance of integrating technological developments with practical implementation strategies, where the effectiveness of engineering solutions is combined with the capabilities and interests of investment partners. Special attention is given to the role of multidisciplinary approaches that combine expertise in technology development, engineering design, and investment support throughout all stages of project implementation.

The relationship between technological development stages and targeted investment strategies is considered as an important factor influencing the successful realization of innovative projects. The article further emphasizes that a comprehensive approach, combining engineering innovation, systematic project planning, and investment coordination, represents a key condition for achieving technological efficiency and commercial success in modern energy and industrial sectors.

Keywords: *Biofuel; Aviation biofuel; Fuel modification; Fuel activation; Homogenized fuel blend; Aviation fuel blend; Combustible gases; Gas dissolution; Dynamic dissolution; Vortex generators; Hydrocarbon fuels; Fuel mixtures; Chemical reactions; Combustion science; Explosion theory; Combustion analysis; Combustible gas temperature; Steady combustion regimes; Ideal gas mixtures; Equilibrium state*

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SCIENTIFIC FOUNDATIONS OF COMBUSTION AND FUEL ACTIVATION TECHNOLOGIES

Figure 1. Innovative vortex generators for the dynamic dissolution of combustible gases in liquid hydrocarbon or biofuel

In mechanics and continuum physics, combustion theory occupies a unique position due to a number of distinctive features that are fundamentally characteristic of this scientific field.

These aspects were already discussed in the introduction; here we will examine simple specific examples illustrating the main concepts of combustion and explosion science. In addition, the first chapter provides essential reference information on chemical kinetics and molecular physics, which will facilitate reading for those becoming acquainted with the subject of this book for the first time.

The progression of combustion chemical reactions is extremely sensitive to minor changes in the initial and boundary conditions of the problem, to heat and mass transfer conditions, to combustion chamber geometry, and so on. Transitions from one regime to another are often perceived as discontinuities or abrupt changes in the process. This may manifest as an explosion, ignition, or flame extinction.

The first chapter presents the theory of thermal explosion proposed by N. N. Semenov, whose work marks the beginning of the history of modern combustion theory. It clearly formulated the condition for the occurrence of a thermal explosion as the result of the disappearance of a stationary solution for an exothermic reaction process under heat removal conditions. The critical reaction regime was identified as the branching point of solutions, and a small parameter characterizing the asymptotic nature of the solution was determined.

An analytical study of the development of a chemical reaction accompanied by heat release in a laminar gas flow and under intensive mixing of reaction products with the initial substances revealed the hysteresis-dependent nature of combustion theory solutions. For example, by increasing the initial temperature of a combustible gas, a point can be reached where ignition occurs; however, to extinguish the gas burning at a high temperature, the initial temperature must be reduced significantly below the value at which ignition took place.

This example of an ideal stirred chemical reactor, considered in the first chapter, also illustrates a fundamental property of the combustion process-the possibility of the existence of multiple stationary combustion regimes under the same specified external parameters.

This ambiguity significantly distinguishes stationary processes involving continuous supply of reactants and removal of reaction products from a static thermodynamic equilibrium situation.

As will be shown below, a reacting mixture of ideal gases is characterized by a single equilibrium state smoothly dependent on its parameters.

The first part of this article also discusses flame stability – a problem closely related to the fundamental concepts of combustion theory and highly important for practical applications of the theory.

Figure 2.

The significant features of explosive reactions were noted as early as the middle of the last century by Bunsen (R. W. Bunsen) and Van't Hoff (J. H. Van't Hoff). Depending on temperature, the reaction rate changes very sharply. For example, at room temperature and atmospheric pressure, hydrogen and oxygen practically do not react over many years.

As the temperature increases, the reaction rate remains immeasurably small up to a certain critical value, which depends on the experimental conditions. For example, for a stoichiometric hydrogen–oxygen mixture-the so-called “detonating gas mixture”-at atmospheric pressure, this critical value is approximately 550 °C.

Figure 3.

At higher temperatures, even if the temperature exceeds the critical value by only a few degrees, the detonating gas mixture reacts very rapidly, the pressure rises sharply, and the vessel may rupture. The reaction rate during such an explosion is so high that researchers of the last century were unable to study its kinetics in detail.

There are two methods for carrying out an exothermic chemical reaction in a flow of pre-mixed gases.

The first method consists of supplying a mixture of fuel and oxygen or air into a cylindrical combustion chamber from one end in such a way that it moves in parallel layers, meaning that the velocity of all gas particles within a given cross-section, except those located directly near the chamber walls, is practically identical. If the flow velocity is sufficiently high so that diffusion and heat transfer in the direction opposite to the flow are negligible, then each gas element behaves in the same manner as in a reacting stationary medium under constant pressure.

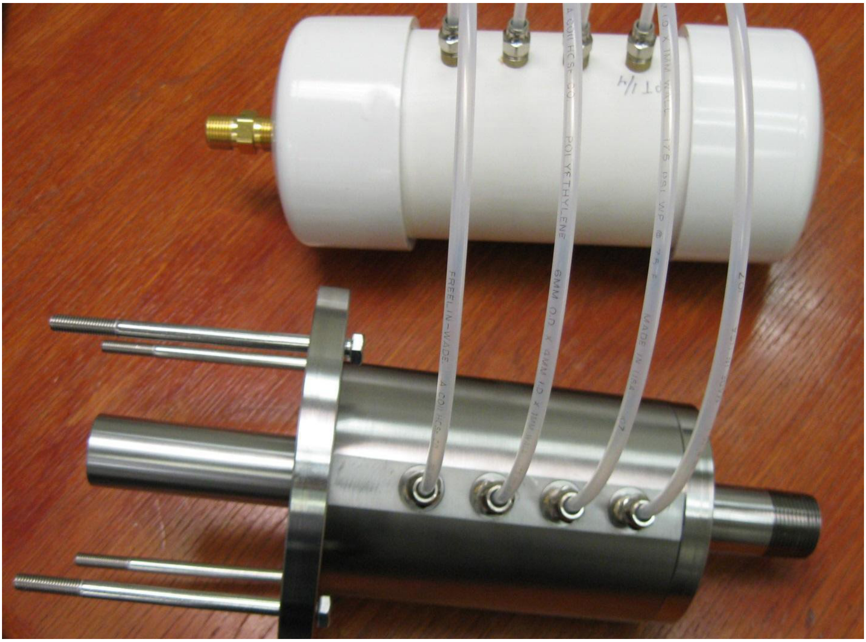

Figure 4.

As the gas moves along the tube, provided heat loss is small, its temperature continuously increases due to the heat released during the reaction. The dependencies of temperature and reactant concentration on the coordinate along the gas flow correspond to the dependencies of temperature and concentration on time during a reaction occurring in a stationary medium.

Each leading point ensures the development of subsequent sections of the flame-front surface behind it; flame regions convex with respect to the combustible gas tend, according to Huygens' principle, to increase the overall flame-front surface area and contribute to increasing the overall combustion rate of the combustible gas in turbulent flow.