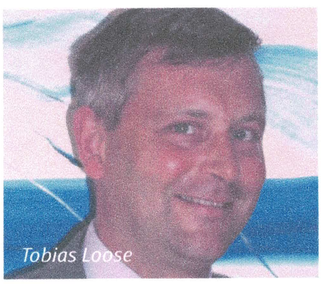
Welding simulations for industry



Welding simulations hold vast potential for industry, allowing testing of numerous variations of assemblies for strength. However, due to the long duration of simulation times, they are not yet widely used. **Tobias Loose** has been coordinating a project to test how well welding simulations will run on massively parallelised computers to finally bring these types of simulations to a wider audience

Welding literally holds the modern world together. It is the most effective and economical way to join metals permanently and is a vital component of the manufacturing economy. It is estimated that more than 50% of the world's domestic and engineering products contain welded joints. Methods for providing insight into the structural properties of welds can help make these products stronger and safer.

Tobias Loose has been running numerical welding simulations on computers since 2004, when he started his PhD at the Karlsruhe Institute of Technology. When he completed his doctorate, he started his own company so that he could continue working in this area. "It is not an established area of industrial simulations," says Loose. "In 2007, my company was one of the first in the field. At that time, the long duration time for simulations was preventing their acceptance by industry. I realised that I needed to educate the market about welding simulations if my company was going to be a success."

Loose's company, Ingenieurbüro Tobias Loose (ITL), specialises in simulations for welding and heat treatment and provides engineering consulting for industrial customers. The goal of welding and heat treatment simulations is to determine the final state of the assemblies after the manufacturing processes, as well as to optimise the processes themselves.

Welding simulation models need a fine discretisation in the weld area. Furthermore, industry has been requesting the analysis of large assemblies as well as the analysis of thick plates with multi-layered welds. In addition, welding is a transient process and its numerical analysis involves a large number of time steps. This leads to welding simulation models with a large number of elements and a large number of time steps, resulting in long simulation times on small computing clusters.

Loose has carried out pioneering work in welding simulations using the LS-DYNA multiphysics simulation software. "The biggest problem we face with welding simulations in general is that they have to be large models," says Loose. "This is because of both the fine discretisation of the mesh, and the long simulation times that are necessary. With smaller models you may be looking at one or two hours of simulation time, but larger industrial ones can take days or even a week. This is the reason I first decided to start using HPC resources."

"The SHAPE project allowed me to test my simulations as well as receive guidance and support from the staff at HLRS"

The Finite Element Code LS-DYNA on high performance computers provides good performance for welding analysis and permits parallelised computation using domain decomposition. While the parallelised LS-DYNA code has successfully been used in explicit crash analysis, parallelised welding simulation is a new field for the LS-DYNA solver and and it has not been tested.

After discussions with DYNAmore in Stuttgart (promoters of LS-DYNA in Europe), Loose decided to test it. He knew that he could not afford to have an HPC cluster in his office and so he decided to apply to SHAPE, a programme run by PRACE that helps support HPC adoption by SMEs. "The SHAPE project allowed me to test my simulations as well as receive guidance and support from the staff at Stuttgart," he explains.

"I want potential customers to see the possibilities that high performance computing offers for welding simulations"

There are several kinds of welding simulations. The welding process simulation is a fluid analysis in which the droplet, the flow in the melt pool and the solidification are analysed. The other kind of welding simulation —and the one in which which Loose is involved — is welding structure analysis. This comprises a coupled thermal-mechanical analysis on a discrete finite element mesh, and allows the analysis of the distortion and stress of welded structures.

Loose's goal after the SHAPE project is to apply the knowledge gained about HPC-aided welding analysis to his customers' designs. "My hope is to provide HPC as part of my welding consultancy, which supports the design and optimisation of welded assemblies. If someone wants to test a number of variants of a certain design in a short space of time, I could help them do that."

Together with other partners, Loose has produced a white paper that outlines the feasibility and performance of parallelised welding analysis using LS-DYNA. "I want potential customers to be able to see the possibilities that high performance computing offers for welding simulations. This will help to improve the acceptance of simulations in this area in general and will help to drive more business for ITL. I have an account with the HPC cluster in Stuttgart (HLRS) that allows me to use their resources remotely from my office, so we are ready to go now."

For more information

www.tl-ing.eu
www.dynaweld.eu
www.hlrs.de
www.dynamore.de

Resources awarded by PRACE

This project was awarded 50 000 core hours on HORNET, hosted by GCS at HLRS, Germany.

Publications

Loose, T. ; Bernreuther, M. ; Große-Wöhrmann, B. ; Göhner, U.: SHAPE Project Ingenieurbüro Tobias Loose: HPCWelding: Parallelized Welding Analysis with LS-DYNA, SHAPE White Paper, 2016
www.prace-ri.eu/IMG/pdf/WP220.pdf

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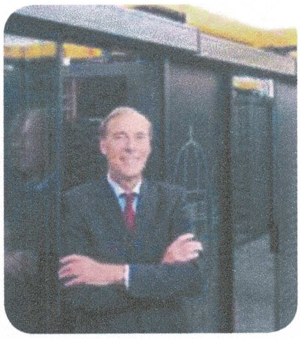

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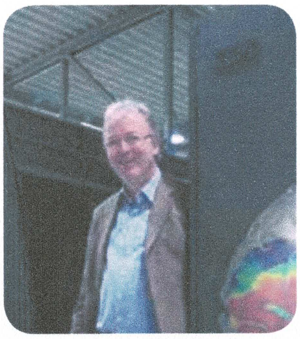

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