The Numerical Challenges in Multiphysical Modeling of Laser Welding with ALE
I. Tomashchuk, Issam Bendaoud, Jean-Marie Jouvard, Pierre Sallamand

To cite this version:
I. Tomashchuk, Issam Bendaoud, Jean-Marie Jouvard, Pierre Sallamand. The Numerical Challenges in Multiphysical Modeling of Laser Welding with ALE. COMSOL Conference, Oct 2018, Lausanne, Switzerland. hal-01962652

HAL Id: hal-01962652
https://hal.archives-ouvertes.fr/hal-01962652
Submitted on 20 Dec 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
**INTRODUCTION:** The present work summarizes the numerical challenges in creation and validation of free-surface models using ALE moving mesh coupled with heat transfer equation and Navier-Stokes fluid flow. The influence of a set of numerical parameters as well as physical hypotheses on the dynamics of the keyhole and the characteristics of the melt formed in titanium alloy Ti-6Al-4V is analyzed.

**COMPUTATIONAL METHODS:**

- **Heat transfer**
  - time-dependent
  - standalone laser pulse
  - T-dependent absorption coefficient

- **Navier-Stokes**
  - Newtonian liquid
  - Mean viscosity in solid phase
  - Inconsistent stabilization

- **ALE**
  - Hyperelastic smoothing is better
  - Deformation driven by velocity field

**PARAMETRIC STUDIES:**
- ALE smoothing methods
- Numerical stabilization of N-S equation
- Solid and liquid viscosity
- Adsorption in the keyhole $A_{KH}$
- Condensation coefficient $\beta$
- Incompressible VS weakly compressible N-S

**RESULTS:** Optimal parameters allow to reproduce the whole lifetime of the keyhole during pulsed welding of Ti6Al4V alloy (temperature field + velocity field).

**INFLUENCE OF CRITICAL PARAMETERS:**
- Parasite velocities in solid
- Less profound keyhole
- Unphysical relaxation of solid

**FIGURE 1:** Nd:YAG laser pulse of 6 ms, 1.5 kW, $\varnothing = 560 \mu$m, $\eta_{solid} = 200$ Pa.s.

**FIGURE 2:** Unphysical relaxation of solidified weld between the end of solidification and the end of cooling for different solid viscosities.

**FIGURE 3:** The influence of solid viscosity on the evolution of maximal temperature, melt velocity and keyhole depth for standalone Nd:YAG laser pulse on Ti-6Al-4V plate (6 ms, 1.5 kW, $\varnothing = 560 \mu$m).

**CONCLUSIONS:**
- Convergence problems associated with too important deformation of free surface (remeshing?)
- Keyhole depth sensitive to : solid and liquid viscosity, keyhole adsorption coefficient and condensation coefficient
- Acceptable mass conservation