

MAE 656 – Final Report

# Effect of Fillet radius of an Engine valve on stress concentration

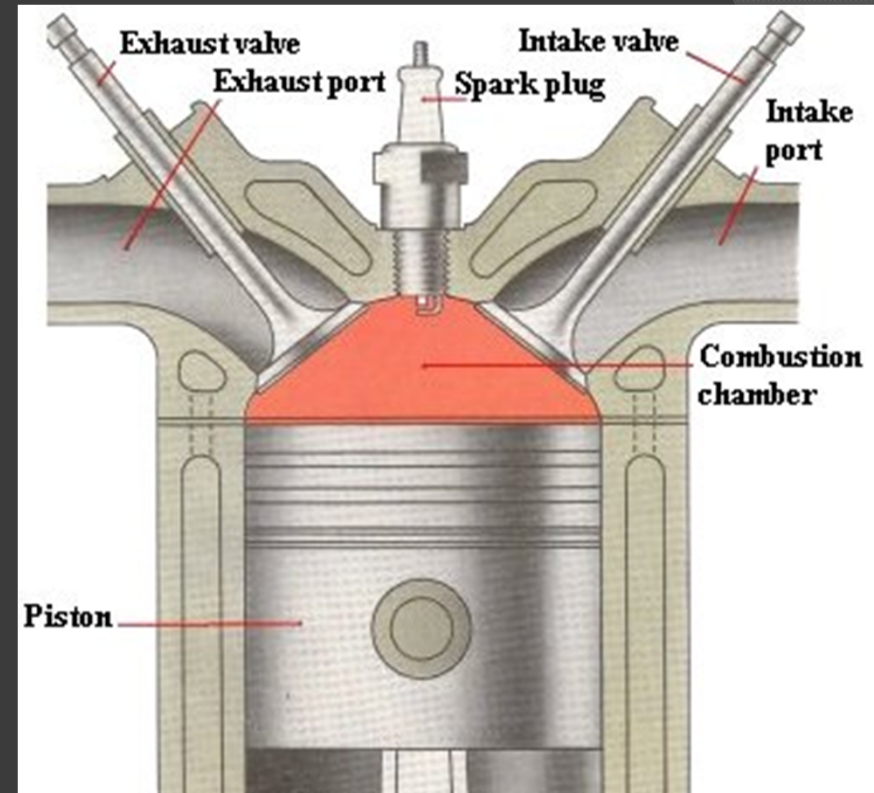
Pragalath Thiruvengadam

# Overview

- Introduction- Stress Concentration, Material Properties, Problem Definition
- Geometry
- Boundary Conditions
- Meshing
- Results
- Model Limitations
- Conclusion

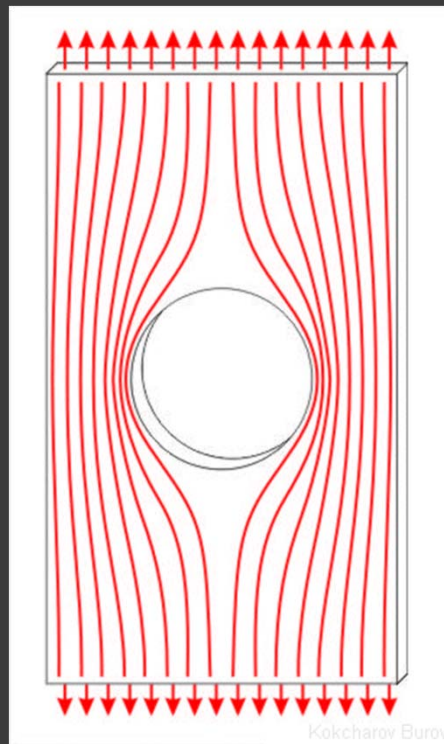
# Introduction

- Engine valves are primarily used to open and close the intake port in order to facilitate air to flow into or out of the cylinder.
- These valves are subjected to oscillating tensile and compressive loads.
- Tensile loads on the valve loads are larger in magnitude this is mainly due to pre-tensions applied to the valve springs and the impact loading on the valve when valve returns back to close position during high engine speed operations.
- Compressive Loads are primarily caused to inertial forces acting on the valve stock during high engine speed operation.
- Pre-tension is used to create an air-tight hydrostatic seal at the intake.



# Stress Concentration

- It refers to the place in which stresses on an object concentrate due to the geometry of the object.
- It usual occurs at notches, cracks and near holes in the geometry.

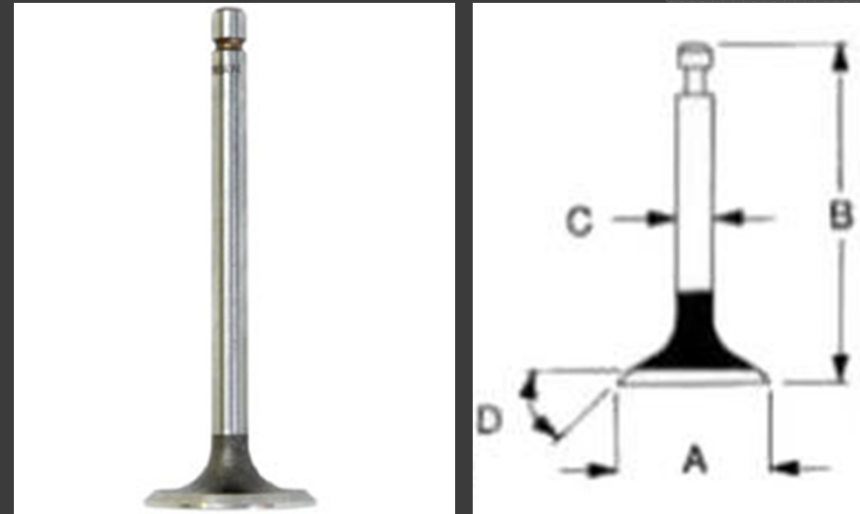


# Material Properties

- ⦿ High grade Alloy Steel (42CrMo4).
- ⦿ Known for its excellent Wear Resistance, and low Co-efficient of friction.
- ⦿ Primarily used in high-stressed valves.
  
- ⦿ Young's Modulus = 210 GPa
- ⦿ Poison's Ratio = 0.32
- ⦿ Yield Strength = 800 MPa
- ⦿ Density = 7830 Kg/m<sup>3</sup>

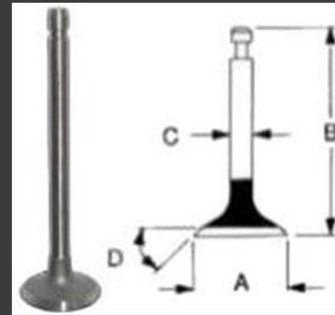
# Problem Definition

- Valves are manufactured by turning solid bar of metal to the desired geometry which takes a lot of time and resources.
- **Objectives:** To study the effect of fillet radius on stress concentration on the fillet angle we are simulating only pre-tension loads on the valve stock.
- This type of loading is only observed when the engine is not running and the valve is in closed position.
- Compressive loads can be ignored since they are caused only due to inertial loading and are small in magnitude.
- Pre-tension force was calculated by using minimum compression of spring at valve close position and spring rate.

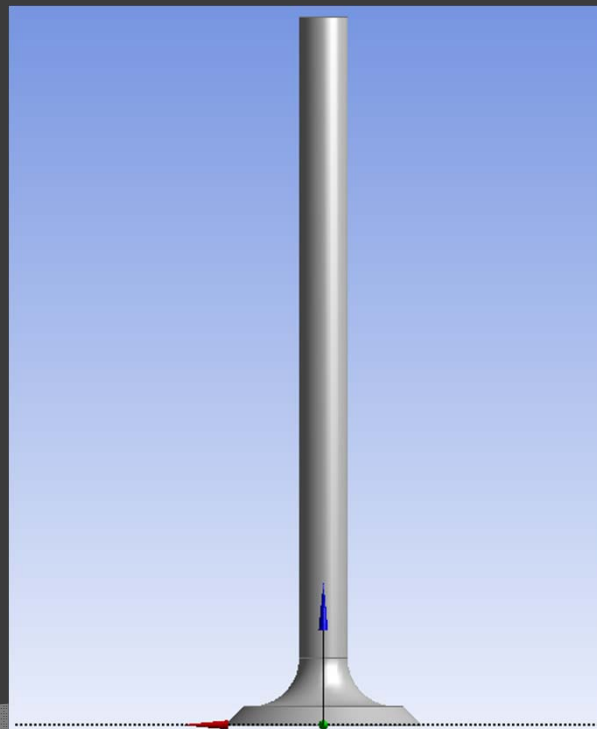
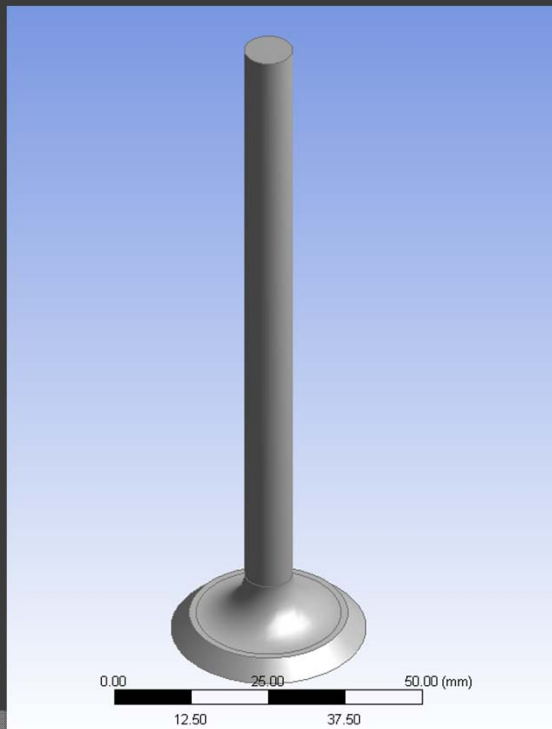


# Geometry

- A valve typically has its fillet radius equal to its stock diameter.
- Several fillet angles were considered including a  $45^\circ$  angle.

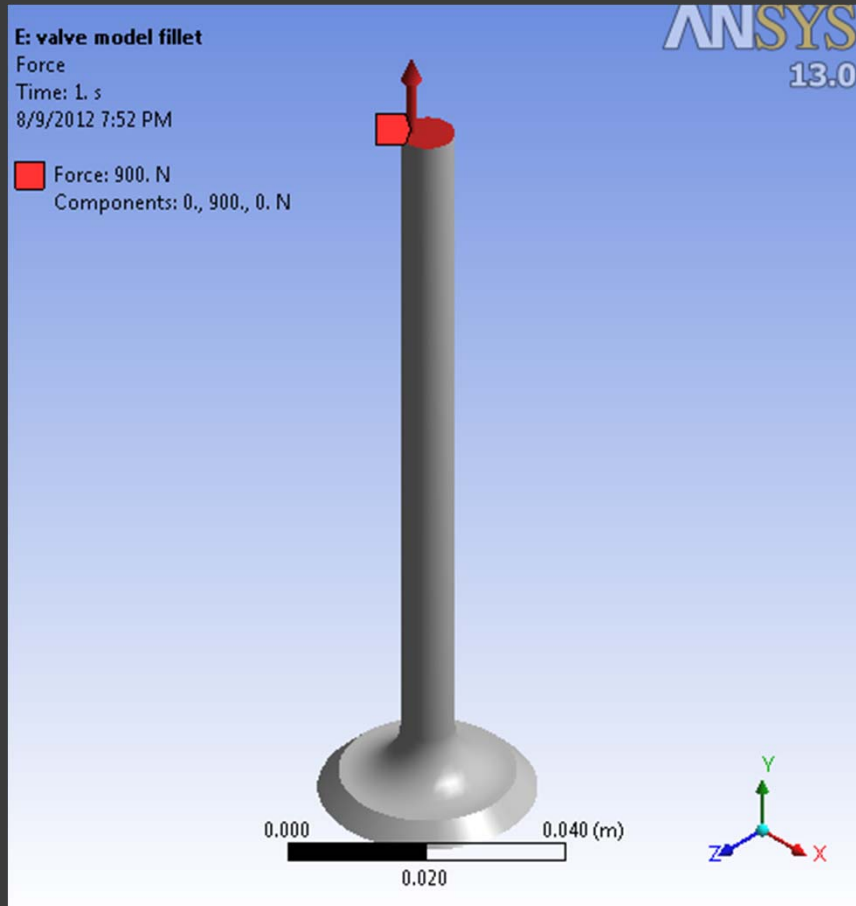


A=31.75 mm  
B=111.91mm  
C=7.8486mm  
D=45°

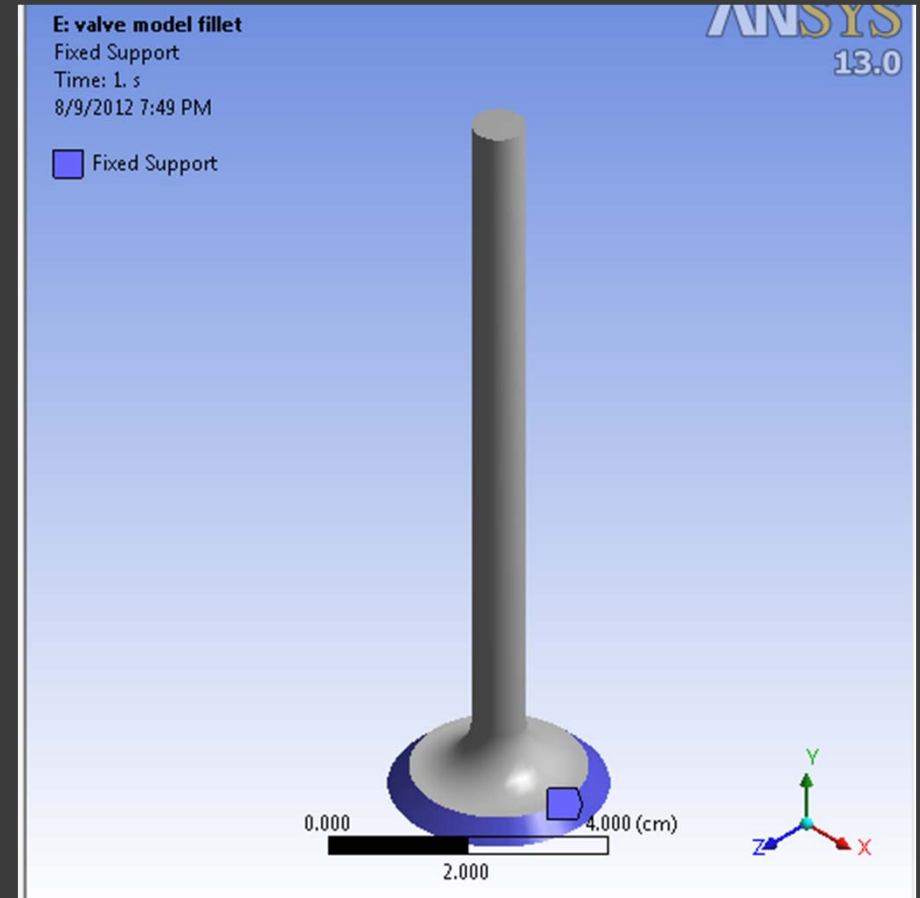


Volume = 7.8406 cc  
Mass = 61.392 g

# Boundary Conditions



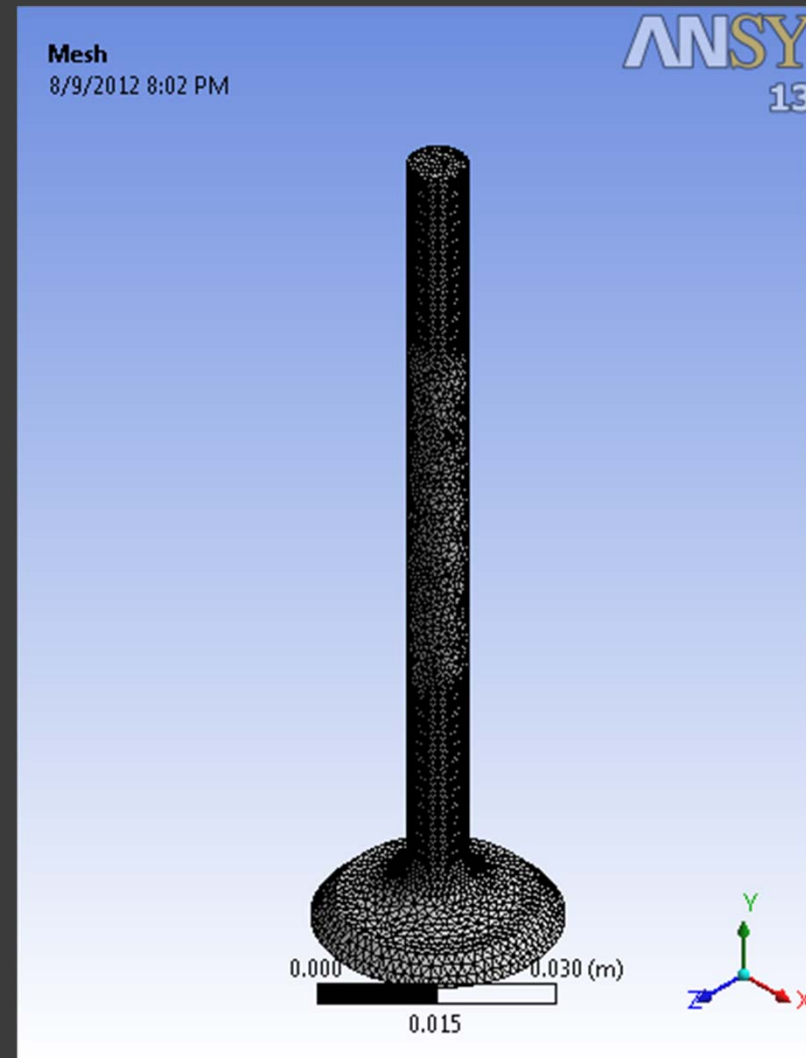
A tensile force of 900N was applied on the upper surface. This is approximately the Pre-tension force exerted on the valve when the spring having spring rate of 300 lbs/in is compressed by 0.703 inches.



The colored region also known as the valve seating is assumed to be a fixed support.

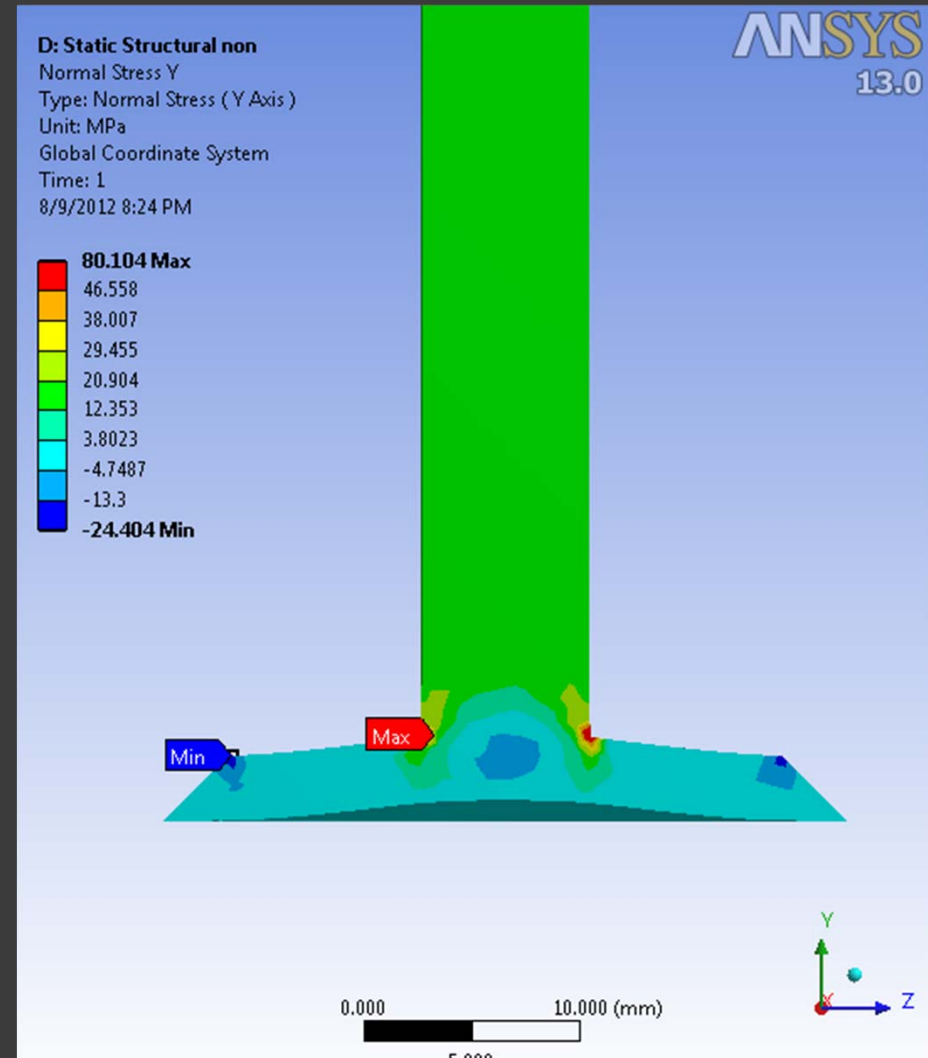
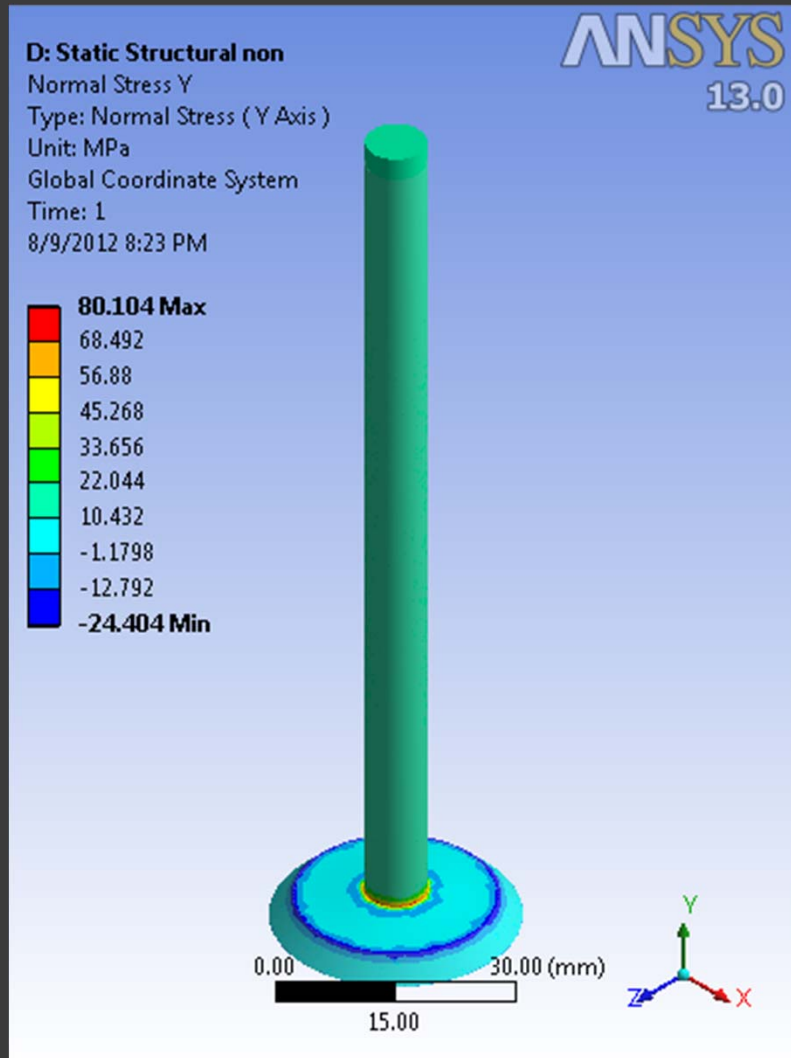
# Meshing

- Mesh method was set to tetrahedron elements and a relevance of 100 was used.
- Mesh sizing properties were also set to fine to generate a finer mesh
- Mesh statistics:
  - Nodes: 51665
  - Elements: 31018

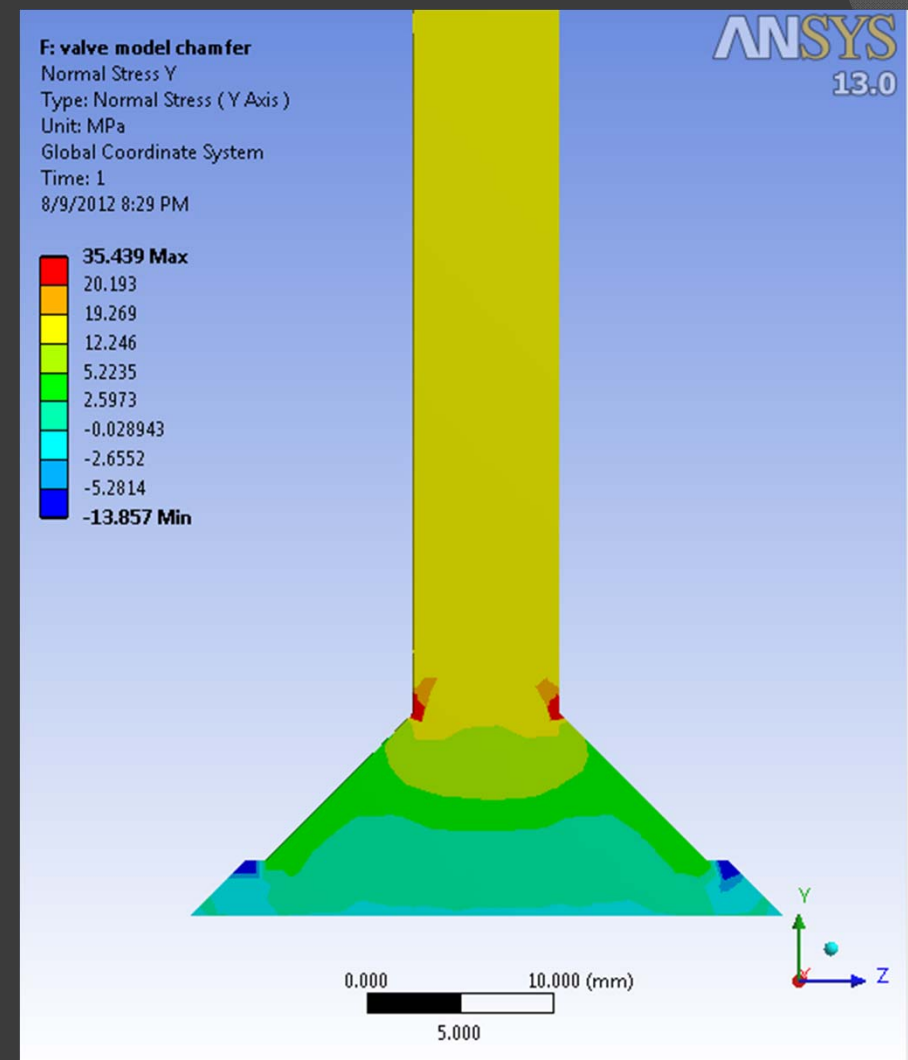
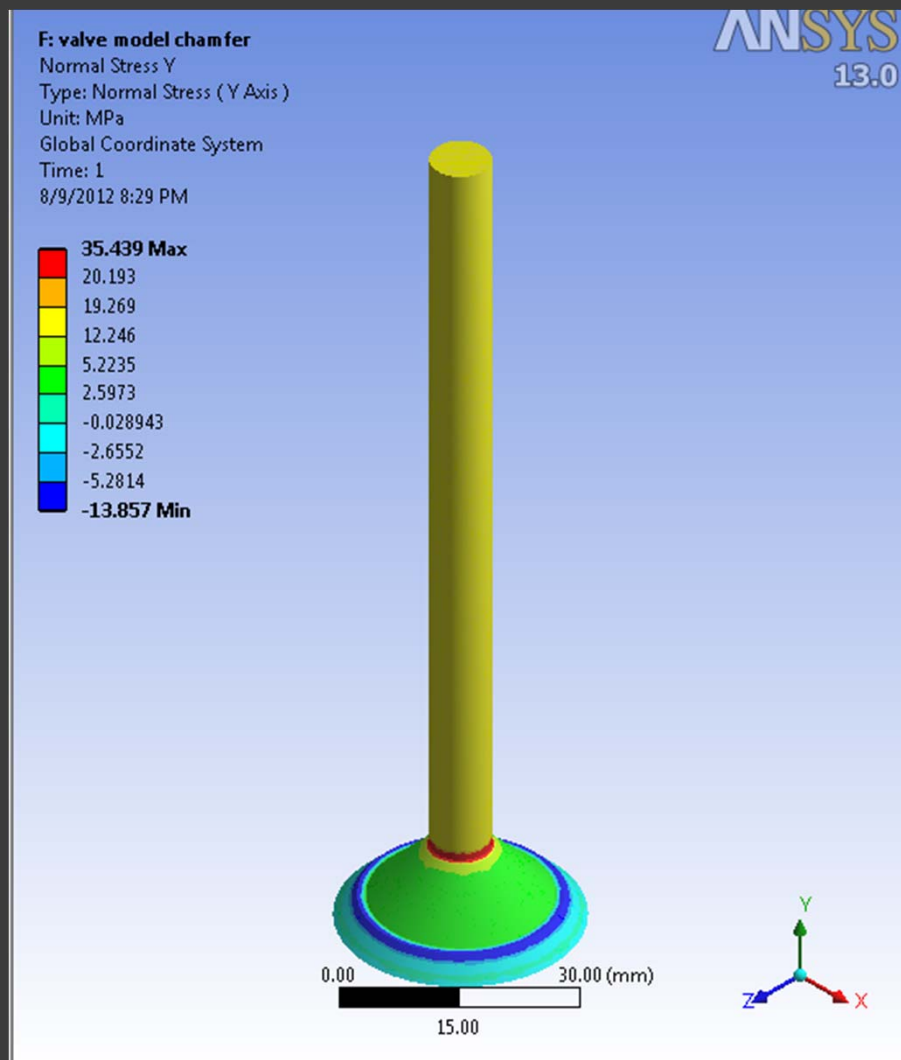


# Results

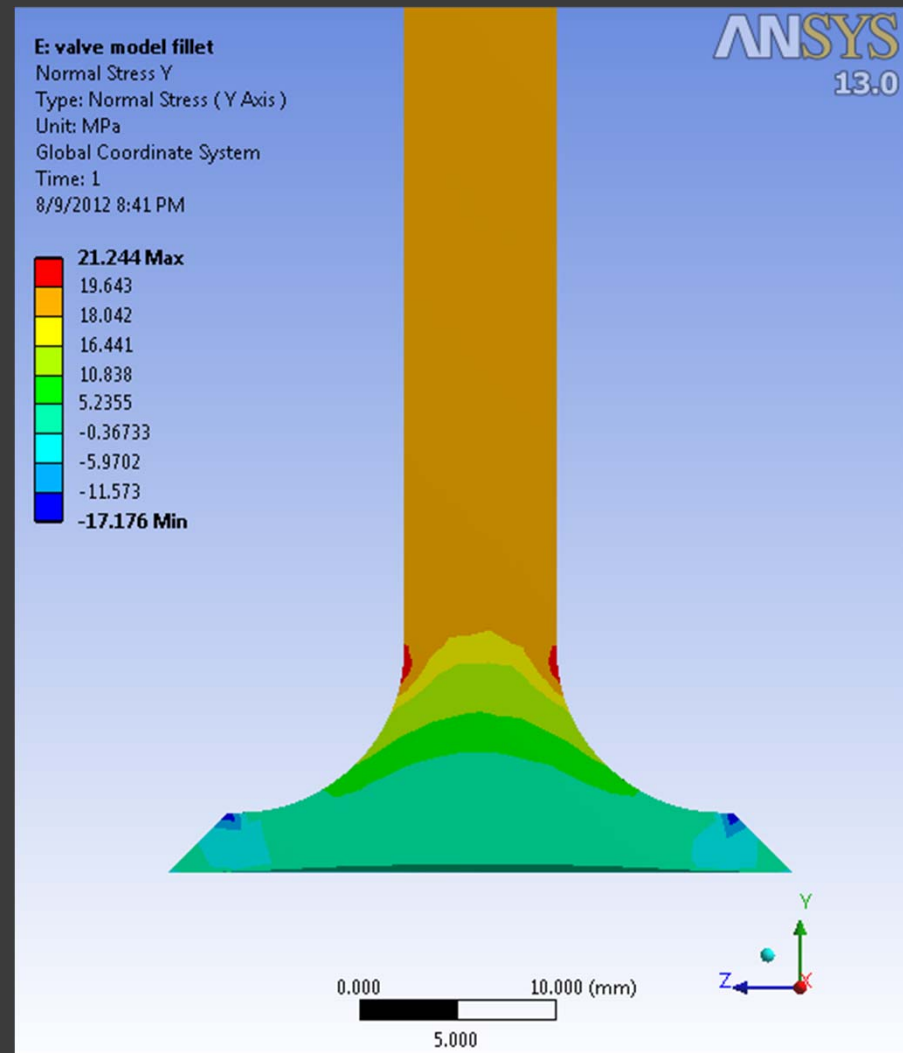
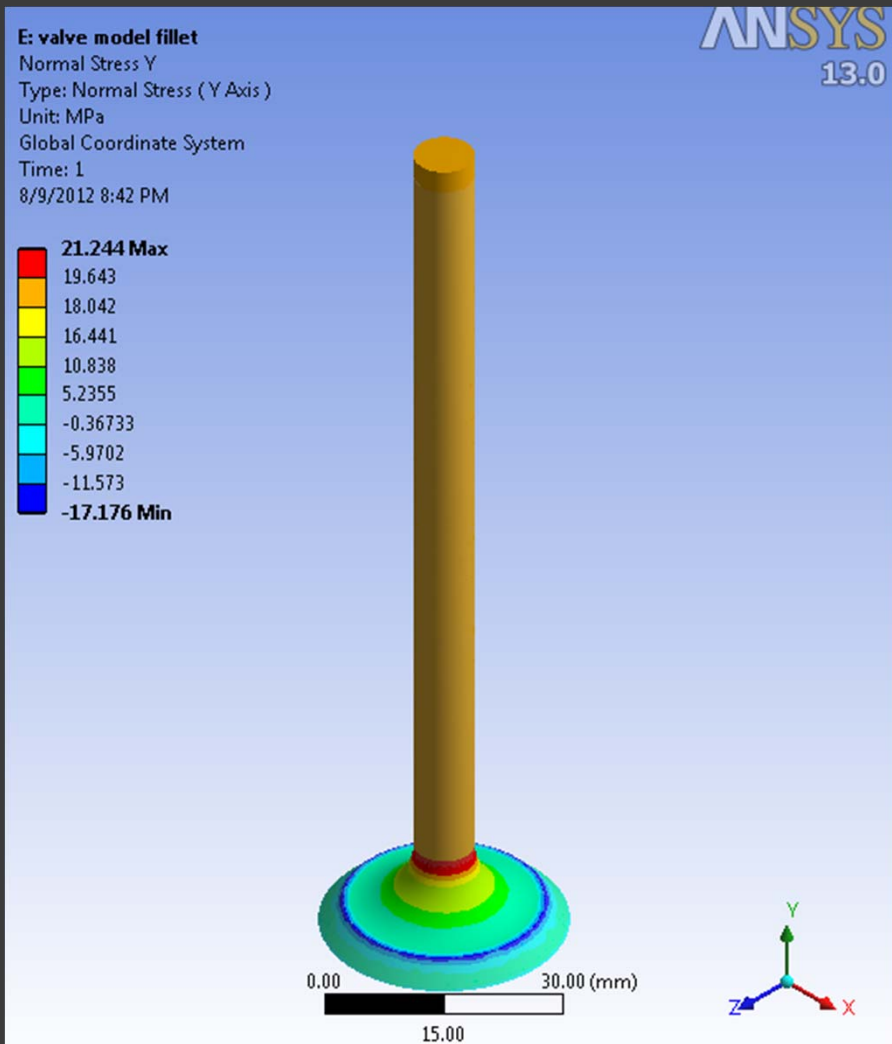
# Normal stress along Y-axis (No fillet)



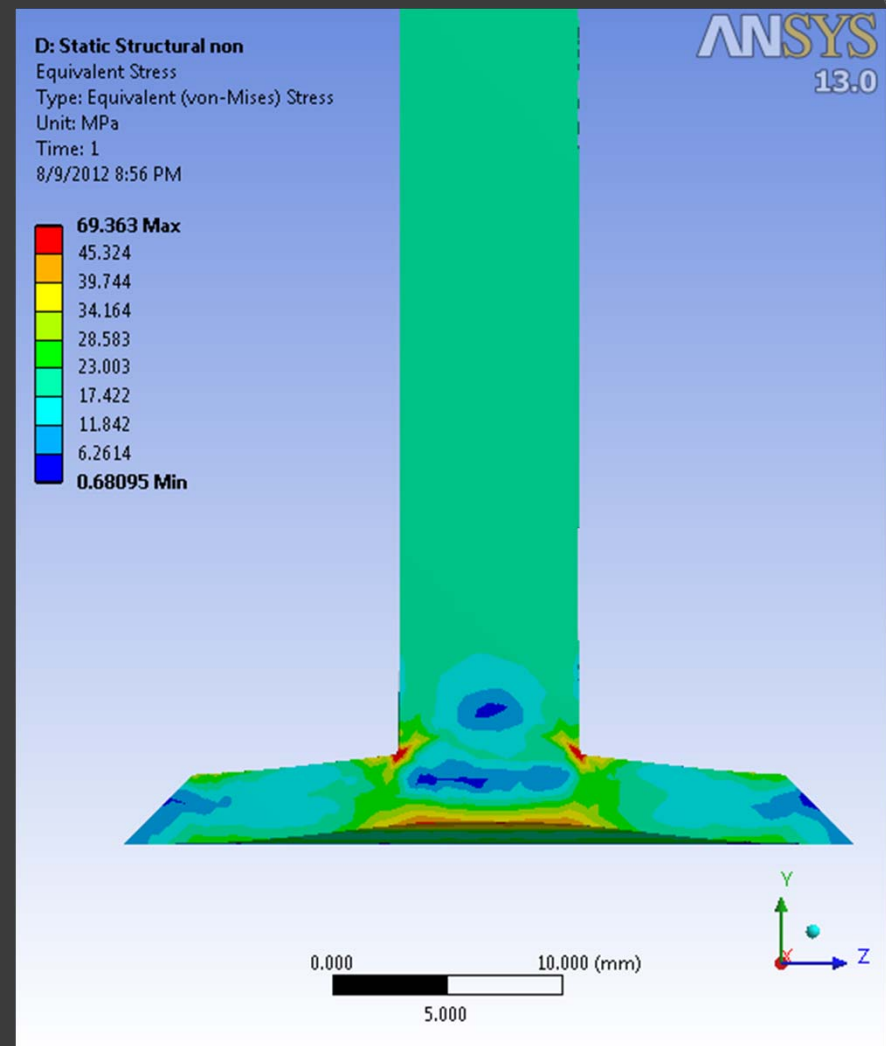
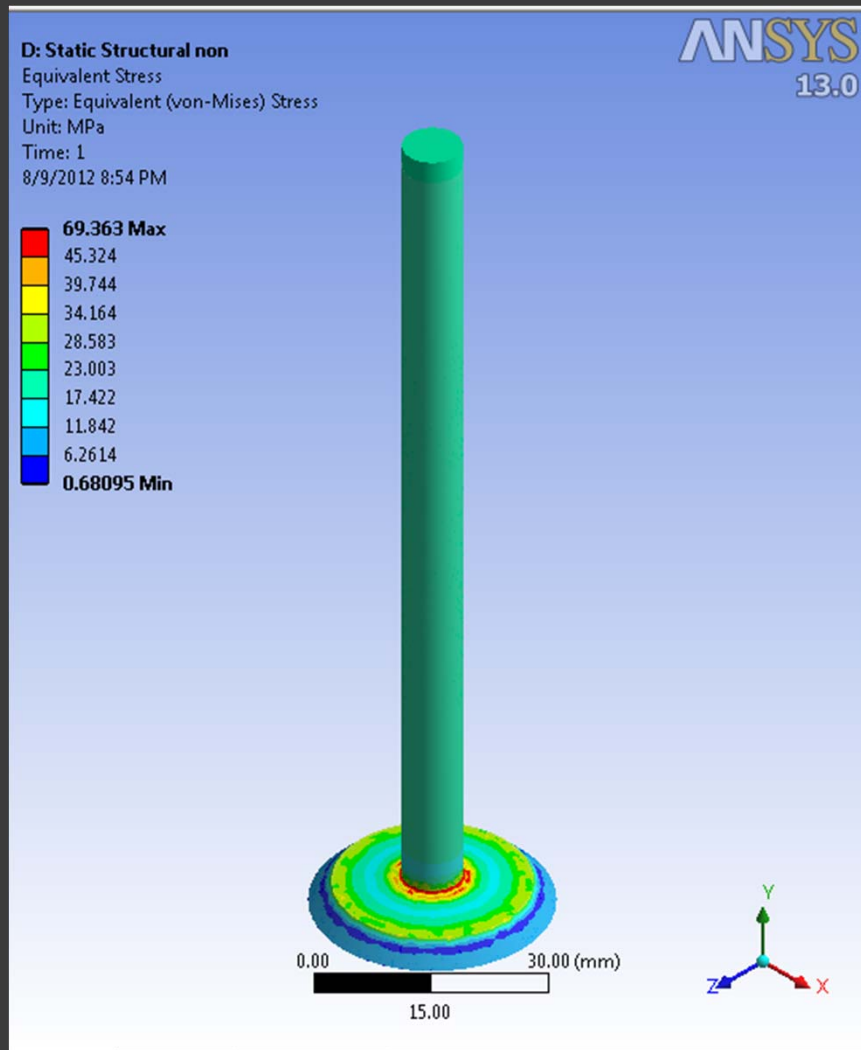
# Normal stress along Y-axis (45° degree chamfer)



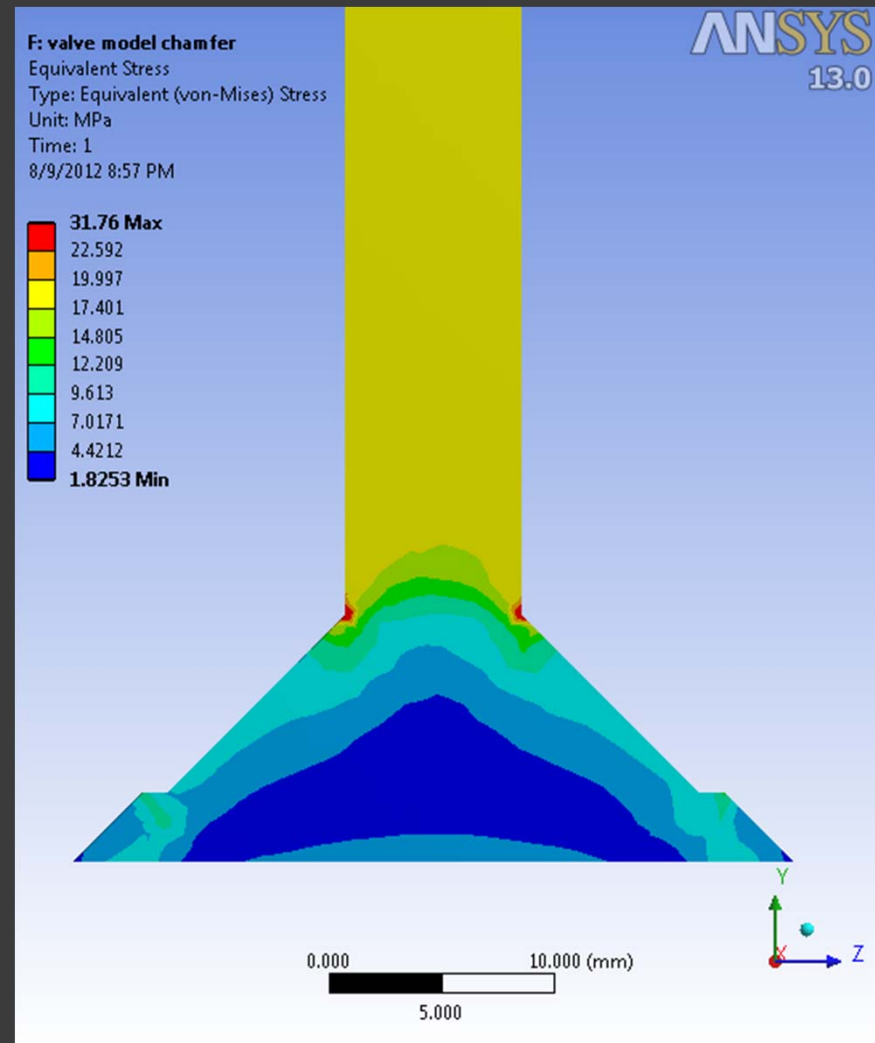
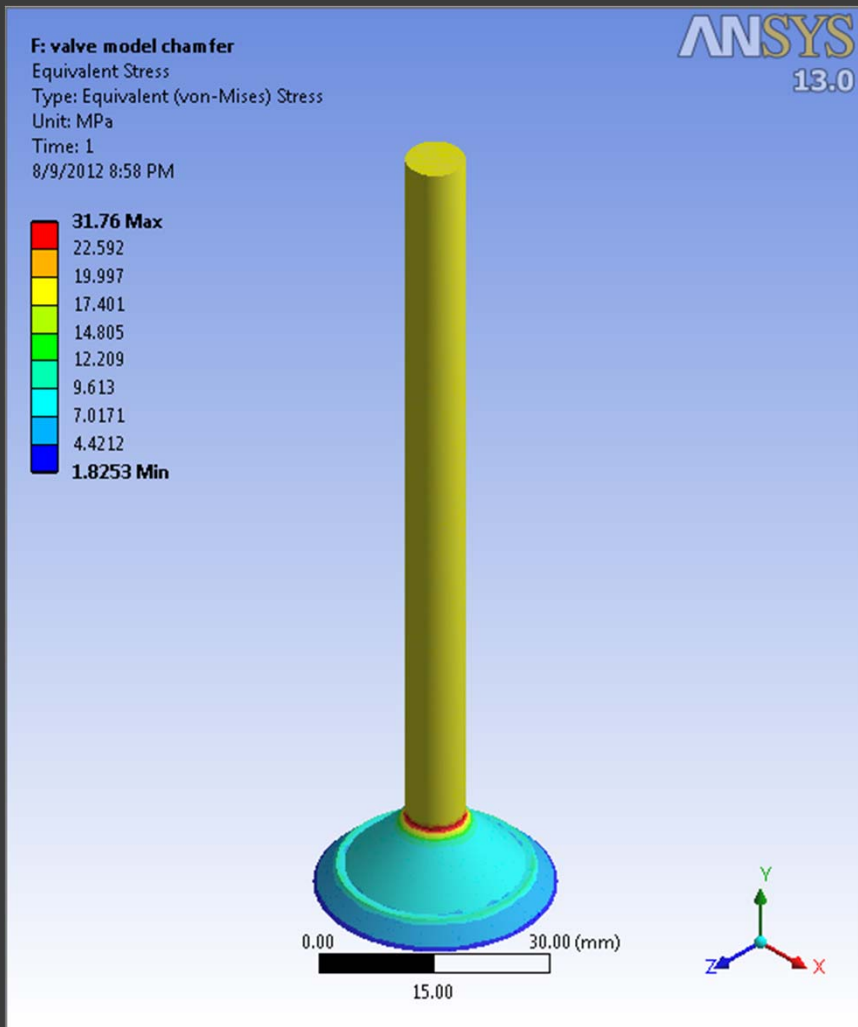
# Normal stress along Y-axis (Fillet Radius=7.8486mm)



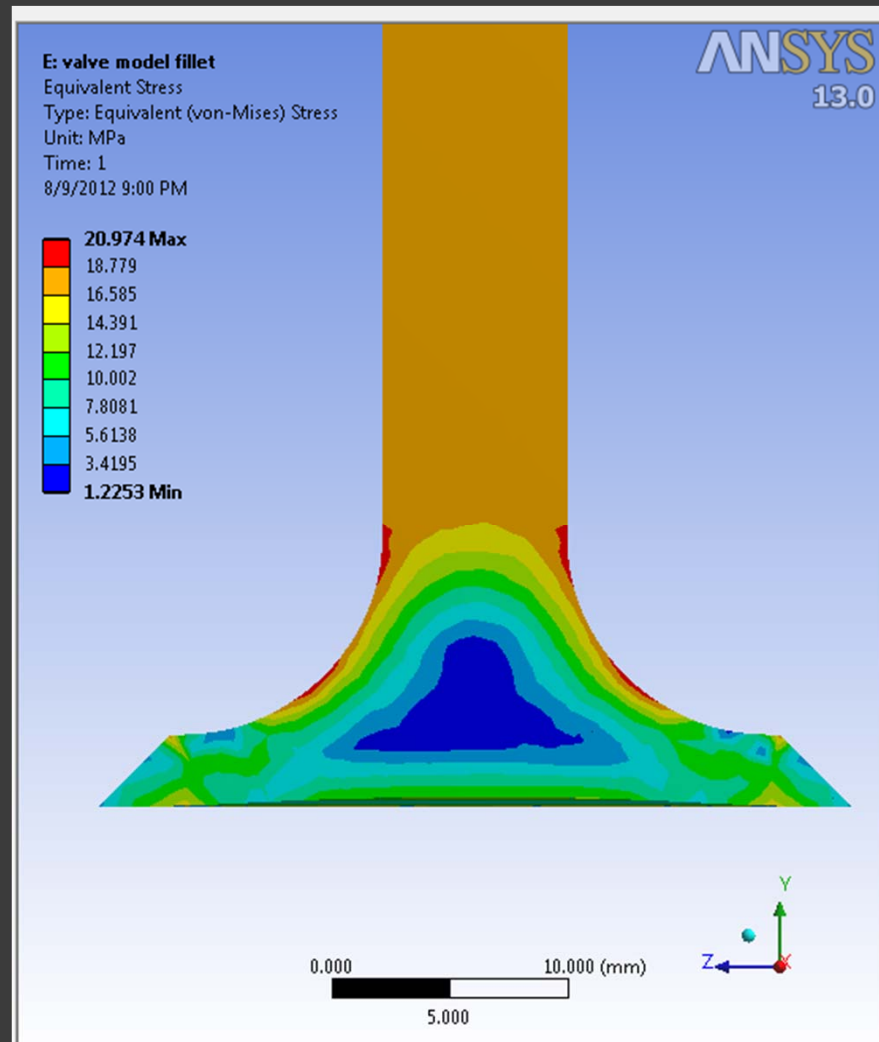
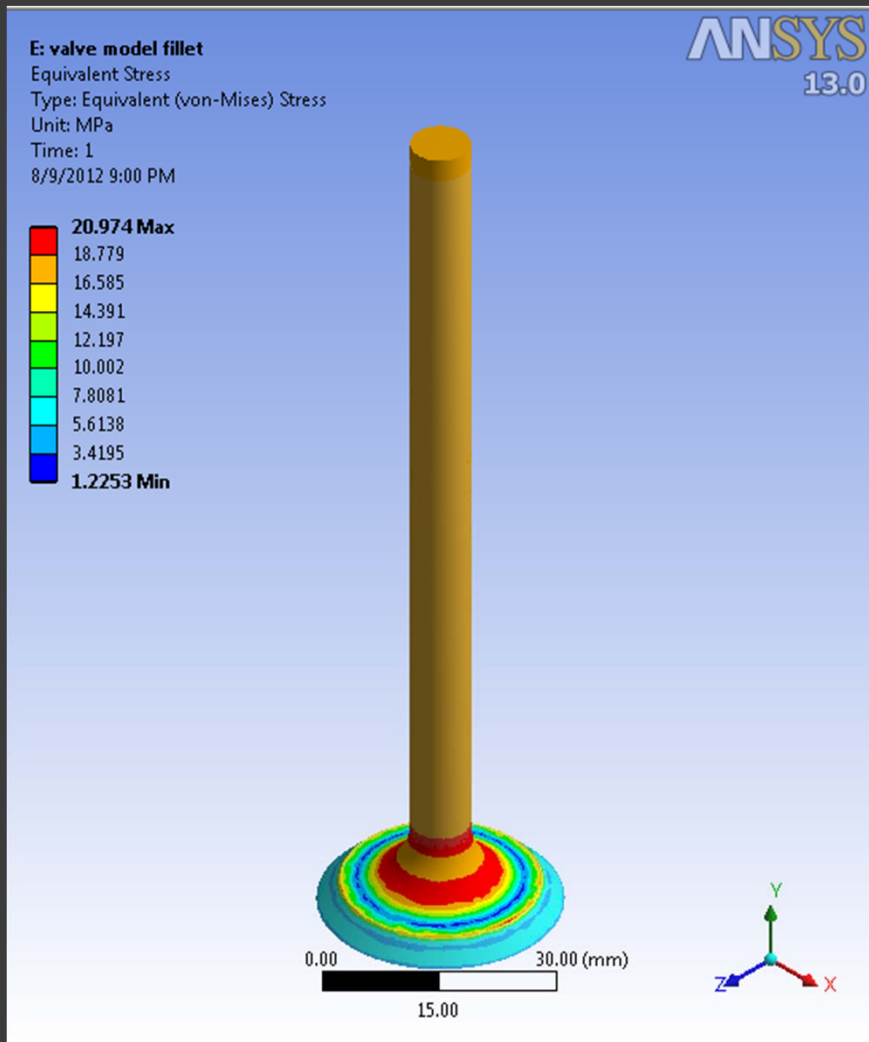
# Equivalent stresses (No Fillet)



# Equivalent stresses (45° degree chamfer)



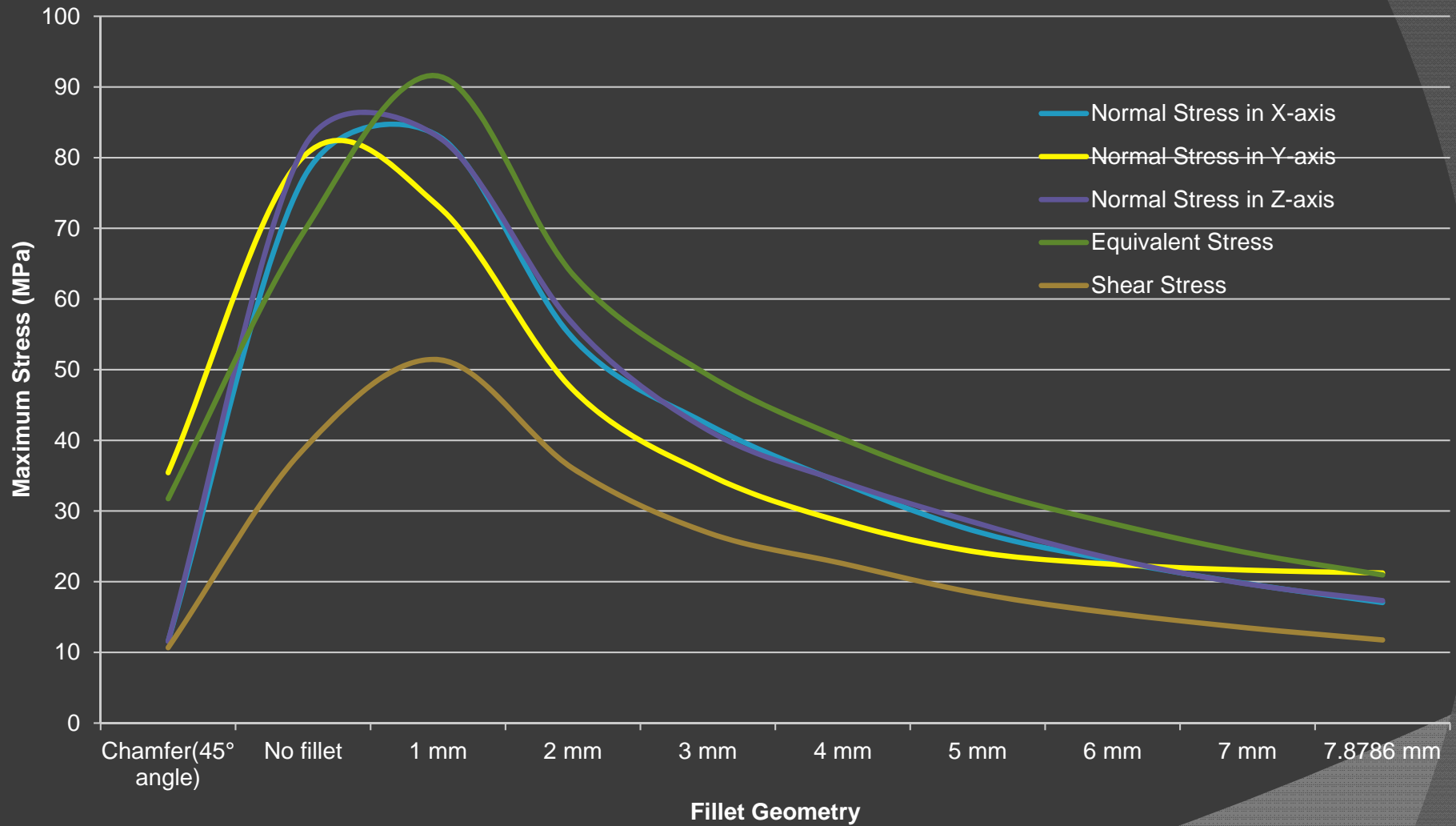
# Equivalent stresses (Fillet Radius=7.8486mm)



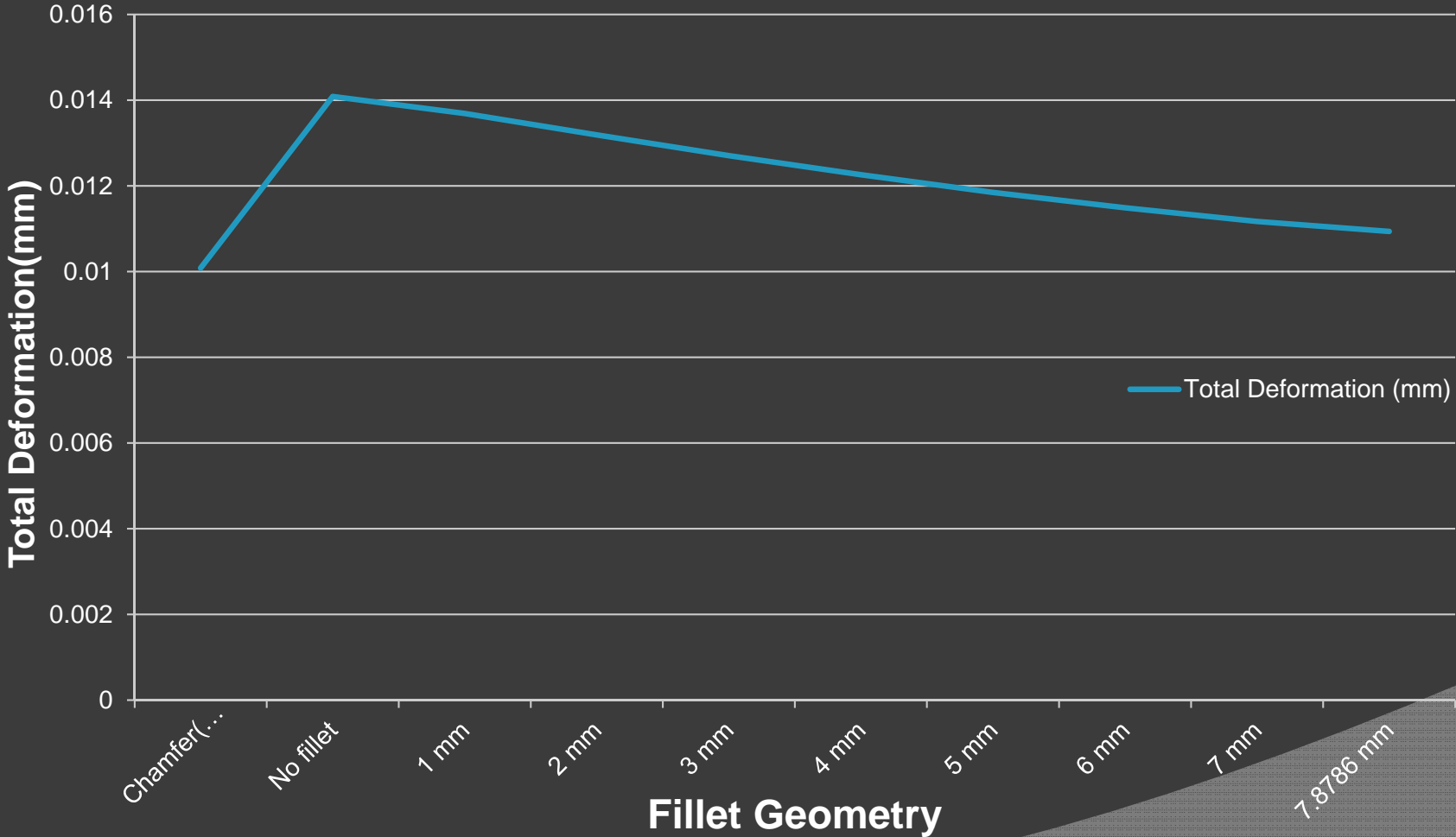
# Overall Results

Fillet Radius	Maximum Normal Stresses (Mpa)			Equivalent Stresses (Von Misses)	Shear Stress	Total Deformation
	X	Y	Z	(MPa)	(MPa)	(mm)
Chamfer(45° angle)	11.605	35.439	11.581	31.76	10.678	0.010084
No fillet	76.998	80.104	81.26	69.363	38.683	0.014087
1 mm	83.111	73.172	82.97	91.567	51.436	0.013691
2 mm	54.456	47.169	56.438	63.468	36.019	0.013189
3 mm	42.282	35.201	41.455	49.253	26.946	0.012706
4 mm	33.902	28.429	34.112	40.205	22.574	0.012261
5 mm	27.066	24.186	28.272	33.213	18.343	0.011849
6 mm	22.978	22.485	23.227	28.227	15.578	0.011491
7 mm	19.72	21.646	19.676	24.106	13.475	0.011171
7.8786 mm	17.057	21.244	17.334	20.974	11.761	0.010937

# Maximum Stress Values



# Total Deformation(mm)



# Model Limitations

- Transient Analysis could not be performed due in adequate computational resources thus time dependent inertial loads where ignored.
- Model only simulates static loading that is conditions when engine is not running.
- Impact loads that could occur during engine operation where not considered .
- This analysis can only be used to observe stress concentration effects on different geometry.

# Conclusion

- Stress concentration occurs at the notch of the valve.
- Chamfering reduces normal stress along X and Z direction but normal stresses along Y directions are not affected greatly.
- Filleting the notch helps greatly reduces and the stress concentration and distributes the stress equally among other directions as well.
- Maximum stress values reduces with increase in fillet radius.