Thermo-mechanical stress analysis for a bi-metallic strip

Nandan Seshadri

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1. Summary:

This report presents the findings of a Finite Element Analysis (FEA) conducted on a bimetallic strip composed of brass and iron. The analysis focuses on understanding the thermo-mechanical stresses induced due to temperature changes from 300K to 600K. The study aims to predict the stress distribution and deformation of the strip under thermal loading.

2. Introduction:

The bimetallic strip, composed of brass and iron, is a common component in temperature sensing and control applications. This analysis investigates the behavior of the strip when subjected to a significant temperature change, considering its unique geometry, including two holes and a rounded notch.

3. Material Properties:

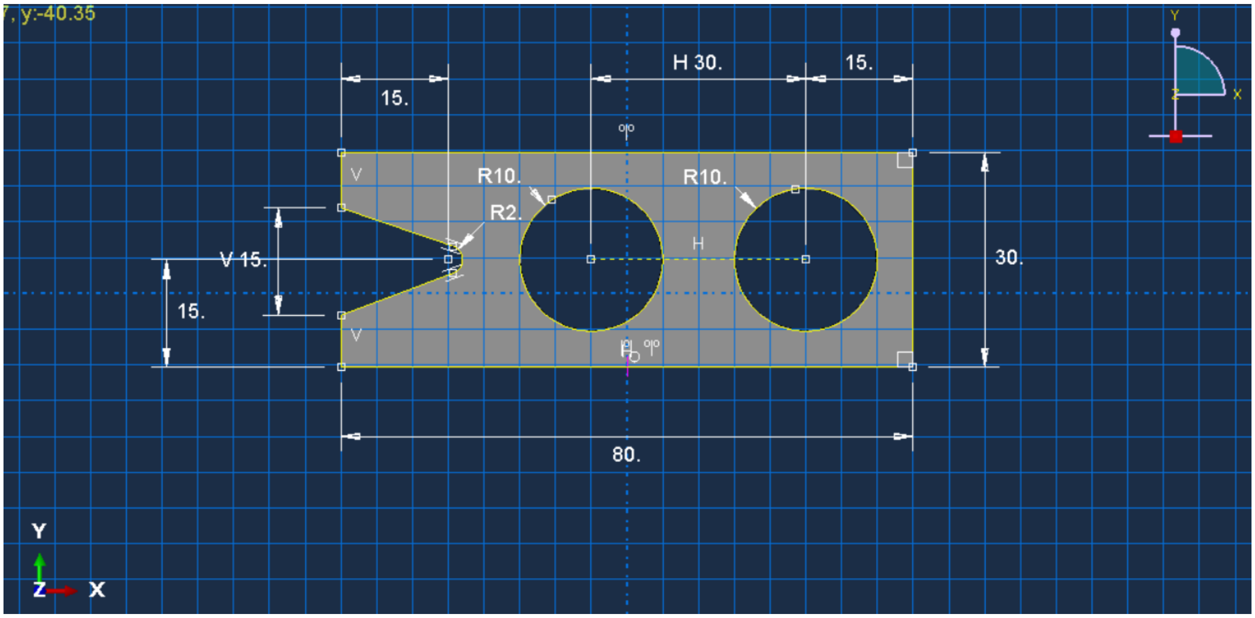
The material properties for iron and brass are -

- **Iron:**
  Young's Modulus: 200 GPa
  Poisson's Ratio: 0.3
  Coefficient of Thermal Expansion: 12 x 10^-6 /K

- **Brass:**
  Young's Modulus: 100 GPa
  Poisson's Ratio: 0.33
  Coefficient of Thermal Expansion: 19 x 10^-6 /K

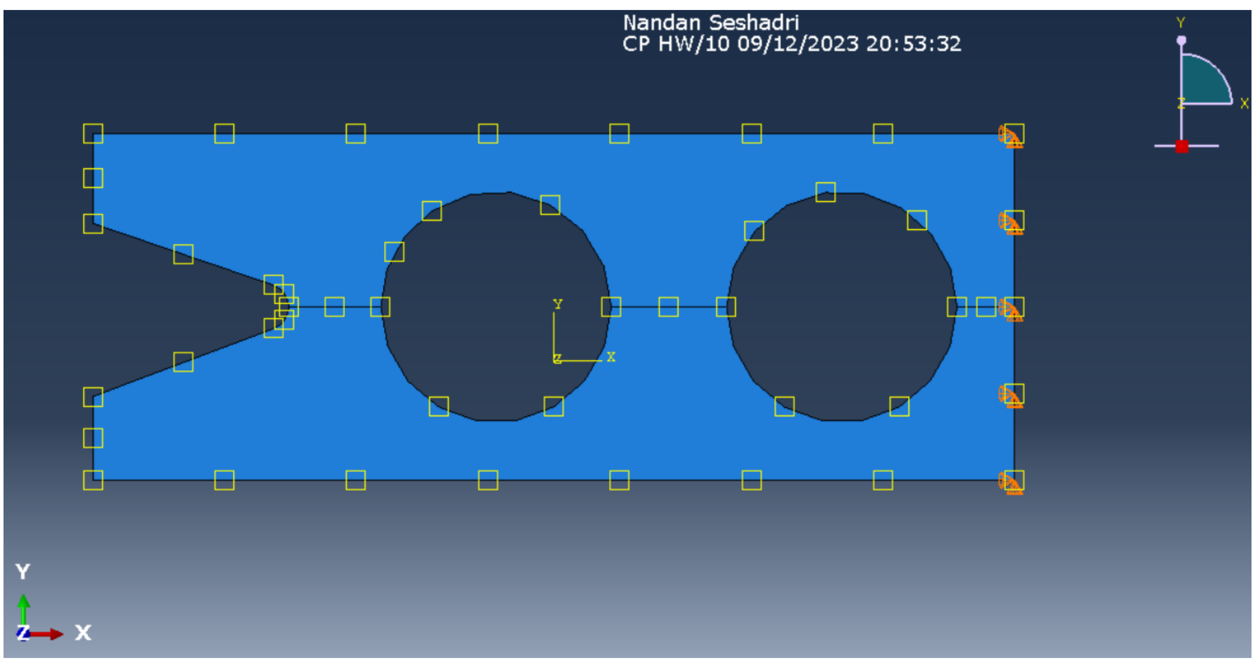
4. Geometry:

The geometry used for this simulation is given in the image below with a plane stress/strain of 1mm.



5. Boundary Conditions:

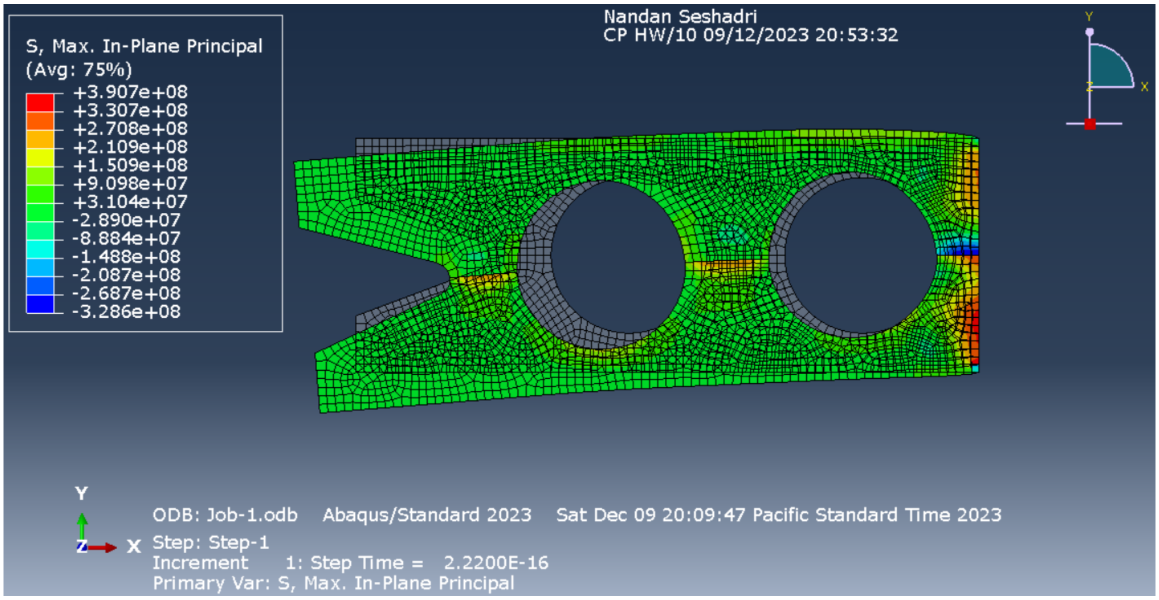
- The strip is fixed with a rigid support at one end.
- An initial uniform temperature of 300K is applied to the entire strip, followed by a final temperature of 600K to simulate the thermal loading is defined in the predefined fields.



6. Calculation:

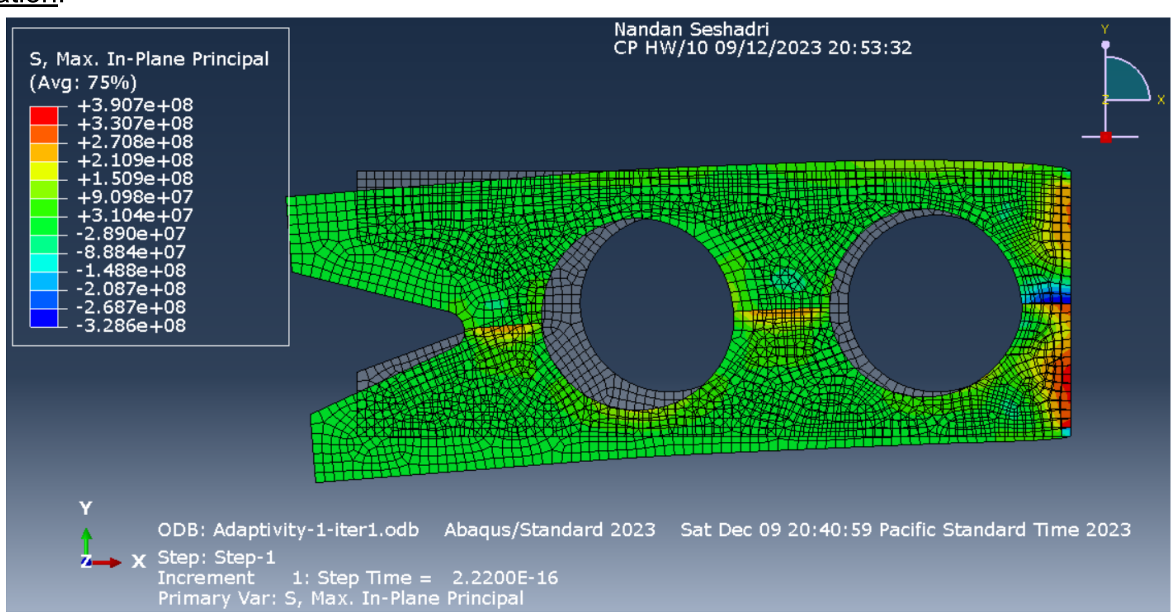
The FEA calculations involve determining the stress distribution and deformation in the strip due to thermal expansion. To ensure the accuracy of the results, H-adaptivity (mesh refinement) was employed. This process involves the following steps:

- Initial Analysis: The initial mesh was applied to the entire geometry of the strip and the first analysis was conducted with a global size of 1.



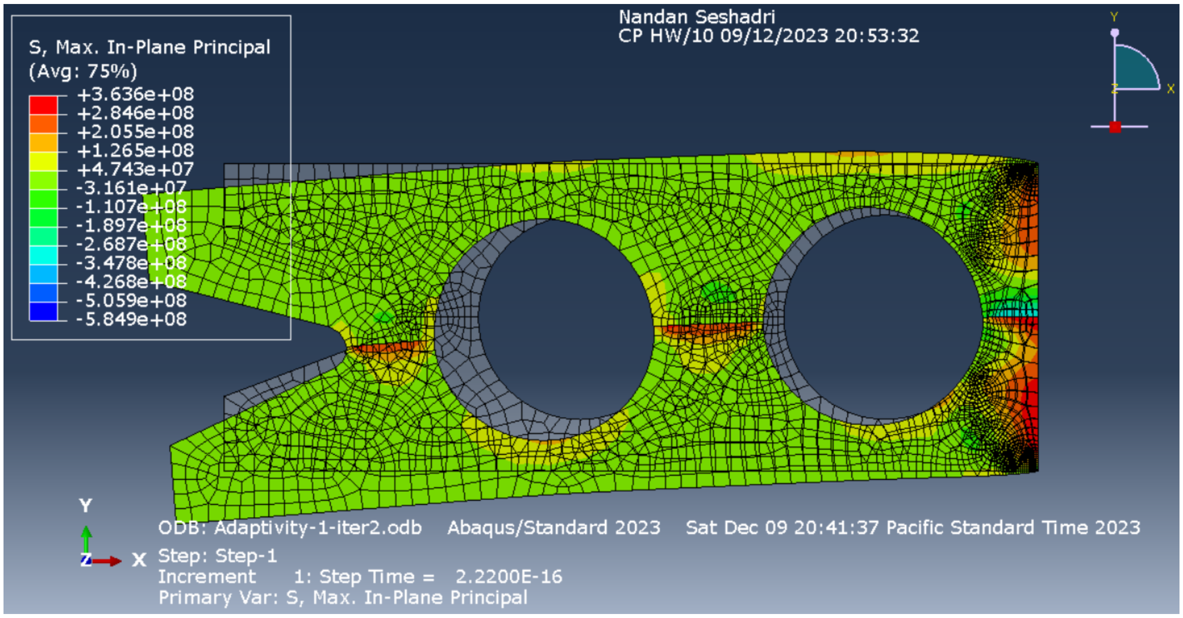
- Mesh Refinement (H-Adaptivity): Based on the error estimation, the mesh was refined in areas with high stress gradients. This step was crucial around the holes and the notch, where stress concentrations were expected to be significant.

1st iteration:

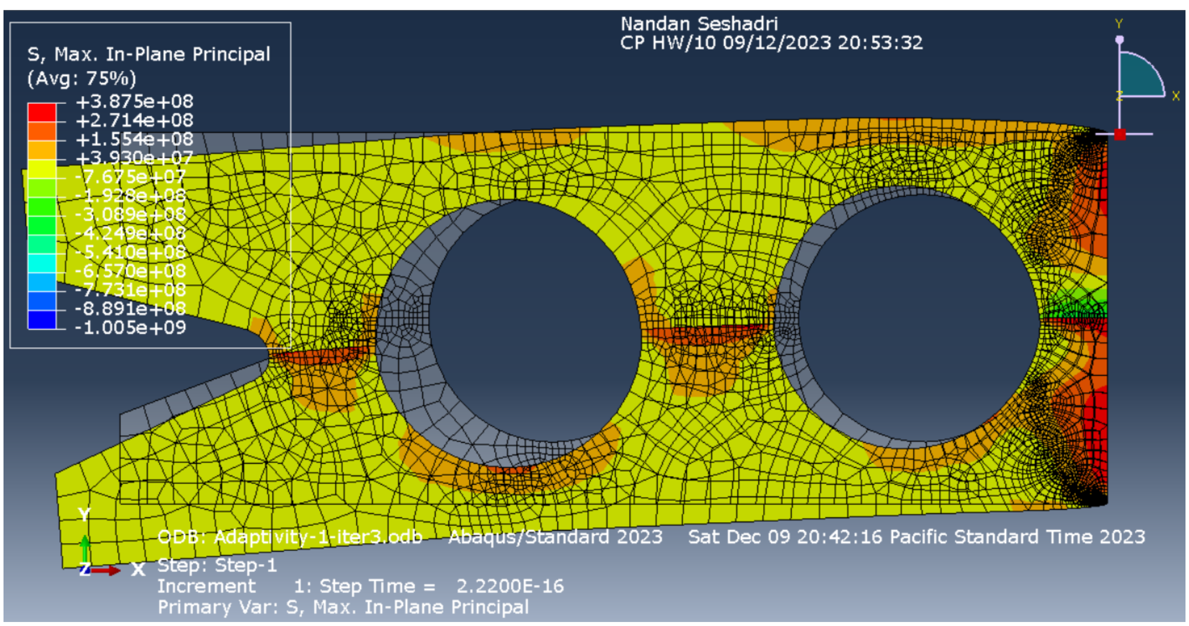


- <u>Subsequent Iterations</u>: This process of analysis, error estimation, and mesh refinement was repeated for a total of 5 iterations. With each iteration, the mesh became finer in the critical regions, leading to more accurate results.

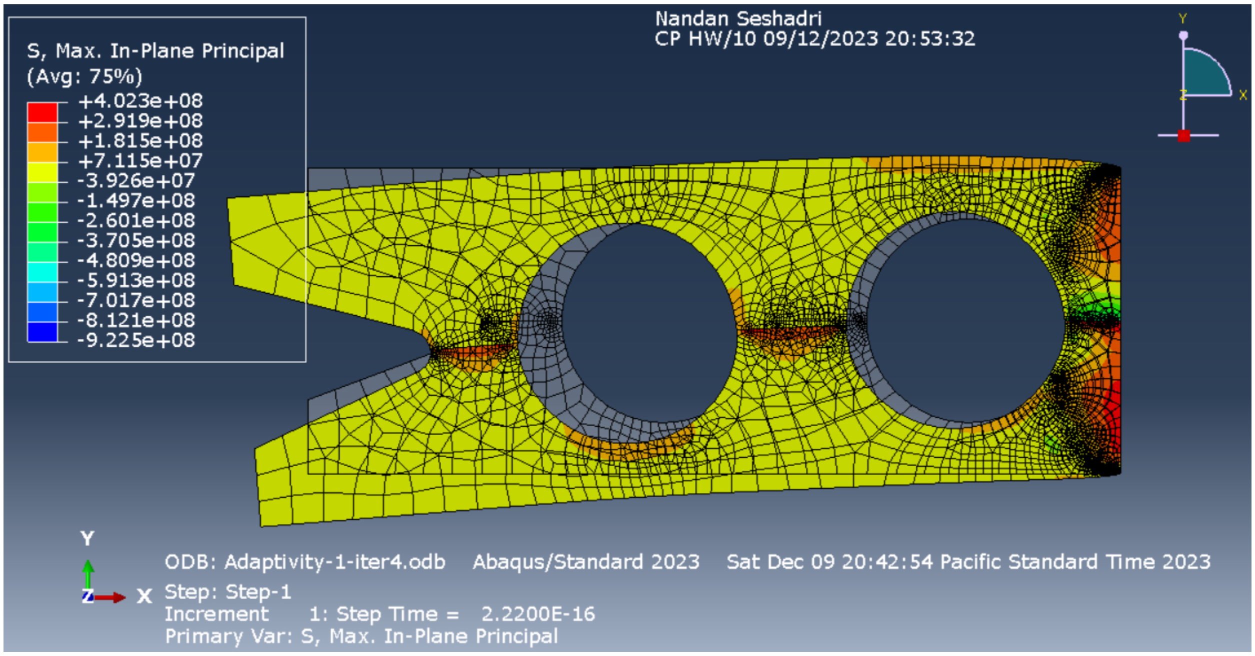
<u>2nd iteration</u>:



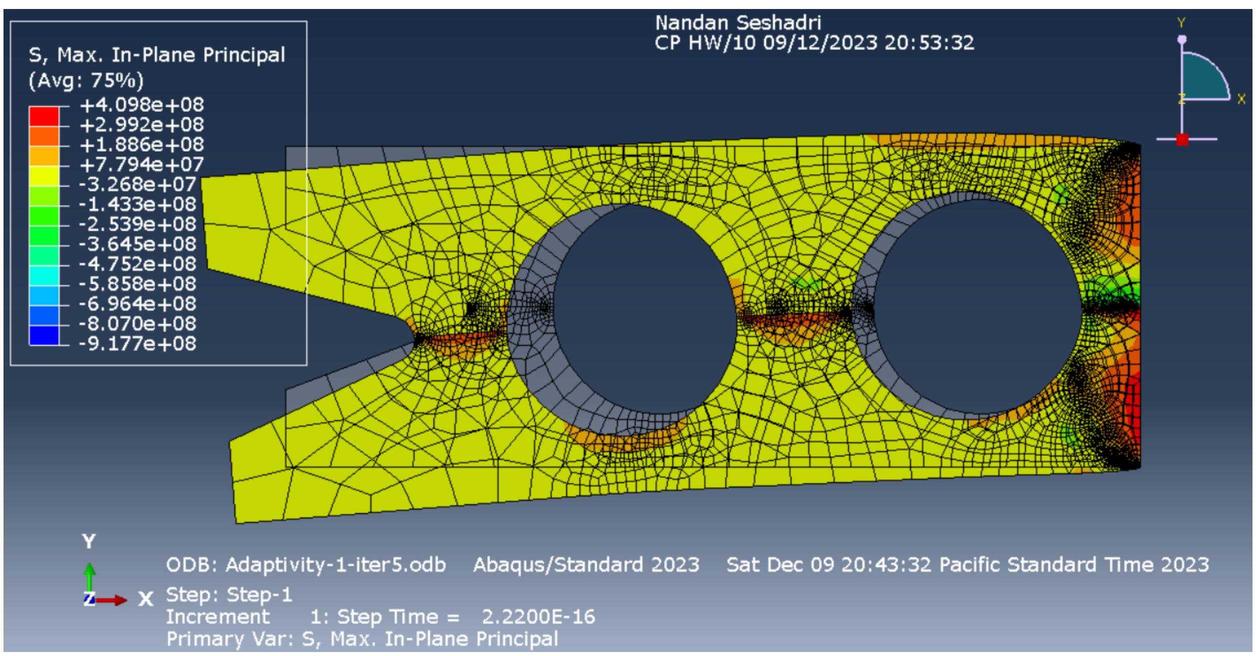
<u>3rd interaction</u>:



<u>4th iteration</u>:



- <u>Final Analysis:</u> After the fifth iteration, the final stress distribution and deformation were calculated. The differential expansion of brass and iron, particularly around the holes and notch, led to complex stress patterns.



7. Conclusion:

The Finite Element Analysis (FEA) of a brass-iron bimetallic strip subjected to a temperature change from 300K to 600K revealed key insights:

- Differential Expansion and Deflection: The brass layer, with a higher thermal expansion coefficient, expanded more than the iron layer, causing the strip to deflect downwards. This behavior was particularly pronounced at the free end of the strip.

- Stress Concentrations: Notable stress concentrations were identified around the holes and the notch, which are critical areas for potential failure under thermal cycling. It has a maximum principal thermal stress of **4.098e+08 N/mm^2.**

- Role of H-Adaptivity: The use of H-adaptivity for mesh refinement was essential in accurately capturing these phenomena, especially around geometric irregularities.

These findings have significant implications for the design and application of bimetallic strips, emphasizing the need to consider thermal expansion properties and geometric features to prevent failure. Further research and design optimization are recommended to enhance the reliability of such components in practical applications.