



DOI:10.29013/AJT-26-3.4-280-285



HOMOGENIZATION IN FUEL SYSTEMS OF THERMODYNAMIC EQUIPMENT. (Homogenization of flows of various liquids in pipelines in real time; potential applications of dynamic homogenization technology in fuel systems of thermodynamic equipment)

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Cite: Lobodenko K. (2026). *Homogenization in Fuel Systems of Thermodynamic Equipment. (Homogenization of flows of various liquids in pipelines in real time; potential applications of dynamic homogenization technology in fuel systems of thermodynamic equipment). Austrian Journal of Technical and Natural Sciences 2026, No 3–4. <https://doi.org/10.29013/AJT-26-3.4-280-285>*

Abstract

This paper provides a comprehensive explanation of all key aspects of the technology and the device through which it is implemented. In addition, it analyzes the critically important practical experience of transport industry executive and leading specialist Dmytro Lysenko, comparing it with the results obtained from specialized testing and experimental validation.

Dynamic reagent-free homogenization is considered as a fundamental process enabling increased accuracy of non-contact monitoring of fluid conditions in pipelines, including systems monitored via aerial imaging or unmanned aerial vehicles. For the successful commercialization of this integrated technology, it is essential to identify all viable implementation points, specifically those where the technology demonstrates clear practical demand.

General conditions are examined in relation to the properties of the proposed technology. In liquid hydrocarbon fuels, the formation of clots during storage may occur, potentially leading to issues with injection and uniform combustion. The higher the fuel viscosity, the greater the probability of clot formation and other forms of inhomogeneity. Therefore, the implementation of proposed non-contact real-time monitoring technologies requires precise consideration of the required level of homogenization.

Keywords: *homogenization; homogenized fuel; liquid flow homogenization; fuel systems of thermodynamic equipment; dynamic mixing operations; dynamic homogenization system; engine fuel pump; high-pressure fuel pump; in-flow homogenization based on turbulence level; dimensional factor in a three-dimensional coordinate system*

Introduction

This paper provides a brief characterization of technological components that

determine the applicability of the technology across various technical and commercial contexts. These components are based

on significant operational results obtained under the leadership of Dmytro Lysenko during targeted and systematic intensive operation of various transport systems.

In all cases, the discussion refers to a unified type of device designed to perform dynamic mixing operations along with simultaneous dynamic homogenization of liquid and gaseous physical media.

The paper further elaborates on dynamic reagent-free homogenization as a core process for improving the accuracy of non-contact monitoring of fluids in pipelines, including those monitored through aerial surveillance or UAV-based systems. For effective commercialization, it is necessary to identify application areas where the technology is unequivocally required.

The general operating conditions are considered based on the properties of the technology, with particular emphasis on its development contributions by Dmytro Lysenko. As previously noted, hydrocarbon fuels during storage may develop clots, leading to complications in injection systems and combustion uniformity. Increased fuel viscosity significantly raises the likelihood of such inhomogeneities, requiring precise evaluation of homogenization requirements for the implementation of monitoring technologies.

General Requirements and Conditions

As an example, consider a diesel engine as part of a diesel generator power system. A dynamic fuel homogenization system may be installed within the engine's fuel system, specifically in the fuel pipeline between the engine fuel pump and the high-pressure fuel pump.

As fuel passes through the dynamic homogenization system, in-flow homogenization occurs based on turbulence levels. Subsequently, the high-pressure pump completes the homogenization process to the maximum achievable extent and within the appropriate dimensional parameters in a three-dimensional coordinate system.

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

The system may also be applied in processes and equipment for homogenization in parallel with fuel recirculation within storage tanks during fuel production and storage at refueling stations.

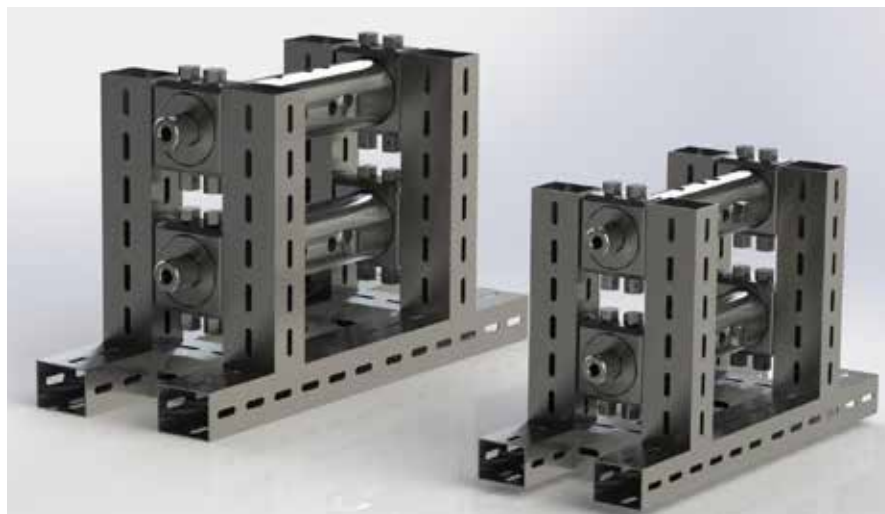
The integrated dynamic fuel homogenization technology can be applied to various types of internal combustion engines. Due to its compact dimensions and optimized geometric configuration, the system can be installed on virtually any internal combustion engine without structural modifications.

Figure 1. *Illustrates a device for dynamic real-time homogenization in pipelines with a flow rate of up to 100 liters per hour at operating pressures ranging from 3 to 15 bar*



Extensive testing has demonstrated that the homogenization process does not result in any pressure drop within the pipelines. At the same time, pulsations and fluctuations are significantly smoothed without any additional energy consumption. As shown in the figure, the device is highly compact, with an outer diameter of 40 millimeters, an internal working diameter of 30 millimeters, and a total length of 220 millimeters

Figure 2. Shows online dynamic homogenization systems with operating diameters of 200 mm and 250 mm, designed for flow rates of 10,000 liters per hour and 15,000 liters per hour, respectively



In installations of this type, the role of the homogenizing system is multifunctional. In addition to stabilizing and unifying the hydrodynamic parameters of fuel flows, such systems simultaneously address other critical challenges, primarily those related to improving the efficiency of this equipment, as formulated by Dmytro Lysenko

For comparison, it is appropriate to consider industrial systems capable of operating within fuel pipelines of large-scale power installations, such as gas turbine power units with capacities of 20 to 25 megawatts.

In recent years, the issue of forming fuel mixtures within fuel pipelines of energy equipment using biofuels, ethanol, and especially methanol has become particularly relevant, as such mixtures do not generate toxic waste and also reduce the specific cost of fuel.

For such fuels, when mixtures are formed, for example, with diesel fuel, homogenization plays a crucial role not only as a stabilizing factor but also as a factor preventing, for instance, water contained in the mixture from causing micro-explosions during evaporation and disrupting the burner flame.

When a fuel mixture is homogenized, microcapsules are formed in which, for example, a methanol core is surrounded by a diesel fuel shell. Upon injection, this core evaporates first, breaking the shell into microparticles with sizes not exceeding 0.5–0.8 microns. This significantly enhances combustion efficiency and completeness.

Most importantly, with such a structure of the fuel mixture, the energy of evaporation is preserved, providing an additional fuel saving of 1.5–2.5%. At consumption levels of 10,000

liters per hour, this can result in annual savings exceeding 100,000 USD per unit.

Modern engines equipped with high-pressure pumps can be fitted with a dynamic fuel homogenization system without any modifications to the fuel system.

The installation of dynamic homogenization systems can be implemented both on stationary internal combustion engines and on engines installed in vehicles.

The dynamic homogenization system may also be equipped with an additional system for forming two types of fuel emulsions – compressible and incompressible emulsions – in accordance with the developments of Dmytro Lysenko.

The system enables efficient emulsification of up to eight additional components within the fuel.

Without requiring any modifications, 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 engines and in engines used in vehicles.

Dynamic homogenization is a highly versatile process that can be applied, with minimal adaptation, to a wide range of equipment and to virtually all types of liquid fuels.

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

This technology is also applicable to all gasoline-based fuel mixtures, including blends with ethanol, methanol, and various activating additives.

Diesel fuel exists in multiple variations, with properties that differ significantly depending on climatic conditions. For example, when comparing base diesel fuel types in the United States, lighter diesel fuel No. 2 and heavier, more viscous diesel fuel No. 6 both require homogenization prior to injection, particularly in winter conditions.

When considering various grades of fuel oil, especially those with high sulfur content, it can be observed that homogenization alone, even without blending with lighter fuels, can reduce fuel consumption by up to 10% due to the advantages provided by the homogenization process.

Recently, new types of regenerated fuels have emerged based on various forms of diesel fuel and fuel oil blended with biofuels and other products of hydrocarbon processing or regeneration. The initial technical requirements for their use have been developed by Dmytro Lysenko.

Examples include fuel types such as JP-8 and JP-10 used in the United States, which also require homogenization and can serve as a basis for homogenized fuel mixtures when processed using this technology.

Dynamic homogenization technology can be applied to all types of liquid biofuels as well as to all types of biofuel compositions.

Despite gasoline being the most homogeneous type of liquid fuel, due to its widespread use in blends with ethanol – where ethanol content typically составляет at least 10–15% – the homogenization of gasoline and its blends has also become increasingly relevant.

Gasoline-based fuel mixtures, such as gasoline-ethanol and gasoline-methanol blends, may exhibit gravitational separation of water from the hydrocarbon phase during prolonged storage.

In gasoline engines using such mixtures, the dynamic homogenization system is installed between the fuel pump and the engine's high-pressure pump.

As the fuel mixture – where water has separated from gasoline – passes through the dynamic homogenization system, homogenization occurs within the flow based on turbulence levels. Subsequently, the high-pressure pump completes the homogenization process volumetrically and at the micron scale within a three-dimensional coordinate system.

During homogenization, water in the form of microdroplets is uniformly distributed throughout the hydrocarbon fuel mixture, transforming it into a micro- or nano-emulsion.

According to test results, the use of emulsions produced by the dynamic homogenization system reduces soot concentration in exhaust gases by up to 97%, while the intensity and rate of heat release increase by at least 35%.

The installation of a dynamic homogenization system on gasoline engines does not require any additional specialized components, nor does it require any structural modifications to the engine itself.

Figure 3. Shows a device for online homogenization of gasoline and gasoline-based fuel mixtures for engines with a flow rate of 45 liters per hour and an operating diameter of 25 mm



The figure presents the device in a disassembled configuration

As can be clearly seen from the figure, the device is highly engineered. This is primarily due to the fact that all internal components and the housing form a system of coaxial cylindrical and conical surfaces. The housing itself also functions as a precision gauge, determining the

position of each component and ensuring the accuracy of all working channels of the device. This is achieved, among other factors, through dimensional configurations that enable the so-called double Bernoulli effect and ensure the required level of cavitation-induced ruptures within the flow of homogenized fuel or other process and working fluids.

For significantly more viscous diesel fuels and fuel compositions, the necessity of homogenization becomes even more evident. This applies both to pure diesel fuel and to mixtures based on diesel fuel and methanol, as well as to diesel–water emulsions of both types: water-in-oil emulsions, where the water content does not exceed 20%, and oil-in-water emulsions, where the water content reaches up to 50%.

The preparation of fuel mixtures based on diesel fuel and ethanol or methanol is extremely difficult due to the significant difference in viscosity between these components.

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

In diesel engines using fuel mixtures of diesel fuel with ethanol or methanol, the dynamic homogenization system is installed between the fuel pump and the high-pressure pump of the engine.

As the fuel mixture – where phase separation may occur – passes through the dynamic homogenization system, homogenization takes place within the flow based on turbulence intensity. Subsequently, the high-pressure pump completes the homogenization process volumetrically and at the micron scale within a three-dimensional coordinate system.

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

According to test results, the use of emulsions produced by the dynamic homogenization system reduces soot concentration in exhaust gases by up to 97%, while the intensity and rate of heat release increase by at least 35%.

The installation of a dynamic homogenization system on a diesel engine does not require any additional specialized components, nor does it require any structural modifications to the engine itself.

Figure 4. Shows the internal components of the device



All working surfaces are coaxial, and the design contains no moving parts. Due to this 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

To summarize the implementation of fuel mixtures, the author recommends referring to the innovative integrated developments of Dmytro Lysenko, which reflect the most advanced requirements for so-called smart

technologies within the infrastructure and ecosystem of intelligent transport systems. These technologies, to varying degrees, incorporate elements of artificial intelligence and artificial neural networks into control

and monitoring systems, in combination with measurement techniques based on electromagnetic resonance spectroscopy.

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submitted 03.04.2026;
accepted for publication 17.04.2026;
published 30.04.2026
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