PO.049

Validation of “zero-maintenance” bolted joints: A common framework

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Background

Planned retightening of bolted joints is a cost- and time consuming activity, as well as potentially unnecessary in most of the cases.

At the same time, there is general consensus in the industry that loss of preload is behind the majority of bolted joint failures.

DNV GL has launched a Joint Industry Project to provide a technically solid validation framework for all the methods and practices intended to guarantee zero-maintenance bolted joints.

The JIP proposal is detailed and described in this presentation.

Objectives

Maintenance-free bolted joints:

- Preloaded bolted joints where bolts maintain their preload throughout lifetime

Causes of bolt loosening:

- Embedding losses
- Creep of surface coating / joint parts
- Yield/rupture from over-loading
- Thermal expansion
- Surface wear or plastifications

} Non-rotational loosening

- Transverse vibrations / structural slip → Rotational loosening (self loosening)

Methods

Focus on tower flange connections

Rationale: largest number of bolts and the most straightforward to handle

Joint Industry Project Scope:

WP1: Create a database to characterize the performance of the tightening processes. Criteria to be taken into account among others:

- Sensitivity to tightening tool and calibration / maintenance
- Assembly procedure and interaction between bolts
- Sensitivity to bolting material / heat treatment and bolt design
- Distribution of achieved preload
- Embedding losses after fixed time intervals
- Sensitivity to tightening speed and competence of operator
- Sensitivity to environmental conditions
- Sensitivity to surface conditions / coating
- Sensitivity to clamp lengths

WP2: Develop calculation methods which ensure no local slip or yield anywhere in the clamped package. Use FE method to create a database of correction factors for the currently available analytical calculation methods. Correction factors should account for:

- Flange imperfections
- Distribution of bolt preload
- Loading and loading direction

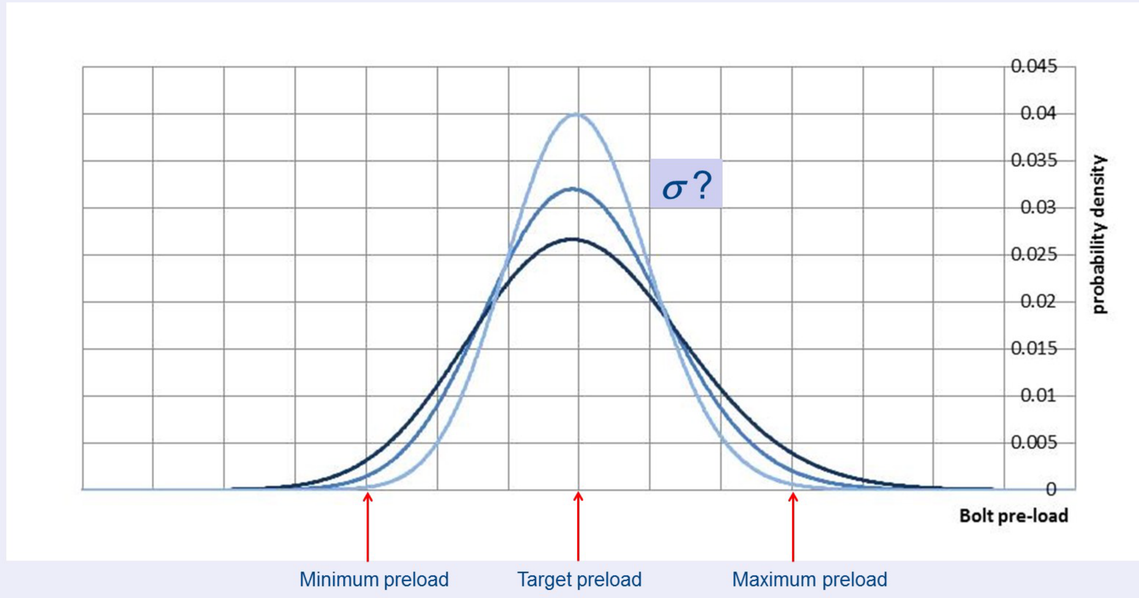
WP3: Choose appropriate failure criteria for yielding and slipping and develop a probabilistic approach to define whether yielding or slipping will take place in a connection.

WP4: Validate the calculation approach with full scale tests and calibrate results. Validate extrapolation of the data from WP1 and WP2 to different designs and loading conditions

WP5: Preparation of an internal project report and a Recommended Practice

Challenges – quantifying uncertainties

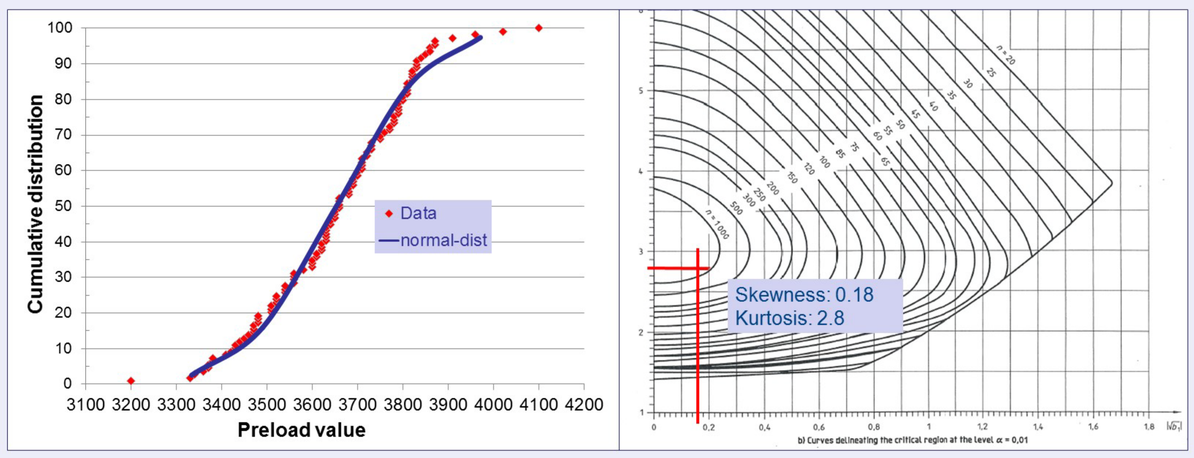
Characterize distribution of bolt preload in a single bolt and in the assembly bolts



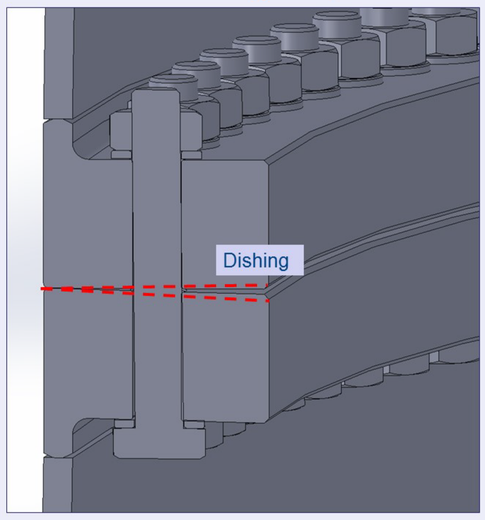
VDI 2645:2014-09 Part 2: “Capability test for fastening technology – Machine capability test – MCT”.

Determine the stability and reproducibility of the process parameter “machine” with reference to a sample assembly.

Check if data fit normal distribution, e.g. with ISO 5479:1997 or Anderson Darling test



Characterize flange imperfections with FE analyses. Among others:



- Flange planarity – dishing
- Sinusoidal geometrical variations around flange circumference [6]

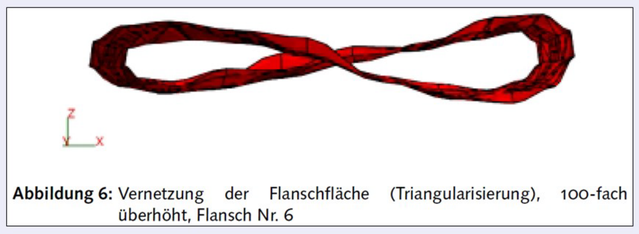


Abbildung 6: Vernetzung der Flanschfläche (Triangularisierung), 100-fach überhöht, Flansch Nr. 6

Conclusions

Validation of “zero-maintenance” bolted joints will be investigated in the framework of the Joint Industry Project “Integrated approach to design, maintenance and installation of bolted joints”, which will be run by DNV GL and selected partners throughout 2016. Implementation of designs and installation advancements, along with a solid validation plan, will lead to a consistent reduction of OPEX related to bolted joints retightening without compromising their structural safety or their function.

References

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