IUT

ULTRASONIC-ASSISTED DESULPHURIZATION SOLUTION

REVOLUTIONARY SOLUTION FOR IMO 2020 VLSFO REQUIREMENTS

Ultrasonic Assisted Oxidative/ Catalytic Process

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About Company

International Ultrasonic Technologies Inc. "IUT" is a privately held company, with its headquarters located in Calgary, Alberta, Canada. IUT is the IP owner and developer of a patented process /technology related to the use of ultrasonic waves in conjunction with an oxidant and catalytic process to desulphurize hydrocarbons.

Depending upon the feedstock, IUT's ultrasonic technology can be used to obtain higher grades of petroleum products at reduced costs. The process can remove sulphur up to 98% from different oil streams.

The process applies high-power Ultrasonic energy to a mixture of light and heavy fuel oils, (bunker fuel, crude oil, etc.) to alter naturally occurring molecular structures in conjunction with an oxidizing formula. Depending on the feedstock, the sulphur can be extracted using a basic water wash (in the case of light fossil fuels) or through a second proprietary catalytic/steam process developed by IUT (high sulphur heavy fuel oils).

Research and Development, Chemical Engineering, Analytical and
Conceptual Engineering Service Partners:

'Upgrade' your Desulphurization process

ACHIEVE OPTIMAL VLSFO RESULTS IN A MORE ECONOMICAL AND EFFICIENT MANNER.

Sulphur is often the most abundant element in crude oil after carbon and hydrogen. Desulphurizaton of the oil is an important process as most petrochemical products are produced to be almost sulphur-free. Standard desulphurization methods, using hydrogen or hydrotreating for light oil are not as efficient for the desulphurization of heavy oils. This is mainly due to the properties of heavy oils; especially High Sulphur Fuel Oil (HSFO), such as high sulphur content, high viscosity, high boiling point, and refractory nature of the sulphur compounds present. While the desulphurization of HSFO can reduce the sulphur content to as low as 0.5% in hydro-treating processes, it is by brute force of increasing severity conditions such as operating pressure and temperature, residence time, etc. . Conventional hydro-treating processes also require large quantities of hydrogen to extract the sulphur, which produces additional CO2. All these factors cause the desulphurization of HSFO to require significant additional investment and operating costs of the process resulting in it being unsustainable for a continuous long term process.

In light of the shortcomings, the IUT team initiated a research project to develop an oxidative desulphurization approach to process HSFO to reduce the sulphur content to at least 0.5% using a lower energy, lower pressure process and no external hydrogen. This process involved a chemical reaction between an oxidant and sulphur to facilitate desulphurization in two major steps. The first step was the sulphur oxidation, which changes the nature of the sulphur from sulfide and thiophenic compounds to sulfoxides and sulfones. While sulfoxides and sulfones would typically be removed via a solvent extraction, the sulfones and sulfoxides produced from HSFO would be of large molecular weight making solvent extraction nonviable. To overcome this limitation, the second step for the sulphur removal was replaced with a catalytic sulfones/sulfoxides decomposition process, which exploits the properties of the oxidized sulphur compounds to facilitate their removal with the utilization of a proprietary catalyst. The objective of the project was to develop a generic approach to reduce the sulphur levels to 0.5% for HSFO regardless of their specific characteristics (e.g. levels of sulphur, viscosity, etc.) in a continuous process that does not require manual external manipulation.

The IUT Process has been designed to produce a number of desirable effects, including the oxidation and removal of sulphur compounds. Other improvements, such as the heavy metal reduction/concentration may also be possible. The degree to which any one or more of these improvements occur after treatment with the IUT UAOD process depends heavily on the feed oil or fuel characteristics, including molecular makeup of sulphur compounds asphaltene level and microstructure, acidity and other factors.

Out with the Old, in with the New : Conventional vs New State-of-the-Art

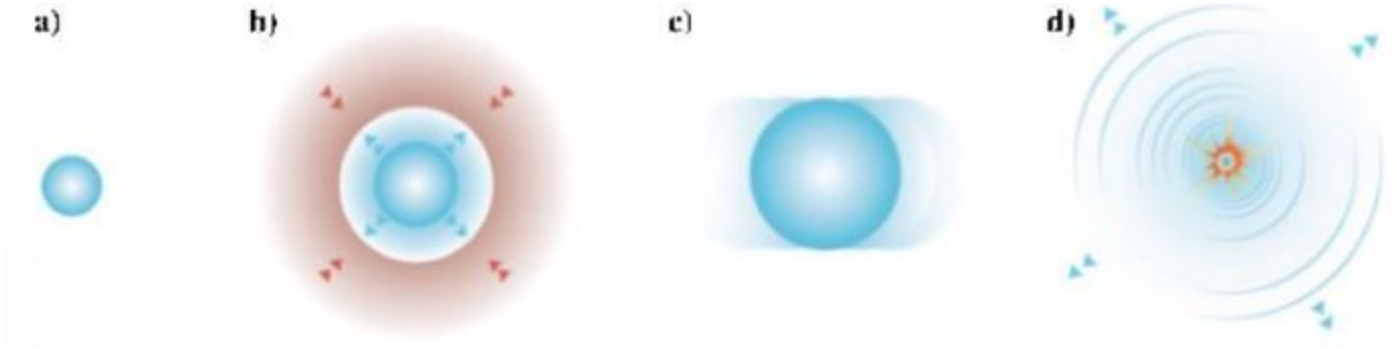
WHY ULTRASOUND?

The ultrasound provides an intense shearing and mixing environment for the mixture and, along with the effects from cavitation, allows for efficient oxygen transfer from the oxidant to sulphur (creating sulphones/sulphoxides) which are subsequently extracted.

Depending on the feedstock, the sulphones can be extracted via basic water wash, or through IUT's second catalytic reactor stage.

Ultrasonics are state of the art technology and are being widely adopted throughout various verticals such as industrial units, food processing, cleaning and even healthcare are using ultrasound as it is considered a highly efficient technology.

As of 2019, ultrasonics have been considered as one of the top emerging technologies in retail applications, using ultrasonics to pair to consumer devices and mobility through ultrasonic data transmission.



a) Ultrasound induces cavities in process fluids

b) Rectified diffusion and bubble growth over several compression cycles

c) Bubbles grow to an unstable size

d) Implosion of bubbles leads to intense mixing

Hydrocracking and hydrotreating have been proposed as desulphurization technologies to be applied to produce compliant fuels. However, when applied to heavy oil fractions, high pressures and temperatures and externally sourced hydrogen consumptions are needed to meet the low sulphur levels required, which makes this alternative economically challenging with substantial investment in upgrading fuel oil residues to gasoil grades needed.

To curb this, the IUT UAOD technology has been optimized for HSFO to meet continuing regulatory demand drivers like the 2020 IMO low sulphur fuel oil regulations. Our second generation process is currently being developed for land based applications (ex. refineries, bunker operations, terminals), with a goal to commercialize and to construct the first plants in 2020. Our company's vision is to become a proven industry leader in providing an alternative low sulphur fuel oil desulphurization solution to industry users.

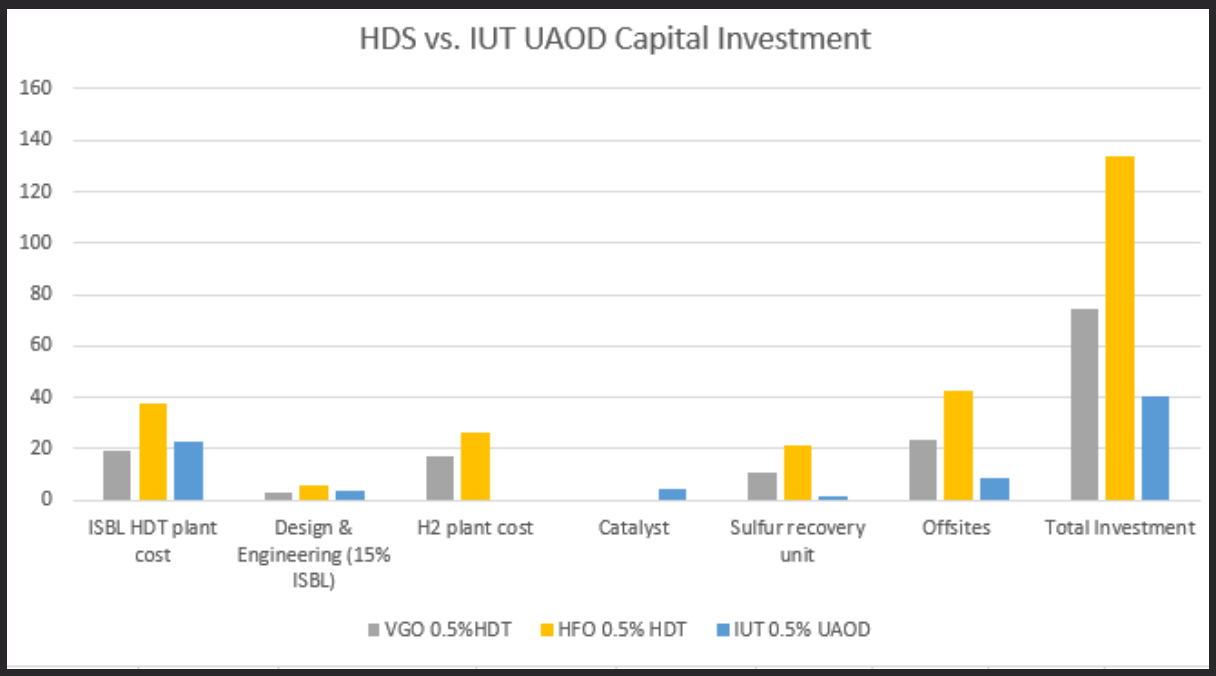
While the desulphurization of HSFO can reduce the sulphur content to as low as 0.5%, it is by brute force of increasing severity conditions such as operating pressure and temperature, residence time, etc. for hydro-treating processes.

The Benefits

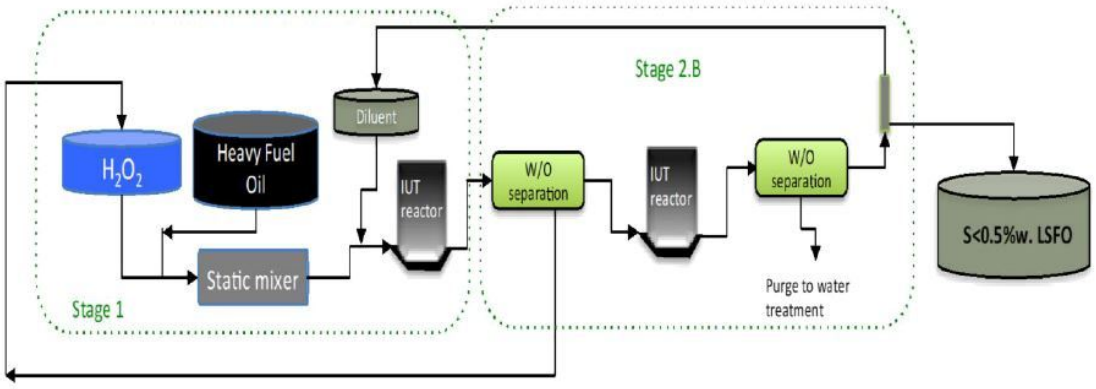
PROCESS DRIVEN RESULTS

- Lower CapEx
- Lower Operating costs
  - Lower heat/temperatures used in process
  - Lower energy
  - Lower pressure
- Reduced carbon footprint/GHG Emissions
- Improved processing flexibility
- State of the Art solution

4000 BPD feed	VGO 0.5%HDT	HFO 0.5% HDT	IUT 0.5% UAOD
MMUS$			
ISBL HDT plant cost	19.2	37.4	23.1
Design & Engineering (15% ISBL)	2.88	5.61	3.465
H2 plant cost	17.5	26.3	0
Catalyst	0	0	4.2
Sulfur recovery unit	10.8	21.6	1.5
Offsites	23.8	42.7	8.57
Total Investment	**74.18**	**133.61**	**40.835**



With the sponsoring of Maxcom Petroli S.p.A. since mid 2019 the laboratory of **Catalysis for Energy and Fuels, research group of the Department of Chemical and Petroleum Engineering at the University of Calgary**, undertook the setting up and continuous operation of the IUT two stage process by building the ultrasound process (stage 1) attached to a pre existing steam processing unit (stage 2) adapted to the project requirements. The US unit is used at a throughput of approximately 1 liter per hour (US capacity is about 5 times that) and the steam processing unit is typically operated at a throughput of approximately 0.1 liters per hour. These units are now operating continuously and are connected for purposes of demonstration as a continuous pilot plant, demonstrating the stability of the process for long periods.



FIRST REACTOR STAGE (ULTRASONICS)

SECOND REACTOR STAGE (CATALYTIC PROCESS)

PROJECT SPONSORS/INVESTORS/STRATEGIC PARTNERS:

MAXCOM

Talisman Maritime Venture Ltd
Limassol-Cyprus

The Results

PROCESS DRIVEN RESULTS

NEWS ON THE IUT HEAVY FUEL OILS DESULPHURIZATION VIA ULTRASONIC DESULPHURIZATION AND STEAM CATALYTIC PROCESSING

The Catalysis and Adsorption for Fuels and Energy (CAFE) group at the University of Calgary has undertaken the continuous test operation of the IUT's OxiDeSulphurization (ODS) technology. This process started in mid August 2019 with a sequence of procurement, construction and operation of IUT's continuous flow pilot plant, contemporaneously with the required chemical analytical investigation and new characterization methods development, trial and error adjustments and in general expertise building on this proposed technology.

The continuous test consisted in starting the operation of the catalytic steam processing section of the technology on previously oxidized feedstock produced early December via hydrogen peroxide ultrasonic sulfonation of a high sulfur fuel oil containing 1.45%w. S. (RMG 1.45%S)

The oxidation level achieved for said stream in December was in the range of 75%, this according to the estimate calculated via FTIR analyses of the oxidized sample, confidential method developed for the purpose by this research group. It is to be remarked that no such fast quantitative or semi-quantitative sulfones-sulfoxides analysis method is available currently in the literature. This means that approximately 75% of the sulphur existing in the feed was oxidized to sulfones and sulfoxides.

Meanwhile the startup, stabilization and steady operation of this second stage, the CAFE group restarted the operation of the UltraSound first stage attached to the Steam Cracking unit.

In order to adjust expectations on the level of success that the IUT processing can achieve, it is convenient to indicate that for a feedstock of 1.45%w S (the one used for purposes of the analysis) oxidized to the level of 75%, in December 2019, approximately o.36%w S would still remain in the processed fuel if the second stage were 100% efficient at decomposing the sulfones and sulfoxides into sulphur gases and liquid hydrocarbons clean of sulphur.

Assuming for the second stage of catalytic steam processing ,a more realistic sulfones-sulfoxides decomposition level of 80%, we could expect to obtain about 0.58%w. S in the processed fuel oil if a liquid yield better than 98% were obtained. This is to suggest the size of the challenge.

The results, once steam catalytic processing unit reached stability on Tuesday Jan 21, two 24 hour mass balance periods were opened and samples collected on Wednesday Jan 22 and Thursday Jan 23. Also on Thursday Jan 23 ,the UltraSound unit was back operating producing more oxidized fuel oil, and on Friday Jan 24 the steam cracking unit started receiving a fresh stream of oxidized fuel oil, which continues to be the RMG 1.45%S. Currently (Jan 25) the steam cracking plant is being stabilized in operation with this newly oxidized material and is already producing an average of 0.5w% S fuel oil with a high yield to liquids close to 100%. Current results obtained on the three mass balances produced so far between Wednesday and Friday Jan 22 to Jan 24, the results obtained after proper XRF analysis to accurately determine the content of w% S in the produced liquid result in values of **0.47-0.49; 0.48-0.50, and 0.50-0.53** respectively, not having yet started tuning of current process conditions. This activity is to be undertaken in the second week of February. We can estimate the yield achieved during the tests of last week in the steam catalytic process to be higher than 90%. Or higher than 80% if the ultrasonic stage reached about 80% of sulphur oxidation. We are optimizing the analytical methods to more precisely control the process.

These results are sufficiently satisfactory in terms of weight Percent of Sulphur steadily achieved in the resulting fuel oil, under continuous operation mode, and with an accumulated level of understanding sufficient to undertake optimization and modifications in the process setting. In the few next weeks, additional data will be produced to demonstrate beyond any doubt the repeatability of the results and that the process is reproducible . Also further remaining to be produced are results regarding the most detailed characterization of the samples obtained, to confirm that the now VLSFO we are producing complies with ease with the specifications for said fuel oil, which is very much expected. All of which bringing the process configuration proposed by IUT and co-sponsored by MAXCOM as technically viable and with high chances of becoming the operational and economic breakthrough envisaged.

The final conceptual engineering report will be produced in February with additional resources being put in place to conveniently cope with the many different aspects that now require tuning to obtain higher performance, lower costs and operational reliability for this technology, given that the risks associated to these investments has now been considerably reduced.

CAFE team

Dr. Carlos Scott, Research coordinator, Ultrasound Processing

Florian Isufaj, Chem Eng. MSc student

Antonio Garcia, Chem Eng. PhD student

Dr. Monica Bartolini, PDF steam processing leader

Dr. Gerardo Vitale, catalysts manufacturing leader

Lante Carbognani, chemical analyses specialist, methods developer

Prepared by Dr. Pedro Pereira Almao, professor Uof C, Principal Investigator

Next Steps

PROCESS DRIVEN RESULTS

With the completion of the Final Conceptual Engineering in February 2020, IUT is looking to collaborate with site partners to develop a base field development plan and to commence the Front End Engineering and Design and integration process to reflect all the client's project specific requirements.

Are you our next site partner?

Call us - or email us today for a technical due diligence package to discover how the IUT team can enhance your operation, meeting the expectations of the IMO 2020 VLSFO requirements in a more efficient and economical manner.

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