Project Report

Multiphysics FEA of a Parametric Single-Cylinder Engine Crank Mechanism

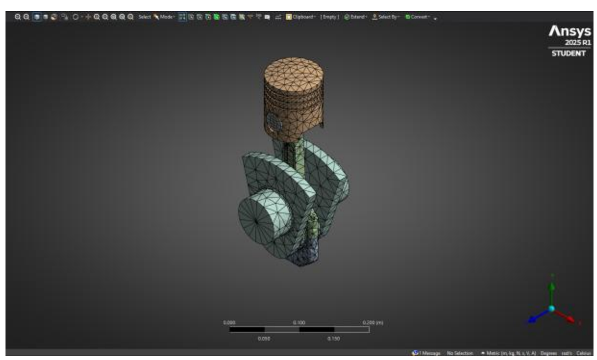
1. Introduction
This project focuses on a parametrically designed single-cylinder engine crank-slider mechanism, which includes:
- Piston head
- Piston pin
- Piston ring
- Connecting rod
- Crankshaft

The goal is to evaluate the mechanical and thermal performance of the assembly using ANSYS Workbench.

2. Tools Used

Task	Software
3D CAD Modeling	Autodesk Inventor 2024
Simulation & FEA	ANSYS Workbench
File Format	STEP (.stp)

3. Mesh Information



Parameter	Value
Element Size	0.005 m
Smoothing	High
Span Angle Center	Fine

4. Static Structural Analysis

4.1 Boundary Conditions
Load: 6 MPa pressure on piston head
Support: Crankshaft end fixed

4.2 Results

a) Total Deformation

Component	Min (m)	Max (m)	Avg (m)
All Bodies	1.62E-09	3.18E-04	3.83E-05
Piston Head	0.00	3.18E-04	4.43E-05
Connecting Rod	1.27E-06	1.06E-04	2.19E-05
Crankshaft	3.72E-08	9.75E-06	1.99E-06

b) Equivalent (von-Mises) Stress

Component	Min (Pa)	Max (Pa)	Avg (Pa)
All Bodies	3.41E+02	2.39E+08	3.44E+07
Piston Head	2.84E+02	2.39E+08	5.05E+07
Connecting Rod	6.09E+01	1.89E+08	5.83E+07
Crankshaft	1.08E+01	1.33E+08	2.79E+07

c) Equivalent Elastic Strain

Component	Min	Max	Avg
All Bodies	5.83E-07	2.74E-03	2.57E-04
Piston Head	4.54E-07	2.74E-03	3.59E-04
Connecting Rod	9.73E-08	2.05E-03	4.12E-04
Crankshaft	1.78E-08	1.38E-03	1.96E-04

5. Steady-State Thermal Analysis

5.1 Boundary Conditions

Ambient Temperature: 22°C

Applied Temperature on Piston Head: 660°C

Radiation Enabled: Crankshaft sides

5.2 a) Temperature Distribution

Component	Min (°C)	Max (°C)	Avg (°C)
All Bodies	22.00	660.00	443.70
Piston Head	65.80	660.00	450.40
Connecting Rod	52.27	660.00	453.80
Crankshaft	22.00	252.60	146.13

5.2 b) Total Heat Flux

Component	Min (W/m^2)	Max (W/m^2)	Avg (W/m^2)
All Bodies	5.77E-01	1.82E+05	4.26E+04
Piston Head	5.53E-01	1.47E+05	4.67E+04
Connecting Rod	7.84E-01	1.82E+05	5.96E+04
Crankshaft	5.77E-01	5.64E+04	6.12E+03

6. Transient Structural Analysis

6.1 Joint Setup

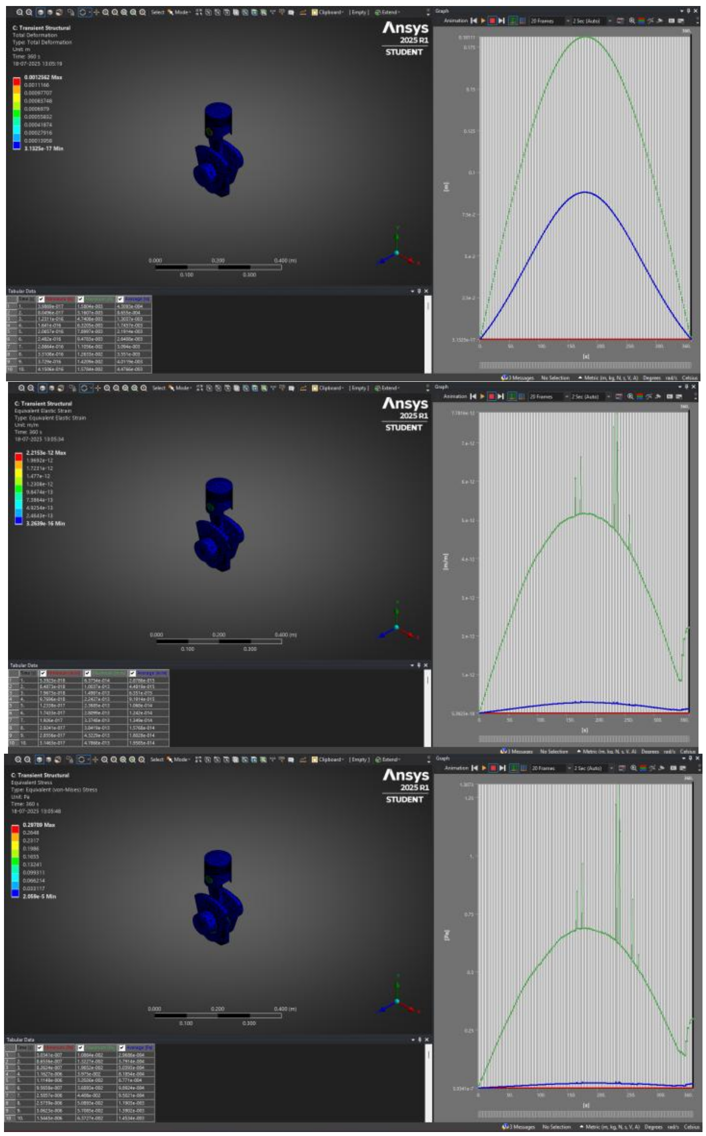
Connection	Joint Type

Crankshaft ↔ Ground	Revolute
Piston Head (linear travel only)	Translational
Crankshaft ↔ Connecting Rod	Revolute
Connecting Rod ↔ Piston Pin	Revolute
Piston Pin ↔ Piston Head	Revolute

6.2 Motion Setup

Input Motion: Rotational Displacement on crankshaft (Z-axis)
Time Duration: 0 to 360 seconds
Boundary Conditions: Joint-based motion, no external pressure applied

6.3 Solutions



7. Discussion

- Structural results confirm that deformations and stresses are within safe operating limits.
- Thermal analysis shows effective heat flow from piston to crankshaft, aligning with expected

conduction behavior.
- Transient study validates motion constraints, simulating actual engine kinematics, useful for future fatigue and vibration studies.

8. Conclusion

The analysis of this crank-slider engine assembly provides a complete understanding of how real-world forces and temperatures affect the mechanism. The design is mechanically sound, thermally consistent, and dynamically stable under the given conditions.

9. Future Work

- Integrate fatigue life prediction from transient stress results
- Run modal/harmonic analysis for vibration characteristics
- Perform material optimization to reduce weight
- Apply thermal-structural coupling for accuracy
- Introduce CFD loading for pressure realism

10. References

- ANSYS Theory & Application Guides
- Autodesk Inventor Documentation
- Internal Combustion Engine Design References
- Research papers on crank-slider dynamics