Технічні науки

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APPLICATIONS OF DYNAMIC HOMOGENIZATION TECHNOLOGY

Real-Time Homogenization of Various Liquid Flows in Pipelines; Potential Applications of Dynamic Homogenization Technology in Fuel Systems of Thermodynamic Equipment and Smart Vehicle Engines

Summary. *This article provides a brief overview of key fragments of an integrated technology that determine its applicability across various technical and commercial scenarios.*

In all cases, the focus is on a single type of device that performs dynamic mixing and simultaneous dynamic homogenization of liquid and gaseous physical media.

The article explores all potential aspects of the technology and the device that implements it. Special attention is given to dynamic reagent-free homogenization as a fundamental integrative process that enhances the accuracy of non-contact monitoring of liquid conditions in pipelines. These pipelines can be monitored using aerial imaging or unmanned aerial vehicles (UAVs).

For the successful commercialization of this integrated technology, it is crucial to identify all viable implementation opportunities—specifically those where the technology is clearly in demand.

Key words: *Integrated Dynamic Homogenization Technology; Dynamic Mixing and Simultaneous Dynamic Homogenization; Liquid Physical Medium; Gaseous Physical Medium; Dynamic Reagent-Free Homogenization as a Fundamental Integrative Process Enhancing the Accuracy of Non-Contact Monitoring; Non-Contact Monitoring of Liquid Conditions in Pipelines; Diesel Engine as Part of a Diesel Generator Power System.*

Consideration of General Conditions Based on the Properties of the New Technology

In hydrocarbon liquid fuels, during storage, fuel agglomerates may form, which can later lead to issues with injection and uniform combustion. The higher the viscosity of the fuel, the greater the likelihood of agglomerate formation and other fuel heterogeneities. Therefore, for the implementation of the proposed on-line non-contact monitoring technology, it is essential to precisely assess the level of homogenization required.

A few general requirements and conditions:

As an example, consider a diesel engine as part of a diesel generator power system.

The dynamic homogenization system for fuel, for instance, is installed in the fuel system of the engine along the fuel pipeline between the engine's fuel pump and the engine's high-pressure pump.

As the fuel passes through the dynamic homogenization system, homogenization occurs within the flow based on the turbulence level. Afterward, in the high-pressure pump, the dynamic homogenization process is completed to the maximum possible volume and corresponding dimensional factor in a three-dimensional coordinate system.

The operation of the dynamic fuel homogenization system does not require any additional energy sources or structural elements.

The dynamic fuel homogenization system can also be used in processes and equipment for homogenization in parallel with fuel recirculation in storage tanks during fuel production and storage at refueling stations.

Consider the types of internal combustion engines in which the integrated dynamic fuel homogenization technology and fuel mixtures can be applied.

The dynamic homogenization system has minimal dimensions and an optimal geometric form, making it suitable for installation on any internal combustion engine.

Fig. 1.

Device for dynamic on-line homogenization of pipelines with a flow rate of up to 100 liters per hour and pressure ranging from 3 bar to 15 bar. As demonstrated by numerous tests, no pressure drop occurs in the pipelines during homogenization, and all pulsations and fluctuations are significantly smoothed out, without additional energy expenditure.

As seen in the figure, the device is very compact: the outer diameter is only 40 millimeters, with a working diameter of 30 millimeters, and the device length is 220 millimeters.

For comparison, let us consider industrial systems that can operate in fuel pipelines of large power plants, such as gas turbine power installations with capacities of 20 and 25 megawatts.

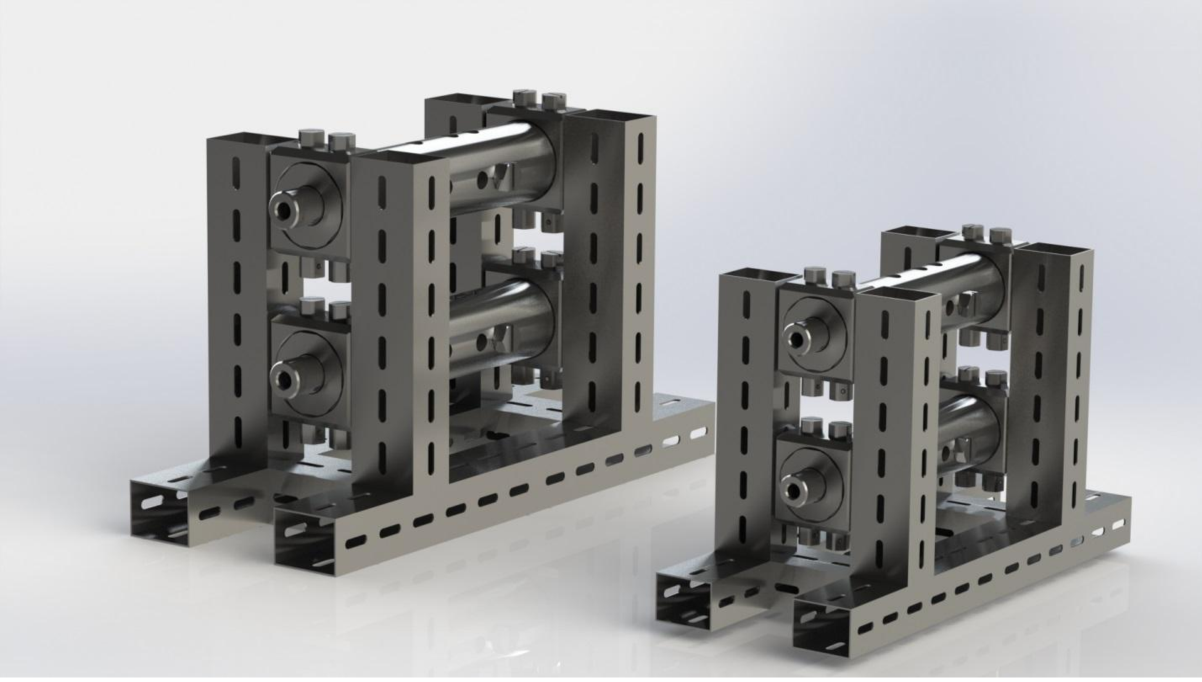

Fig. 2.

The figure shows on-line dynamic homogenization systems with a working diameter of 200 and 250 millimeters, designed for flow rates of 10,000 liters per hour and 15,000 liters per hour.

In such installations, the homogenizing system plays a multifunctional role, as in addition to stabilizing and standardizing the hydrodynamic parameters of fuel flow, it also addresses other critical issues, primarily those aimed at improving the efficiency of such equipment.

Recently, there has been a particularly urgent need to address the formation of fuel mixtures in the fuel pipelines of energy equipment, utilizing biofuels, ethanol, and especially methanol. These mixtures do not create toxic waste and, moreover, reduce the cost per unit of fuel.

For such fuels, if the mixture is formed with, for example, diesel fuel, homogenization plays a crucial role not only as a stabilizing factor but also as a factor preventing, for instance, water in the mixture from causing micro-explosions during evaporation, which could disturb the flame in the burner.

When the fuel mixture is homogenized, micro-capsules are formed in which the core, for example, of methanol, is encased in a shell of diesel fuel.

Upon injection, the core evaporates first, rupturing the shell into micro-particles no larger than 0.5–0.8 microns, which significantly improves the efficiency and completeness of combustion, leading to higher efficiency.

Most importantly, with this fuel mixture structure, the evaporation energy is not lost, resulting in an additional 1.5–2.5% fuel savings. With a flow rate of 10,000 liters per hour, this can save more than $100,000 annually per unit.

Modern engines equipped with a high-pressure pump can be fitted with a dynamic fuel mixture homogenization system with minimal modifications to the fuel system.

The dynamic homogenization system can be installed on both stationary internal combustion engines and internal combustion engines mounted on vehicles.

The dynamic homogenization system can be equipped with an additional system for forming two types of fuel emulsions: compressible emulsion and incompressible emulsion.

The dynamic homogenization system allows for the effective emulsification of up to eight additional components in the emulsion.

Without modification, the dynamic homogenization system can effectively dissolve combustible gases in the flow of liquid hydrocarbon fuel before injection into the combustion chamber, both in stationary internal combustion engines and in internal combustion engines installed on vehicles.

Dynamic homogenization is a highly versatile process that, with virtually no major adaptation efforts, can be applied to a wide range of equipment and virtually all types of liquid fuels.

Using dynamic homogenization technology, any type of liquid hydrocarbon fuel can be processed, including nearly all types of biofuels.

mixture based on gasoline can be processed, including mixtures with ethanol and methanol, as well as mixtures with various activating additives.

Diesel fuel comes in many variations, the properties of which differ significantly depending on climatic conditions.

For a comparative analysis of the basic types of diesel fuel in the U.S., the cleanest and lightest diesel fuel, No. 2, and the heaviest and most viscous diesel fuel, No. 6, require homogenization before injection, especially during the winter months.

When considering various types of fuel oil, particularly those with high sulfur content, it becomes clear that only the homogenization of standard fuel oil, without the addition of lighter fuels, allows for a fuel consumption reduction of up to 10% due to the benefits of homogenization.

Recently, new types of regenerated fuel have also emerged, based on all types of diesel fuel and fuel oil, mixed with biofuels and other products from the processing or regeneration of hydrocarbon raw materials.

An example of such fuel mixtures is JP-8 and JP-10 in the U.S., which also require homogenization and can, through homogenization technology, form the basis for homogenized fuel mixtures.

Dynamic homogenization technology can process any type of liquid biofuel.

Dynamic homogenization technology can process any type of biofuel composition.

Although gasoline is the most homogeneous type of liquid fuel, due to the reasons for its use, primarily as a blend with ethanol, where the ethanol content is at least 10-15%, homogenization of gasoline and its blends has also become relevant.

Gasoline-based fuel mixtures, such as gasoline-ethanol and gasoline-methanol blends, can experience gravitational separation of water from the hydrocarbon portion of the fuel mixture during long-term storage.

The dynamic homogenization system for gasoline engines using gasoline-ethanol or gasoline-methanol blends as fuel is installed between the fuel pump and the engine's high-pressure pump.

During the passage of the fuel mixture, in which water has separated from the gasoline, through the dynamic homogenization system, homogenization occurs within the flow at the turbulence level. Afterward, in the high-pressure pump, the dynamic homogenization process is completed in terms of volume and micron-scale dimension in a three-dimensional coordinate system.

During the homogenization process, water in the form of micro-droplets is evenly distributed throughout the hydrocarbon fuel mixture. Subsequently, the mixture transforms into a micro or nano-emulsion.

According to the test results, the emulsion obtained using the dynamic homogenization system reduces the soot concentration in exhaust gases by 97%, and the level and rate of heat release increase by at least 35%.

The installation of the dynamic homogenization system on a gasoline engine does not require any original additional components, and no structural changes are needed in the engine itself.

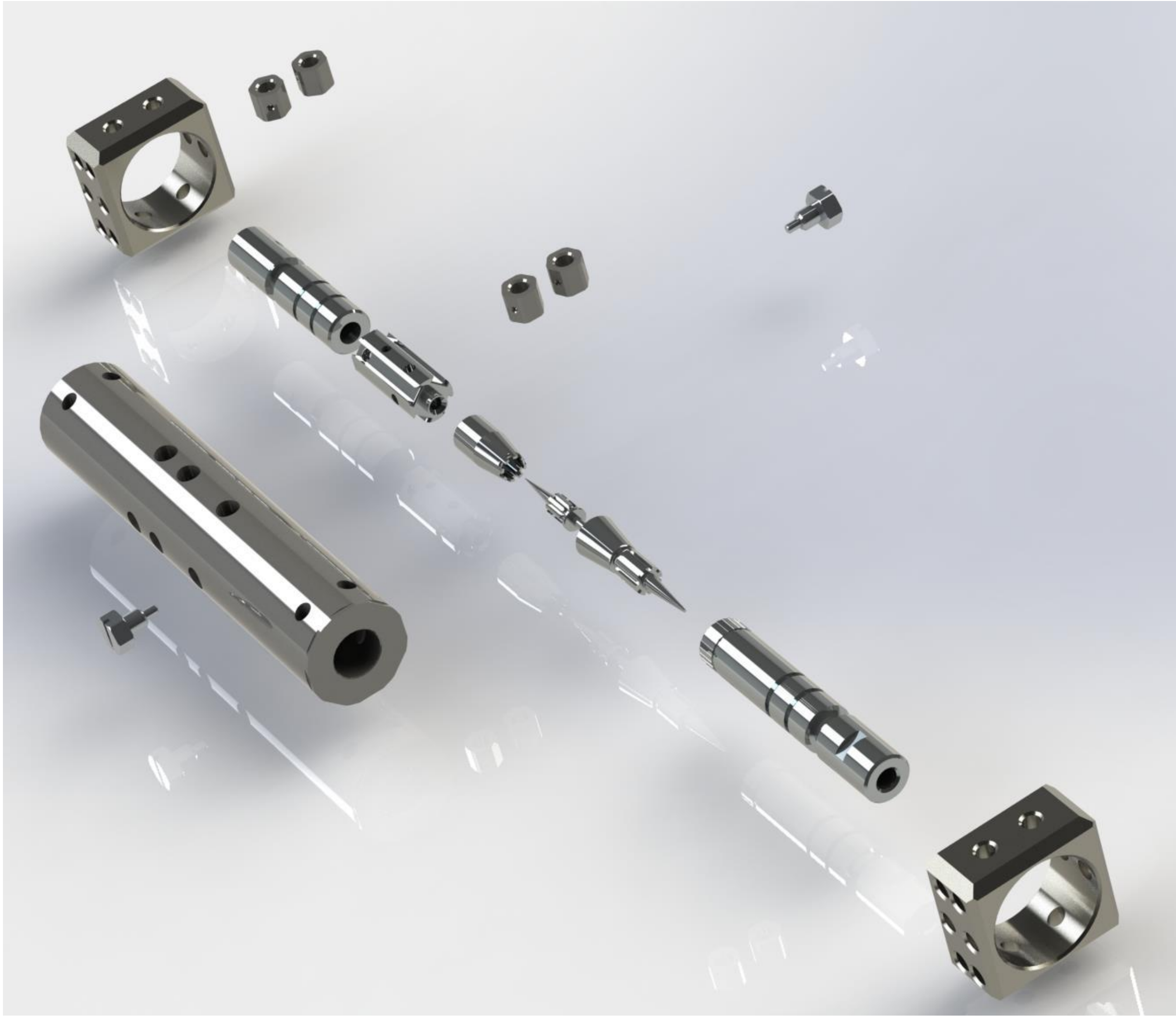

Fig. 3.

Device for online homogenization of gasoline and gasoline-based fuel mixtures for engines with a flow rate of 45 liters per hour and a working diameter of 25 millimeters. The figure shows the device in disassembled form.

From the figure, it is clear how technologically advanced the device is, primarily because all internal components and the casing form a system of coaxial cylindrical and conical surfaces. For all of them, the casing serves as a specific gauge, determining the position of each part and ensuring the accuracy of all working channels of the device. This is achieved through dimensional combinations that enable the so-called Bernoulli effect and ensure the necessary level of cavitational breaks in the flow of the homogenized fuel or any other technological and working liquids.

For much more viscous diesel fuels and fuel compositions, the need for homogenization is even more evident, both for pure diesel fuel and for mixtures based on diesel fuel and methanol, as well as emulsions of diesel fuel and water, of both types – such as water-in-oil emulsions with water content not exceeding 20%, and oil-in-water emulsions with a water content of up to 50%.

Significant difference in viscosity between these materials.

The dynamic homogenization system for fuel mixtures can prepare a high-quality, homogeneous blend of diesel fuel and ethanol or methanol within fractions of a second, directly within the pipeline, and in any required proportion.

The dynamic homogenization system in diesel engines, using a fuel mixture of diesel fuel and ethanol or a mixture of diesel fuel and methanol, is installed between the fuel pump and the high-pressure pump of the diesel engine.

As the fuel mixture, in which water has separated from the gasoline, passes through the dynamic homogenization system, homogenization occurs within the flow at the level of turbulence. After this, the process of dynamic homogenization is completed in volume and at a dimensional factor within the three-dimensional coordinate system in the high-pressure pump.

During the homogenization process, water in the form of micro-droplets is evenly distributed within the hydrocarbon mixture of the fuel, and thereafter, the mixture is transformed into a micro or nano-emulsion.

According to the results of tests on emulsions obtained with the dynamic homogenization system, the concentration of soot in exhaust gases is reduced by 97%, and the level and rate of heat release increase by at least 35%.

No additional original elements are required for the installation of the dynamic homogenization system on a diesel engine, and no structural modifications are needed in the engine itself.

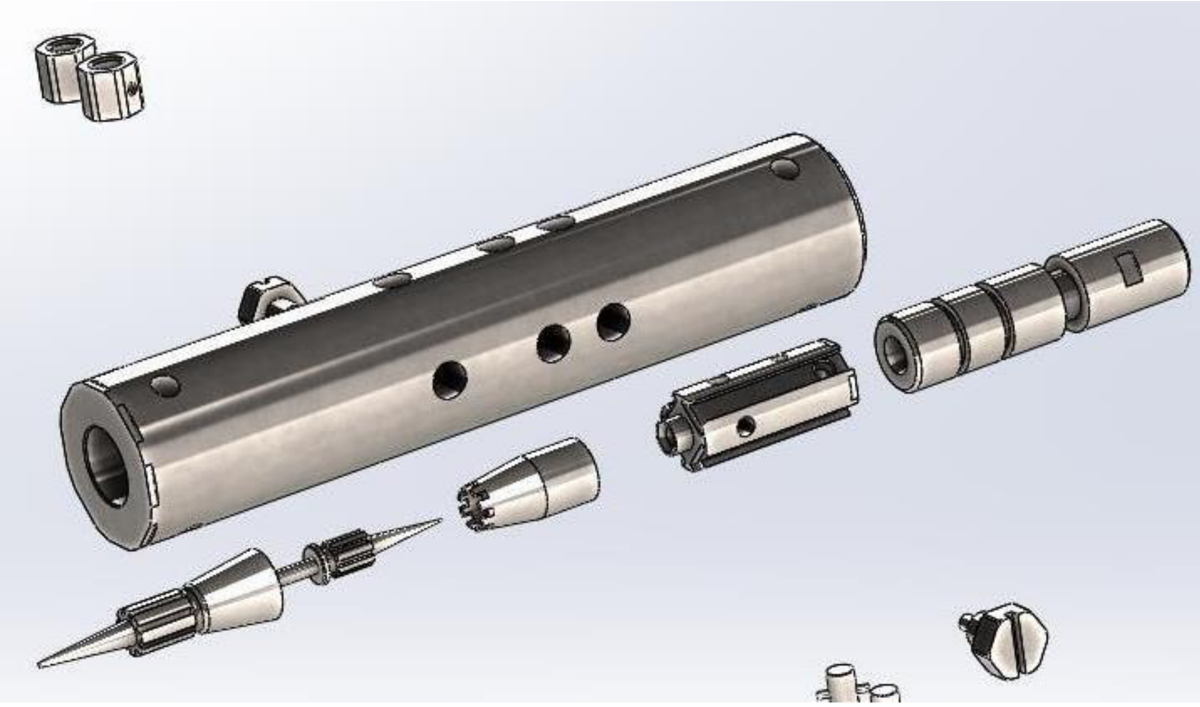

Fig. 4.

Internal components of the device; all working surfaces are coaxial, and there are no moving parts in the design. Thanks to the mutual coaxiality, it is possible to achieve the precision of all working channels at the level of 25 microns, with a maximum tolerance of 1 micron.

List of References and Patent and Licensing Materials:

Appendix 1

United States Patent Application	**20180162377**
Kind Code	**A1**
COLAVINCENZO; David D.	**June 14, 2018**

Hybrid Commercial Vehicle Thermal Management Using Dynamic Heat Generator

Abstract

A system and method are provided for hybrid electric internal combustion ***engine*** applications in which a motor-generator, a narrow switchable coupling and a torque transfer unit therebetween are arranged and positioned in the constrained environment at the front of an ***engine*** in applications such as commercial vehicles, off-road vehicles and stationary ***engine*** installations. The motor-generator is preferably positioned laterally offset from the switchable coupling, which is co-axially-arranged with the front end of the ***engine*** crankshaft. The switchable coupling is an ***integrated*** unit in which a crankshaft vibration damper, an ***engine*** accessory drive pulley and a disengageable clutch overlap such that the axial depth of the clutch-pulley-damper unit is nearly the same as a conventional belt drive pulley and ***engine*** damper. The front end motor-generator system includes an electrical energy store that receives electrical energy generated by the motor-generator when the coupling is engaged. When the coupling is disengaged, the motor-generator may drive the pulley portion of the clutch-pulley-damper to drive the ***engine*** accessories using energy returned from the energy store, independent of the ***engine*** crankshaft.

Appendix 2

United States Patent Application	**20180163649**
Kind Code	**A1**
Glugla; Chris Paul ; et al.	**June 14, 2018**

METHOD AND SYSTEM FOR PRE-IGNITION CONTROL

Abstract

Methods and systems are provided for improving the detection and mitigation of high speed pre-ignition. In one example, high speed pre-ignition is detected based on concurrent or sequential changes in an ***integrated*** knock sensor output in a knock window as well as a pre-ignition window. The high speed pre-ignition is addressed using cylinder fuel deactivation and/or ***engine*** load limiting to reduce the risk for run-away pre-ignition.

Appendix 3

United States Patent Application	**20180171890**
Kind Code	**A1**
KAMEI; Wittison	**June 21, 2018**

Dual Fumigation Homogeneous Charge Compression Ignition (DF-HCCI) Engine

Abstract

A dual fumigation homogeneous charge compression ignition (DF-HCCI) ***engine*** runs on low volatility internal combustion (IC) ***engine*** fuel such as diesel in combination with another IC ***engine*** fuel, both simultaneously fumigated in ***engine*** intake air stream. Both fumigated fuels mix with***engine*** intake air and they are inducted together, at the same time, into ***engine*** combustion chamber where homogeneous charge compression ignition combustion takes place. Fumigation of two fuels, in which one fuel has low volatility, is done by a novel dual fuel fumigation system comprising of at least one ultrasonic atomizer. Combustion phasing control is done by varying proportions of fumigated fuels, EGR rate, and EGR temperature and additionally by controlling ***engine*** intake air temperature. ***Engine*** intake air is controlled to a desirable temperature by heat exchanger utilizing heat from ***engine*** and/or exhaust gas. A controller monitors inputs from relevant sensors and, based on these inputs, adjusts fumigation rates of fuels, EGR rates, EGR temperature and ***engine*** intake air temperature.

Appendix 4

United States Patent Application	**20180171925**
Kind Code	**A1**
PAVLOV; Kevin J.	**June 21, 2018**

SECONDARY FUEL INJECTION SYSTEM AND METHOD FOR DIESEL ENGINES

Abstract

A secondary fueling system for a diesel internal combustion ***engine*** includes an injector which injects an oxygen-containing secondary fuel into the ***engine's*** air intake system, a pump which pumps the secondary fuel to the injector, a sensor which senses pressure in the air intake system, and a secondary fuel controller which receives output signals from the sensor and pump, operator inputs for the ***engine,*** and data signals pertaining to operation of the ***engine*** from the main ***engine*** controller, determines an injection amount of the secondary fuel based thereon, and controls the pump based on the determined injection amount. The secondary controller may operate an additional control wherein the injection amount of secondary fuel determined by the programmed secondary fuel controller is modified based on at least one of topology conditions of roads on which the vehicle is traveling and considerations of efficient ***engine*** output in comparison to driver requests for ***engine*** output.

Appendix 5

United States Patent Application	**20180179975**
Kind Code	**A1**
Merlino; Gennaro ; et al.	**June 28, 2018**

ENGINE CONTROL SYSTEM INCLUDING FEED-FORWARD NEURAL NETWORK CONTROLLER

Abstract

An automotive internal combustion ***engine*** combusts an air/fuel mixture to generate a drive torque. An ***engine*** control unit (ECU) determines a torque request to output a fuel request signal indicative of an amount of the fuel to inject into a cylinder of the ***engine***. The ECU includes neural network controller installed with a neural network to generate a fuel setpoint signal based on the torque request and to define a combustion model of the ***engine***. The neural network generates a start of injection (SOI) signal indicating a start time at which to inject the fuel based a crankshaft angle. The ECU further outputs the fuel request signal based on the fuel setpoint and the SOI. A fuel injector injects the fuel into the cylinder based on the fuel request signal to generate the drive torque indicated by the torque request.