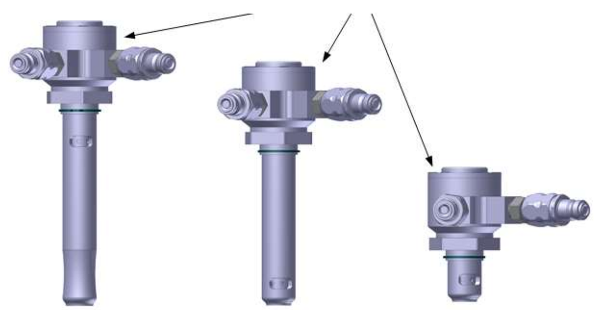
Stresses in Novel Plate Joining Method for Space

A new method for joining together two plates, namely the Torque Free Tension Tool (TFTT), has been validated to achieve favorable stresses compared to conventional methods. Neutron diffraction was utilized to show stresses in bolts and plates after joining using either a conventional wrench or the TFTT tool.



The TFTT tool used during assembly to pre-tension the bolt before tightening.

The Experiment

The investigation was performed at the EnginX instrument at the ISIS neutron facility in England, cooperatively between the Danish Technological Institute and OHB

The samples consisted of aluminium plates

- joined by a conventional bolt,
- assembled using the TFTT tool, where the plates are pre-strained before fixing the bolt,
- Loose bolts and unassembled plates were brought as reference specimens.

This results show the stress distribution in a conventional bolt and a TFTT bolt, relative to a bolt that was not in assembly. The largest differences were found in the axial (z) direction and are presented below.

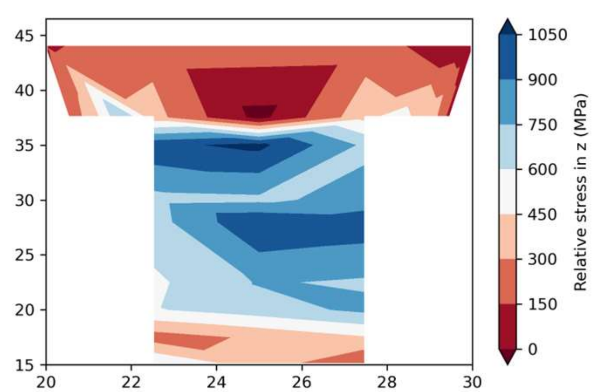
Stress distribution

From the stress distribution in the axial direction of the bolt, it can be seen that the conventional bolt is fully tensile compared to the unassembled bolt. The highest tensile stresses are found in the shaft inserted in the top plate, whereas the screw head remains relatively unchanged in stress. In contrast the TFTT retains the same stress level along its axis into the head. The edges of the head are in relative compression from the imposing plate.

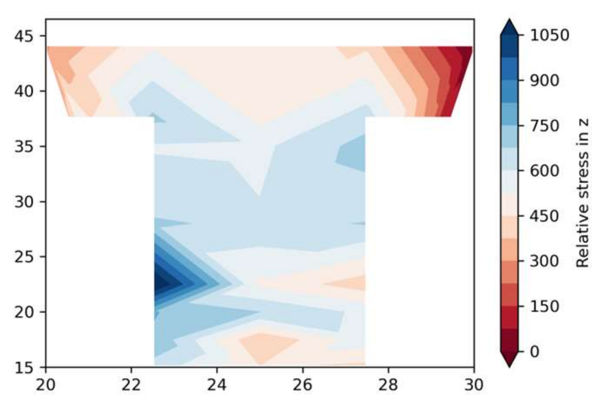
Interpretation

The conventional assembly resulted in large forces imposed on the screw along its shaft-axis. This may impact the lifetime and dimensional stability during application.

The TFTT tool gave a uniform stress distribution in the shaft, indicating that pre-straining the plates spares the bolt from the bulk of the joining stresses. There will still be forces imposed on the screw head in the sides, but this is less likely to impact lifetime and stability



Conventional bolt



TFTT

EASI-STRESS

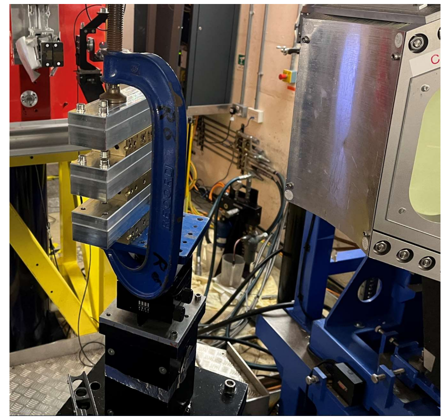
This work was funded by the EASI-STRESS project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953219.

More Results & Background →

Additional Results & Background

Background

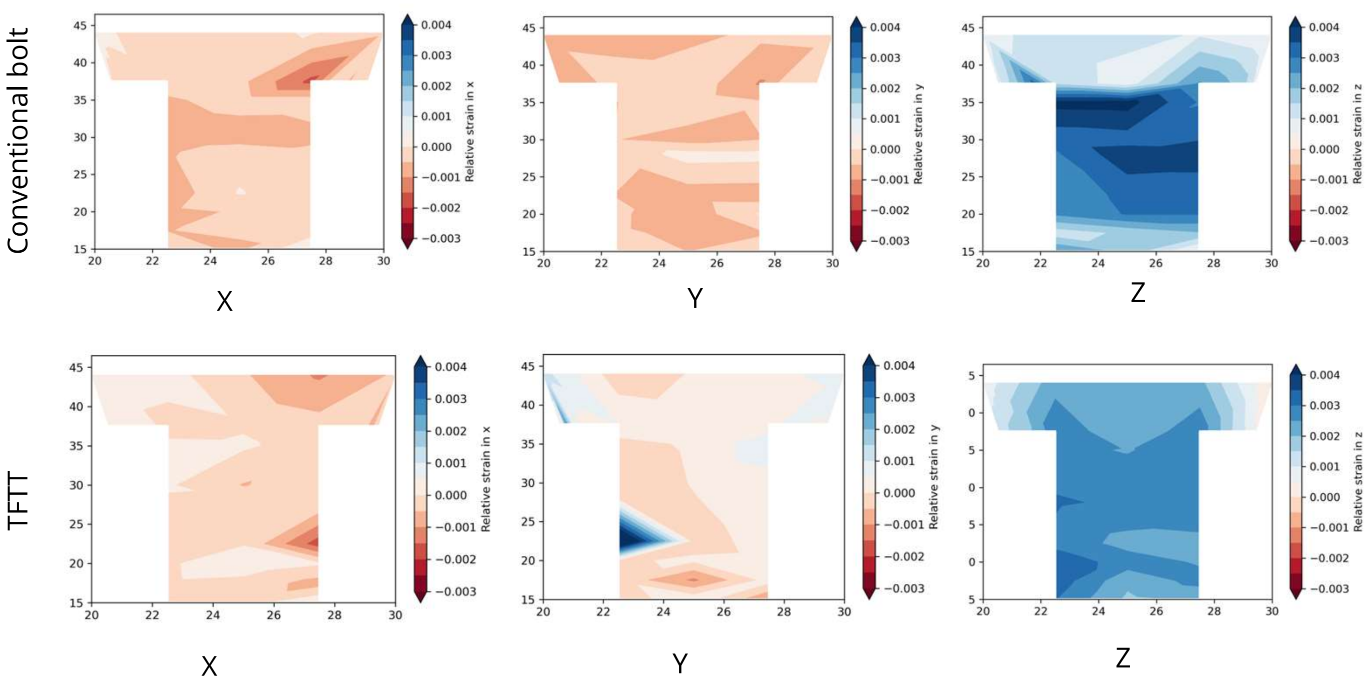
The investigation was funded by the EU Horizon2020 project EASI-STRESS, in which DTI and OHB are partners.
The neutron-based instrument EnginX was chosen for the excellent ability of neutrons to penetrate deep into steel and aluminium, allowing great flexibility and measurement depth. This makes it a unique tool to measure the full strain tensor in the bulk of industrial components.
The samples in the EnginX instrument is shown in the picture on the right. The neutrons enter the sample from the left and the diffracted signal is recorded in the detector to the right.



Strains

The strains are the degree of deformation from which the stresses are calculated. Neutron diffraction utilized the distance between atoms as an internal stress gauge, allowing for calculation of the strain relative to a strain free reference. Both the conventional bolt and the TFTT screw has been tightened to the same momentum.
As expected, the most interesting strains are found in the z-axis, where the bolt is tightened. Here we see that the conventional method results in a pulling force on the bolt. The TFTT results in uniform strain along the shaft, indicating a better performance.
In the other directions, the bolt is in compression from the forces between it and the aluminium plates in which it is inserted.

Right: Sketch of the samples (two aluminium plates, top and bottom) joined by a convetional bolt or the TFTT tool) and coordinate system defining the strain directions.
Below: relative strain (compared to loose bolt) in all three primary directions in the conventional bolt (top row) and TFTT tool (bottom row).



Contacts:
Dr. Nikolaj Henriksen
nigh@teknologisk.dk

Dr. Axel Mueller
axel.mueller@ohb.de