Mech 410 – Computer Aided Design

Final Project: Stirling Engine Modeling and Analysis

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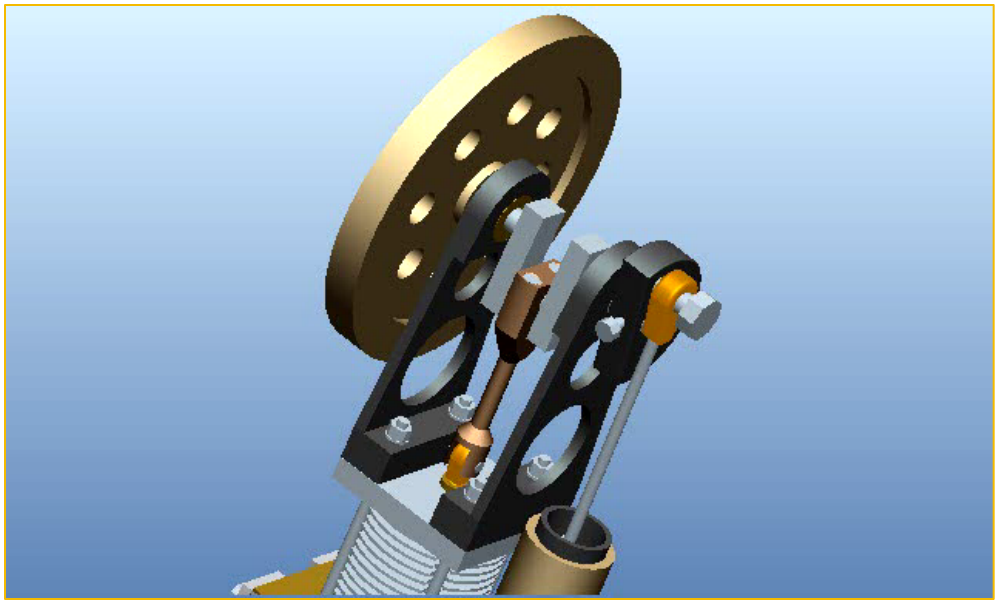
Agenda

- Objective
- CAD software used
- Modeling Process/Challenges
- Assembly Process/Challenges
- Animation Process/Challenges
- Structural Analysis
- Recommendation/Conclusions
- Questions?

Objective

- To become familiar with CAD software common in industry
- Model a Stirling Engine using shop drawings
- Gain experience by testing FEA analysis



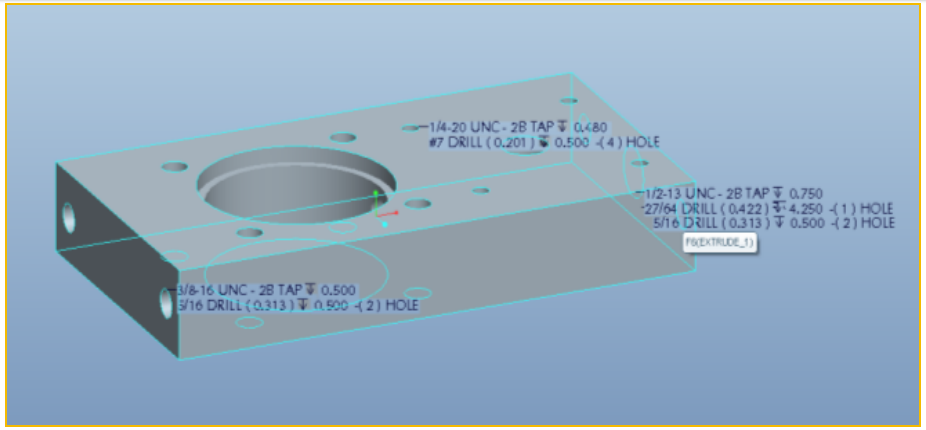
- Apply animation and photo rendering techniques

CAD Software

- **Pro/Engineering:**
  - ✓ Primary modeling and assembly tool
  - ✓ Primary FEA tool for Mesh refinement
  - ✓ Animation
- **SolidWorks and PhotoView 360:**
  - ✓ Used to compare FEA results
  - ✓ Rendering with PhotoView 360

Part Modeling

- 30+ Engine Components
- Notable Techniques Used
  - Hole Feature
  - Mirror/Pattern Feature
  - Cosmetic Threads

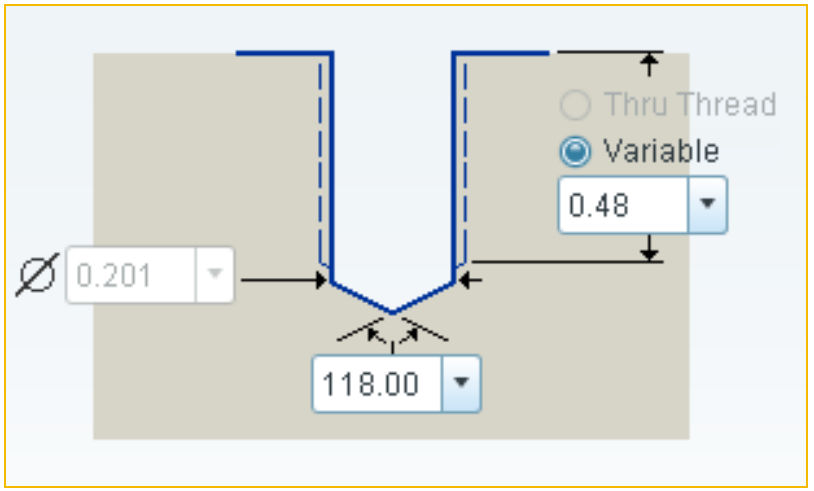


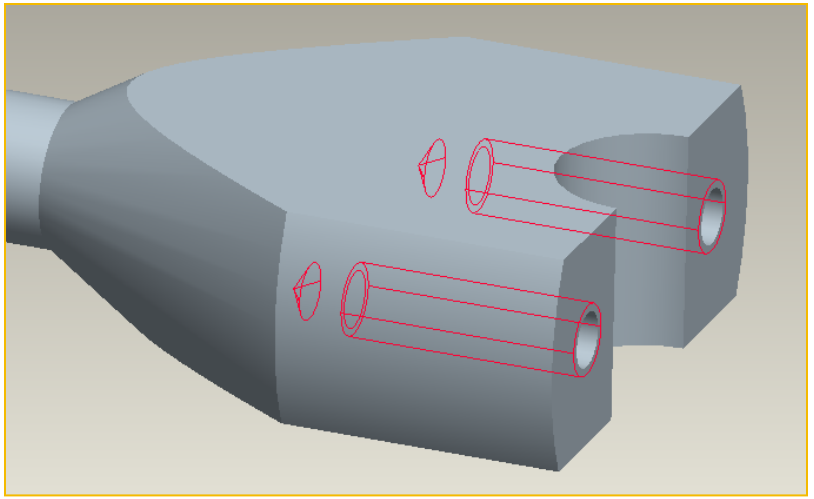
Cylinder Block

Connecting Rod

Part Modeling

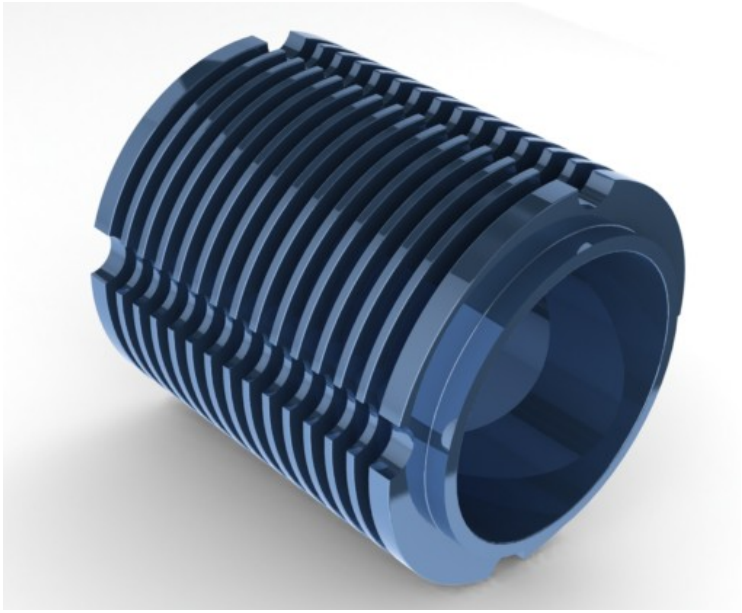
- Hole Feature
  - Define hole placement
  - Shape of hole
    - Size
    - Depth
    - Threads
    - Countersunk





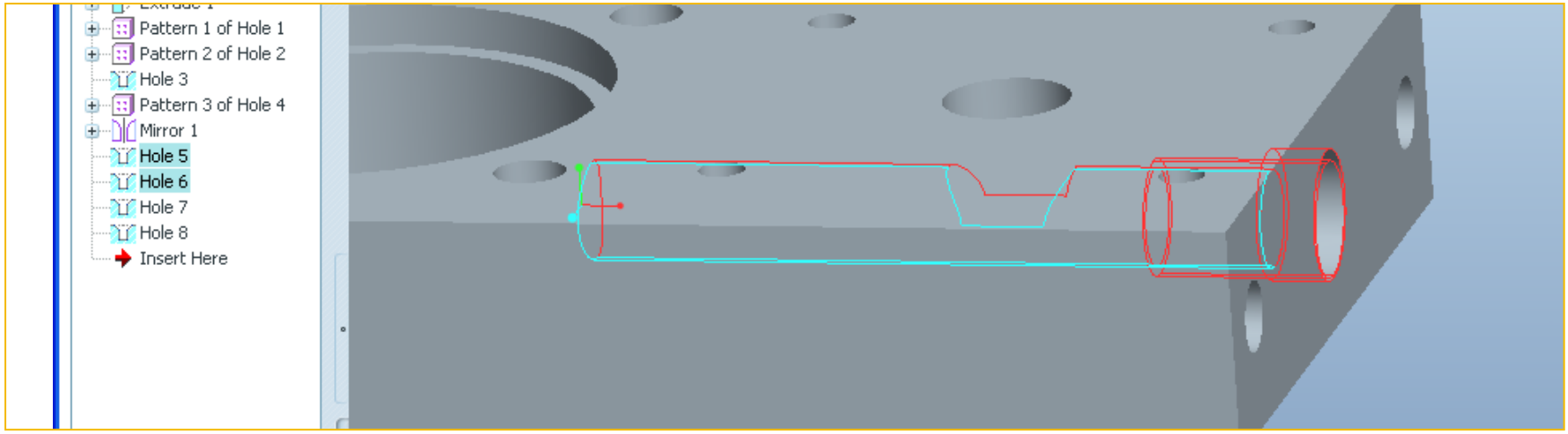
Part Modeling

- External Threads
  - Cosmetic Thread Feature
    - Define needed Elements
- Pattern and Mirror Tool
  - Holes
  - Complex Geometry



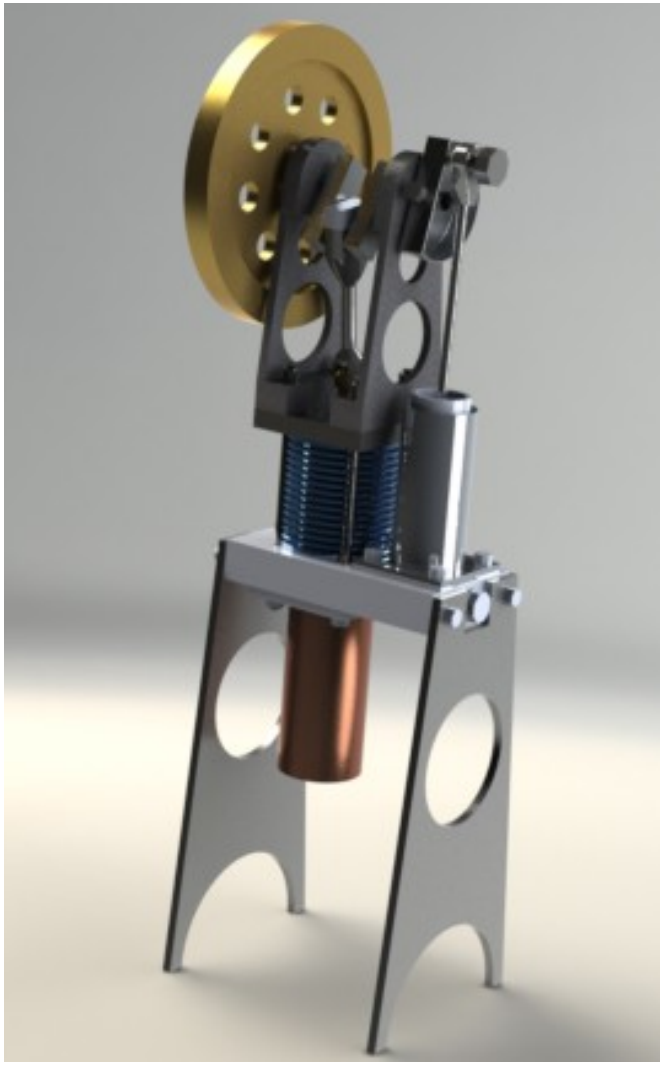
Part Modeling Problems

- Problem 1
  - Hole has more detail than hole tool can provide .
- Solution
  - Apply hole tool multiple times



Assemble Model

- Assembling the Model
  - Three Sub-Assemblies
  - One Final Assembly
  - Appearances

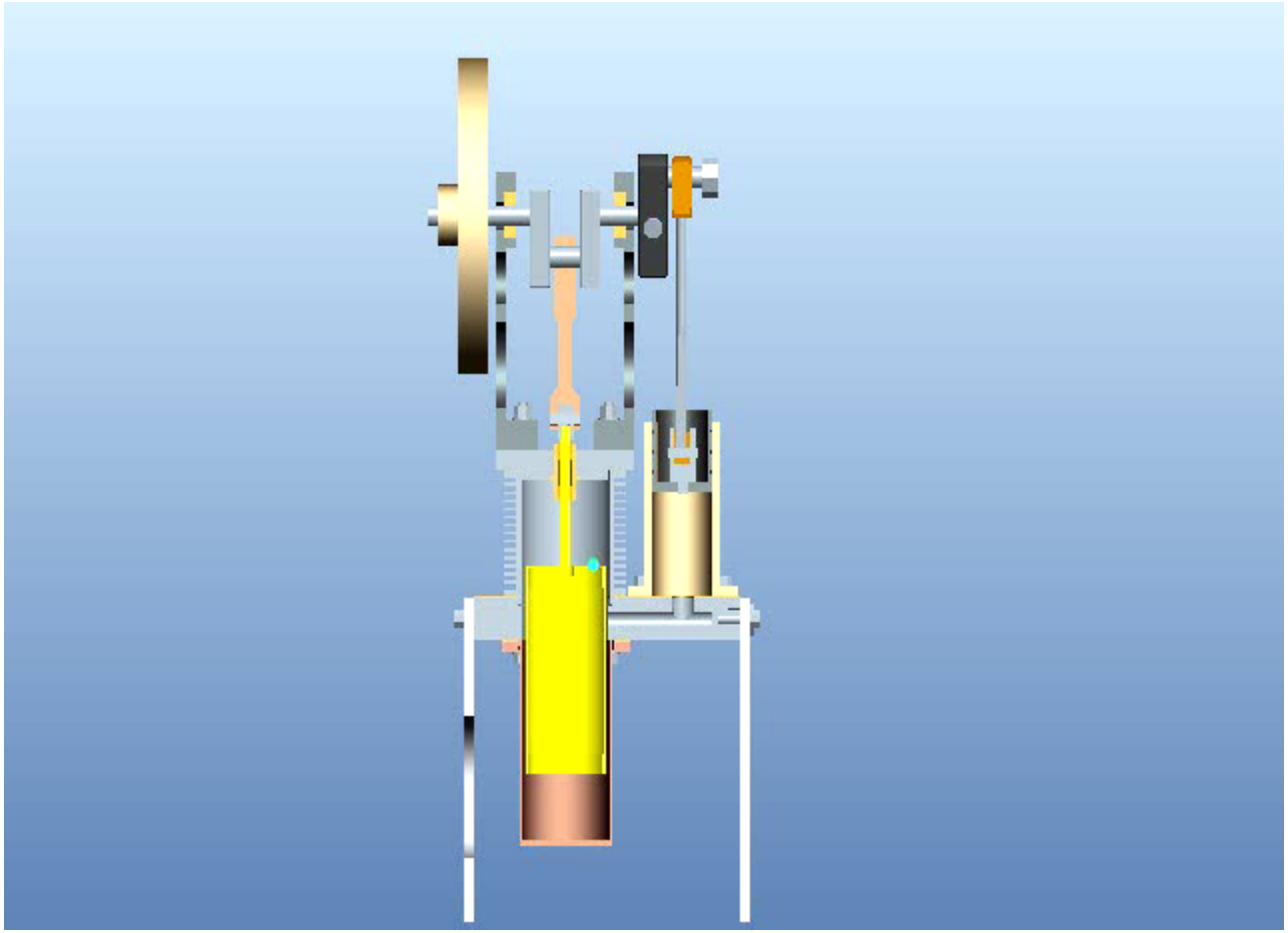


Assemble Model Problems

- Problem 3
  - Unable to constrain certain components
  - Multiple people could not work on the same assembly at the same time
- Solution
  - Consistent hole spacing between parts
    - 1/3 ≠ 0.33333
  - Create sub-assembly to be connected into a final assembly

Animation

- Animation Application
  - Demonstrates system cycle

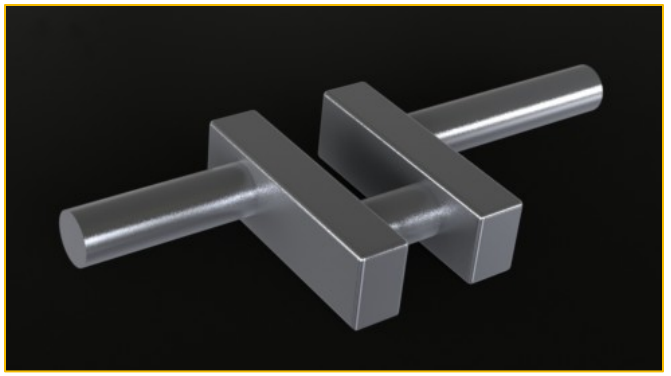


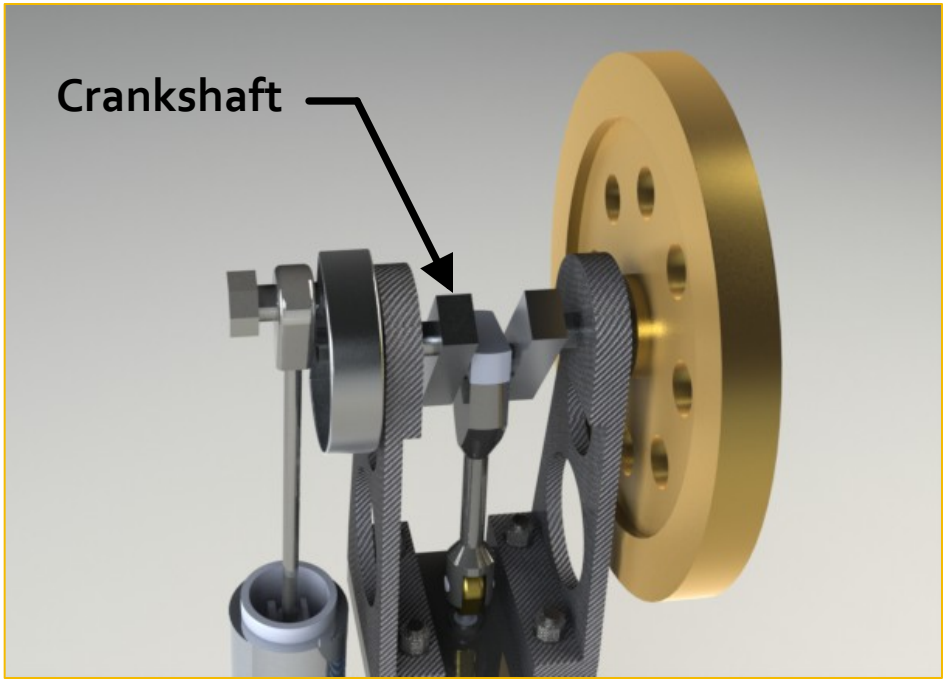
Animation Problems

- Problem
  - Animation jumps form frame to frame
  - Could not see all moving parts
  - Change in rotational speed and direction
- Solution
  - Change the interpolation setting from linear to smooth
  - Cut the assembly model, make parts invisible or use wire frame.
  - Take more snap shoot between frames and adjust frame spacing with the timeline

Structural Analysis

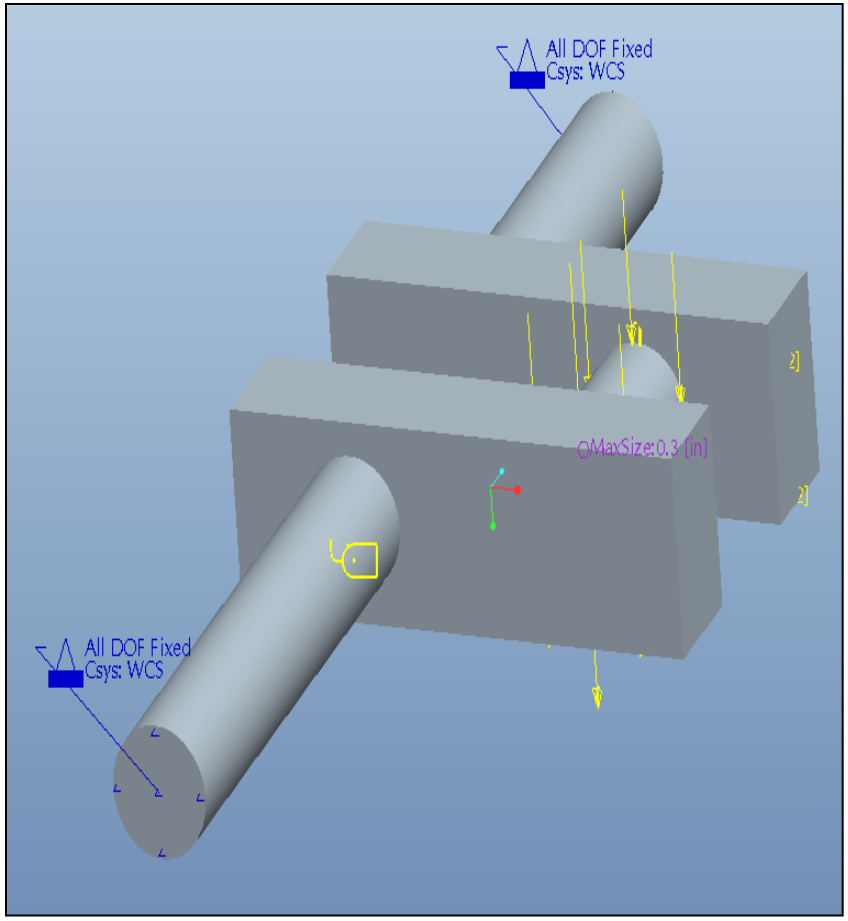
- Objectives
  - Gain Experience
  - Analyze 1 component
    - Crankshaft
  - Refine Mesh to Improve Results





Structural Analysis

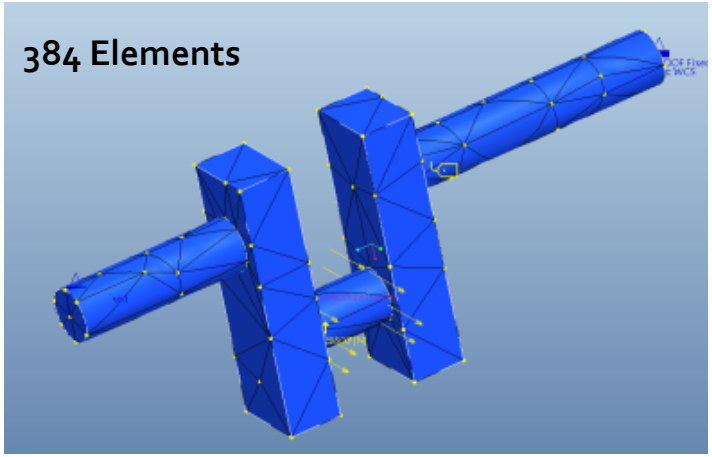
- Loading
  - Constraints
  - Simulate system failure
  - Combined Bending Stresses and Torsion
  - Random value of 2500N and steel as a material

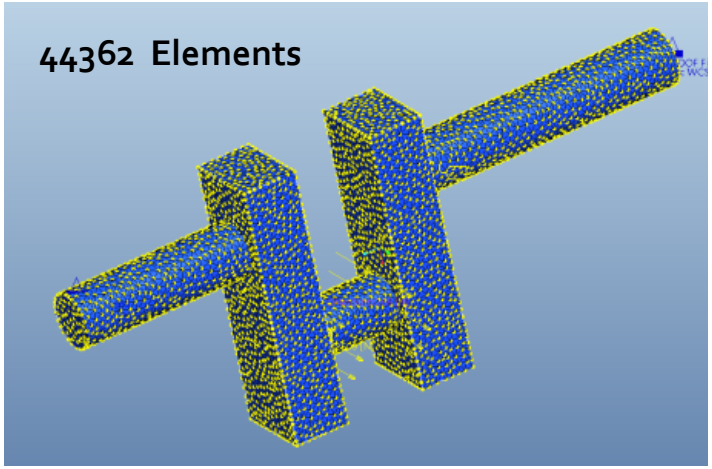


Structural Analysis

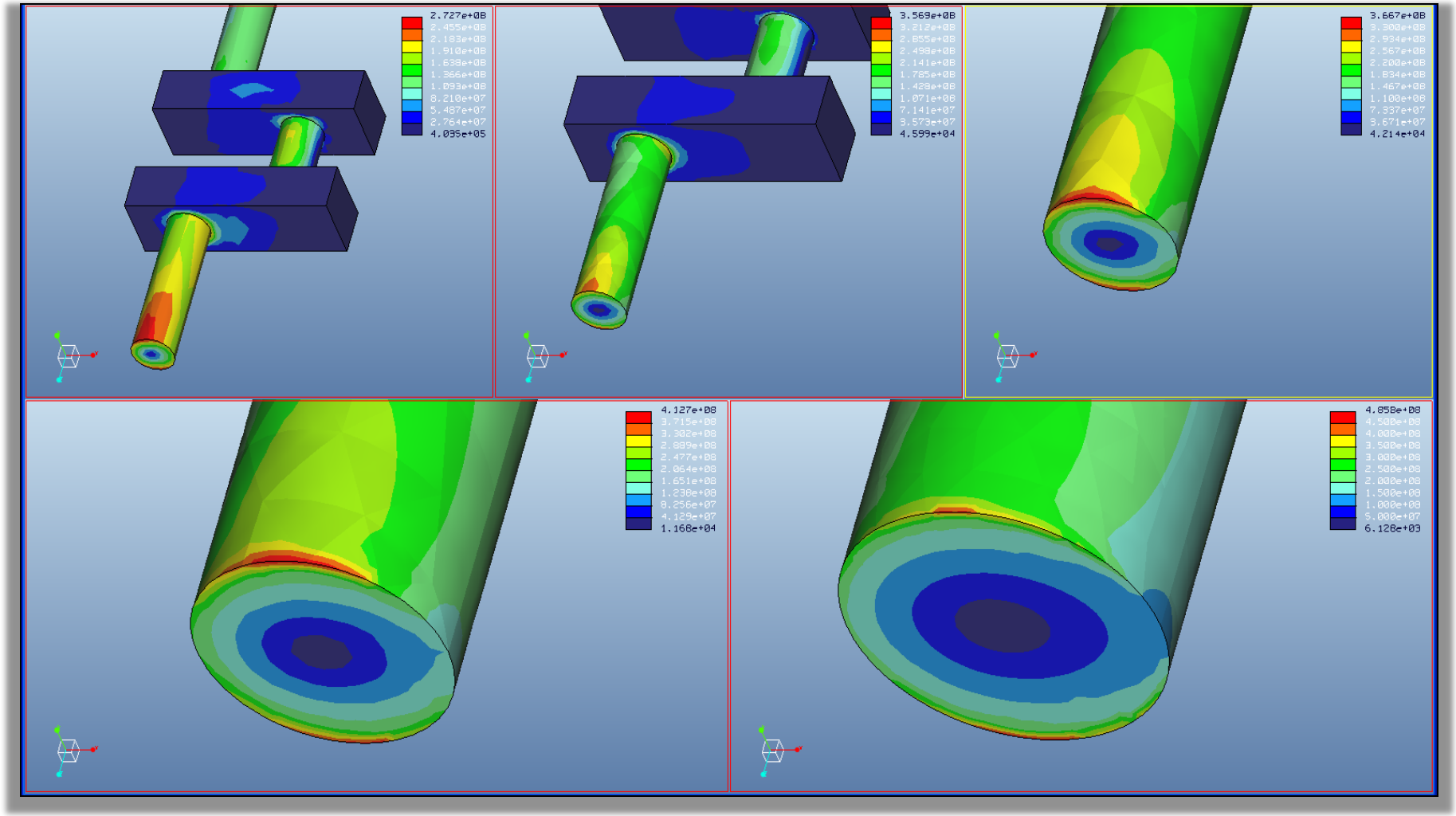
- Refining the Mesh
  - AutoGem Controls
  - Reduced maximum element size

Maximum Element Size (in)	# of Nodes	# of Elements
0.7	147	384
0.6	190	515
0.5	231	627
0.4	327	949
0.3	570	1851
0.2	1455	5572
0.1	6494	27471
0.08	10332	44362

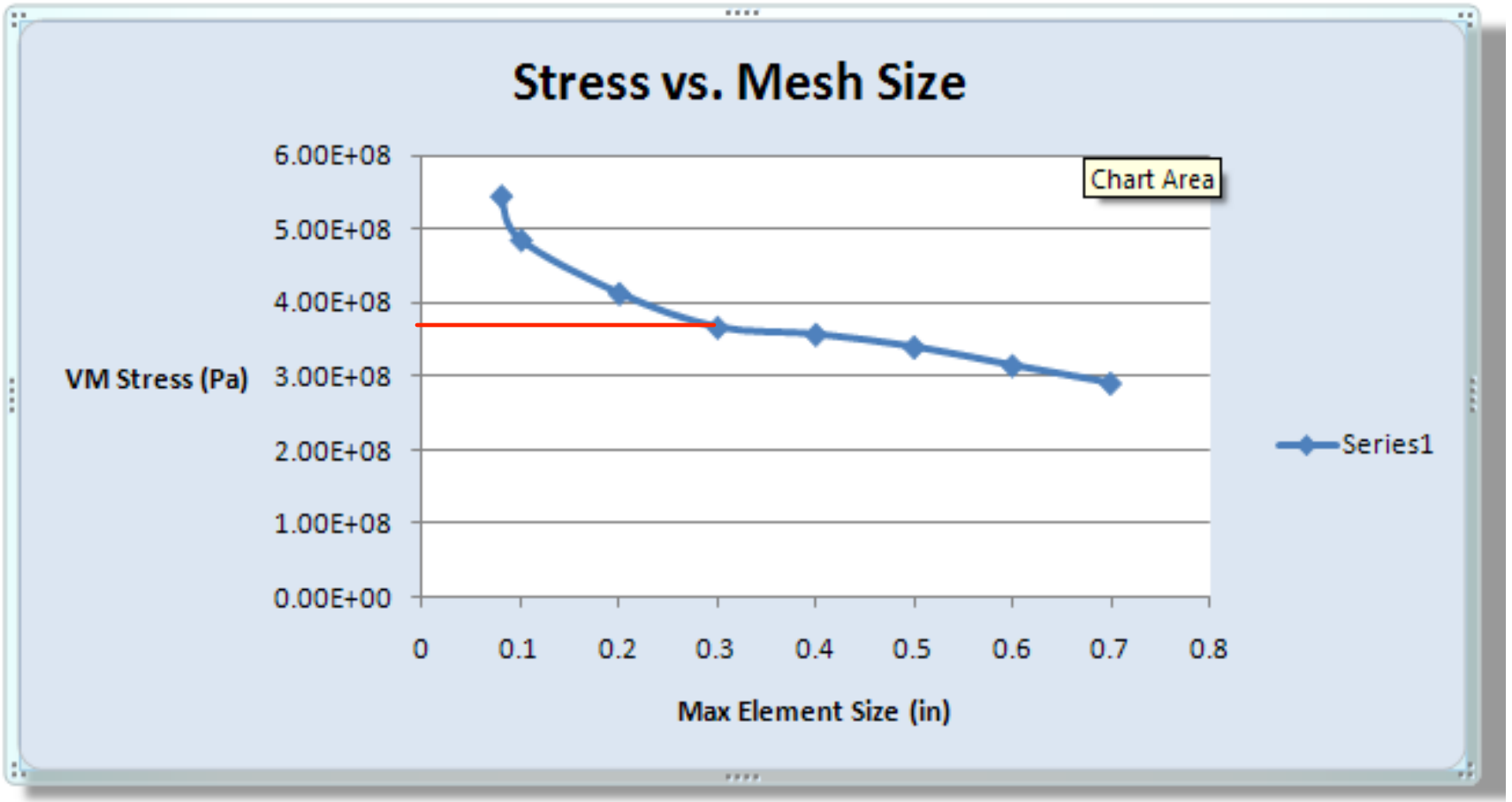




Structural Analysis



Structural Analysis

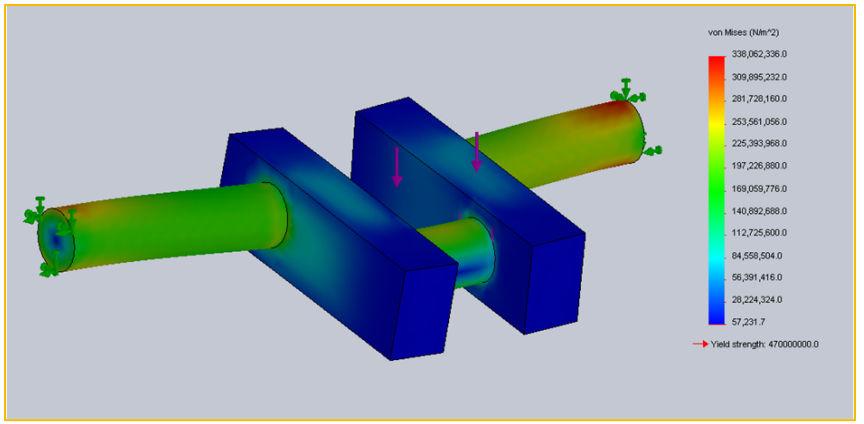


Structural Analysis Problems

- Problems
  - Unsure of the Reliability of FEA Results for very fine mesh sizes
- Solutions
  - Used another CAD software to compare results

Secondary Stress Anaylsis

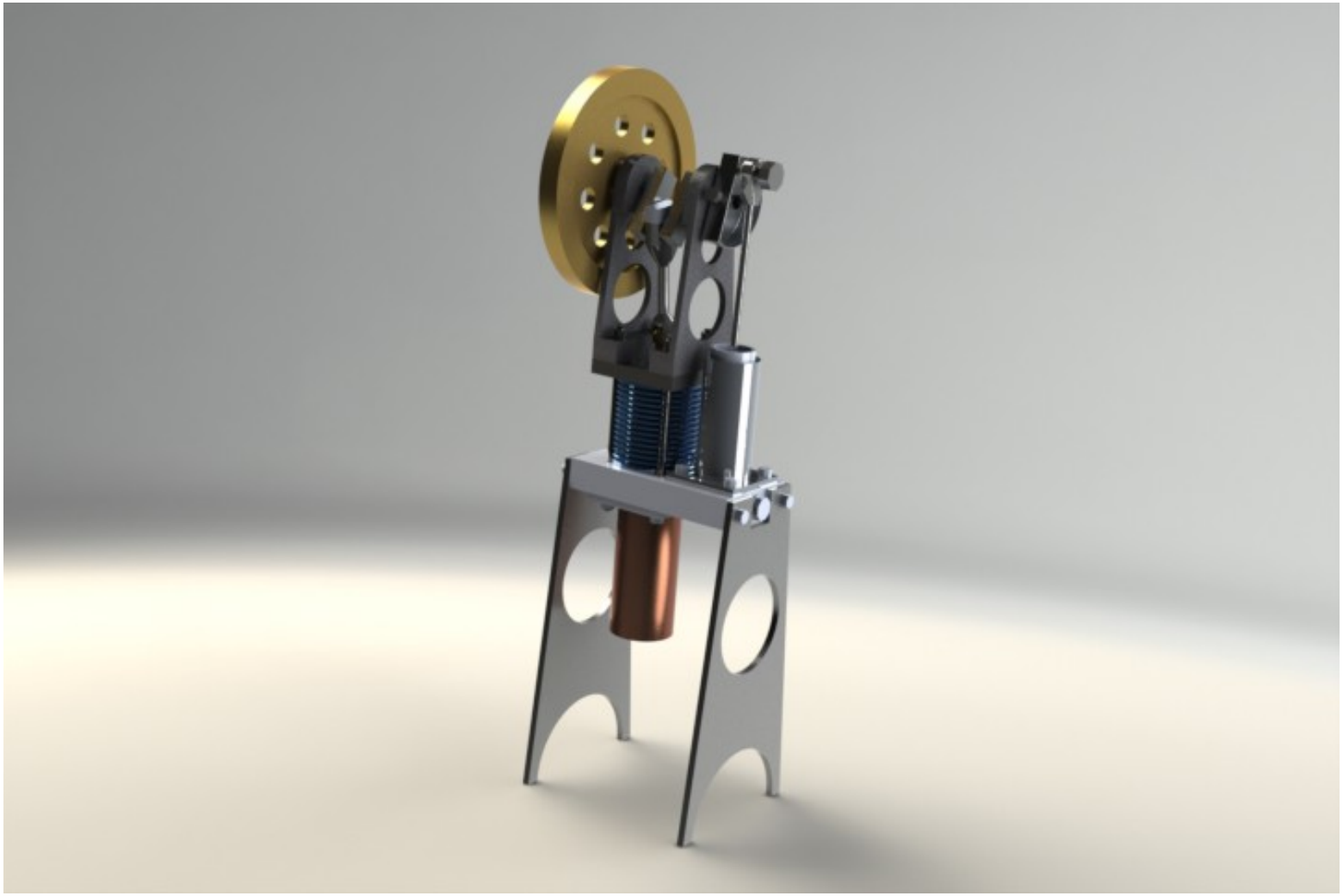
- SolidWorks Simulation was used to compare to Pro/ Mechanica results
- σ_{Max} = 338Mpa
- 11.1% Percent difference from average Pro/ Mechanica max stress



Secondary Stress Anaylsis

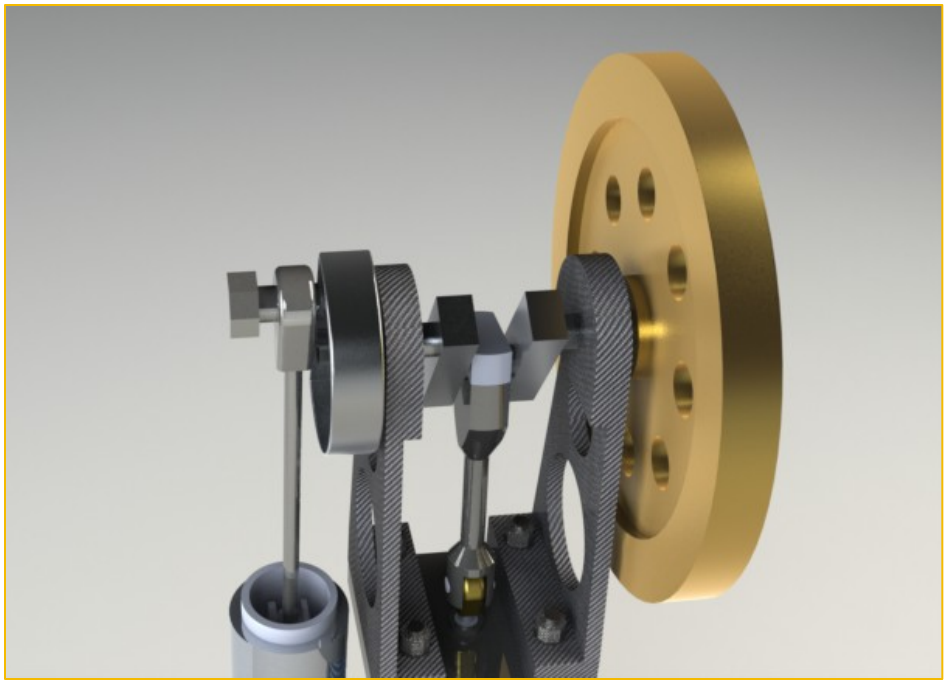
Pros	Cons
User Friendly	Over simplified
Tutorial guide	Difficulty refining mesh
Low computation time	Limited user interaction

Rendering with PhotoView 360



Conclusions

- Gained further experience with modeling and assembly
- Learned how to better interpret FEA results
- Animation Techniques and limitations
- Photo Rendering



Questions?