Welding analysis in LS-DYNA

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Objective : Welding Simulation (Welding residual stress, Distortion)

Idea : Simulation of tolerances is more efficient (time & cost) than real physical tasks (trial and error)
Welding simulation Workflow:

**Heat source modeling**

- Welding parameters (Geometry, WPS*,..) are needed.

**Welding Simulation** (Thermo-mechanical coupled simulation)

- Weld Procedure Specification
- Heat source modeling
- Material database
  - Temperature dependant
  - Phase transitions

**Material simulation**

- Thermal and mechanical
  - Material properties are needed.

**Structural Simulation**

**Process Simulation**

**LS-DYNA**

Thermal Mechanical Analysis

DynaWeld

*Dr.-Ing. Tobias Loose*

www.tl-ing.eu

LS-PrePost

*Dr. Mikael Schill*

www.dynamore.se

Volvo Construction Equipment

*Weld Procedure Specification*
Welding simulation Setup:

- Geometry of structure and weld.
- Meshing (by ANSA,...) and import to LSPREPOST

Weld input parameters (WPS)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding Current (A)</td>
<td>390</td>
</tr>
<tr>
<td>Voltage (V)</td>
<td>30</td>
</tr>
<tr>
<td>Welding Speed</td>
<td>13.33 mm/s</td>
</tr>
<tr>
<td>Material</td>
<td>Plate S355 (thk=8 mm)</td>
</tr>
</tbody>
</table>
Welding simulation Setup:

- Sets of nodes to define mechanical constraints.
- Segments that define thermal boundaries.
Welding simulation Setup:

- MAT_CWM (Mechanical), MAT_CWM_THERMAL (Thermal)
- Welding Material: “Ghost” or “Silent” until activated
- Activated at specific temperature
Welding simulation Setup:

- Define Weld path and orientation path (Beam elements).
- Welds can be either merged to structure or connected by tied contact.

![Diagram showing Weld Path and Orientation Path](Image)
LSPREPOST_Welding simulation GUI:
LSPREPOST_Welding simulation GUI:

1- Welding properties

\[
q = \frac{2n\sqrt{n}FQ}{\pi \sqrt{abc}} \exp\left(\frac{-nx^2}{a^2}\right) \exp\left(\frac{-ny^2}{b^2}\right) \exp\left(\frac{-nz^2}{c^2}\right)
\]
LSPREPOST_Welding simulation GUI:

1- Welding properties

Weld source moves with prescribed motion. Weld path (Trajectory) and orientation path (Reference) as beam element.

Weld pool geometry:

- Ellipsoid
- a: 4.7
- b: 6.7
- cf: 3
- cr: 3
- Ff: 1
- Fr: 1
- n: 3

Weld stroke:
- Velocity: 13.3
- Weld Power: 1.014e+07
- Eff. factor: 0.8
- Step/8e: 0.5
- NCYC: 3
- Cool down Time: 5

Orientation Path (Reference)

Weld Path (Trajectory)
LSPREPOST_Welding simulation GUI:

2- Structural and Thermal and B.C

To each weld, corresponding clamping and thermal boundary condition can be chosen.

3- Welding plan

Weld order
Results_Temperature:
Results_Stress_Deformation:
Parametric study:

Weld order

![Graphs showing stress and displacement for different weld orders.]

Weld direction

![Graphs showing stress and displacement for different weld directions.]

Simulation time

<table>
<thead>
<tr>
<th>step/ele</th>
<th>Number of Time step</th>
<th>Time Step (s)</th>
<th>Thermo Mechanical DISC=0.3</th>
<th>DISC=1.5</th>
<th>Thermal only DISC=1.5</th>
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<tbody>
<tr>
<td>0.2</td>
<td>6</td>
<td>3.759</td>
<td>00:02:36</td>
<td>00:05:16</td>
<td>00:00:58</td>
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<tr>
<td>0.5</td>
<td>15</td>
<td>1.504</td>
<td>00:12:40</td>
<td>00:05:50</td>
<td>00:01:08</td>
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<tr>
<td>1</td>
<td>30</td>
<td>0.752</td>
<td>00:15:40</td>
<td>00:08:34</td>
<td>00:02:06</td>
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<td>45</td>
<td>0.501</td>
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<td>00:10:08</td>
<td>00:02:48</td>
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<tr>
<td>6</td>
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<td>00:21:55</td>
<td>00:05:15</td>
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<tr>
<td>15</td>
<td>450</td>
<td>0.050</td>
<td>01:20:16</td>
<td>00:56:13</td>
<td>00:12:20</td>
</tr>
</tbody>
</table>
Multipass welds:
Summary:

Welding simulation set up by means of LS-PREPOST user friendly Welding GUI.

Weld material modeling using: MAT_CWM (Mechanical), MAT_CWM_THERMAL (Thermal), solid, liquid, ghost elements activated and anneal at specific temperatures.

Heat source modeling: Weld pool geometry (Goldak double elipsoidal), welding input parameters (weld speed, time, power).

Thermal only analysis provides short simulation time (heat source calibration).

Parametric study: weld order, weld direction, Heat input, time step,…

Thank you