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APPLICATIONS OF COMPLEX DYNAMIC HOMOGENIZATION TECHNOLOGY. (Possible applications of complex dynamic homogenization technology for hydrocarbon fuel mixtures in internal combustion engines)

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Abstract

The dynamic homogenization system is characterized by compact dimensions and an optimized geometric configuration, with fully standardized fuel inlet and outlet connections that enable seamless integration into internal combustion engines without requiring structural modifications. Modern engines equipped with high-pressure fuel pumps can incorporate the system without altering existing fuel supply architectures. The technology is applicable to both stationary engines and those used in transportation.

The system can be enhanced with an additional module designed to produce two types of fuel emulsions – compressible and incompressible – while enabling the efficient incorporation of up to eight supplementary components into the fuel composition. It also provides the capability to dissolve combustible gases into liquid hydrocarbon fuels in a continuous flow prior to injection into the combustion chamber, without requiring structural modifications.

The proposed technology demonstrates broad applicability across various fuel types, including liquid hydrocarbons, gasoline- and diesel-based mixtures, fuel oil, as well as liquid biofuels and complex biofuel compositions.

Keywords: *Homogenization; Dynamic homogenization; Complex dynamic homogenization; Applications of homogenization technology; Hydrocarbon fuel mixtures; Internal combustion engines; Liquid injection into the system; Discharge of homogenized liquid from the system; Stationary internal combustion engines; Internal combustion engines installed on vehicles; Minimal modification of the fuel system; Equipping with a dynamic homogenization system*

Types of internal combustion engines in which complex dynamic fuel homogenization technology and fuel mixture homogenization technology can be applied.

Figure 1. Device for compressible emulsion



Figure 2. Device for compressible emulsion



The dynamic homogenization system has minimal overall dimensions and an optimal geometric shape.

The liquid inlets into the system and outlets of the homogenized liquid from the system are completely standard, therefore the dynamic homogenization system for fuel mixtures can be installed on any internal combustion engine.

Modern engines that include a high-pressure pump can be equipped with a dynamic homogenization system for the fuel mixture without any modifications to the fuel system.

Equipping with a dynamic homogenization system can be carried out both on stationary internal combustion engines and on internal combustion engines installed in vehicles.

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

The dynamic homogenization system enables efficient 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 prior to injection into the combustion chamber, both in stationary internal combustion engines and in internal combustion engines installed in vehicles.

Figure 3. Device for compressible emulsion



Types of liquid hydrocarbon fuels that can be subjected to dynamic homogenization.

Using dynamic homogenization technology, any types of liquid hydrocarbon fuels can be processed.

Using dynamic homogenization technology, any types of fuel mixtures based on gasoline, all types of diesel fuel, and fuel oil can be processed.

Using dynamic homogenization technology, any types of liquid biofuels can be processed.

Using dynamic homogenization technology, any types of biofuel compositions can be processed.

Dynamic Homogenization of Fuel Without Impurities

During storage of liquid hydrocarbon fuels, fuel agglomerations may form, which can later cause problems with injection and uniform combustion.

The higher the fuel viscosity, the higher the probability of formation of agglomerates and other types of fuel inhomogeneity.

The fuel dynamic homogenization system is installed in the engine fuel system on the fuel pipeline between the engine fuel pump and the high-pressure pump of the engine.

During fuel passage through the dynamic homogenization system, homogenization occurs in the flow under the level of turbulence, after which the high-pressure pump completes the dynamic homogenization process in volume and dimensional factors in a three-dimensional coordinate system.

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

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

Dynamic Homogenization of Fuel Mixtures Based on Gasoline

Fuel mixtures based on gasoline, such as gasoline-ethanol blends and gasoline-methanol blends, during long-term storage may exhibit gravitational separation of water from the hydrocarbon part of the fuel mixture.

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

During the passage of the fuel mixture in which water has separated from gasoline through the dynamic homogenization system, homogenization occurs in the flow under the level of turbulence, after which the high-pressure pump completes the dynamic homogenization process in volume and dimensional factors in a three-dimensional coordinate system.

During the homogenization process, water in the form of micro-droplets is uniformly distributed throughout the volume of the hydrocarbon fuel mixture, after which the mixture is transformed into a micro- or nano-emulsion.

Figure 4. *Device for compressible emulsion*



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

For installation of the dynamic homogenization system on a gasoline engine, no original additional components are required,

and no structural modifications to the engine are necessary.

Figure 5. *Device for compressible emulsion*



Dynamic Homogenization of Fuel Mixtures Based on Diesel Fuel

Preparation of fuel mixtures from diesel fuel and ethanol or methanol is extremely difficult due to the large difference in viscosity of these materials.

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

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

During the passage of the fuel mixture in which water has separated from gasoline through the dynamic homogenization system, homogenization occurs in the flow under the level of turbulence, after which the high-pressure pump completes the dynamic homogenization process in volume and dimensional factors in a three-dimensional coordinate system.

During the homogenization process, water in the form of micro-droplets is uniformly distributed throughout the volume of the hydrocarbon fuel mixture, after which the mixture is transformed into a micro- or nano-emulsion.

According to test results of the emulsion obtained using the dynamic homogenization system, soot concentration in exhaust gases

is reduced by 97%, and the level and rate of heat release increase by at least 35%.

For installation of the dynamic homogenization system on a diesel engine, no original additional components are required, and no structural modifications to the engine are necessary.

Dynamic Homogenization of Fuel Mixtures Based on Heavy Diesel Fuel

Preparation of fuel mixtures from heavy diesel fuel and ethanol or methanol is extremely difficult due to the large difference in viscosity of these materials.

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

The dynamic homogenization system in heavy diesel engines using a mixture of heavy diesel fuel with ethanol or methanol as fuel is installed between the fuel pump and the high-pressure pump of the engine (if present). If a high-pressure pump is not part of the engine, the dynamic homogenization system is installed on the fuel pipeline after the fuel pump.

During the passage of the fuel mixture in which either water has separated from heavy diesel fuel or agglomerates of heavy diesel fuel have formed through the dynamic homogenization system, homogenization occurs in the flow under the level of turbulence, after which the high-pressure pump or injectors complete the dynamic homogenization process in volume and dimensional factors in a three-dimensional coordinate system.

During the homogenization process, water in the form of micro-droplets is uniformly distributed throughout the volume of the hydrocarbon fuel mixture, after which the mixture is transformed into a micro- or nano-emulsion.

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

For installation of the dynamic homogenization system on an engine using heavy diesel fuel, no original additional compo-

nents are required, and no structural modifications to the engine are necessary.

Dynamic Homogenization of Fuel Mixtures Based on Fuel Oil

Preparation of fuel mixtures from fuel oil and ethanol or methanol is extremely difficult due to the large difference in viscosity of these materials and due to the inhomogeneity of fuel oil.

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

In cases of particularly high inhomogeneity of fuel oil, the structural simplicity of the system allows its staged use with the formation of a gradual (step-by-step) sequential scheme for preparing a fuel mixture based on fuel oil.

The dynamic homogenization system in large engines using a mixture of fuel oil with ethanol or methanol as fuel is installed between the fuel pump and the subsequent element of the engine fuel system.

During the passage of the fuel mixture in which water has separated from fuel oil or in which agglomerates and lumps have formed in the fuel oil flow through the dynamic homogenization system, homogenization occurs in the flow under the level of turbulence, after which the injector or nozzle completes the dynamic homogenization process in volume and dimensional factors in a three-dimensional coordinate system.

During the homogenization process, water in the form of micro-droplets is uniformly distributed throughout the volume of the hydrocarbon fuel mixture, after which the mixture is transformed into a micro- or nano-emulsion.

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

For installation of the dynamic homogenization system on the specified engine, no original additional components are required, and no structural modifications to the engine are necessary.

Preparation of Fuel Mixtures at Oil Refineries

At oil refineries, the system for dynamic homogenization of hydrocarbon liquids must include a high-pressure pump operating on the principle of a diesel engine high-pressure pump.

The specified integrated system can be used either as a pump for mixing components of the fuel mixture or as a system ensuring recirculation of the fuel mixture in storage tanks.

Installation of such systems can be carried out on existing equipment without its

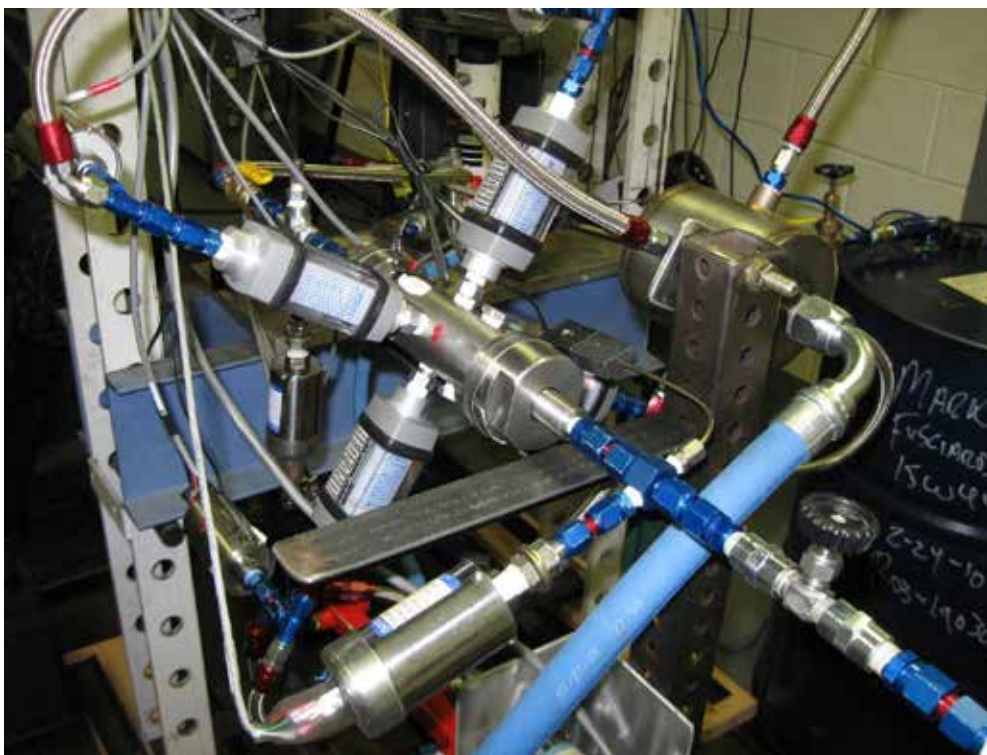
alteration or modernization; however, in this case, the system must include pumps for supplying mixture components into the system.

One of the applications of the dynamic homogenization system at oil refineries is the formation of a fuel mixture during the supply of its components into a transport tank. Since the time required to prepare the fuel mixture in the system amounts to fractions of a second, preparation during transfer into a transport tank eliminates the need for dedicated storage tanks for the fuel mixture at the facility.

Figure 6. *Device for compressible emulsion*



Figure 7. *Device for compressible emulsion*



Preparation of Fuel Mixtures at Fuel Filling Stations

At fuel filling stations, the system for dynamic homogenization of hydrocarbon liquids must include a high-pressure pump operating on the principle of a diesel engine high-pressure pump.

The specified integrated system can be used either as a pump for mixing components of the fuel mixture or as a system ensuring recirculation of the fuel mixture in storage tanks.

Installation of such systems can be carried out on existing equipment without its alteration or modernization; however, in this case, the system must include pumps for supplying mixture components into the system.

One of the applications of the dynamic homogenization system at fuel filling stations is the formation of a fuel mixture during the direct supply of its components into the fuel tank of a car or other vehicle. Since the time required to prepare the fuel mixture in the system amounts to fractions of a second, preparation during filling into a vehicle tank eliminates the need for dedicated storage tanks for the fuel mixture at the facility.

Preparation of Fuel Mixtures Directly Within the Internal Combustion Engine

In cases where an additional tank for a second fuel component can be installed on a vehicle, fuel mixture preparation can be carried out by the dynamic homogenization system directly in the fuel pipeline.

The feasibility of this option was tested on a serial diesel engine, in which a water-in-oil fuel emulsion was produced, i.e., diesel fuel was emulsified with ordinary tap water.

As a result of using such an emulsion, soot concentration in exhaust gases was reduced by 97% (mixing ratio in the emulsion: 20% water to 80% diesel fuel).

Installation of the Dynamic Homogenization System on a Newly Manufactured Internal Combustion Engine

For installing the dynamic homogenization system on a newly manufactured internal combustion engine, no new elements are required in the engine design.

The system is introduced into the fuel pipeline after the fuel pump, and its outlet is connected to the inlet of the high-pressure pump, or, if it is absent, to the inlet of the structural component following the fuel pump.

Installation of the Dynamic Homogenization System on a Retro Internal Combustion Engine

For installing the dynamic homogenization system on a repaired or modified internal combustion engine, no new elements are required in the engine design.

The system is introduced into the fuel pipeline after the fuel pump, and its outlet is connected to the inlet of the high-pressure pump, or, if it is absent, to the inlet of the structural component following the fuel pump.

Installation of the Dynamic Homogenization System on Industrial Facilities For the Production of Fuel Mixtures

The system can be supplied by the manufacturer in a modular form.

The composition of the system and its functions can be modified at the manufacturing facility without additional design work.

The system has no limitations or elements that would prevent its installation on any industrial equipment.

Installation of the Dynamic Homogenization System on Tanks With Fuel Mixture at Fuel Filling Stations

The system can be supplied by the manufacturer in a modular form and can be produced at any required scale.

The composition of the system and its functions can be modified at the manufacturing facility without additional design work.

The system has no limitations or elements that would prevent its installation on any industrial equipment.

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