Versatile level sensor for marine alternative fuels and cargo

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ІННОВАЦІЇ В СУДНОБУДУВАННІ ТА ОКЕАНОТЕХНІЦІ
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пропонується реалізувати пасивну екстремальну адаптивну систему автоматичного регулювання, в якій достатнім є можливість:

– здійснювати змінювання лише керуючих впливів;

– здійснювати зміни лише за наперед розробленою програмою, наприклад, оброблення початкової інформації (кут нахилу, швидкість, маса кермувальника та ін.) у системі керування рухом моноколеса.

Висновки: 1. Розглянуті основні технічні характеристики індивідуального електротранспорту, принципи їх керування та основні недоліки щодо експлуатації.

2. Визначено індивідуальний моно- транспорт як найбільш енергоефективний.

3. Запропоновано впровадити в систему керування рухом моно- транспорту пасивну екстремальну адаптивну систему автоматичного регулювання з метою підвищення рівня безпеки його експлуатації під час динамічного розгону.

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Problems of energy efficiency of the electric drive individual mono-transport

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Abstract. The main technical characteristics of individual electric transport, the principles of their management and the main disadvantages regarding operation are considered. Individual mono-transport is singled out as the most energy-efficient. It is proposed to introduce a passive extreme adaptive automatic control system into the mono- transport traffic control system in order to increase the safety level of its operation during dynamic acceleration.

Key words: individual electric transport; energy efficiency; automatic control system

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VERSATILE LEVEL SENSOR FOR MARINE ALTERNATIVE FUELS AND CARGO

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Abstract. A brief overview and analysis of future clean fuels are given. The concept of a universal sensor for promising marine alternative fuel quality monitoring onboard the ship is presented. The main features of the idea are the versatility, reliability, and high accuracy of controlling propulsion efficiency regardless of the type of fuel and the differences in its properties.

Keywords: alternative fuels, sensory monitoring system, propulsion efficiency, monitoring.

The level of liquids is one of the most frequently measured parameters in industrial applications (right after temperature, pressure and flow) [1] and the marine industry isn't an exception. Ships carry more than 80% of global trade by volume, therefore shipping plays a central role in global supply chains and the economy. Current decarbonization trends lead to the implementation of various strategies including the use of alternative fuels in the maritime industry to reduce greenhouse gas emissions and speed up the implementation of new technologies/concepts for a sustainable future. Already by 2030, almost 5% of the energy for shipping should come from carbon-neutral fuels, requiring huge investments in onboard technologies and onshore infrastructure. This causes a strong trend in the development and usage of various alternative fuels. Alternative fuels must be produced, stored, and distributed most efficiently, so the appropriate control and monitoring systems are required. This infrastructure requires corresponding information sources – measurement devices that are adapted or even developed, especially for alternatives. Various analyses of prospective «clean fuels» were performed, but the discussion is still actual. One of the most important problems is the estimation of the perceptiveness of alternative fuels for maritime transport, from the infrastructure readiness point of view. As the properties of all these fuels are very different it's natural that storage conditions and measurement approaches can differ significantly. As a prerequisite of the research, it's necessary to analyze the properties of each alternative fuel type which have a significant impact on measurement techniques, instruments, and related processes. The main goal of the study is the analysis of all the measurement tasks which occur during the use and distribution of new fuels, and the selection of a flexible and universal measurement technique/instrument applied for the various alternative fuels control onboard a ship or at onshore infrastructure intermediate transportation terminals as a cargo.

According to the latest research [2-4], the most promising alternatives to standard marine diesel are Liquefied Natural Gas (LNG), liquid hydrogen (LH_2), hydrogen carriers such as «green ammonia», liquefied petroleum gas (LPG), ethanol and methanol or their bio alternatives. Each alternative fuel has its advantages and disadvantages, e.g. liquid hydrogen LH_2 has one of the highest energy densities and low ecological impact on the environment, while the volumetric energy density is the lowest and the hardest storage conditions among other alternatives. Specific technologies and hardware are used for the storage of liquid hydrogen (extreme pressures and temperatures, specific pipes, distribution mechanisms). LNG is a fuel with well-known and ready-to-use technological solutions. It's the first candidate for the fast displacement of traditional fossil fuels because of its relatively low price, known issues and infrastructure readiness. The storage conditions for LNG are also constrained because LNG is a cryogen, it is kept in its liquid state at very low temperatures, while pressure can reach up to 12 MPa. LPG is also considered a convenient alternative to traditional marine diesel because unlike LNG it doesn't require cryogen temperature for storage or high pressures (it's stored in pressurized tanks with pressure up to 1.6 MPa), while it's much more ecologically friendly in comparison with traditional diesel. Another advantage of LPG and LNG have relatively high infrastructure readiness levels compared to LH_2. Methanol and ethanol are the next promising alternatives because they have a lower level of challenges in adopting as marine fuel compared to LNG or hydrogen (onboard containment of methanol is much easier than LNG or hydrogen); both can be produced using renewable sources such as biomass or electrolysis; they are widespread liquid products, so existing supply chains are ensuring reliable supply. Another potential marine fuel is ammonia – a simple molecule that carries hydrogen in a liquid form. Storage conditions for ammonia are like those of LPG. But comparing ammonia to LPG/LNG or Methanol it is carbon-free. Ammonia can become a transitional fuel soon because of its relative easiness of storage and distribution. It must be noted that traditional marine diesel or MGO can be used in various mixes with biodiesel or other alternative fuels. It seems clear that various fuel mixes will be used in the first stage of decarbonization strategy implementation. It has been reported about many projects of dual-fueled new builds, ships that use fuel cells for electrical propulsion, etc. Regardless of fuel under control, it's very convenient to have standardized/universal hardware on the ship and onshore. A sensor selection/synthesis task must be done considering various possible storage conditions and aggregate states of the alternatives. Large temperature/pressure/density spans, and deviations of mentioned parameters during the lifecycle impose very strict requirements for equipment.

Regardless of liquids being controlled (fuels, oils or sewages, or any other liquids), measurement accuracy and operational reliability are crucial factors to choose the right measurement method and provide the necessary safety level. It's obligatory to measure fuel and liquid cargo quantity. In addition to the levels of fuels, it's necessary to know the current density for each fuel or cargo for mass calculation and ballasting purposes [5]. For accurate estimation of fuel and cargo mass, the ship's roll and trim angles must be considered when calculating fuel and cargo volumes. It's known that for LPG/LNG or ammonia the densities are very dependent on temperature/pressure [6]. In this case, several types of level sensors can't be used because of the sensitivity to the density deviation of liquids under control. Temperature and pressure in the fuel tanks must be measured not only for safety reasons but for additional calculations of current quantities or other parameters. The level sensor analysis led to the predictable result there is no universal sensor or a system that successfully and accurately can handle the issues with all mentioned alternative fuels.

One of the most prominent sensory techniques for presented applications is polymetric sensors [7-8], based on the forming and processing of special TDR signals. The MIRA+™ series sensor was selected as a technology prototype [9]. The concept idea is to maximize the information capacity of the signal by forming it especially for functioning with any type of mentioned liquids or the presence of vapor phase with the changing density or the presence of water (the non-frequent situation with LPG). It's known that classical TDR sensors require the application of additional techniques to achieve high accuracy while a dense vapor phase is present [10]. The key difference in measurement technique is that the sensor must be optimized for the propagation of electromagnetic waves through a set of layers of controllable liquids with minimal attenuation with simultaneous maximization of reflections on the media borders so the waves can travel along the measurement line several times in both directions: from the top side and the bottom side of a sensor. A concept includes the next features: a multipoint temperature sensor inside a waveguide part; an ability to connect or to use the data from a set of pressure sensors (e.g. distributed along a waveguide or a frame); a capacitance-based part, used for an alternative way of level measurement (e.g. for measurements of low-reflectance liquids, like hydrogen).

The current global decarbonization trend led to the new fuels which have varying properties and require an adaptation of existing or development of new concepts for their measurements. The prospective marine fuels were analyzed, and it's shown that soon hydrogen and hydrogen carriers can become a game changer and ammonia as the best accumulator of hydrogen can become a transitional fuel [11, 12]. It's shown that the goal of standardizing the measurement devices for various fuel types including ammonia and green hydrogen can be achieved by the development and application of complex polymetric sensors and appropriate monitoring and onboard propulsion efficiency control & monitoring systems, based on further development of polymetric sensors concepts and their industrialization prospects presented in this paper.

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АНАЛІЗ ПЕРЕТВОРЮВАЧА ПОСТІЙНОГО СТРУМУ, ЩО ПРАЦЮЄ НА ПЛАЗМОВУ ДУГУ

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Виконано аналіз роботи стабілізованого перетворювача постійного струму, що працює на плазмову дугу. Отримано частотні характеристики вхідного та вихідного опорів та передавальних функцій Г-подібного *LC*-фільтра, навантаженого на активний опір навантаження.

Ключові слова: фільтр; імпеданс; комплексне навантаження.