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Linear Friction Welding of Aeronautical alloys
Modeling and Numerical Simulation

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Thermo-mechanical coupled process

\[ \rho \frac{dv}{dt} = -\nabla p + \rho_s \]
\[ \rho C_\text{p} \frac{dT}{dt} = \nabla . (k \nabla T) + \dot{q} \]

full 3D, entire process simulation

Forge* solver
- (metal forming framework)
- Implicit formulation
- Updated lagrangian
- (v-p) based formulation
- Remeshing

Considered material
Ti6242, TA6V, Ti17, Inconel718

Material model
JMatPro based
- elasto-viscoplastic material

Friction model
Friction model is critical but unknown

Proposed solution: inverse analysis from recorded real-process data

Results presented here are based on a Coulomb model

\[ \tau = \mu \Delta \sigma_n \]

Friction Coulomb coefficient influence

On shortening

LFW simulation

2 bodies model
- friction/contact model
- Sensitivity to contact algorithm
- New surface smoothing algorithm

Symmetric bodies model
- friction/contact model
- Simplified to friction against rigid body

Perfect weld model
- Assumption of a perfect perfect weld
- Can simulate the end of the process
- No friction / perfect contact
- Requires initial temperature distribution

Process insights
- Purely surfacic to volumic heat generation transition
- Relative irrelevance of heat exchange model with air and clamps

Numerical challenge
- Surface phenomena are dominant
- Locally refined mesh must be used to ensure accuracy

Proposed solution: Mesh adaptation

Experimental Measurements

LFW process measures*
- friction model calibration
- model validation

*Processes were realized with ACB machine and expertise

K-type thermocouple measurements

Machine builtin upset and global friction force monitoring

Bibliography

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