

SAE FD&E Fall 2016

Simufact and MSC Software

Welded Axle Assembly

Welding and Fatigue Analysis Chained Simulation



Presented by:
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Oct 12th, 2016

Background

Prior Involvement

- Numerical modelling the welding process (T-joint)
- Imported welding results into fatigue software to predict fatigue life
- Good agreement between simulated and measured values for RS and fatigue life

Simufact

- Welding and Metal Forming FE Simulation Software
- Ability to chain multiple processes (forming -> welding)
- Runs on Marc (general purpose) solver
- Complete multi-physics, non-linear, elastic-plastic modeling capability
- Fully coupled thermal, mechanical, metallurgical solution

MSC Fatigue

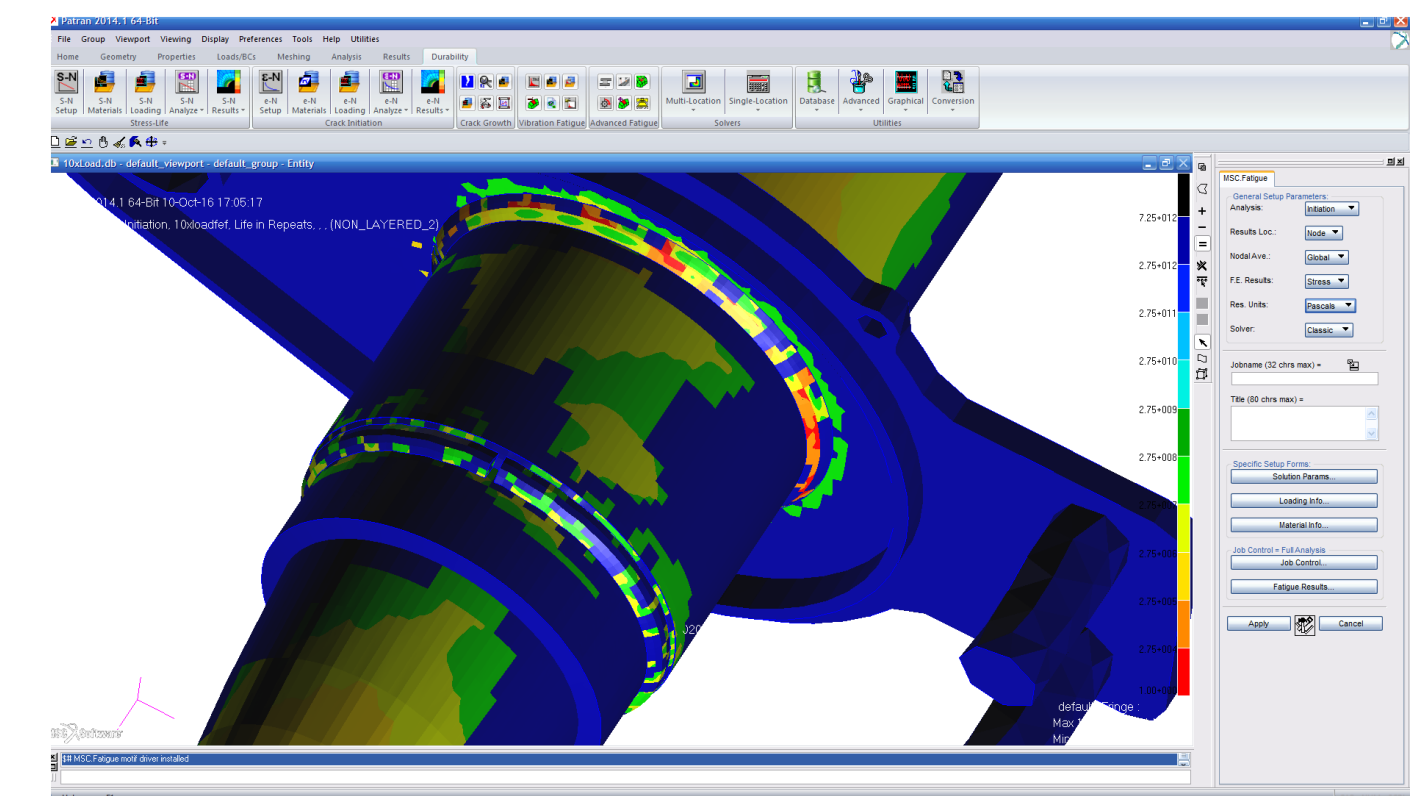
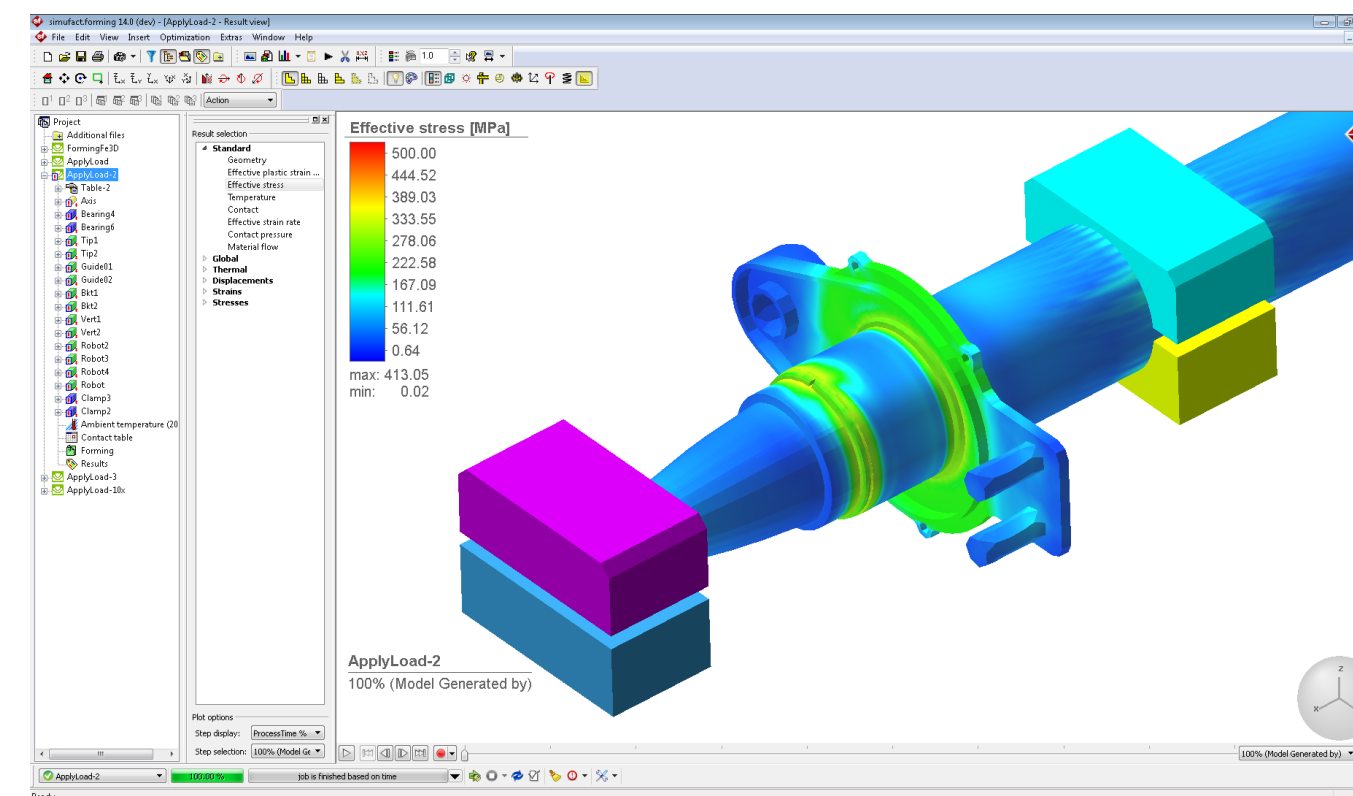
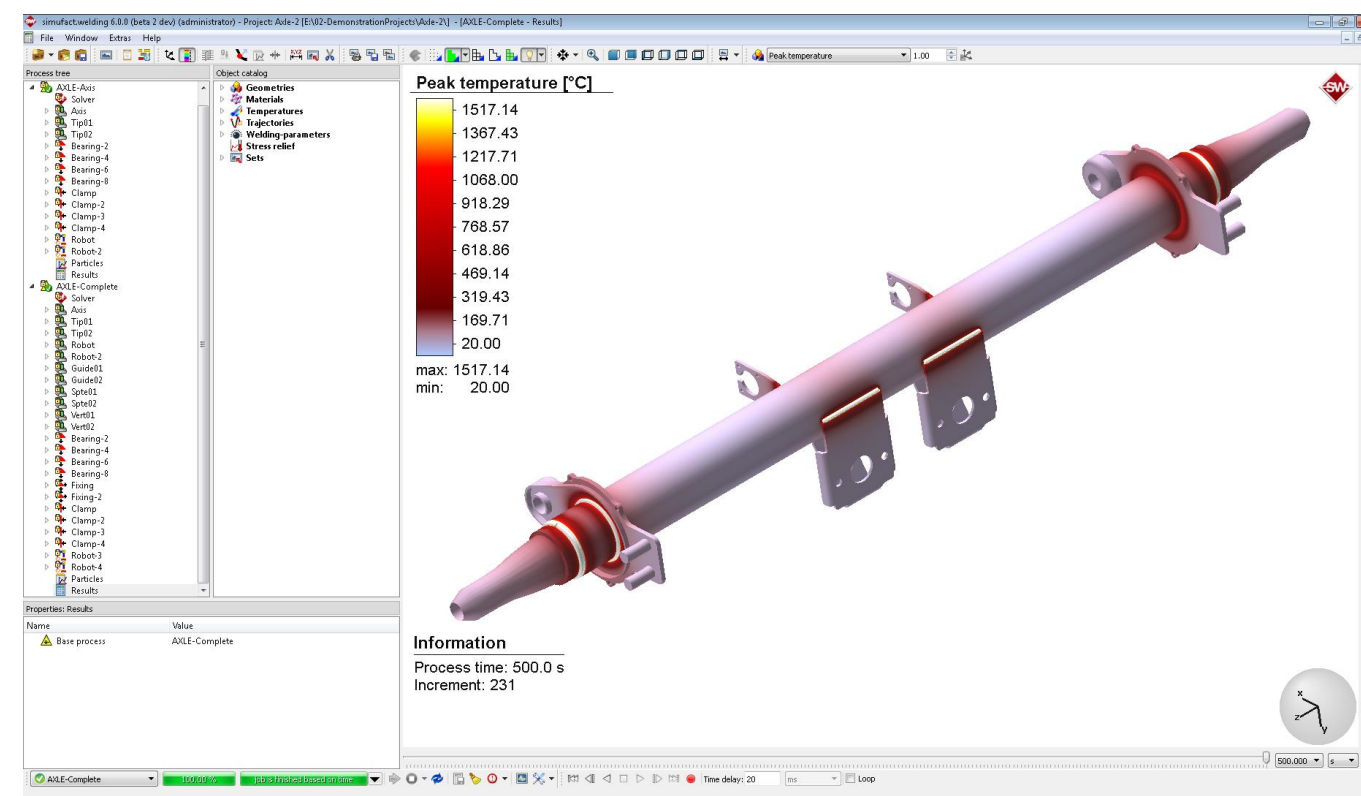
- nCode based fatigue simulation
- Capable of crack initiation and propagation analysis



Objective

Primary Objectives:

1. Simulate welding process of trailer axle assembly to predict residual stress
2. Simulate cyclical load case on welded assembly
3. Simulate fatigue life based on load case and weld induced residual stress



Welding
Simulation



Loading
Simulation

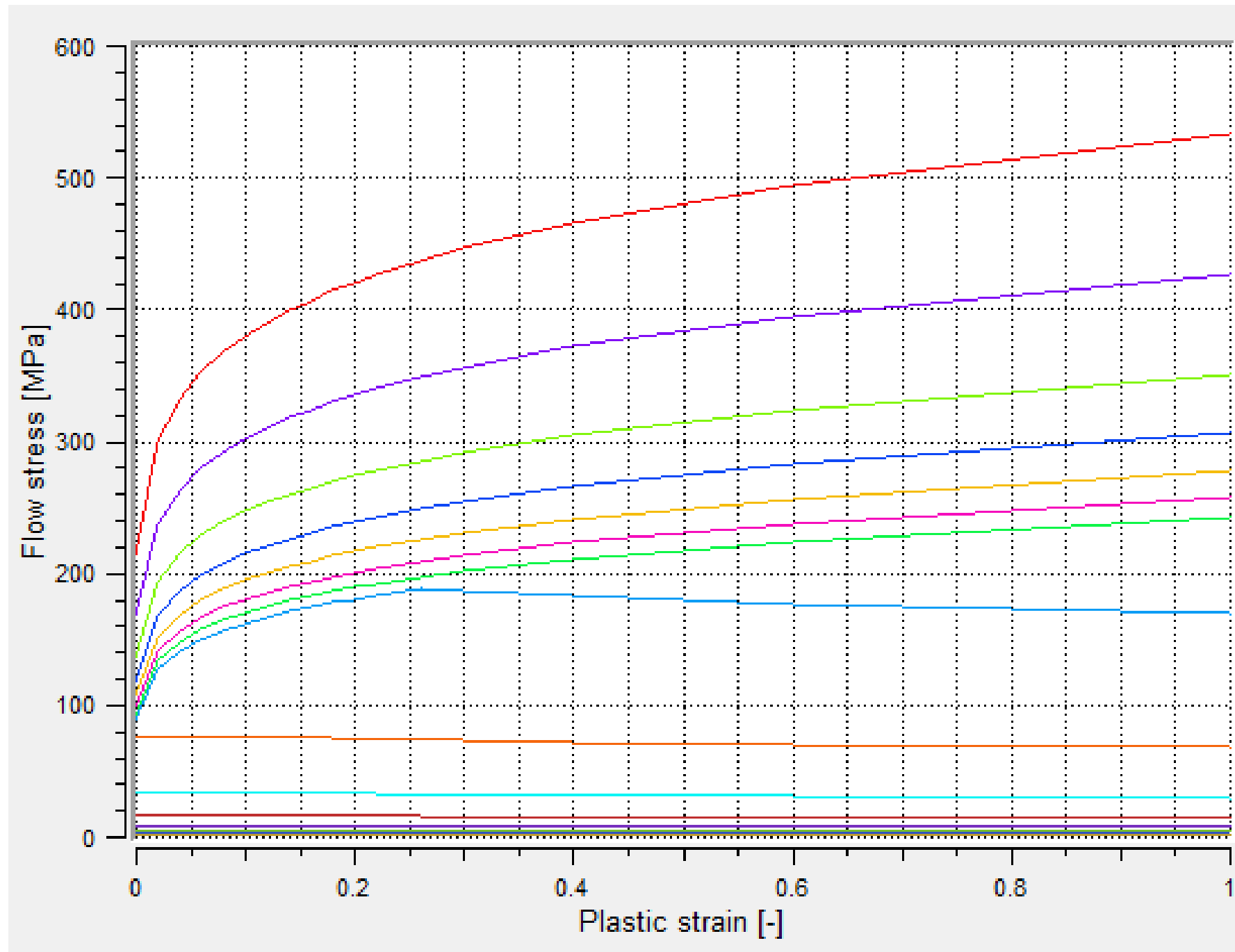


Fatigue Life
Simulation

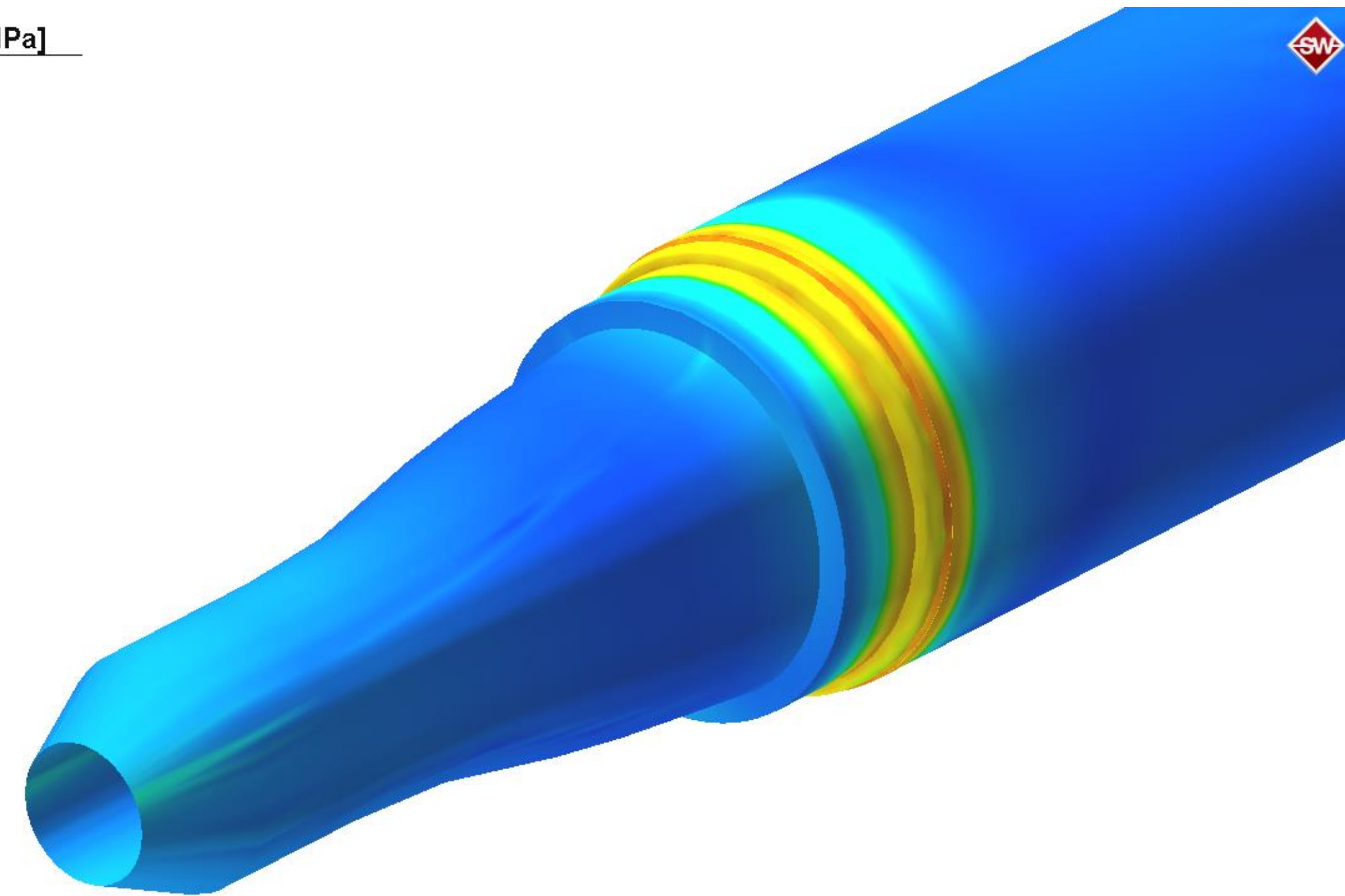
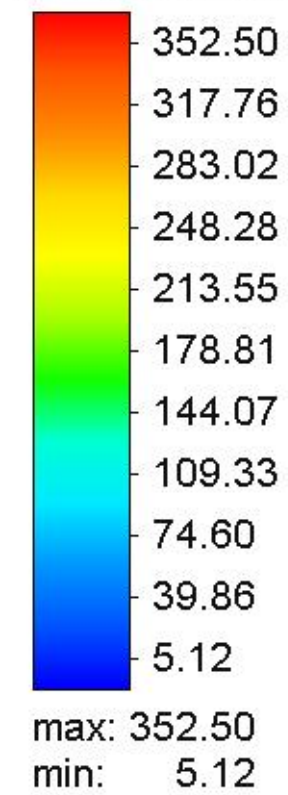
Welding Simulation Setup and Assumptions

Simulation Setup and Assumptions

- Trailer axle assembly – 22.5k lbs rating
- Full transient moving heat source
- Single and multi-pass welds applied
- Material used: 1015 Steel



Effective stress [MPa]



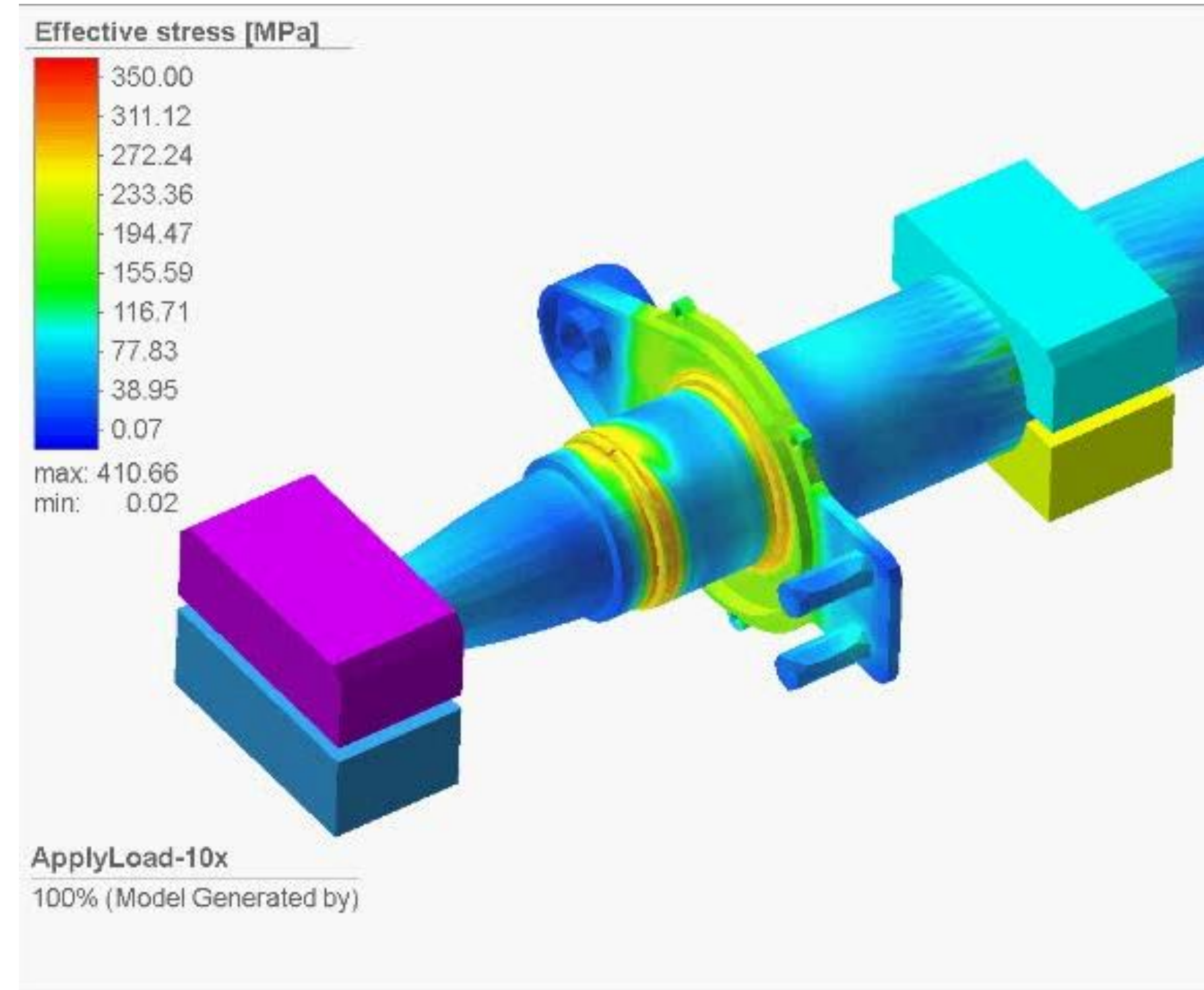
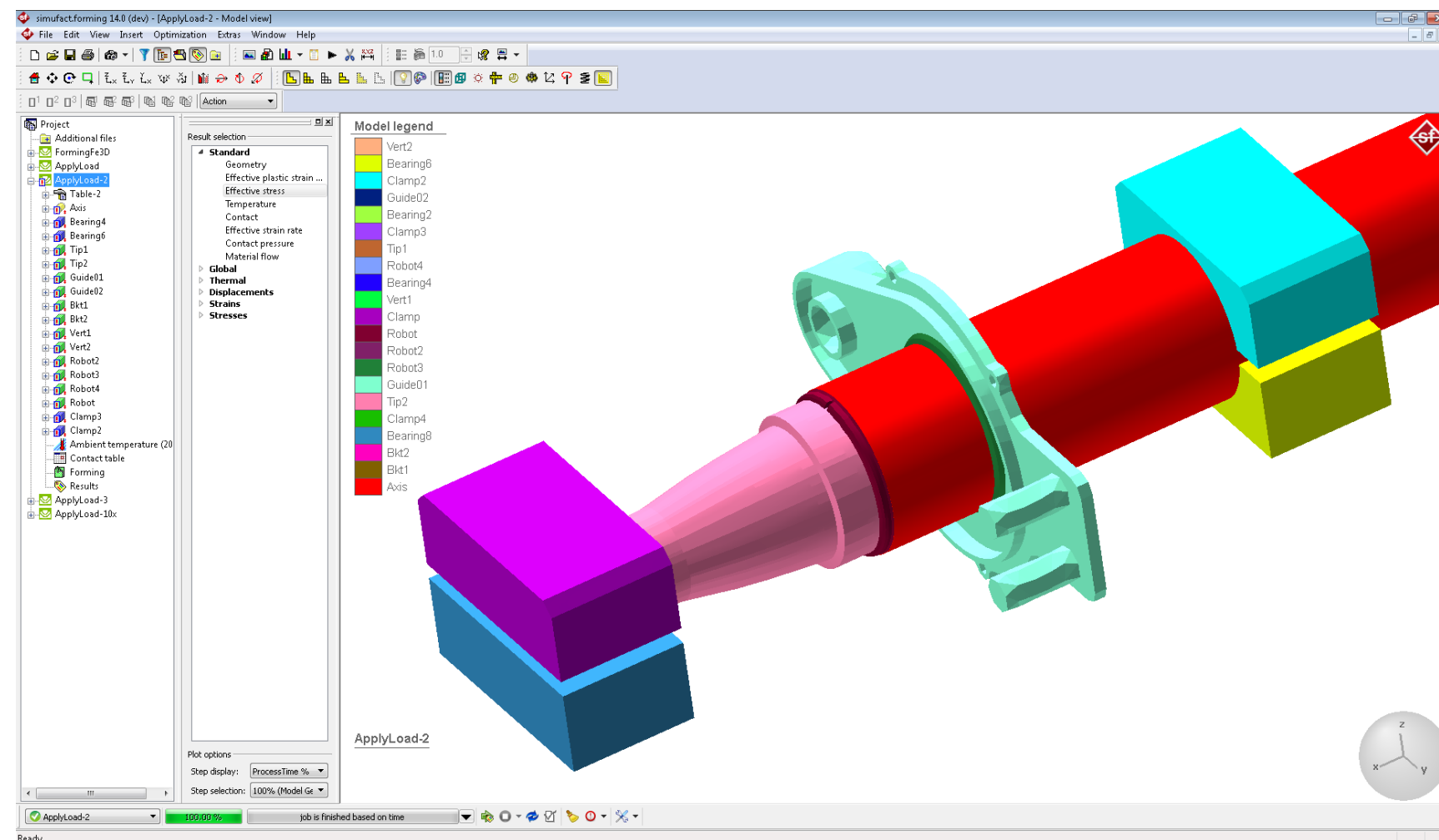
Information

Process time: 500.0 s
Increment: 259

Loading Simulation

Applying the load

- Load applied in Simufact Forming
- Calculates stress levels through load cycle
- Potential to improve results modelling load in Marc or Nastran
- Complete stress history transferred to MSC Fatigue



5.0G Loading – 112k lbs

Fatigue Simulation Workflow

Enabled by Fortran based translator

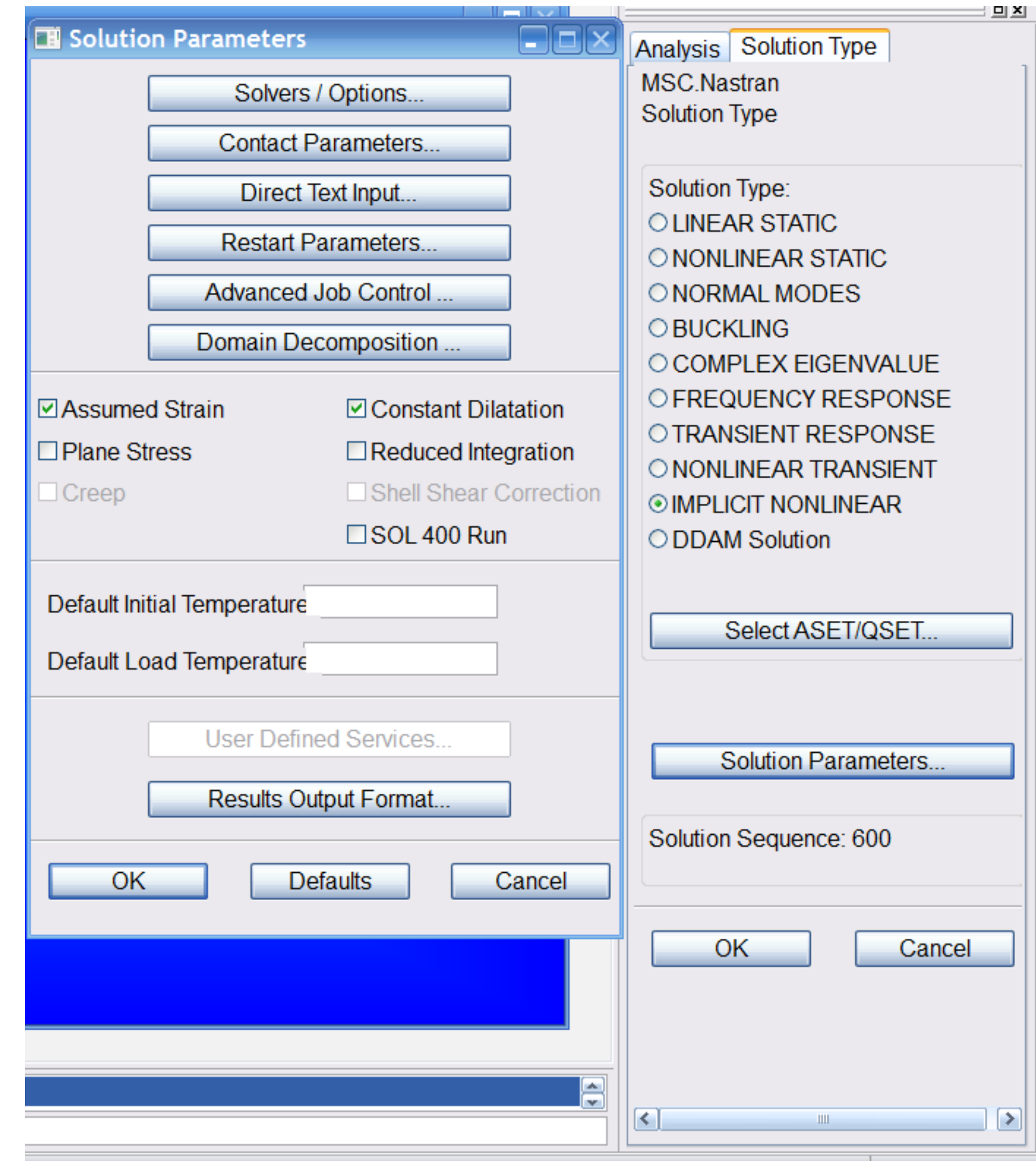
- Converts Simufact output (.t16) to Nastran compatible format (ISTRESS)
- Streamlines data flow
- Eliminates tedious/error prone data manipulation
- Requires same FE mesh for manufacturing (welding) simulation and functional (fatigue) analysis
- Supports any Nastran based simulation: Linear, non-linear, modal, dynamic, etc – not just fatigue

Verified translation of stress fields

- Tests confirm agreement between file input/output

Continued Development

- Capable of translating material properties and other history – requires validation
- Crack initiation + crack propagation – requires additional development



Fatigue Simulation

MSC Fatigue – Current State

- nCode based solution using S-N Method
- Predicts of crack initiation
- Only incorporates residual stress

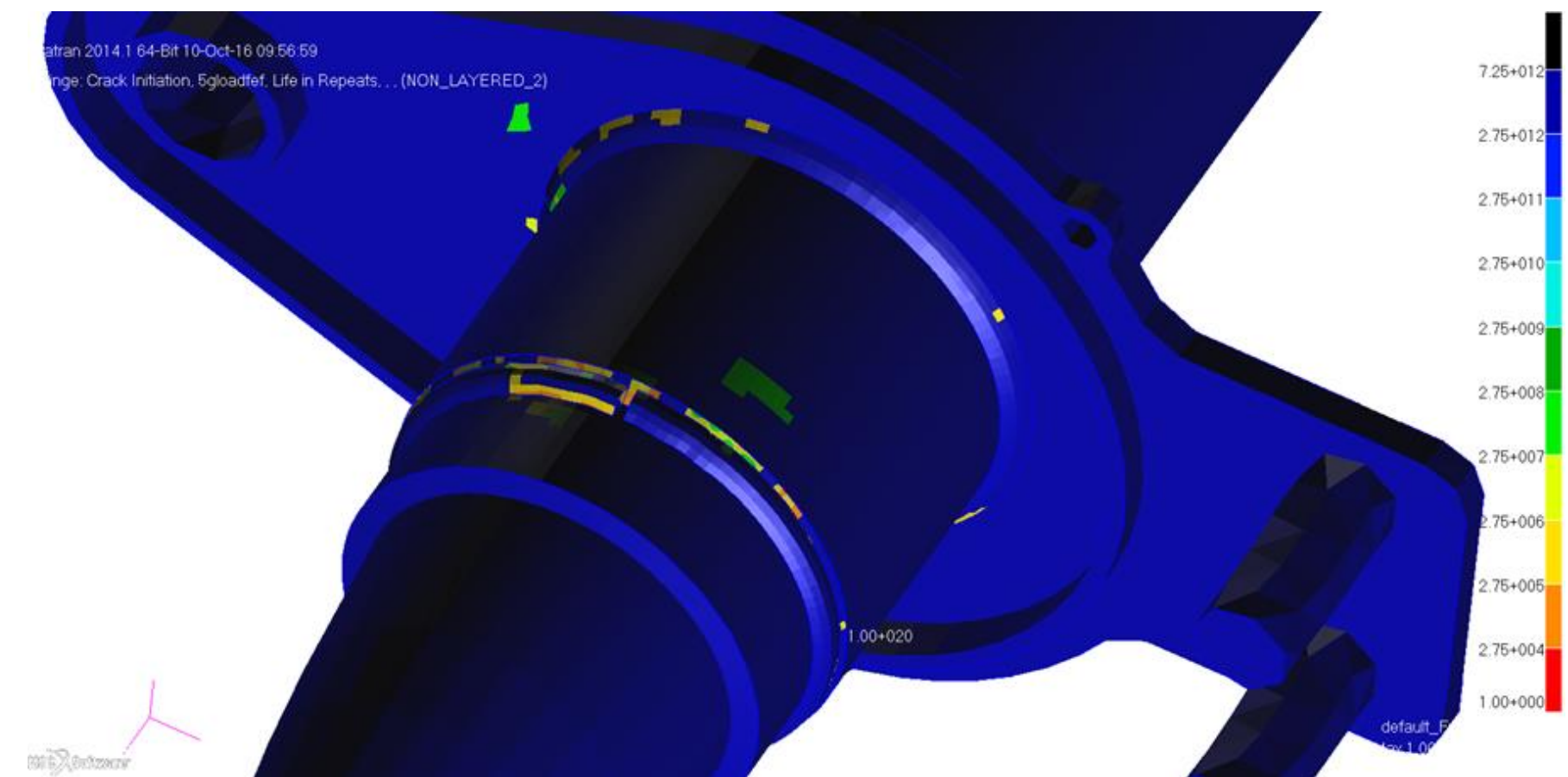
Workflow to analyze:

- Weld induced residual stress
- Combined weld and load stress
- Fatigue life based on combined weld and load stress

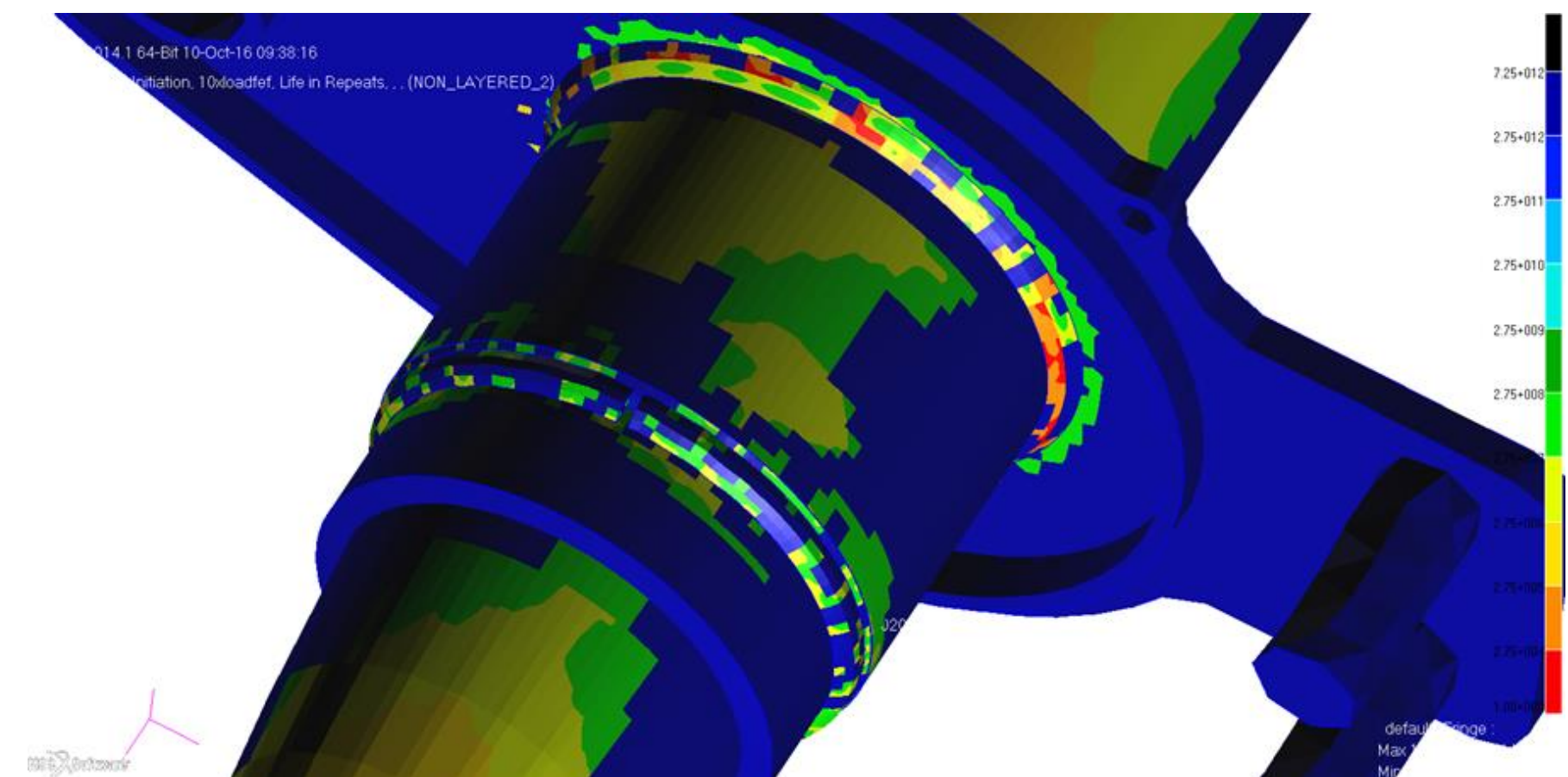
Observations:

- Load modelling approach matters
- Needs to understand real world loading and failure to refine model

2.5G Loading – 56k lbs



5.0G Loading – 112k lbs



Conclusion

Workflow

- Established workflow facilitates advanced analysis with less risk and effort
- Still requires validation of modelling techniques for loading and fatigue

Potential Implementation

- Enables understanding of manufacturing process effects on fatigue life in real world assemblies
- Useful to show improve/degrade based on design changes
- Can support field failure analysis, post-mortem

Next Steps

- Continue to validate welding -> fatigue modelling approach
- Need to work with industry partners to develop best practices for effective analysis
- Better understand what the model can and can't do
- Continue development....

Desired Endstate

- Accurately/reliably model entire workflow: from raw material to finished product

Simulating Manufacturing

Thank you for your attention !

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