Publishable Report

Contract n°: **BRST-CT98-5382**

Project n°: **BE-S2-3038**

Title: **Development of a Novel Fuel Treatment System for Ship Engines by the us of high Intensity Ultrasound (Ultrasaff)**

Project Coordinator:	**Oy ACOMARIN Engineering Ltd.**	**FI**
Partners:	**Marine Technik Manfred Schmidt GmbH**	**DE**
	Dr. Hielscher GmbH	**DE**
	Newlands Technology Ltd.	**GB**
	FG-Shipping OY AB	**FI**
	FH Flensburg (ISF)	**DE**
	Cedrat Recherche	**FR**

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Content:

1 ULTRASAFF Objectives

The objectives of the ULTRASAFF project were the development of three technical innovations for merchant ship operation: finer filtration, homogenisation and emulsification of heavy fuel oil and water by making use of ultrasonic energy.

Within the project a filtration unit (FU) and homogenising units (HU) were to be developed. The development comprised the design, the formation of physical/mathematical finite element models for calculation of the mechanical performance (Eigenvalues /Eigenforms) under the exciting forces of ultrasonic pulses with consequential design optimisation. Furthermore the sonotrodes and transducers had to be designed and modified to fit into the units. Following these steps the units had to be manufactured and implemented into the heavy fuel oil treatment system in order to verify their performance. Following successful tests a full scale prototype unit had to be designed, manufactured and tested ashore and finally on board of a ship.

2 The consortium

2.1 Profiles of the individual Partners

The partners have been selected in order to form a vertical structure ranging from the fuel treatment system manufacturers, two ultrasound transducer manufacturers (one for PZT transducers and one for GMM transducers) and one end-user. Scientific and research know how concerning ship operation and the experimental fuel treatment facilities of the Institute for Ship Operation (ISF) were be combined with special modelling know how and the knowledge in ultrasound transducers of Cedrat Technologies.

Oy Acomarin Engineering, Ltd. (FI)

Oy ACOMARIN Engineering, ltd. is an independent Finnish Maritime Engineering company specialising with over 28 years experience in engine room control technology, fuel and lubrication oil treatment systems as well as valve control systems. Today ACOMARIN designs and supplies additionally to the traditional systems several new Finnish Innovations, such as JAK-Sea Water Intake and Cooling Systems and JAK-Coupling systems for Ocean going Pusher-Barge transport assemblies.

Marine Technik Schmidt GmbH (DE)

Marine Technik Manfred Schmidt (MTMS) designs and manufactures Booster modules for Marine Propulsion, fuel treatment systems, Electronic control systems for temperature, level and viscosity. All products are accredited by major classification societies and used by customers world-wide. MTMS is especially interested to offer its customers innovative products for heavy fuel treatment in developing supply systems according to the highest quality and environmental standards and regulations. It has also recognised the potential to exploit the technology to other applications like stationary power plants and the petrochemical sector.

Newlands Scientific Plc. (GB)

The business of Newlands Scientific PLC (GB) is the design and manufacture of devices and systems incorporating state of the art magnetostrictive technology. Its experience is ranging from the characterisation of materials to device design and construction for controlled actuation. It exports its technology, through international companies based in the UK, to Europe, America and other continents.

As a world leader in the field of magnetostrictive technology, Newlands Scientific has a wide variety of useful experience in the field of GMM ultrasound transducers it can bring to bear on the proposed project. The interest of Newlands aims at demonstrating the capability of giant magnetostrictive ultrasound transducers in the special field of low frequency large displacement transducers, thus exploiting the special advantages of new giant magnetostrictive materials. The market of homogenising heavy fuels would be an interesting market segment.

Dr. Hielscher GmbH (DE)

Dr. Hielscher GmbH develops, manufactures and distributes particular efficient, safe and controllable ultrasonic processors which are adjusted to industrial use. Typical applications are techniques for dispersion, all decomposition, pulverisation, sonochemistry and cleaning. Hielscher is interested in extending the industrial sectors and markets by applying ultrasound transducers to fuel treatment. The results will be exploited also in petrochemical applications and other applications like painting kitchens.

Finnlines (FI)

Finnlines Ab is responsible for the management, manning and time-chartering of the Finnlines Group's vessels, and their development. It also provides vessel management services for other shipowners' vessels as well as passenger services for the Group's own vessels. It aims at fulfilling new environmental regulations concerning ship emissions and reducing operation costs by increasing the reliability and failure safety at the same time.

Institute for Ship Operation (DE)

The Institut für Schiffsbetriebsforschung (ISF, Research Institute for Ship Operation) is a scientific institution of the country Schleswig-Holstein and is affiliated to the Fachhochschule Flensburg (FHF, Flensburg Polytechnic). The Institute was founded in 1954.

Main objectives are the evaluation of operating experiences and the further development of seagoing maritime engineering practices in close co-operation with ship-owners, shipyards and marine engine builders.

Since 1954 more than 900 research projects covering a wide variety of topics were successfully completed. Many projects were carried out in co-operation with other research institutes and industry. The direct implementation of research results to modern marine plants has strongly contributed to the Institute's current status and it's acceptance by the marine industry. Main areas of research at the Institute are operational safety and reliability, process automation, maintenance, data processing, data management, running cost analysis and manning requirements.

Cedrat Technologies (FR)

Cedrat Technologies is a company working in three connected fields: 1. Software: Cedrat industrialises CAD software for magnetic & electric field modelling; 2. Electrical engineering: Cedrat designs electric motors, magnetic sensors etc.; 3. Active material applications: Cedrat designs and produces actuators, transducers and sensors based on piezoelectric, electrostrictive, and magnetostrictive materials.

The experience in this field is applied in different applications : As an industrial company, CEDRAT produces piezo-actuators for micro-positioning applications in optics & space (CNES, ESA, ...). As a Contract Research Organisation, it performs R&D leading to prototypes and customised piezo-products. For example, various acoustic transducers including high power magnetostrictive sources, have been built for sonars (DCN, DRET, THOMSON), for swimming pool loud-speakers (MAGESPRO), for ultrasonic cleaning (FEREDYN) ...

3 Technical Achievements

3.1 Filtration Unit AFUR

The 5µm filtration unit AFUR designed and manufactured by project partner Marine Technik Manfred Schmidt GmbH was extensively tested on three different and complex HFO. In order to allocate the effectiveness of the cavitation field design several design modifications were tested and the back-flushing intervals were registered.

The filtration effectiveness was checked by counting and analysing the particles before and behind the filtration unit in terms of numbers and particle size distribution. This measuring technique has been developed within previous research projects and has been recognised by all manufacturers of fuel oil and lubricating oil treatment system components as the best available measuring technique for assessment of the effectiveness of a fuel treatment.

As regards the filtration unit AFUR the following summarizing conclusions can be drawn: When operated on purified HFO AFUR achieves similar back-flushing intervals as state-of-the art 10µm filtration units despite the significantly finer filtration. This is due to the strong influence of the ultrasonic pressure field.

The tasks of the homogenising units in HFO systems are to reduce the size of plastic elements in the fuel (i.e. asphaltene chains), to emulate free water into a homogenous solution but to leave abrasive particles almost unchanged in size and forms.

Mechanical HU pretend to fulfil these tasks by applying shearing forces when forcing the fuel trough the narrow clearance between two rotating elements. These HUs are also referred to as "Fuel mills".

The units investigated in the ULTRASAFF project use ultrasonic energy to fulfil the a.m. tasks. All together three HU were tested in the ISF-HFO treatment system, in order to answer open questions related to the use of this technology in fuel treatment.

The quality of the emulsion in terms of size and distribution of the water droplets was verified and the stability of the emulsion was checked. The influence of mass flow and ultrasonic energy on the emulsion quality was investigated and the specific energy to produce satisfactory emulsion was measured.

Contrary to the assumptions made when submitting the ULTRASAFF proposal a reliable method to assess the quality of an HFO – Water –emulsion did not exist. The laser analysing system used for the assessment of other emulsions failed due to the specific problem of lacking transparency of the HFO. Therefore an assessment technology had to be newly developed in order to apply it to the emulsion quality assessment necessary to evaluate the emulsions produced in the various test runs. This development took much time as no acceptable solution was available. However the problems encountered were successfully solved by using a special microscope technology and a digital picture evaluating software.

3.2 Homogenising Units

The Dr. Hielscher design *UIP 2000* operating at 20 kHz was successfully tested and showed very good results. Other homogenising designs operating at 7 and 1 KHz were build and tested.

Whereas the UIP 2000 HU operates on a noise level which may be acceptable in merchant ship engine rooms for the 7 kHz HU, as it generates a significantly stronger noise level, additional damping countermeasures will be necessary.

3.3 HU Prototype FOWUS

The FOWUS-9 full scale prototype unit, designed to produce high quality Water-in-HFO Emulsion at a mass flow up to 1800 hg/h HFO + 550 kg/h H_2O was developed by Marine Technik Manfred Schmidt GmbH and successfully tested at the ISF.

FOWUS-9 was tested in three test runs up to the maximum capacity of the ISF HFO-treatment system and gave very good results in terms of emulsion quality and system reliability.

3.4 Position of HU and FU in HFO treatment systems

In state-of-the-art HFO treatment systems homogenizing Units have occasional been arranged before the filtration unit. If the HU's task is merely to chop the asphaltene chains this arrangement may be chosen. However, if the homogenizing unit is used to emulgate water into the HFO, particularly when considering percentages of 30 % or even more the HU should definitely be installed downstream of the FU, as otherwise the FU will catch substantial quantities of water out of the emulsion and dump it into the sludge tank thus increasing the amount of costly to recycle sludge. This was confirmed by a special series of tests.

4 Final Conclusion

Three different homogenizing units were designed, modelled and manufactured for 20 kHz, 7 kHz and 1 kHz ultrasonique excitation. Two of these units were successfully tested in the HFO-treatment system of the Institut für Schiffsbetriebsforschung. One 5µm filtration unit was designed, modelled, manufactured and successfully tested. Finally a full-scale homogenising unit for the supply of a ship engine of 10.000 KW was developed and tested ashore. Prototype Units have been produced and successfully tested in a research testing facility.

The ULTRASAFF objectives: to develop innovative solutions for finer filtration, homogenisation and emulsification for the benefit of improved economical and environmental performance of merchant ship propulsion systems have fully been met.