



INTERACTIONS BETWEEN INVOLUTE SPUR GEARS

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Overview

- What is the purpose of a gear system?
- What is an involute spur gear?
- Why we use the involute spur gear?
- Look at new software SolidWorks
 - Advantages / limitations
- Stress/Strain analysis
 - Von Mises Stress
 - Displacement
 - Factor of Safety
- Conclusion
- Future Work

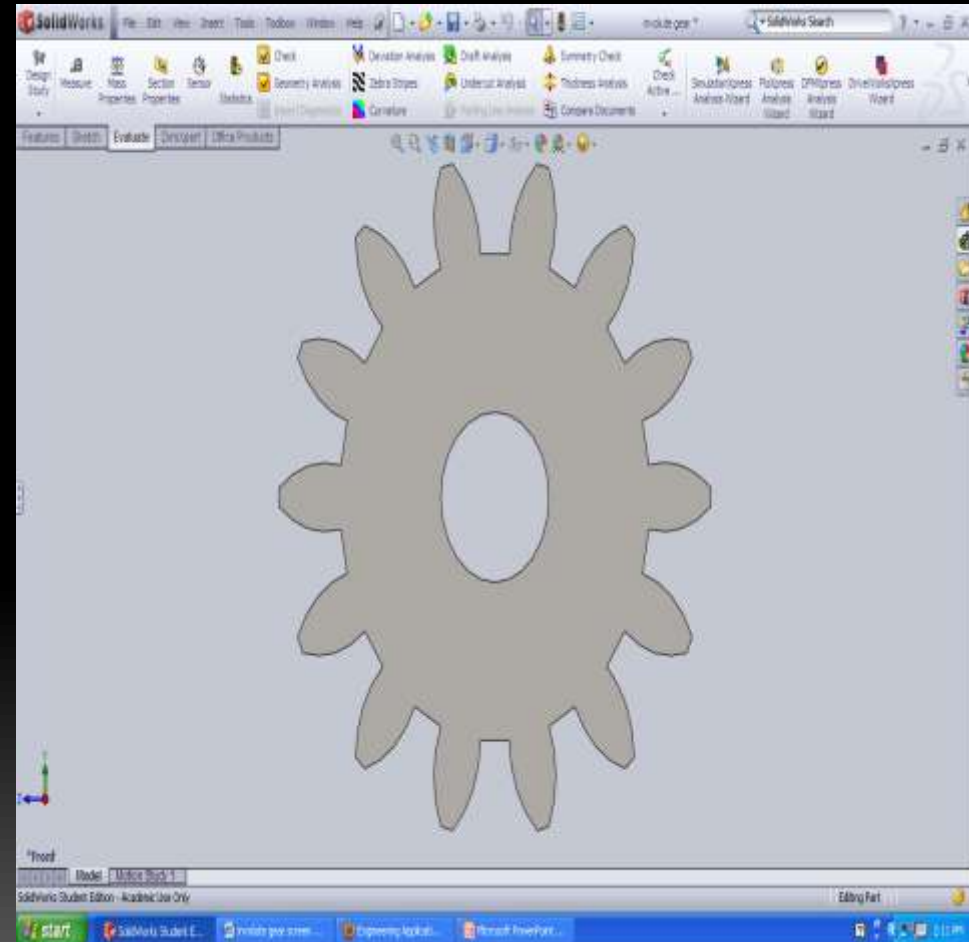
Purpose of a gear system?

- Transmitting power and uniform rotary motion to output shaft and differential
- $P = \tau \omega$
- Trade off τ for ω
 - Fast in 4th gear : high angular velocity
 - Fast in 1st gear : high torque



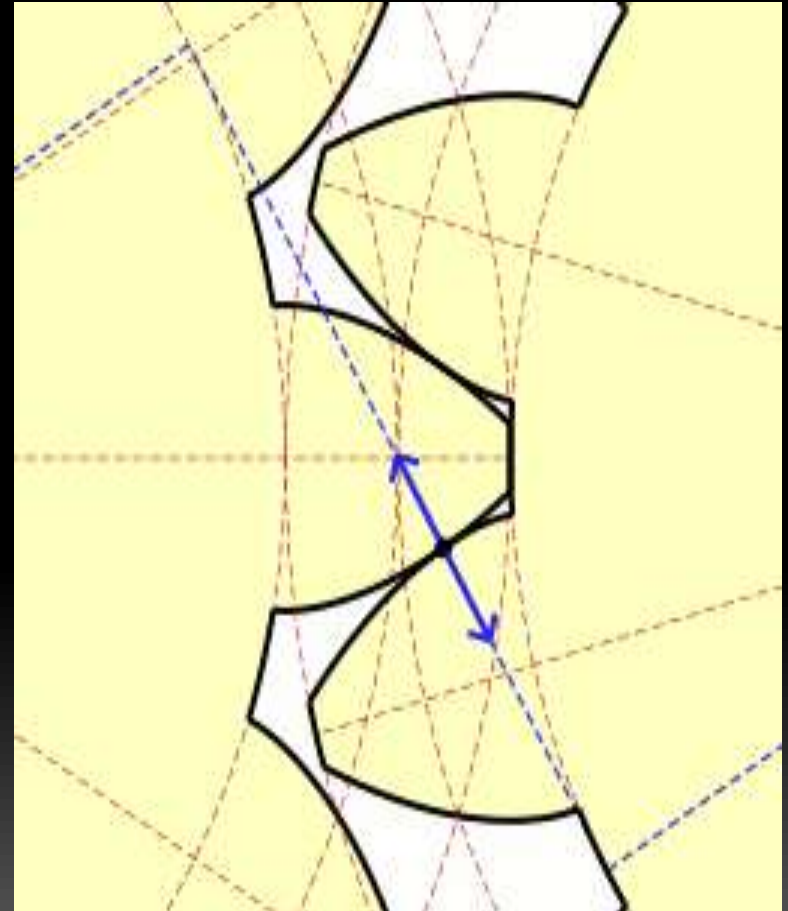
What is an Involute Spur Gear?

- Most common gear used today
- Spur means gear teeth are projected radially to axis of rotation
- Involute describes the contour of the gear teeth curving inward



Why use an Involute Gear?

- Contact surfaces are always perpendicular to the plane of contact, reduces torque variation
- Smoother running and less wear on gears
- Ease of manufacturing accurate gear

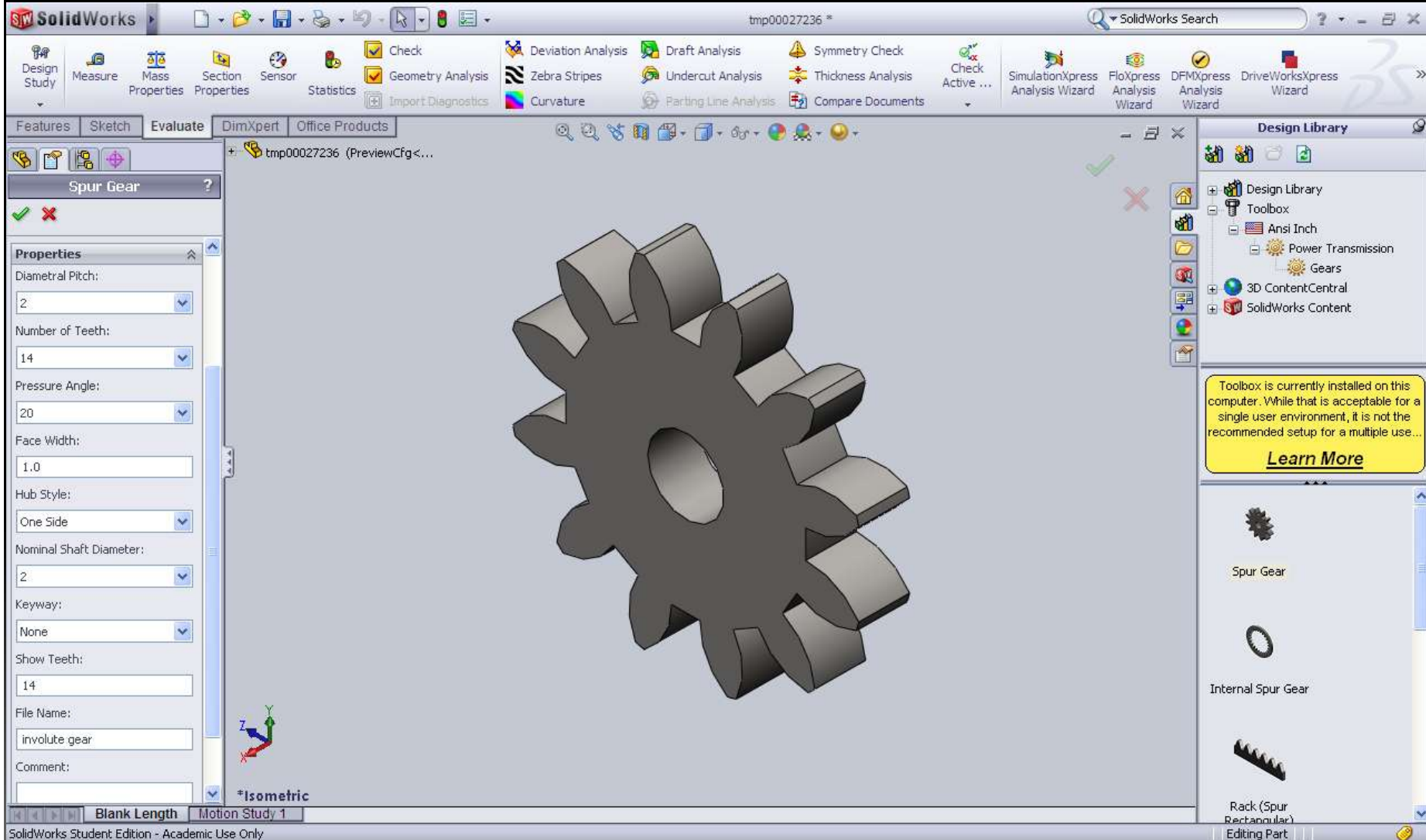




SolidWorks

- CAD software with analysis features – FEA called SimulationXpress
- Professional version allows interaction between parts of an assembly, which in turn costs a \$2,000+
- We can only examine a single part of an assembly
 - Limitations on student version

A look at the interface



Limitations of student version

SolidWorks File Edit View Insert Tools Toolbox Window Help

involute gear * SolidWorks Search

Design Study Measure Mass Properties Section Properties Sensor Statistics Check Geometry Analysis Import Diagnostics Deviation Analysis Zebra Stripes Curvature Draft Analysis Undercut Analysis Parting Line Analysis Symmetry Check Thickness Analysis Compare Documents Check Active ... SimulationXpress Analysis Wizard FloXpress Analysis Wizard DFMXpress Analysis Wizard DriveWorksXpress Wizard

Features Sketch Evaluate DimXpert Office Products

involute gear (involute gear <Display State-4>)
Sensors
Annotations
Lights, Cameras and Scene
Equations
Material <not specified>

SimulationXpress Study (-involute gear-)
involute gear (-Alloy Steel-)
Fixtures
Fixed-1
External Loads
Force-3 (:Per item: 34000 N:)
Results
Stress (-vonMises-)
Displacement (-Res disp-)
Deformation (-Displacement-)
Factor of Safety (-Max von Mises Stress-)

*Isometric

SolidWorks SimulationXpress

- 1 Fixtures ✓
- 2 Loads ✓
- 3 Material ✓
- 4 Run ✓
- 5 Results ✓
- 6 Optimize ✓

To simulate the loading on your part, you apply forces, pressures, or both. [Examples](#)

Warning: These loads are assumed to be uniform and constant. [What does this mean?](#)

- ➔ Add a force
- ➔ Add a pressure
- ➔ Edit an existing force or pressure
- ➔ Next

⏪ Back Start Over

Model Motion Study 1 SimulationXpress Study DesignXpress Study

SolidWorks Student Edition - Academic Use Only

start SolidWorks Student E... involute gear screen ... Factors of Safety - M... Microsoft PowerPoint ... 10:19 AM

Power Comparisons

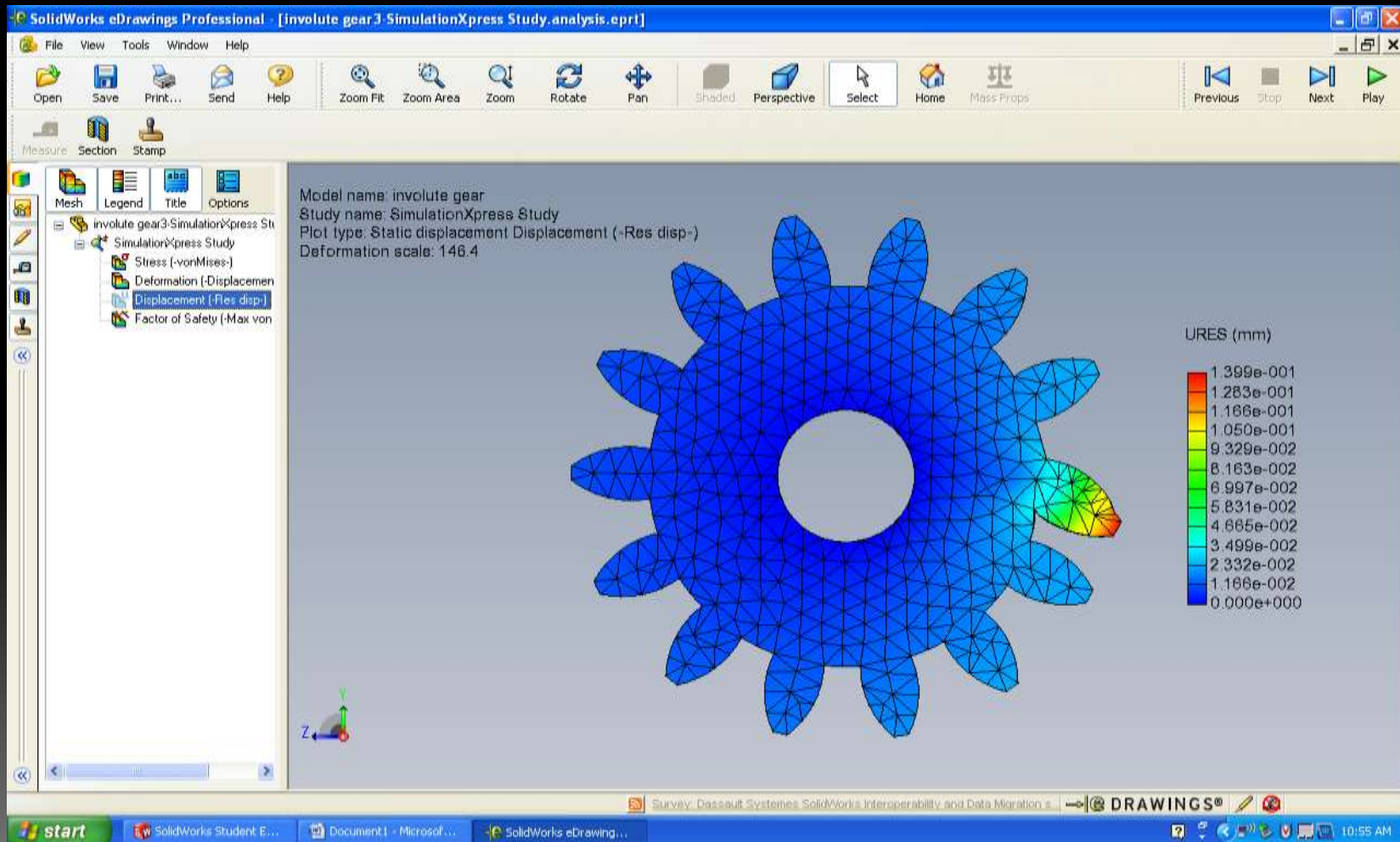
- $1 \text{ hp} = 746 \text{ W}$
- Cars : 100's of hp = 74,600 Watts
- Train : 1340 hp = 1 Mega Watt
- Turbojets : Thousands of hp = Few Mega Watts

Our Values

- Power : 2 Mega watts
- Torque : 15000 in-lbf
- $\omega = 1345$ rad/sec
- Gear Radii : 2 inches
- Force : 34000 N
- Gear material : 1080 Alloy Steel
 - Young's Modulus : 2.1×10^{11} N/m²
 - Yield Strength : 6.20×10^8 N/m²

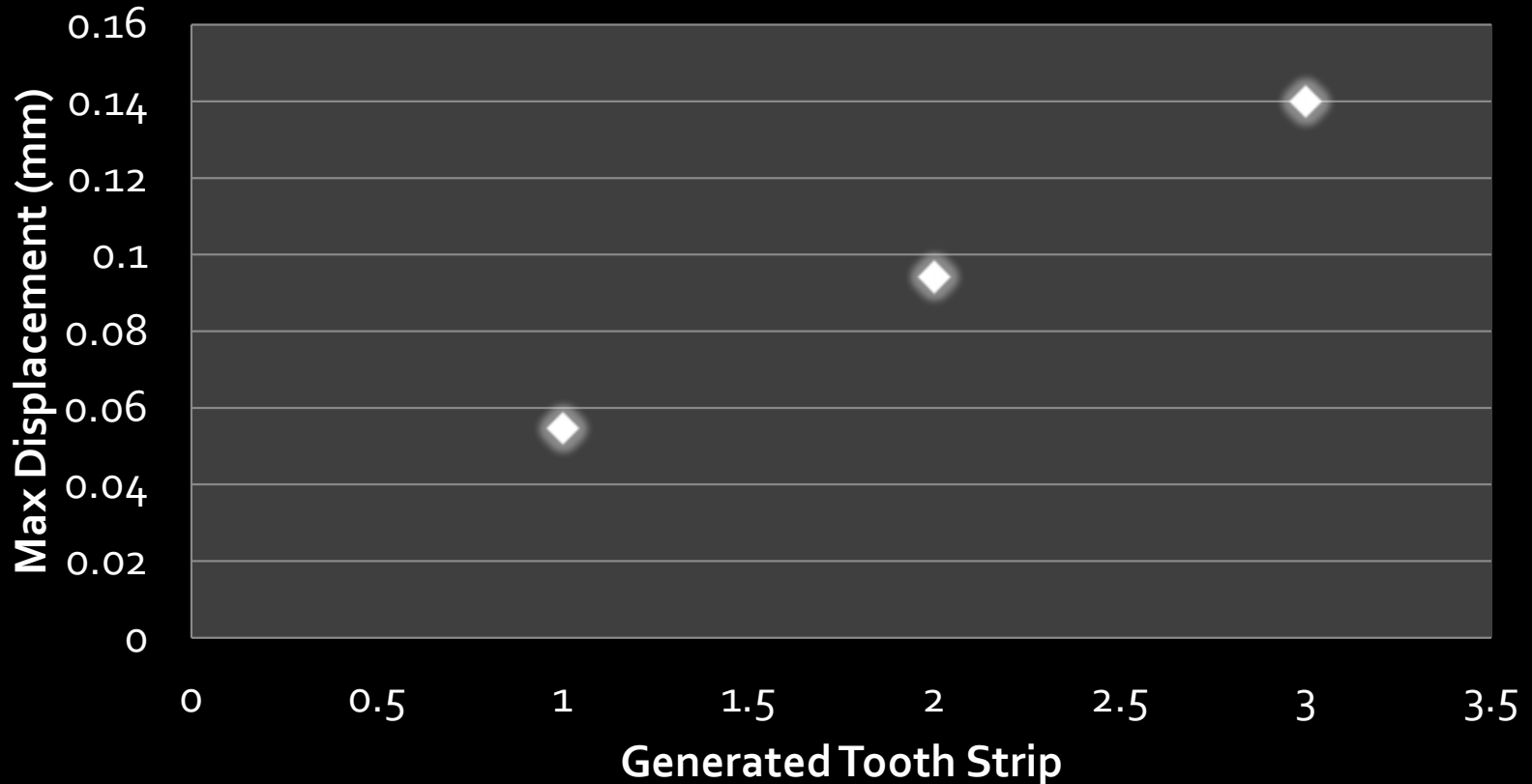
Displacement Results

Red – shows max displacement



How does the displacement vary with change in contact position?

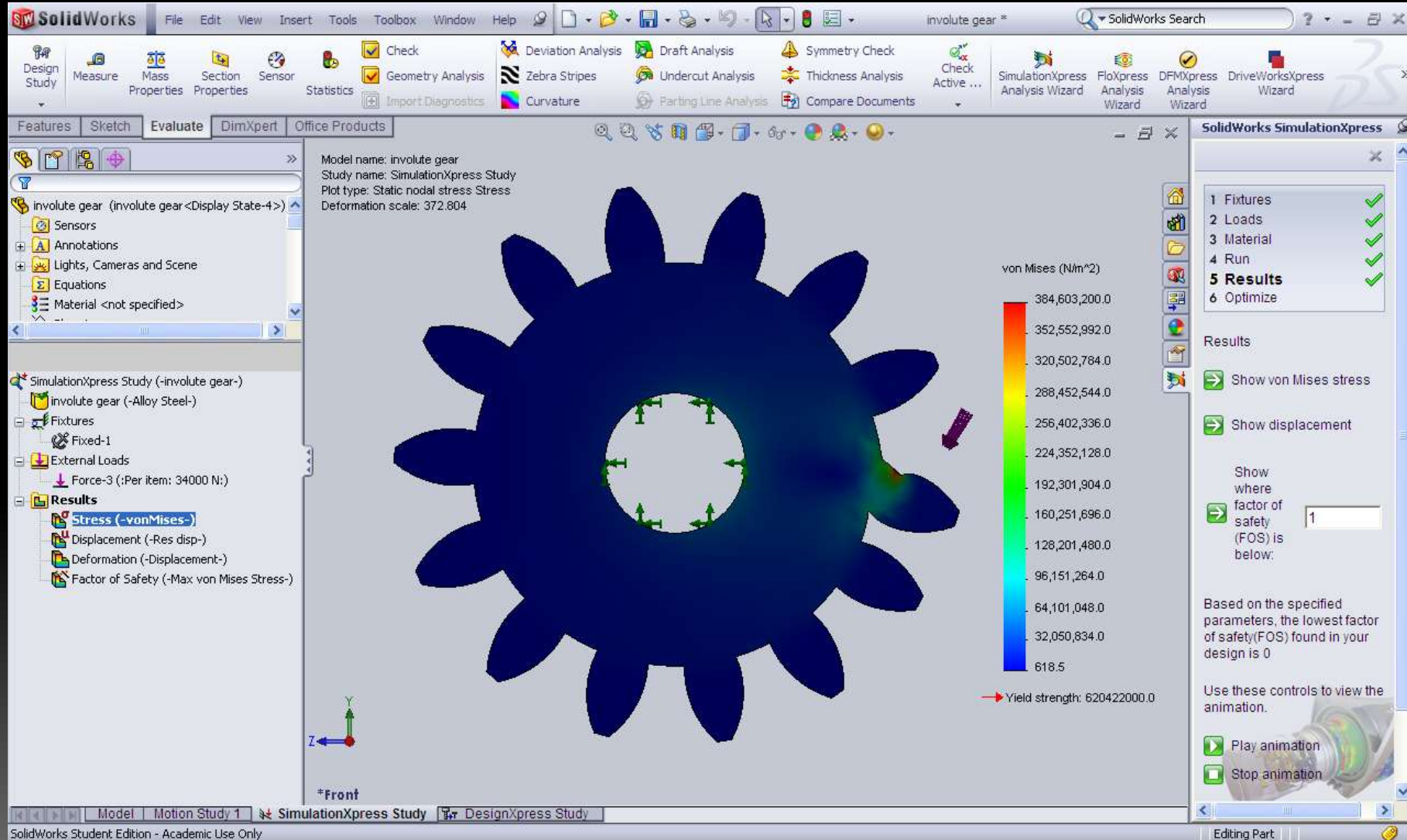
Displacement vs. Generated Strip



Von Mises Stress

- Formulated by James Maxwell in 1865
- Used in the analysis of ductile materials such as metals
- Used to compare yielding of materials to loading conditions
- Local magnitude of stress not (x,y,z) plane stress

Von Mises Stress Results



Factor of Safety (FOS)

- Used in design process to determine uncertainty of material failure
 - Design calculations
 - Material strength
 - Purpose

Our case FOS range from 4-6

Factor of Safety Results

Model name: involute gear
Study name: SimulationXpress Study
Plot type: Factor of Safety Factor of Safety
Criterion: Max von Mises Stress
Red < FOS = 6 < Blue

SimulationXpress Study (-involute gear-)
involute gear (-Alloy Steel-)
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1 Fixtures ✓
2 Loads ✓
3 Material ✓
4 Run ✓
5 Results ✓
6 Optimize ✓

Results
Show von Mises stress
Show displacement
Show where factor of safety (FOS) is below: 6
Based on the specified parameters, the lowest factor of safety(FOS) found in your design is 0
Use these controls to view the animation.
Play animation
Stop animation

SolidWorks Student Edition - Academic Use Only

Editing Part



SolidWorks Student E...

involute gear screen ...

Stress analysis - Wik...

Microsoft PowerPoint ...

11:26 AM

Conclusion

- Learned a great deal of how FEA programs take into account the physics
 - Shear Modulus (deformation of material under force)
- Physics can be applied to engineering designs with reasonable comparisons
- FEA programs are very similar
 - LISA , SolidWorks (closely integrated commands)
- SolidWorks is expensive but a very powerful tool for engineers




Future Work

- Examine different type of gear
 - Helical
- Lubrication Analysis
- Thermal Analysis
 - Shaft / Bearing friction
 - Inter gear friction
 - Heat dissipation within system



Special Thanks

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Works Cited

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- Tofa William Khiralla. *On The Geometry of External Involute Spur Gears*. C/I Learning, North Hollywood, California, 1976.

