

Residual stresses influence the strength of submarine pressure hulls

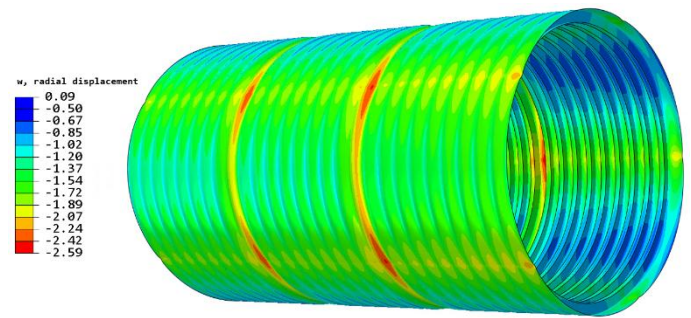
Greta Garne & Jesper Olanders

According to a new study at LTH together with Saab Naval, residual stresses from welding and manufacturing may reduce the collapse strength of submarine pressure hulls more than the imperfections from tolerances alone.

Submarine pressure hulls are designed to withstand extreme water pressures at great depths. However, manufacturing processes such as welding and rolling introduce residual stresses – stresses that remain inside the material after production. These processes can also deform the structure, creating geometric imperfections that affect collapse behavior.

The study investigated how residual stresses and geometric imperfections interact and influence the collapse pressure. The collapse pressure is the pressure at which the structure fails and collapses, similar to a soda can under external pressure. While both effects have been studied separately, their combined influence is less studied.

The work was carried out using the finite element method, a numerical simulation technique where the structure is divided into thousands of smaller elements. By analyzing how each element behaves under pressure, the collapse behavior of the entire hull can be predicted. A fictitious pressure hull was modelled to study the effects of residual stresses and geometric imperfections. However, the model was designed to resemble the design of real submarine structures in terms of both



Contour plot over radial displacement of the pressure hull at relaxation after applied residual stresses. Regions with contracting residual stresses are shown in red.

material and geometry, as found in the literature.

The results showed that a pressure hull containing both residual stresses and geometric imperfections collapses at lower pressures than a hull with imperfections alone. The location of welds was also found to be important. For instance, circumferential welds affected collapse pressure more severely than welds aligned along the submarine's longitudinal direction.

Welding is unavoidable in submarine manufacturing and contributes heavily to reducing collapse pressure. In fact, the total length of welds in a submarine can correspond to the entire width of Skåne. Understanding how these welds influence structural integrity is therefore important when designing pressure hulls. Interestingly, residual stresses are not always harmful. In some cases, carefully designed welds can deform the structure in a way that counteracts the natural collapse path and improves stability.

These findings contribute to a new methodology for predictions of the structural response, potentially leading to more efficient and improved submarine designs.