Phase Transition and Hot Cracking Susceptibility of Nb-Si Alloys

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INTRODUCTION: With Nickel Based Super Alloys reaching its peak performance, its important to develop alternative alloys. This study will focus on Nb-Si alloys looking into its phase transition and hot cracking susceptibility.

COMPUTATIONAL METHODS:

A 3D block was used as the geometry. Material properties in the model were manually evaluated and added as functions allowing to change the alloy composition as needed. Heat Transfer in Solids interface was used to add a heat source. The heat source was modelled using the Goldak double Ellipsoid model. The Solid Mechanics interface was added to the model to evaluate the stresses along with thermal expansion and creep models. The Creep option was set using the Norton creep model and thermal expansion model was added using the secant coefficient of thermal expansion model. The domain ODEs and DAEs physics interfaces were used to add variables fL(fraction of liquid), fS(fraction of solid) and fP(fraction of powder), in order to simulate phase change. A time dependent study was carried out in order to analyse stresses and creep strain during phase change. The simulation is used to evaluate the hot cracking susceptibility index of the alloy using the RDG model for hot cracking and solidification graphs that were produced in the previous study using the data base created for Nb-Si alloys.

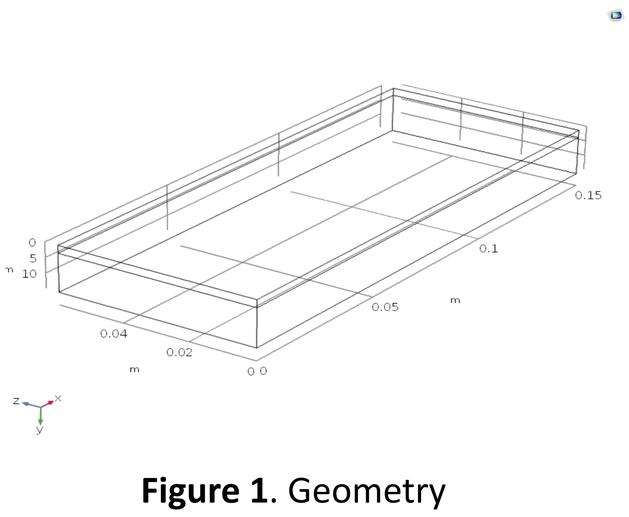

Figure 1. Geometry

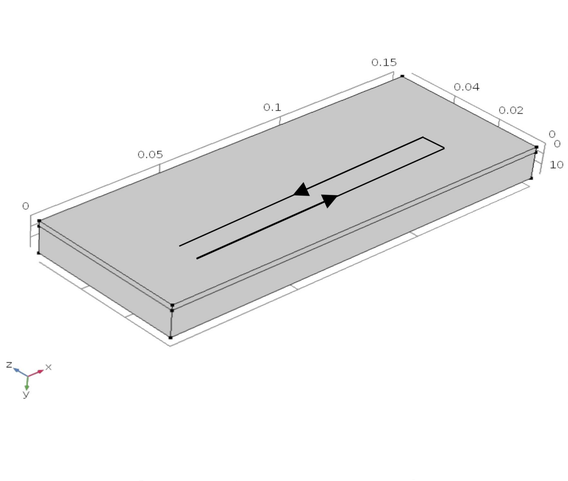

Figure 2. Laser path

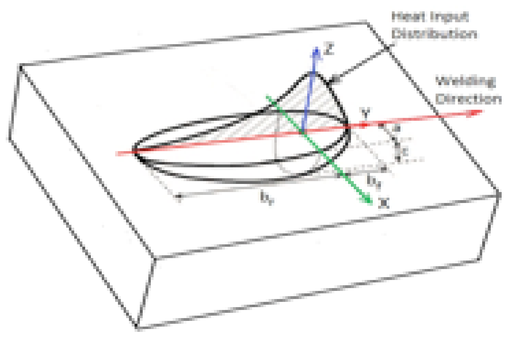

Figure 3. Goldak double ellipsoid model

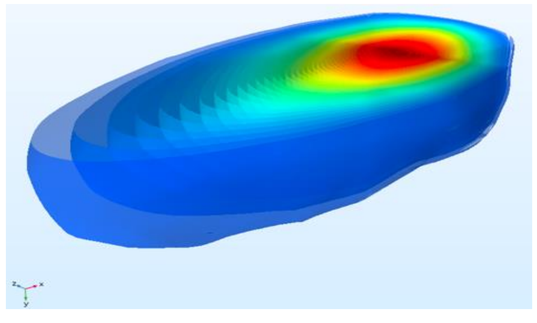

Figure 4. Heat source

RESULTS:

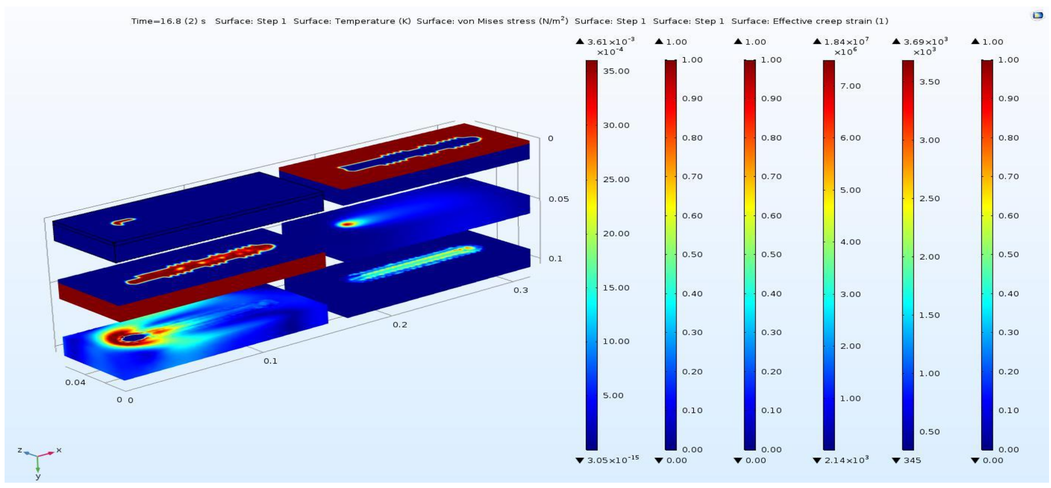

Figure 5. Surface 3D plots

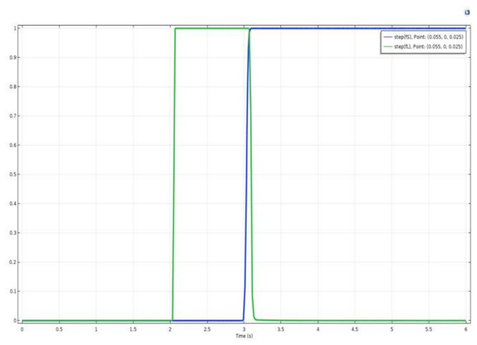

Figure 6. Phase change with time

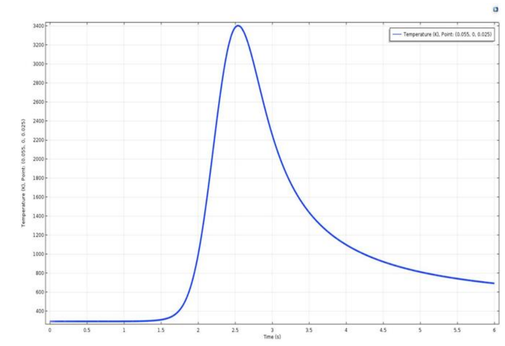

Figure 7. Temperature with time

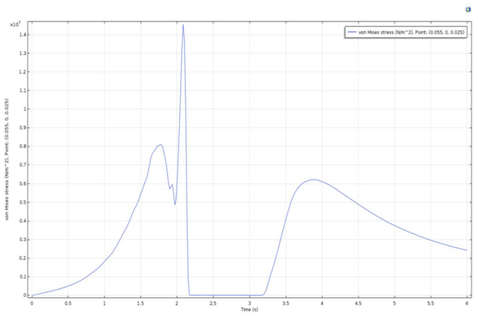

Figure 8. Von Mises stress with time

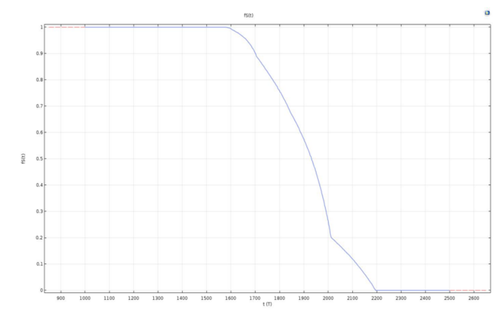

Figure 9. fS with Temperature

Using the RDG model for hot cracking, the cavitation depression can be obtained, using probes at any given point in the laser path.

The cavitation depression is proportional to the alloys susceptibility to hot cracking hence higher the cavitation depression is the more the alloy is susceptible to hot cracking. This is also proportional to $\frac{1}{\dot{\varepsilon}_p{}^{max}}$.

CONCLUSION: In this study a Thermo Mechanical 3D model was created using COMSOL Multiphysics®. This allows to derive the cavitation depression of Nb-Si alloys using the simulation and rectify alloys with higher possibility of cracking during the solidification process in comparison.

REFERENCES:

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2. M. Rappaz, A new hot tearing criterion, (1999)
3. Xavier, C. R., Numerical predictions for the thermal history, Microstructure and hardness distributions at the HAZ during welding of low alloy steels (2016)