Lab #7

Static Analysis of a Bracket

The City College of New York
Department of Mechanical Engineering

ME 37100 Computer Aided Design
Section 1EF

Yesim Kokner
Sarah Liu

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Abstract

In this lab, various modes of meshing is explored on the impact on the accuracy of capturing stress concentrations at areas of changing geometry. A AS A standard mesh is used as a mode of comparison to the change in accuracy through the usage of mesh control, an h-adaptive and p-adaptive and refined p-adaptive model. H-adaptive model was seen to be the most used due to the lower computation time and increased accuracy of all the mesh creation methods. P adaptive models is often more computational heavy and standard meshing may not be able to fully capture the accuracy.

Introduction

Mesh refinement is an important component in proper FEA. Determine the areas of interest can be done both manually and built int certain software such as SolidWorks. Such models include the h-adaptive model and p adaptive model. A choice to choose the mesh refinement may come down to purpose. Usage of the p or h adaptive model saves users the choice of judgement of areas of mesh refinement. Accuracy level increases due to the adaptive natures.

Theoretical Background

H adaptive model is one of the preferred mesh refinement models. Such mesh refinement tool allows for target accuracy which set accuracy for strain energy norms. Accuracy bias is used to determine accuracy on local or global scales. Number of iterations can be changed to look for convergence patterns and mesh coarseness is used to change mesh of regions of low errors as an adaptive feature with increasing iterations.

P-adaptive mesh refinements work of floating orders which changes through the iterations process. Elements can update with iterations and error percentage can be decided by users. Initial starting order can be set as an initial condition to be changed through iterations. The total computing times can further be constrained by defining maximum p orders and number of loops.

Use of standard mesh may be inaccurate as the stress changes in regions of high stress concentration may not fully be captured through a uniform mesh model. By applying mesh control or reducing element size in areas such as sharp edges or filets, stress gradient is further captured through running the FEA.

Graphical Demonstrations of SolidWorks

In this analysis, an AISI304 Steel material bracket is analyzed with a fixed vertical support and a 10,000 N downward force. 2 different adaptive solution method is used and compared to standard meshing and meshing with mesh control.

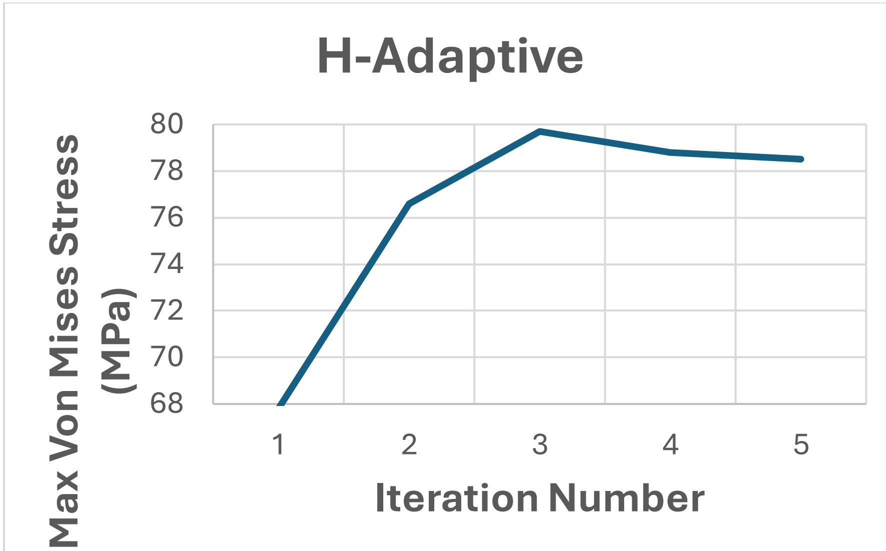

Figure 1: Plot of the max von mises stress of the h adaptive mesh control model through the first 5 iterations

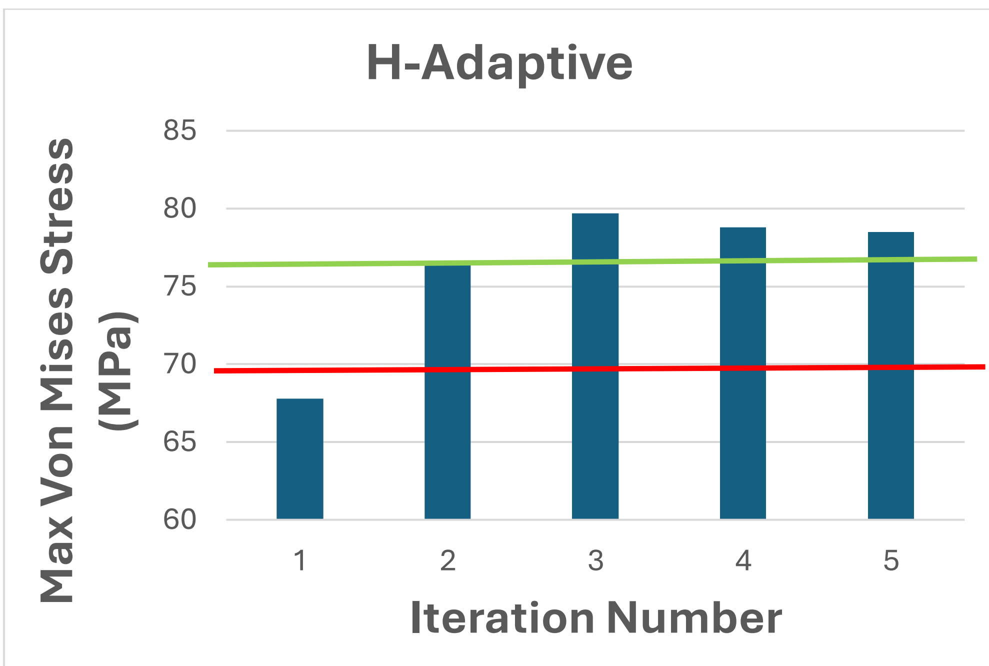

Figure 2: Plot of the max von mises stress of the h adaptive mesh control model through the first 5 iterations compared with the standard mesh (red line) and standard mesh with mesh control (green line)

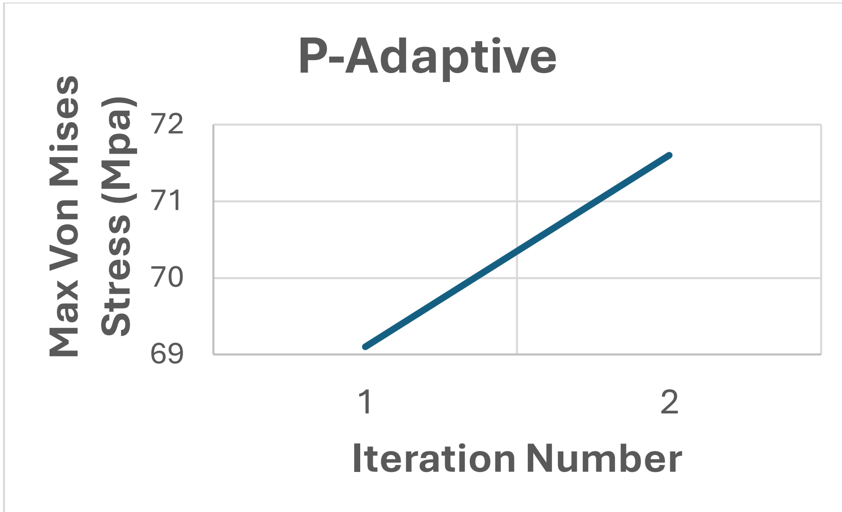

Figure 3: Plot of the max von mises stress of the p adaptive mesh control model through the first 2 iterations

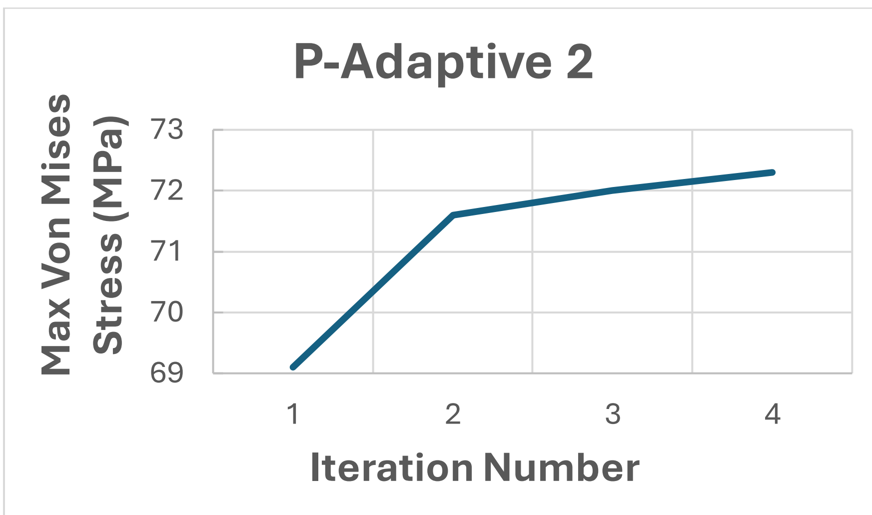

Figure 4: Plot of the max von mises stress of the p adaptive mesh control model through demanding convergence requirements through the first 4 iterations.

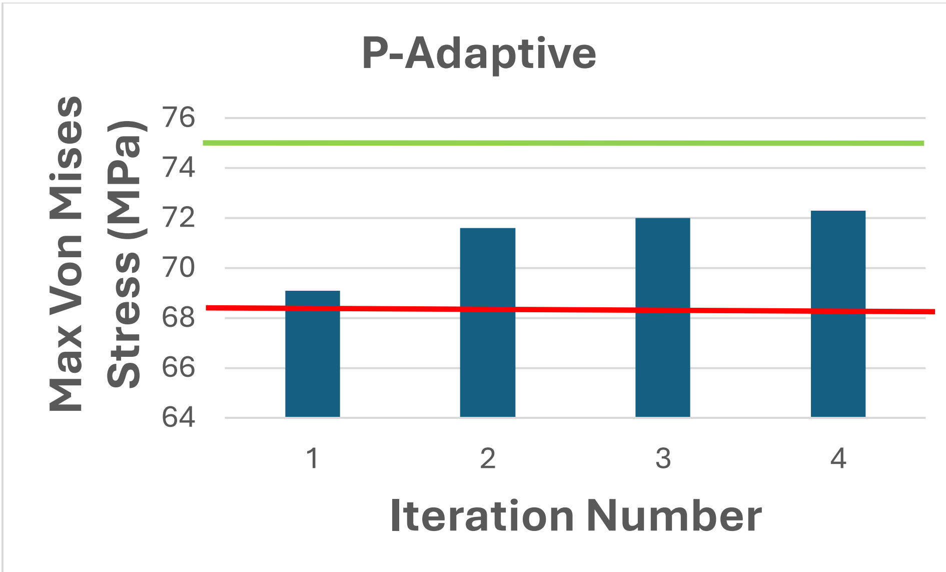

Figure 5: Plot of the max von mises stress of the p adaptive mesh control model through the first 5 iterations compared with the standard mesh (red line) and standard mesh with mesh control (green line)

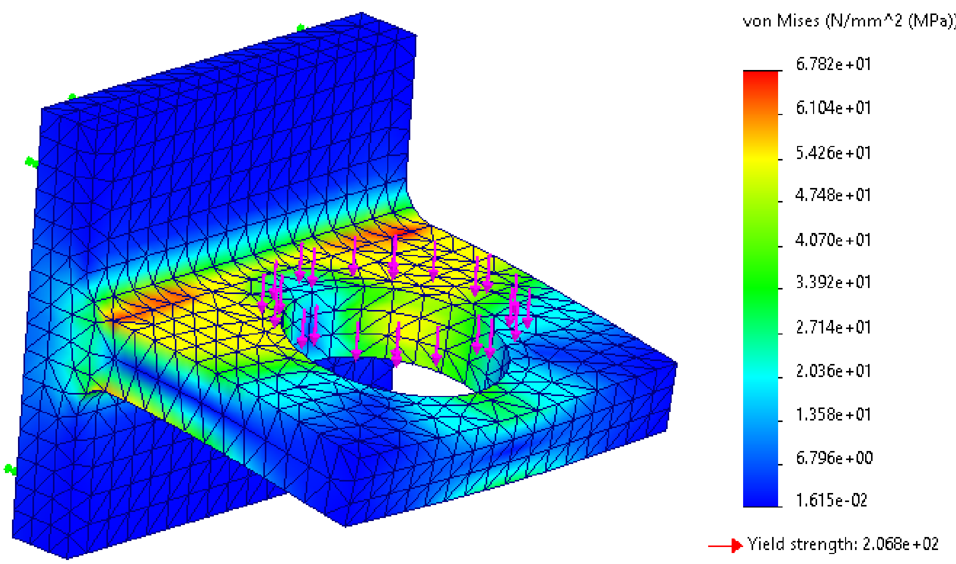

Figure 6: Standard mesh max von mises stress distributed plot. Force of 10 kN applied downwards by the hole and fixed face towards the vertical support of the bracket.

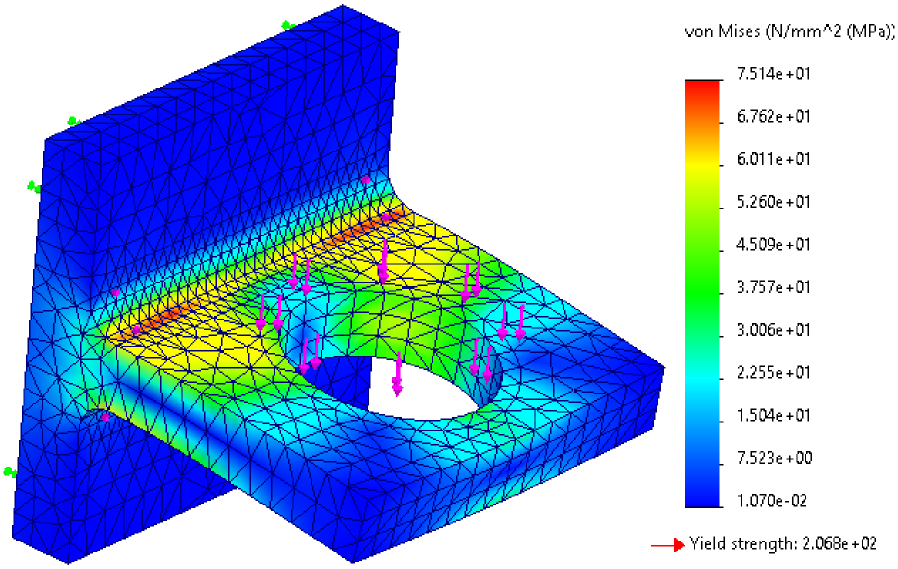

Figure 7: Standard mesh with mesh control max von mises stress distributed plot. Force of 10 kN applied downwards by the hole and fixed face towards the vertical support of the bracket.

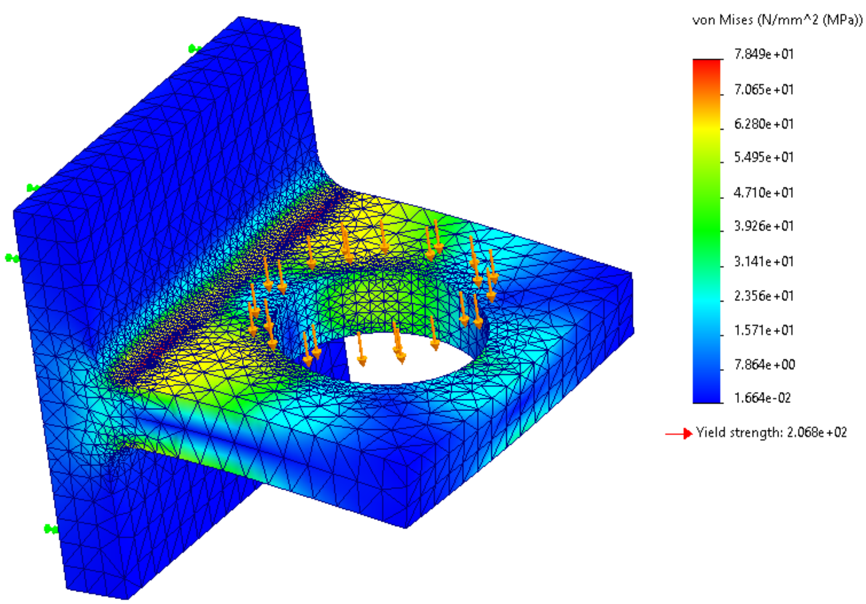

Figure 8: h adaptive mesh model max von mises stress distributed plot. Force of 10 kN applied downwards by the hole and fixed face towards the vertical support of the bracket.

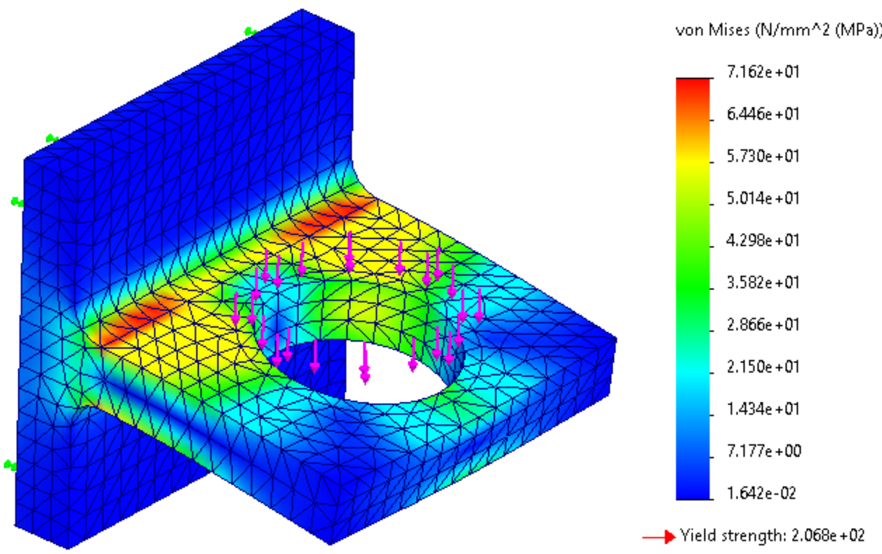

Figure 9: P adaptive mesh model max von mises stress distributed plot. Force of 10 kN applied downwards by the hole and fixed face towards the vertical support of the bracket.

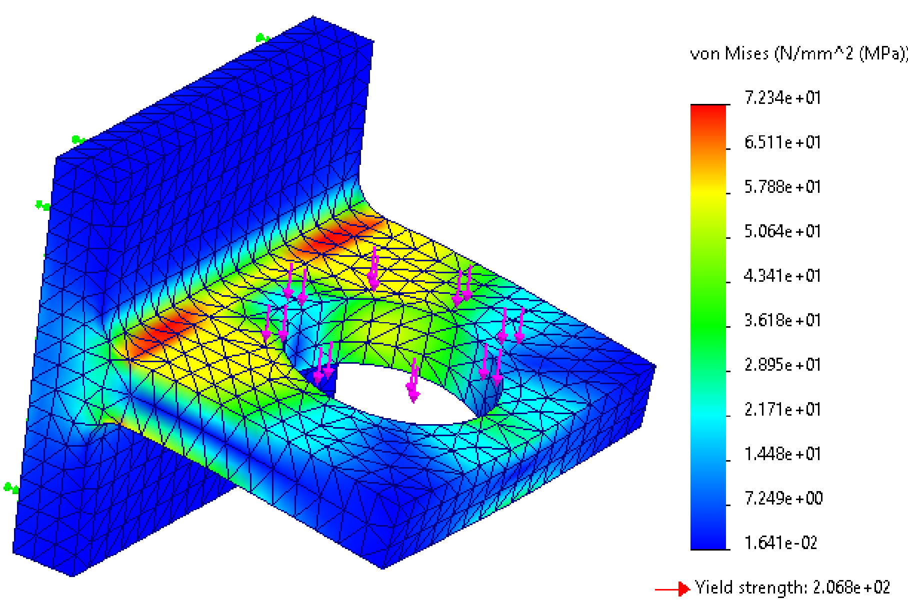

Figure 9: p adaptive mesh model with demanding convergence requirement max von mises stress distributed plot. Force of 10 kN applied downwards by the hole and fixed face towards the vertical support of the bracket.

Discussion and Interpretation of Results

The location of the maximum von Mises Stress can be done by performing a simple static analysis for the bracket. The various adaptive meshing and standard meshing provided by the SolidWork's Software can vary the recorded maximum stress. H adaptive solution is seen to have the finest mesh (figure 8) along the area of the highest stress. While a standard mesh was able to reduce computational time, such results are far off and found to be less accurate in the captured max von Mises stress. As seen with figures 2, by adding mesh control, it can be seen that the accuracy of an manual mesh control is more effective in capturing the max stresses.

Including more iterations is an important step to see convergence of the max stress values. While in the p adaptive solutions with just 2 iterations, the captured stress does not display such trend (figure 3) but by increasing the iterations, by forcing the program to run more iterations, the stress value begins to converge (figure 4). However, despite the increased accuracy, the p adaptive meshing can be seen to increase the computational time much more than that of the h adaptive solution.

Conclusions

H adaptive solution method is seen to have the most accurate results in determine the location and values of the max von Mises stress as opposed to the p adaptive and standard meshing techniques. By observing the convergence and meshing refinement overlapping the location of the max Von Mises stress, it can be concluded that the accuracy is higher than that of the other solution methods (Figure 6,7,9,10). Despite the increased computational time compared with the standard meshing, by taking out the portion of the FEA of judgement of mesh control, the h adaptive solution is seen to be more advantageous.

References

[1] Engineering Analysis with SolidWorks Simulation 2024, by Paul Kurowski (2024), ISBN-10: 1630576298.

[2] A First Course in the Finite Element Method, Enhanced Edition, 6th Ed., by Daryl Logan (2022), ISBN-10: 0357884140