During the past years, evaluation of the fatigue life of ship structures has gained in significance due to the continuous trend towards highly optimised structures. Large container ships, in particular, require special attention when it comes to the design of the upper flange of the ship hull. This part of the ship is characterised by the use of thick plates made of high-strength steel, both of which need special consideration from a fatigue point of view.

Advanced fatigue experience
DNV GL has a long tradition in the assessment of fatigue strength. We use experimental investigations and computation to provide reliable results, particularly necessary in the design phase.

Our fatigue experience encompasses:
- The avoidance of cracks in cyclic-loaded structural components
- The prediction of the fatigue lifetime of ship structures
- Fatigue damages assessment in view of appropriate repair measures

WITH DNV GL, YOU BENEFIT FROM:

- The utilisation of structural components at a balanced level
- Reliable ships
- Reduced repair costs within the service time

Future-oriented joint development projects
DNV GL Maritime continues to participate in many national, European and international research projects. Three joint development projects undertaken in co-operation with major South Korean ship yards and steel mills are briefly described in the following.

MARITIME

FATIGUE AND FRACTURE MECHANICS

Joint research for safer ship structures

For more information on DNV GL's fatigue and fracture assessment methods, please feel free to contact us.

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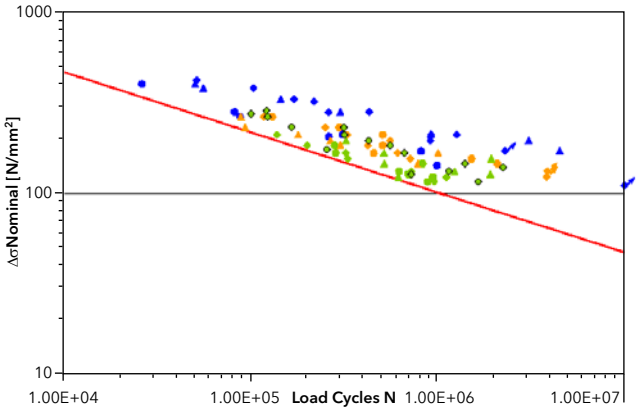
FATIGUE

Both welded joints as well as thermal cut plate edges were investigated.

For welded joints special attention was on:

- High-cycle and low-cycle fatigue
- Thin and thick plates
- FCAW, EGW and laser welding
- As-welded condition and post-weld treatment



S-N curves butt welds

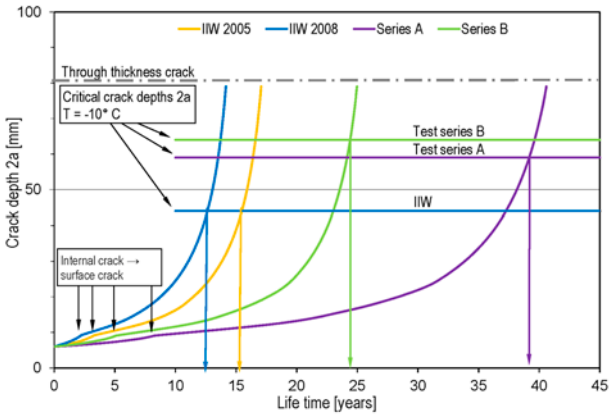
And for plate edges:

- High-cycle and low-cycle fatigue
- Thin and thick plates
- As-cut condition and post-cutting treatment

An example of the effect of the plate thickness on fatigue is shown in the diagram above. The thin specimens (25 mm, blue) have a better fatigue performance than the thick ones (75 mm, green), while the 50 mm-thick specimen results are between the two (orange). As all the test results are above the red design curve, the assessment according DNV GL rules led to a safe design. Calculations using the notch stress approach verified these findings.

FRACTURE MECHANICS

Along with the increase in plate thickness and yield strength of the applied materials, safety against fatal fracture, especially of block-to-block joints, has become an issue. Thus, DNV GL has developed and applied a multi-level safety concept considering NDT possibilities, fatigue and ultimate loads as the dominant parameters. This was accompanied by extensive fracture mechanics research work.



Fracture mechanics based on lifetime calculation

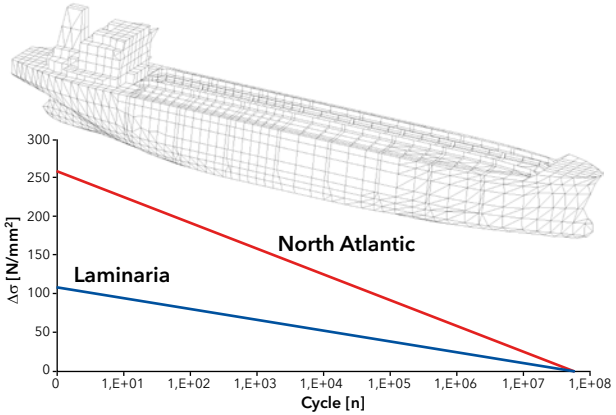
The main objective of the fracture-mechanics-related research work was the investigation and determination of the individual fracture mechanics parameters for high-toughness butt weld joints made of high-tensile steel. Beside the behaviour under cyclic and static load, the influence of welding residual stresses and their redistribution during operation were investigated by means of tests and numerical simulations.

The major findings for high-toughness joints, as illustrated above, can be summarised as follows:

- Significantly decreased crack growth rates compared to the values from common rules and guidelines
- Fully ductile behaviour at design temperature of –10°C accompanied by high-fracture toughness values
- Substantial redistribution and shakedown of welding residual stresses

SPECTRAL FATIGUE ANALYSIS

Distribution of stress ranges is significantly affected by the detail location and by the ship operational parameters (e.g. sea areas, speeds and loading conditions). Numerical simulations need to account for all of these – in particular when results are compared with measurements or when performing route-specific design optimisations (see below).



Spectra of deck longitudinal stress ranges

Individual stress range distributions were computed by spectral method analysis from a large number of wave loads and a finite element model of the whole ship. DNV GL have re-engineered and optimised that process for making it applicable as a matter of routine. For vessels operating at higher speeds, more realistic wave loads can be computed by means of a 3D potential method based on Rankine sources. Furthermore, the consideration of non-linear effects in way of waterline has been improved significantly.

A detailed description of all our major projects and their results will be published in August 2014.