GTT Inside 9
The GTT newsletter - January 2017 - n°9

Message from David Colson, GTT Commercial Vice-President

"GTT provides solutions for the technical problems encountered during improvements and modifications to ships"

GTT provides support to construction sites, shipowners and operators throughout the duration of a ship's life. The company conducts engineering studies on behalf of its clients in order to address very specific technical problems related to the improvement of operational modes, to ensure compliance with regulatory constraints, to prolong the life of the ships and, to optimise performance levels at sea.

GTT possesses a sizeable database containing full records from all of its operations carried out on ships. Mathematical and experimental models are used to predict likely conditions, enabling GTT to anticipate the possible risks of failure, assess their likelihood and justify the technical choices with classification societies.

The introduction of sensors and measuring systems has enabled GTT to access relevant operational data that further increase our capacity to predict physical phenomena such as the warming of the cargo and the operational level of BOG (boil-off gas). By correlating this data with mathematical models, we are able to simulate specific operations such as STS (ship-to-ship) and to optimise levels of BOG consumption.

As such, the studies are supported informed by on-board observations and measures, which enable the development of even more robust solutions and make the GTT engineering model unique. Any proposals made or modifications suggested are therefore covered by a guarantee for fleet safety. By taking this approach to such technical issues, GTT is now fully recognised for the quality of its studies by all the main players in the LNG sector.

I invite you to read this latest edition of GTT Inside, which is dedicated to the subject of engineering studies. You will discover more details of the assessments conducted by GTT.

As we enter 2017, I would also like to wish you all the best for the coming year and hope that GTT will continue to meet your expectations.

***David Colson** – GTT Commercial Vice-President*

Assessment of ship-to-ship LNG transfer

With recent increases to the fleet of LNG vessels and FSRUs (Floating Storage and Regasification Units), in addition to the imminent entry into service of the first FLNG (Floating Liquefied Natural Gas) barges, ship-to-ship (STS) LNG transfers are becoming increasingly frequent.

These transfers necessarily involve a phase in which the ship's tank are in a state of partial filling, and therefore more at risk to the sloshing phenomenon.

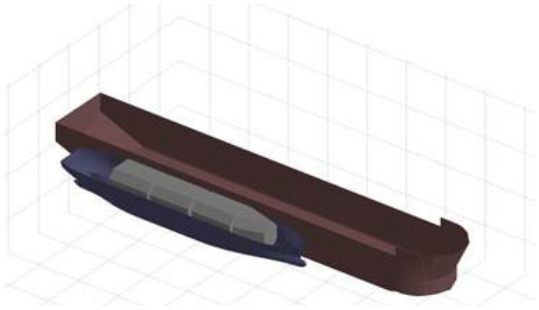
In order to guarantee the highest level of safety, an operational risk assessment is required before any operation of this kind. As such, and in order to respond to this requirement, GTT draws on its expertise in hydrodynamics to offer digital and experimental STS transfer simulations.

The digital simulations enable the vessel's movements to be accurately foreseen. They take the characteristics of the ship and/or the barge into account (geometry of the hull, the tank and the loading case) as well as all non-linear interaction effects. The latter are caused by the connections between, on the one hand, the movements of the liquid cargo and of the ship and, on the other hand, between the two vessels themselves. Furthermore, the digital model takes all mooring components into account (mooring lines, transfer hoses, fenders, etc.).

Experimental model of a membrane LNG tanker

These movements are then experimentally simulated. In accordance with the different sea conditions experienced at the operation site, the ship's loading profile and the frequency of the operation itself, hydrodynamic loadings - both short and long term, to be applied to the tank's insulating structure - are determined and then compared with the latter's mechanical resistance, using a reliability-based approach.

Having analysed the results of these studies, GTT offers the operator different operational windows per filling range, defined in terms of significant wave height, wave period and direction of the ship, so that these transfers may be carried out while under a controlled level of risk for the tanks on the ship. ■



Digital model of a membrane LNG tanker connected to a floating liquefaction terminal

Vessel life extension

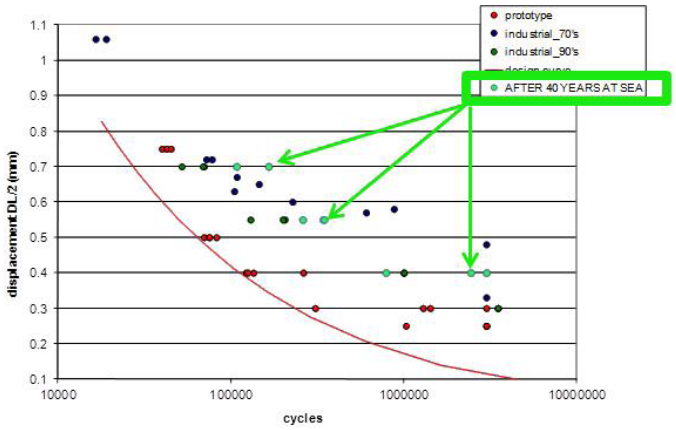
In order to extend a ship's life and particularly for the tanks, it is necessary to gauge the potential damage caused by fatigue to the anchorage areas and the membrane connection points, which are sometimes impossible to inspect due to their position.

The phenomenon of mechanical fatigue is manifested as the wearing down of parts due to moderate but repetitive loading. This is one of the forms of degradation that GTT takes into account, because of the way the ship physically interacts with, among other things, the sea. This leads to a large number of cycles of stress (>108) on the component parts. Extending the life of a ship means exposing it to more cyclic stress, hence the need for this verification.

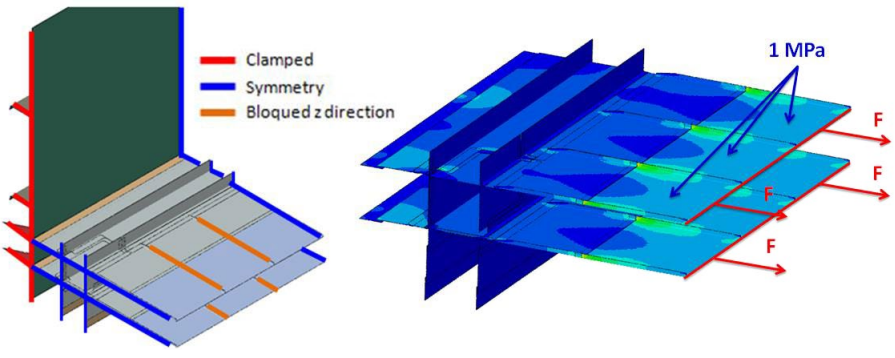
The study firstly consists of assessing the number and nature of the cycles already undergone by the ship. All previous voyages are considered, taking into account the sea conditions experienced. Sea-keeping analysis helps to determine a timeline of previous hull girder flexural moments. Along the same lines, future cycles are also assessed, in relation to the prolongation of the ship's life. Next, for each component, a detailed evaluation of "finite elements" attributes a stress level to each cycle, taking into account stress concentration coefficients for individual areas. Thanks to GTT's access to experimental stress resistance curves (Wöhler curves), a final post-processing of the data using Miner's law allows the future levels of resistance over time to be assessed.

As degradation due to fatigue is generally caused by very localised cases of excessive stress, strengthening the hull in certain areas can extend the life of specific area adjudged to be sensitive by several years.

Finally, it should be noted that the choice of a flexible material for the membrane technology results in better fatigue resistance. By way of an example, Mark primary membranes removed from a ship that had been in operation for 40 years showed similar levels of fatigue resistance to new membranes! ■



Fatigue behaviour of a membrane over 40 years of operation



Calculation of stress concentration factors for fatigue assessment of NO96 Invar tube

Vessel improvements

One of the major challenges facing shipowners is the constant effect to maintain ship operations. The goal is therefore to keep maintenance down to a minimum.

In response to this challenge, GTT uses all of its know-how and expertise in designing membrane containment systems to assist in repairs and improvements to its clients' vessel. Its mastery and exhaustive knowledge of all the varieties of membrane technologies in operation allow GTT to offer maintenance and improvement solutions that best suit the specific requirements and constraints communicated by shipowners and operators.

This activity is coordinated by GTT's Design department, which offers - via its technical studies - engineering services and maintenance consultancy work.

The Design department is called into action on the client's request. The proposed solutions may range from a simple repair to a total restoration of the membrane or even more significant improvements such as, for example, converting the boat's propulsion system, progressing from the business of gas transportation to regasification, extending the vessel life, etc.

Thanks to its detailed database that contains full records of the past construction of its clients' vessels, the GTT Design department works remotely, identifying and precisely defining the improvements to be implemented, without necessarily involving any alterations to the tank in order to minimise the idle time of the vessel (any intervention involving the tank will put that ship out of service for a minimum of five days).

Once the engineering study has been finalised, all the plans for the maintenance and improvement of the ship are put in place to ensure that the shipyard receives the materials and replacement parts in advance of the operation. For the most complex cases, models are produced in order to simulate real on-board conditions. This allows the teams to train and prepare for the intervention as well as they can, and to better anticipate the different operations that need to be carried out once the boat has been taken out of service. With its use of cutting edge engineering tools, GTT can also redesign entire areas of the tank in order to implement specially tailored repairs. The maintenance operations are all supervised by GTT's teams in order to guarantee the quality of the work, the respect of deadlines and the reliability of the repaired or transformed system. ■

Bespoke training for the technical maintenance of GTT solutions at the shipyard

Technical training at shipyard

GTT pays special attention to the notion of service, particularly when it comes to training and support. A range of on-request technical and maintenance training programmes for GTT's membrane solutions are offered by its staff at shipyards. Fine-tuned by GTT's instructors and validated by its experts, they are equally suitable for shipyards, operators and classification societies. Their content is tailored according to the requirements of the specific GTT technology deployed by the client.

Held on site, these training programmes are particularly aimed at staff members recently called upon to carry out operations on ships equipped with GTT membrane technology. Drawing on its considerable experience, during these training sessions GTT focuses on quality control and, above all, points relating to technical surveillance such as, for example, ensuring that all bolts are correctly secured to the tripod mast (bearing in mind that the number of bolts ranges between 2,000 and 3,000 per mast). ■

Contact: newbuilding@gtt.fr

Save the date

GTT will be at **Gastech,** Tokyo,
4-7 April 2017

Please come and visit us at
Hall 6 - Booth 6150

Gastech
Conference & Exhibition

Contact: GTT Communication Department
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FSRU Retrofit

Converting standard LNG Carriers into FSRUs after years of service at sea can offer shipowners improved flexibility for their fleet. Modifications to the design will be necessary in order to allow the new regasification and storage functions of the converted vessels to best suit the operating conditions selected by the customer. Thanks to its expertise and technological mastery of the membrane solution, GTT is a key partner when it comes to conducting the appropriate studies for the necessary modifications of the Cargo Handling System (CHS) and for the validation of the Cargo Containment System (CCS).

Regarding CCS, the main issue is to assess the conditions in which the tanks can remain operational during partial fillings, outside the conventional range (less than 10% and above 70% of tank height) of typical LNG carriers. For any given ship and for any given site, GTT determines, through a dedicated liquid motion analysis, the loads experienced during partial filling operations. In the event that they are found to be excessive with regard to the reinforcement level of the containment system and pump towers fitted in the tanks, operational limitations may be recommended.

For the CHS, GTT provides the engineering for the additional and the modified piping lines to be connected to the new regasification plant, for the new HP feed pumps inside the tanks and for the new tank top filling pipe used for managing the various LNG blends to be loaded.

GTT makes sure that the new pipes, equipment or supports fitted to the ship are compliant with all standards, regulations in force (IGC code, ASME, etc.) and the various suppliers' constraints.

Moreover, a higher tank pressure relief valve setting can be considered in order to allow increased operational flexibility for FSRU mode at quay, and to optimize the ship-to-ship LNG transfer rate.

To improve the operational flexibility of FSRUs, the tanks are set to a pressure that may rise as high as 700 mbarg, in contrast to a classic LNG tanker, which is generally set at 250 mbarg.

For a retrofit, this change in pressure involves a certain number of structural modifications such as reinforcing the hull, or re-fitting gas domes and manholes. Valves and certain piping components are also replaced. The CCS itself is not affected by the pressure increase.

GTT takes pressure changes into account in its conversion studies, by assessing all impacts on the ship's equipment and design. ■