RESIDUAL STRESSES MEASUREMENT WITH THE CONTOUR METHOD ON A COLD EXPANDED HOLE COMPARISON TO FINITE ELEMENT ANALYSIS

Meliad
Expertise & industrial technologies

Capaero
Extending assembly service life

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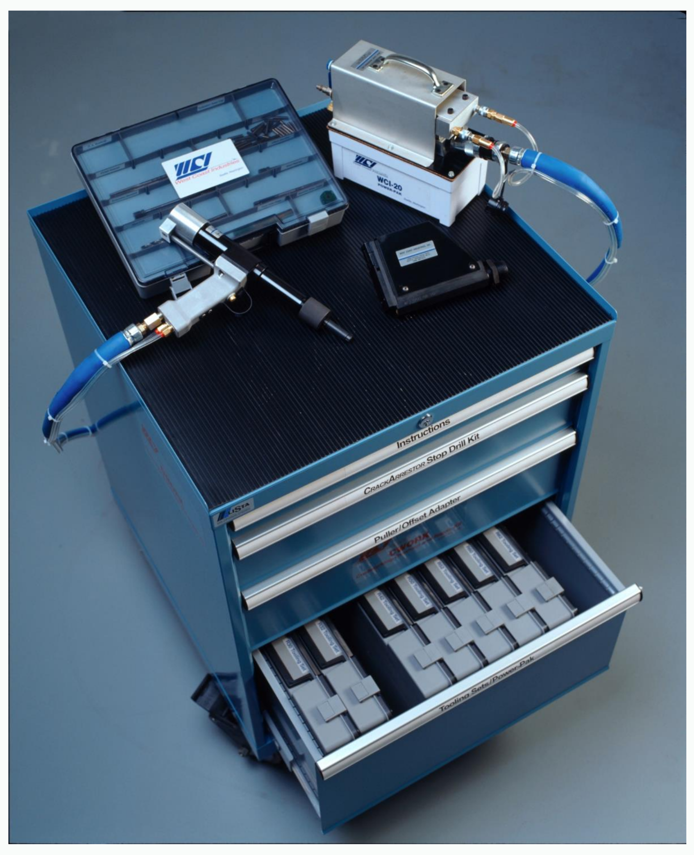
Abstract

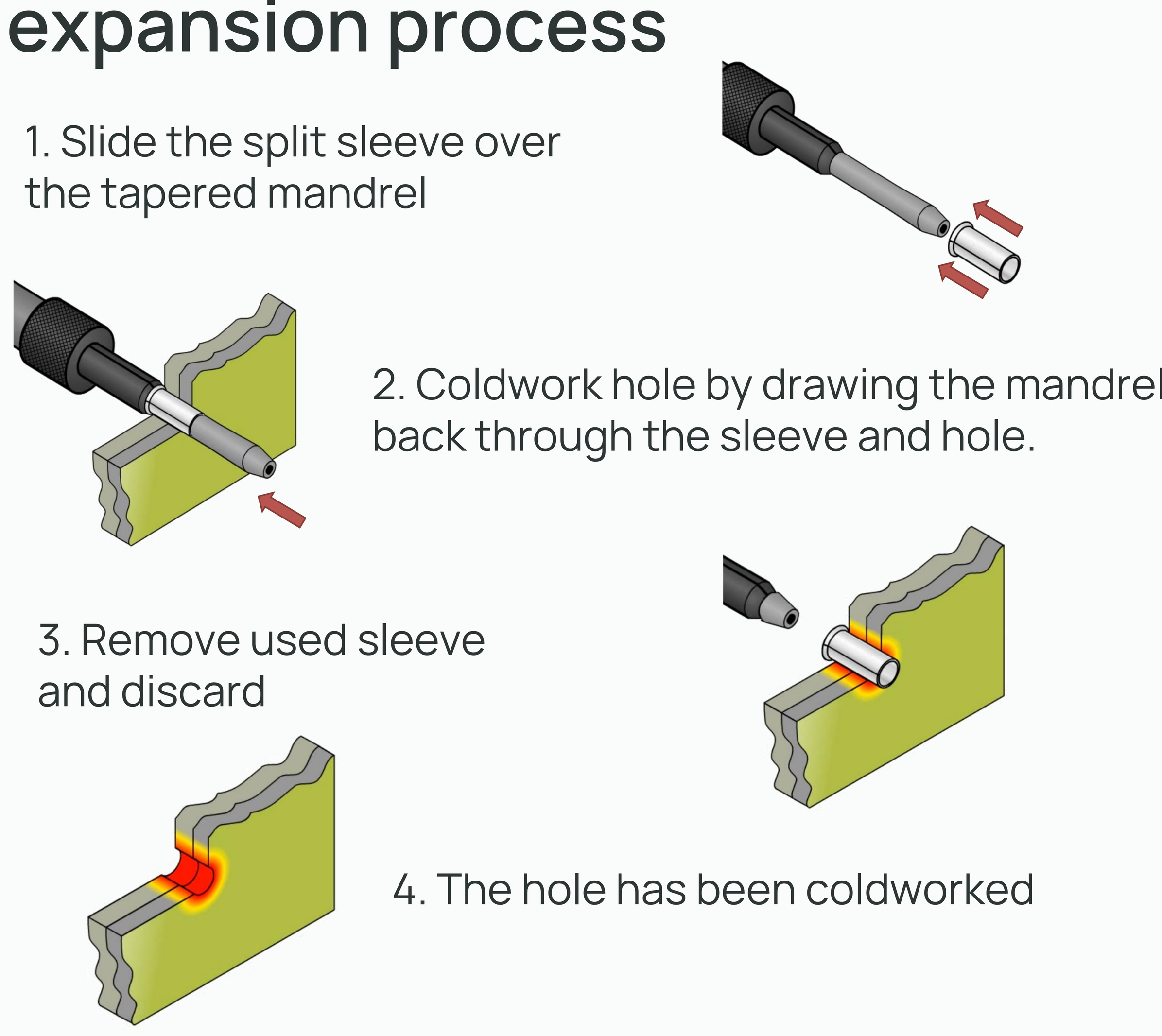
Introducing high residual stress in a hole is critical for many fatigue life components, especially in aerospace industry. The process introduces deep residual stress on hole surface providing fatigue life enhancement.
Cold expansion should be controlled to guaranty both the homogeneity and the repeatability of the compressive stresses generated by the process. However, it is difficult to control the stresses generated into the component. That is why **Meliad** and **Capaero** with **Mat-In-Meca** developed the contour method allowing to control the deep stress profile generated in the part.

This study shows how experimental measurement by the contour method and numerical model through finite element analysis gives effective characterization of the residual stresses introduced after hole expansion.

Material: 35NCD13 Steel

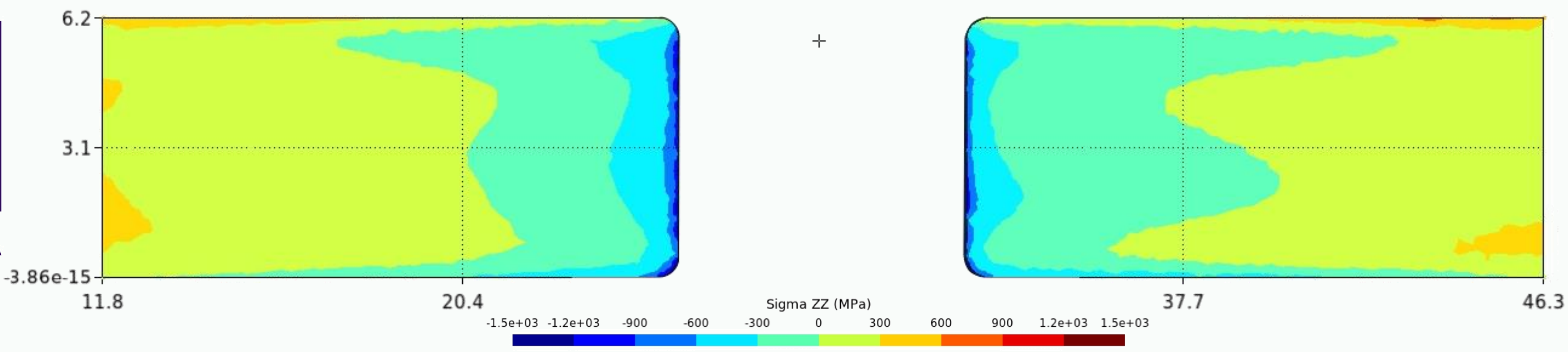
Hole cold expansion process





Residual stresses measurement results with contour method

MAT IN MECA



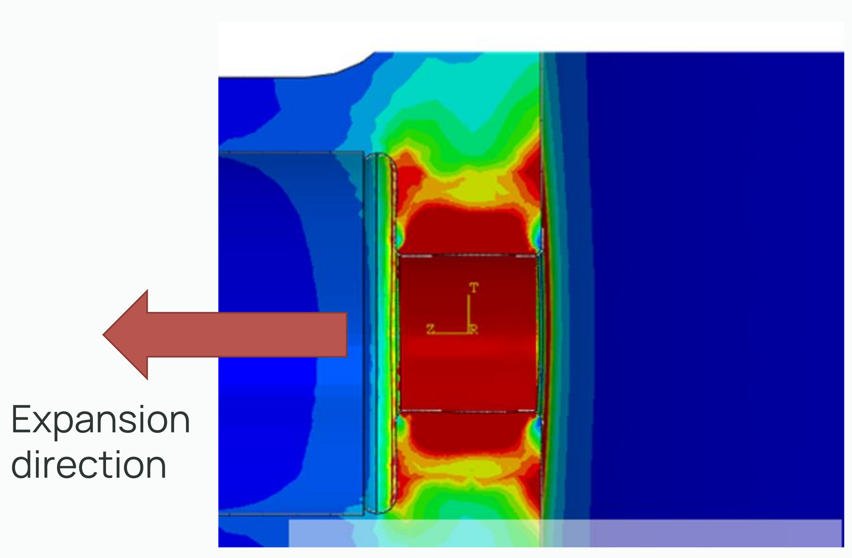
Tangential stresses (MPa)

Finite element analysis results

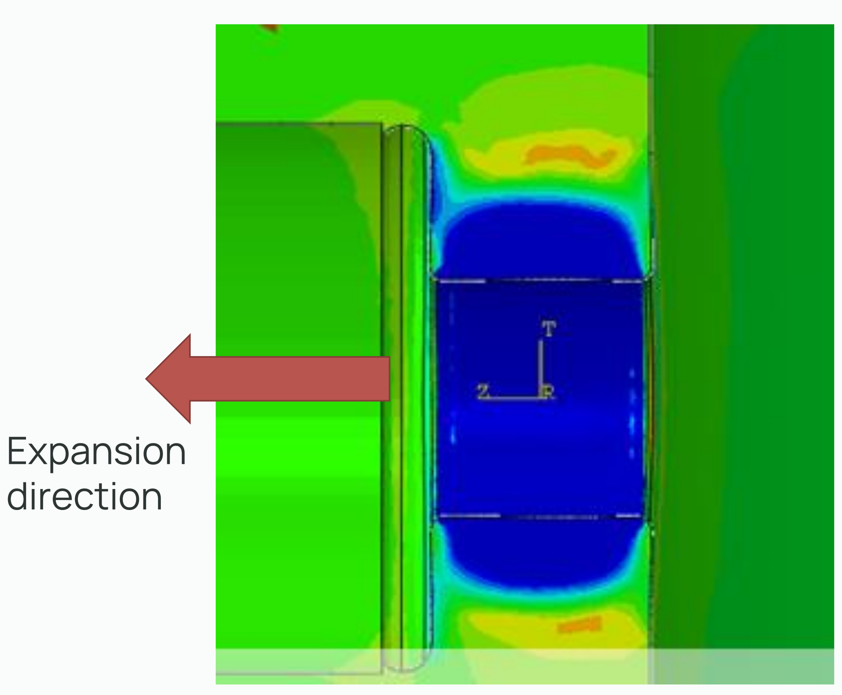
Finite element analysis has been conducted using a 3D model. The model take into account all tools geometry including the split sleeve itself. This approach allows to see the impact of the split on the residual stresses map.

The dynamic explicit simulation was done taking special care of contact properties. This kind of simulation tend to increase the stresses oscillations after spring back but **Capaero** experience allows to lower the uncertainness of the results.

In this study, the measurement plan was taken at 90 degrees of the split location to avoid local behaviours due to the split.

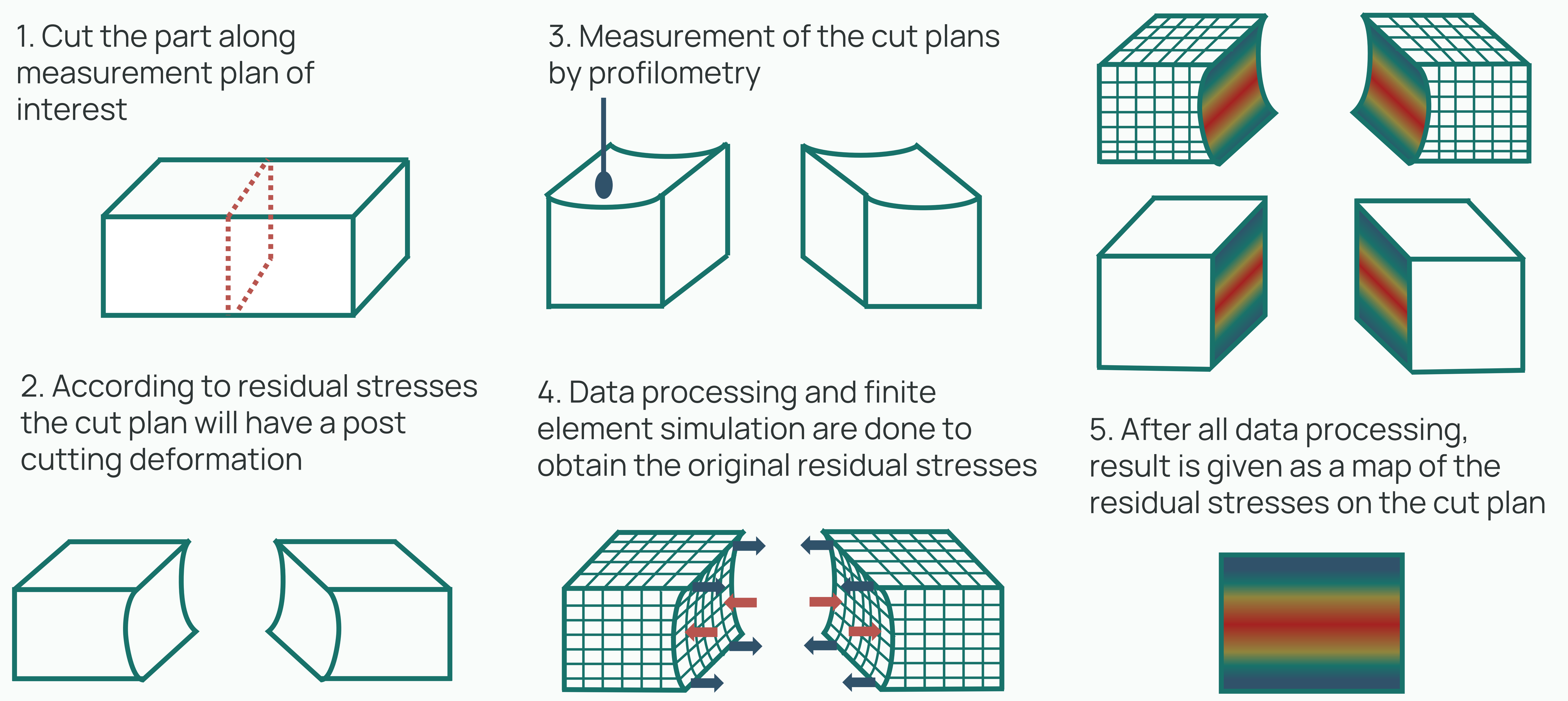


FEA Plastic strain map



FEA
Tangential residual stresses

Contour method process



Comparison between FEA and measurement

FEA and contour method agree on some points. They show that maximum compressive stress near the surface is higher than 1000 MPa and depth-to-zero is between 3 and 5 mm.
Significant differences are also clearly visible. FEA shows a stress plateau while contour method describes immediate decrease.

Uncertainty for the contour method is in the order of ±10%. It is also known that the contour method is hardly capable to measure very high gradient (1000 MPa/mm) close to surfaces.
FEA results is directly dependent of mechanical properties such as yield strength and work hardening considered for the elasto-plastic model. Now, standard properties have been considered for the present steel grade.

Observed differences will be discussed in further study in the light of reproducibility measurement for the contour method, sensitivity study for the FEA, and additional measurements with XRD at **Meliad**.