SIMULATION OF FLOW DRILL SCREWING.

THERMO-MECHANICAL ANALYSIS USING COUPLED EULERIAN-LAGRANGIAN ELEMENT FORMULATION.
AGENDA.

- Motivation.
- Simulation Modell.
- Comparison with an adaptive Velocity Flowdrill Process.
- Simulation Results: Screw Geometries.
- Summary.
MOTIVATION.

Use of Simulation to identify Potentials to develop new Process limits without intensive prototyping.

REDUCE CO2 EMISSIONS.
- Reduce weight
- Aluminium Wrought and Aluminium Casts

INCREASE USER EXPERIENCE.
- Increase Comfort and Safety
- High Strength steels

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BASICS OF FLOW DRILL SCREWING PROCESS.

- Screw Positioning.
- Heat Generation and whole forming.
- Whole Forming.
- Thread Forming.
- Screw in.
- Fastening.

Simulation model.

Flow Drill Screw Process.

1. 2. 3. 4. 5. 6.
**SIMULATION MODEL.**

*DYNAMIC TEMPERATURE-DISPLACEMENT, EXPLICIT.*

**Screw Head:**
Rigid Body Element for Visualizing

**Screw Shaft and Tip:**
- Discretized with C3DT Tetrahedron Elements.
- Density * 1000 (Time Step)
- Minimal Element Length: 0.1mm

**„Eulerian Sheet Space“:**
- Eulerian EC3DRT SOLID Hexahedron Elements.
- Minimum Element Length: 0.1mm

**Sheets to Join:**
- Sheets defined by Volume Fraction in „Eulerian Sheet Space“
  - Top Part: CR440Y780T-DP 2.0mm
  - Bottom Part: AL5STD 3.0mm
- Temperature dependent flow curve calculated by JMAT Pro

**Joint (Input):**
- Feed rate defined by Amplitude (Velocity-Time)
- Rotational Speed defined by Amplitude (Velocity-Time)

**Tool Downholder:**
- Rigid Body Element
- Downholder Force defined by constant Load

**Constraint (Output):**
- Constraint defined as a Rigid Body Wall
- Measure Reaction Forces and Reaction Moments via Joint

**Contact Formulation:**
- Standard coulomb approach with a constraint of the maximum friction shear stress.
- Gap Heat Generation
SIMULATION RESULTS.
COMPARISON OF SIMULATION WITH A FLOWDRILL PROCESS EXPERIMENT.
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SIMULATION RESULTS.
STRESS ANALYSIS- REACTION FORCES AND MOMENTS.

\[ \sigma_{\text{Von Mises}} \approx 1600 \text{ MPa} \]

\[ \sigma_{\text{Von Mises}} \approx 1800 \text{ MPa} \]
SIMULATION RESULTS.
VOLUME FRACTION - REACTION FORCES AND MOMENTS.

Element: Volume fraction (EVF VOID): M4 Screw

Element: Volume fraction (EVF VOID): M5 Screw

Axial Reaction Force vs. Penetration Depth

Axial Reaction Moment vs. Penetration Depth
SIMULATION RESULTS.
STRESS ANALYSIS – REACTION FORCES AND MOMENTS.

Element: Stress components (5): Von Mises

M4 Screw

M5 Screw

Axial Reaction Force vs. Penetration Depth

Axial Reaction Moment vs. Penetration Depth
SIMULATION RESULTS.
STRESS ANALYSIS – REACTION FORCES AND MOMENTS.

M4 Screw

M5 Screw
SUMMARY AND CONCLUSION.

- A Finite-Element-Model based on a coupled-Eulerian-Lagrangian Analysis in Combination with Dynamic Temperature-Displacement Explicit-Solver has been shown to simulate flow-drill-screwing process.

- A comparison to an adaptive velocity process has been shown as well as a first stress analysis.

- A mechanical stress Analysis of two Flow Drill Screw Types (M4 and M5) has been compared.

**Conclusion.**

- Stresses, reaction Forces and reaction Moments can be investigated as well as strains and temperatures.

- The Simulation can be used to develop new Screw Geometries and new Process Parameters for prototyping to reach new process limits for the Flow-Drill-Screw Process.
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