Finite Element Analysis of a 6061-T6 Aluminium Pyramid Fixture

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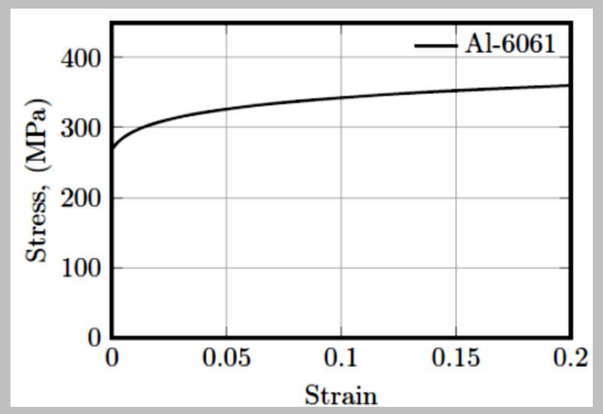
Aim of the Project

- To analyse the structural integrity of a 6061-T6 Aluminium pyramid fixture using Finite Element Analysis (FEA).
- Evaluate the suitability of specific grade of aluminium used and understands its material properties for its application
- Carry out high level design suggestions to maximise the necessary constraints needed.

Background / Lit Review

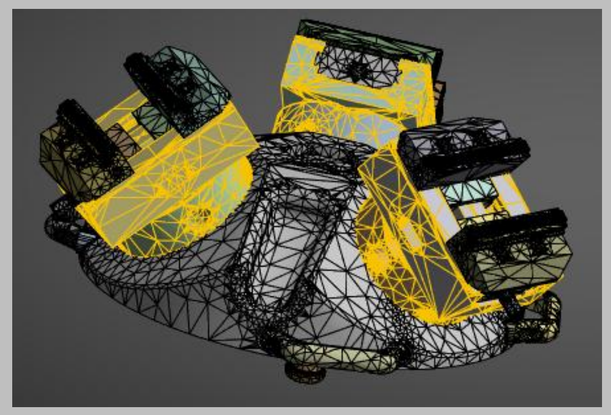
- Jigs and fixtures are essential tools in manufacturing, enabling efficient and precise machining processes.
- 6061-T6 Aluminium is a popular choice for these fixtures due to its favorable properties, including high strength-to-weight ratio, good machinability, and excellent corrosion resistance
- FEA is a powerful computational tool used to simulate the behavior of structures under various loads, providing insights into stress distribution, deformation, and safety factors.



Aluminium 6061 T-6 Stress Strain Graph

Methodology

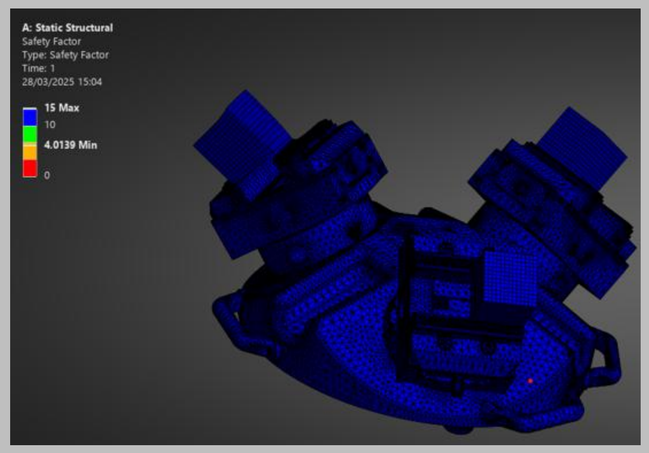
- **FEA Setup:** The fixture was analysed using ANSYS, involving CAD model conversion, material assignment (6061-T6 Aluminium, 316 Stainless Steel), and meshing (5mm element size with refinement).
- **Load Application:** Simulated cutting forces from manual calculations were applied to the model along with the correctly assigned fixed supports to represent machining conditions.
- **FEA Solution:** A static structural analysis was performed to calculate stress, deformation, and safety factor distributions.
- **Validation and Implementation:** The FEA results were validated through comparison with manual calculations. Design suggestions implemented and ran through simulation procedure again to maximise design while meeting constraints.



Meshed Pyramid Fixture

Results / Analysis / Findings

The maximum Von-Mises stress in the fixture was significantly lower than the yield strengths of both 6061-T6 Aluminium (276 MPa) and 316 Stainless Steel (205 MPa), indicating a large safety margin and a low risk of yielding.



Pyramid Fixture Safety Factor (4.01)

The FEA revealed a minimum safety factor of 4.0139, indicating that the fixture can withstand loads significantly greater than the applied cutting forces before failure. This high safety factor confirms a robust design and a low probability of structural failure during operation.

Comparing the safety factor of the manual calculations compared to that of the results from ANSYS further validate the results for the pyramid fixture. A safety factor of 4.01 also opens a lot of room to maximise the design efficiency of the pyramid while still meeting a safety factor of at least 2 which would be considered safe.

Conclusion

- The Finite Element Analysis (FEA) successfully analysed the structural integrity of the 6061-T6 Aluminium pyramid fixture under simulated machining conditions.
- The analysis demonstrated that the fixture can safely withstand the applied cutting forces, with a maximum Von-Mises stress of 62.807 MPa, significantly lower than the yield strengths of both 6061-T6 Aluminium and 316 Stainless Steel.
- A minimum safety factor of 4.0139 was observed, indicating a robust design and a low probability of structural failure during operation.
- The FEA results validate the suitability of 6061-T6 Aluminium for this fixture application, confirming its ability to provide the necessary strength and rigidity.
- The comparison of FEA results with manual calculations highlighted the limitations of simplified manual approaches and emphasized the importance of FEA for accurate stress analysis in complex geometries.
- Future work could explore design optimization to further maximize the safety factor while minimizing the pyramid fixtures weight,

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