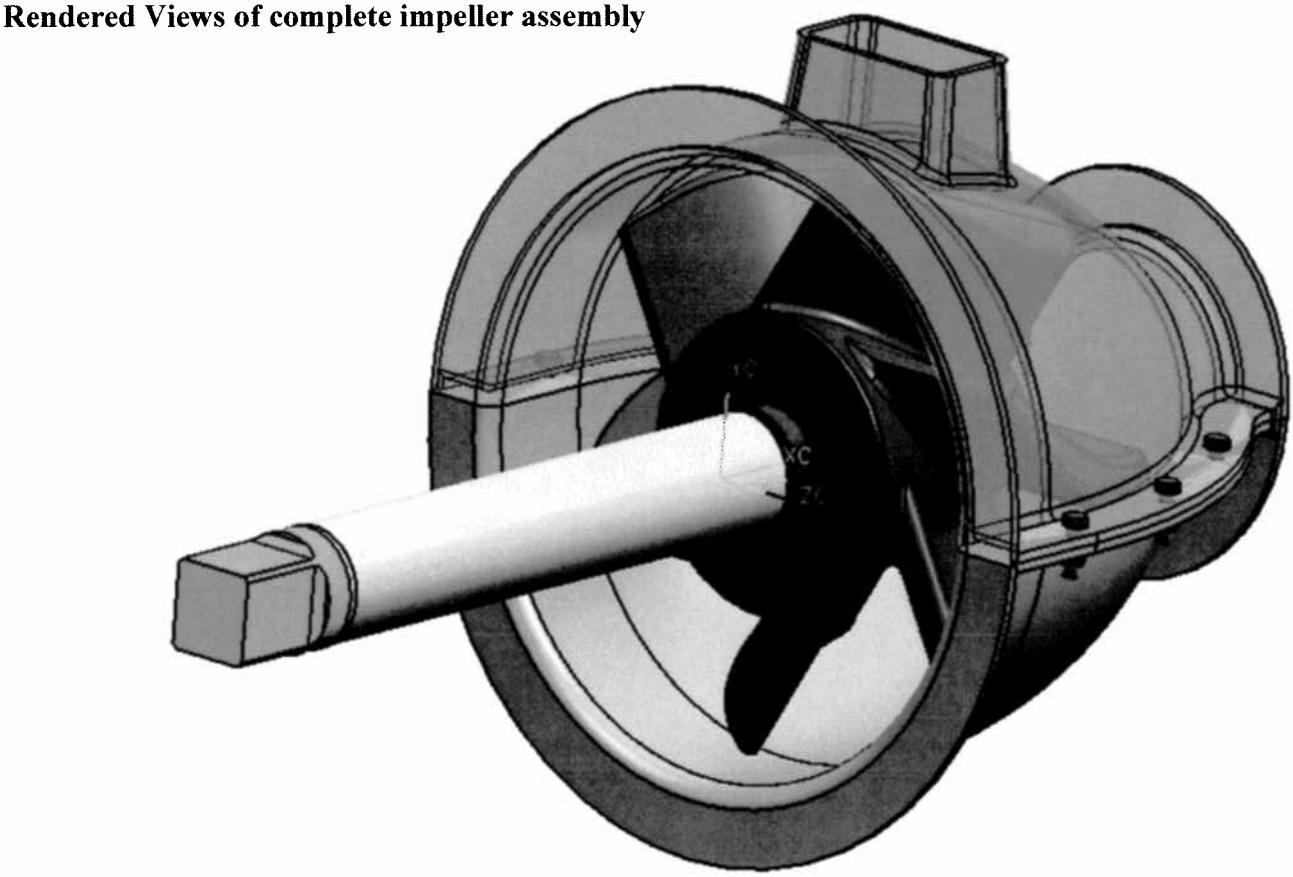
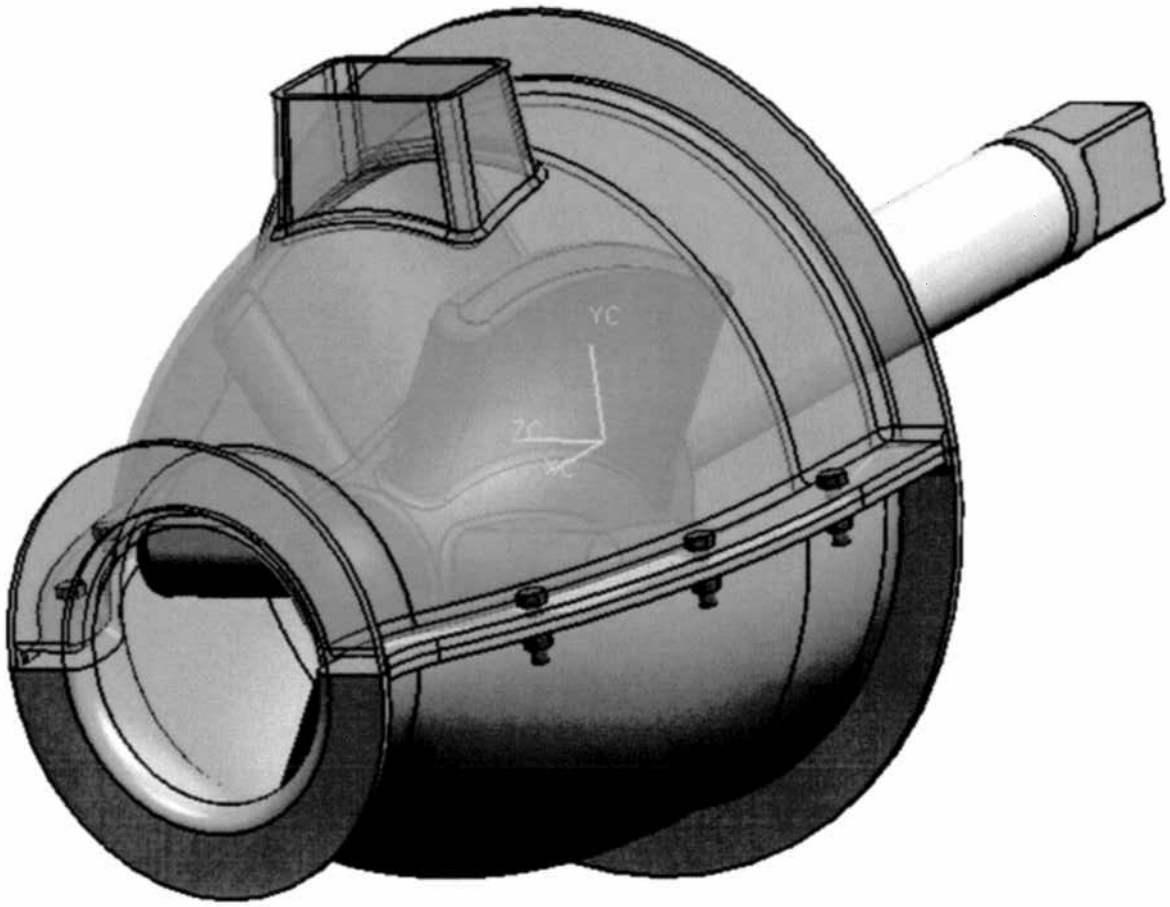
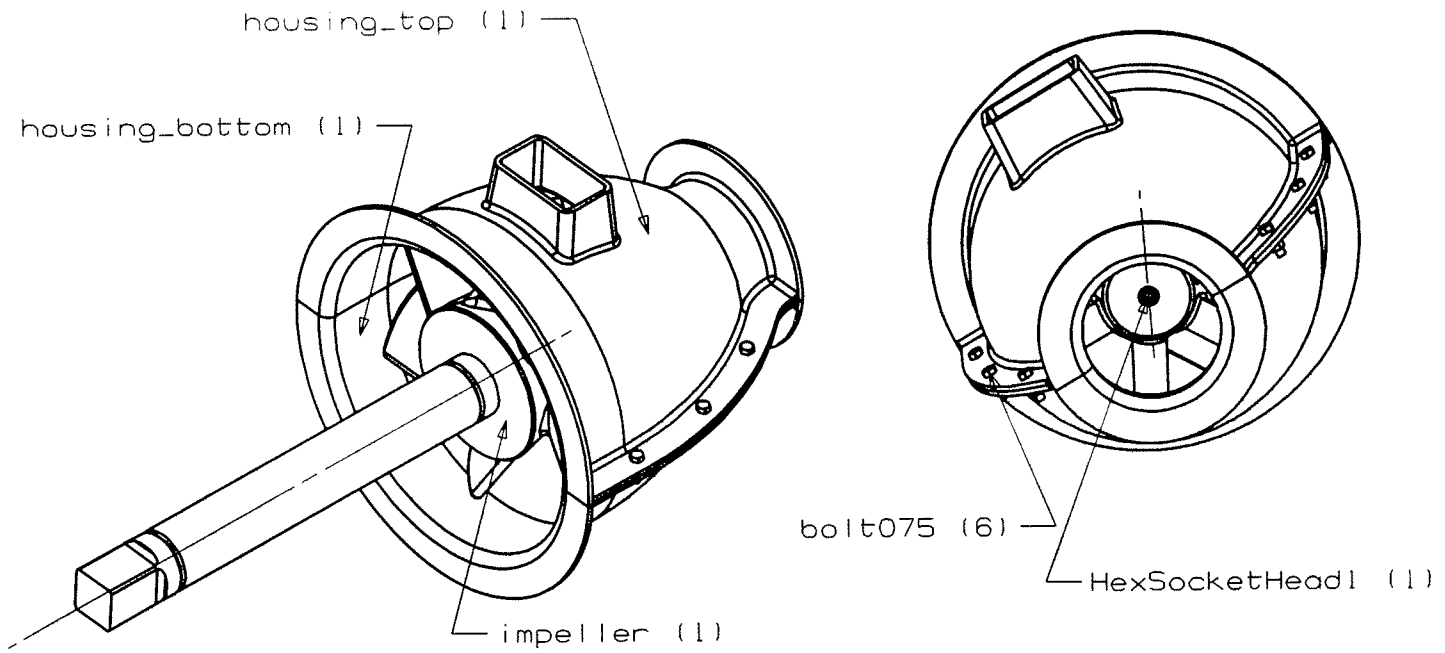
Rendered Views of complete impeller assembly





Engineering Drawings

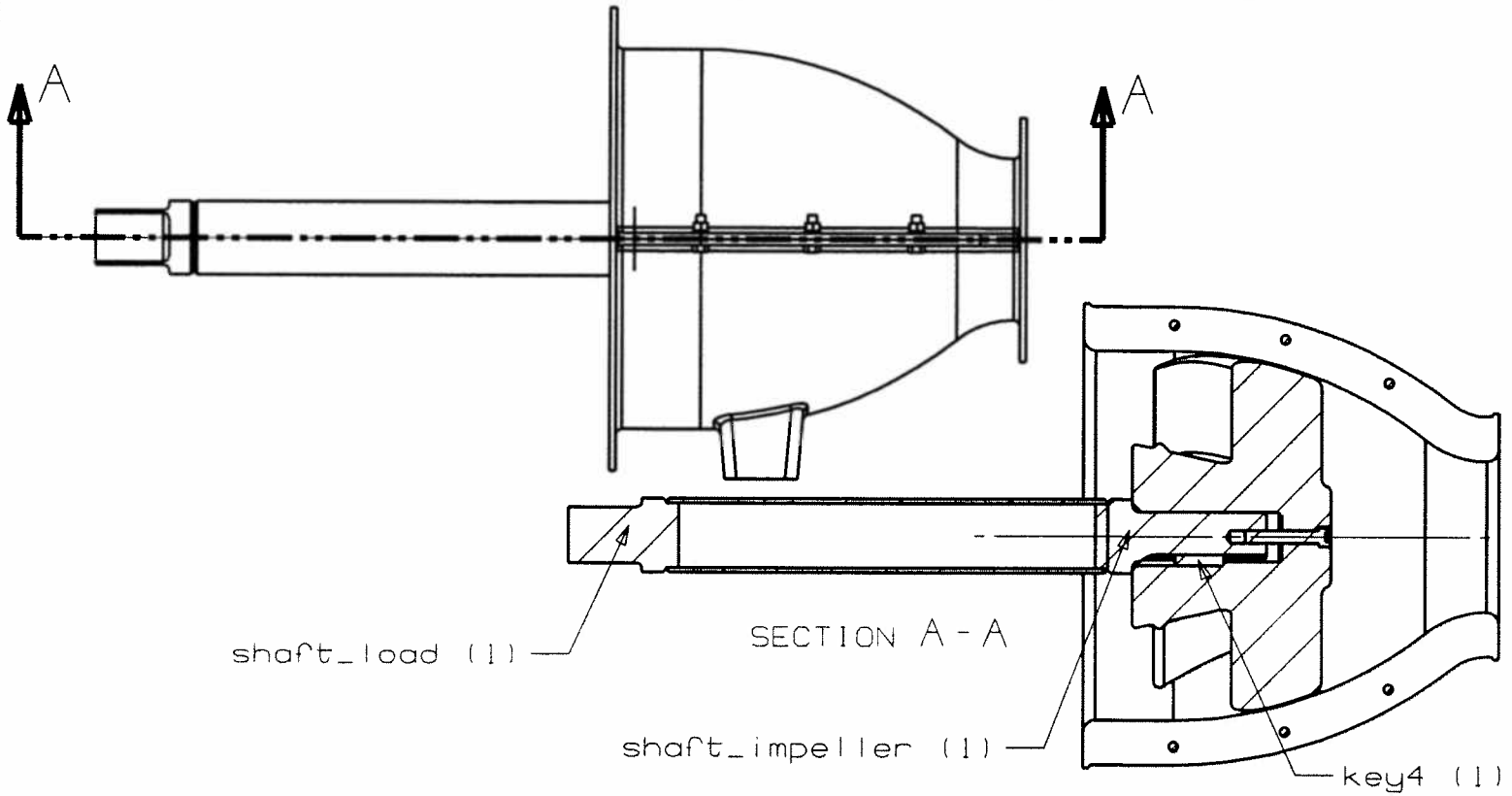
REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED



weight = 1010.907

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_impeller_assm
	SIZE: A | CAGE CODE | DWG NO | REV
	SCALE 2:25 | SHEET 1 of 2

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

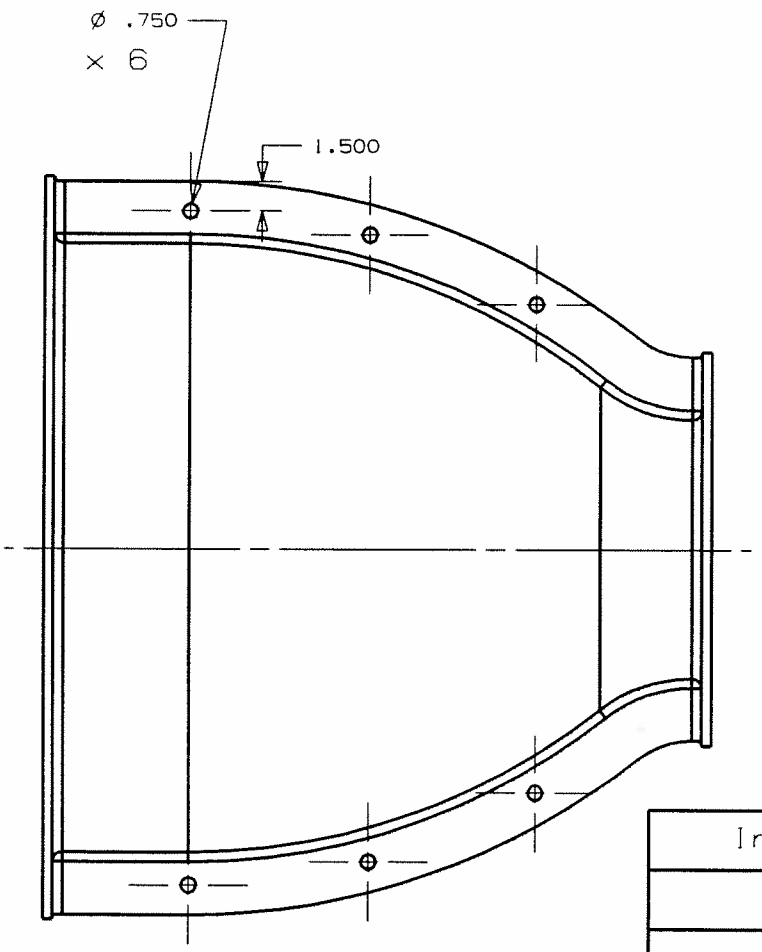


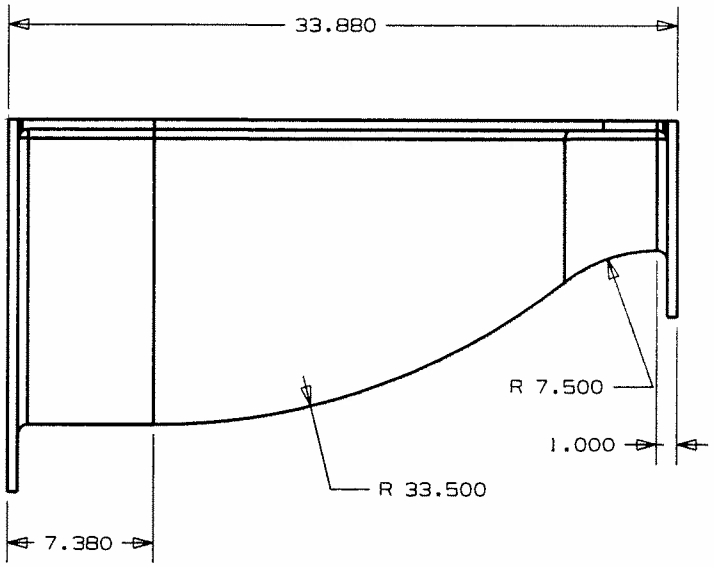
weight = 1010.907

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_impeller_assm
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 2:25; SHEET 2 of 2

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

ucalled radi = 0.5 in



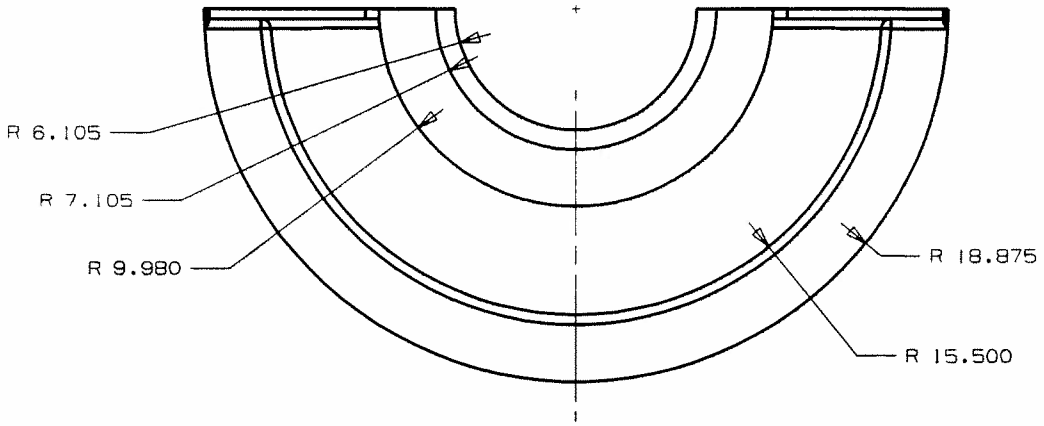


weight = 241.201 lb

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_housing_bottom
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 1:8; SHEET 1 of 2

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

ucalled radi = 0.5 in

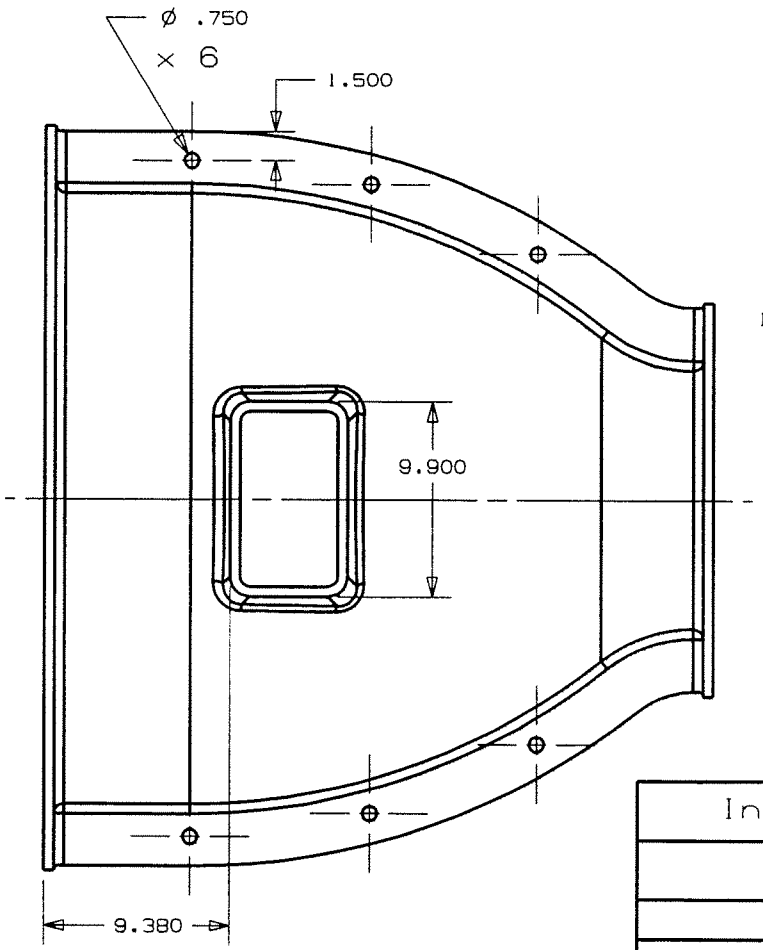


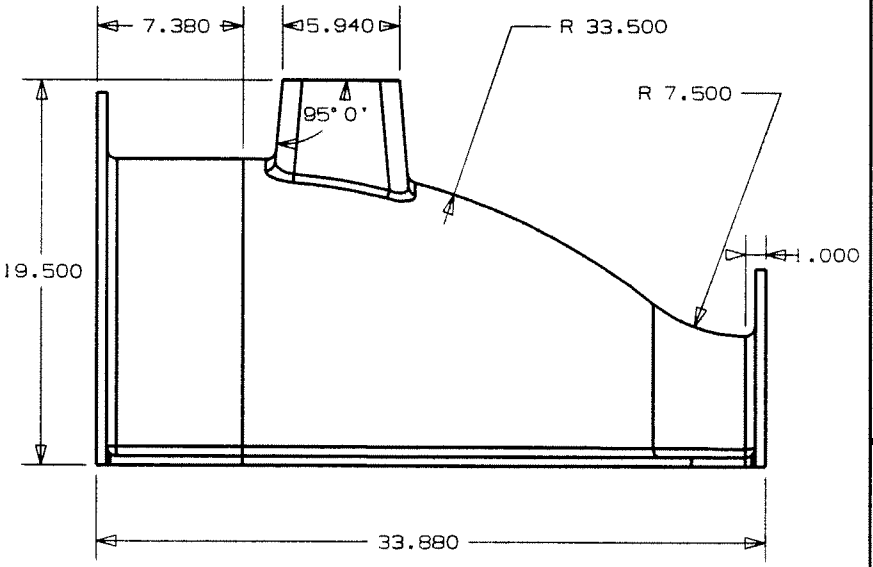
weight = 241.201 lb

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_housing_bottom
	SIZE: A | CAGE CODE | DWG NO | REV
	SCALE 1:8 | SHEET 2 of 2

uncalled radi = 0.5 in

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED



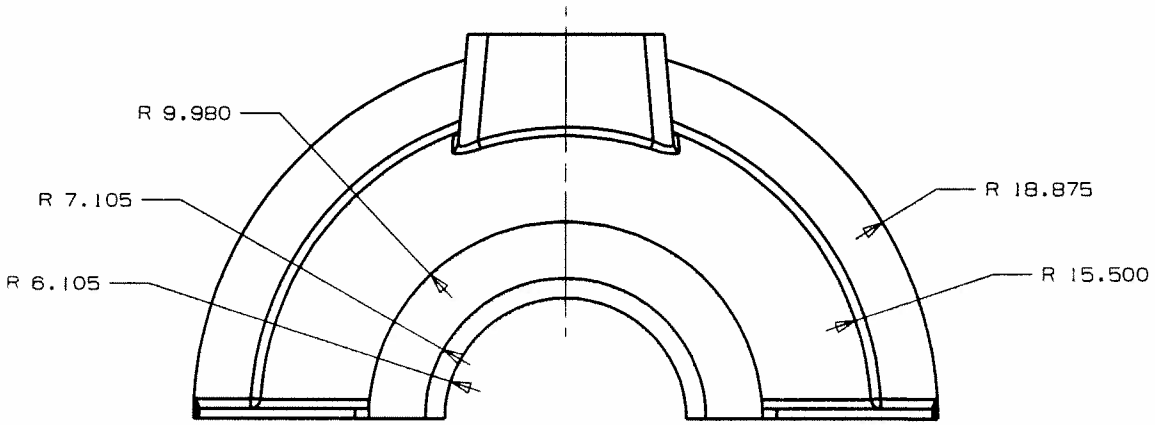


weight = 253.155 lb

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_housing_top
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 1 : ; SHEET 1 of 1

uncalled radi = 0.5 in

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

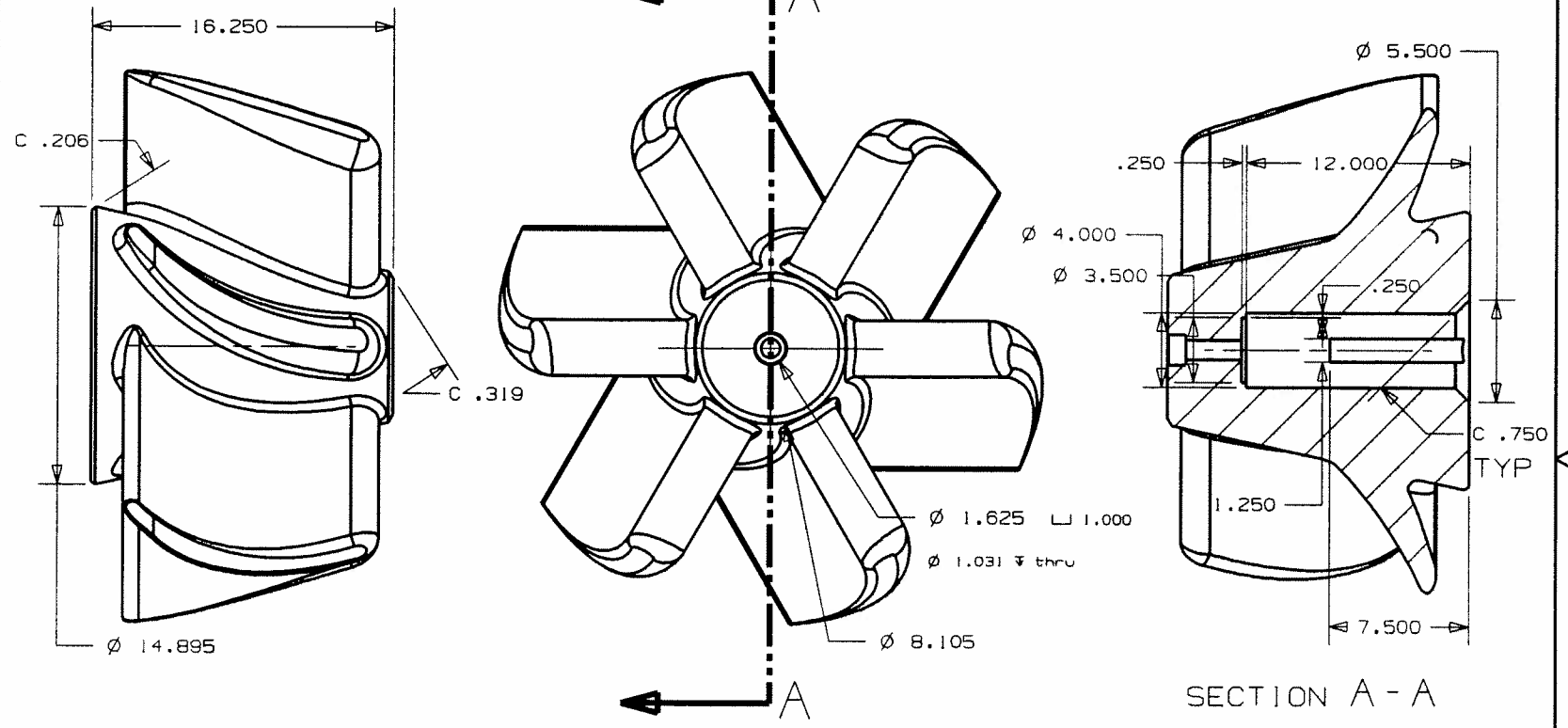


weight = 253.155 lb

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_housing_top
	SIZE: A | CAGE CODE | DWG NO | REV
	SCALE 1:8 | SHEET 1 of 2

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

blends around blades = 0.5 in

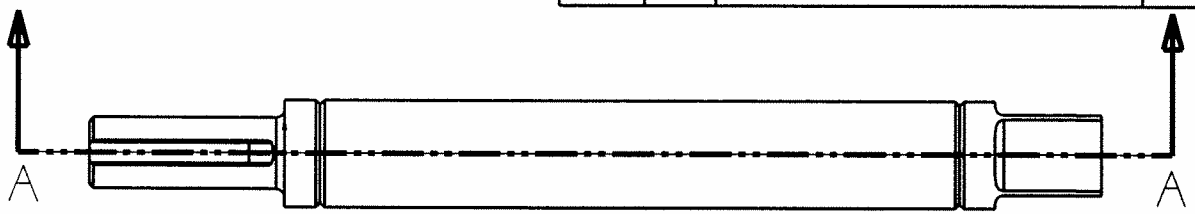


SECTION A-A

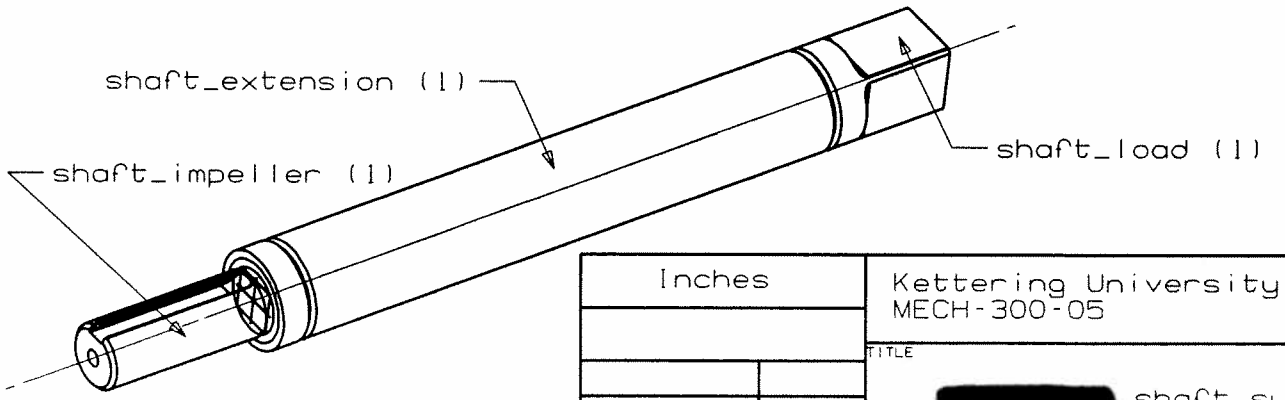
weight = 342.358

Inches	Kettering University MECH-300-05
	TITLE: [redacted] impeller
	SIZE: A | CAGE CODE | DWG NO | REV
	SCALE 1:8 | SHEET 1 of 1

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED



SECTION A - A



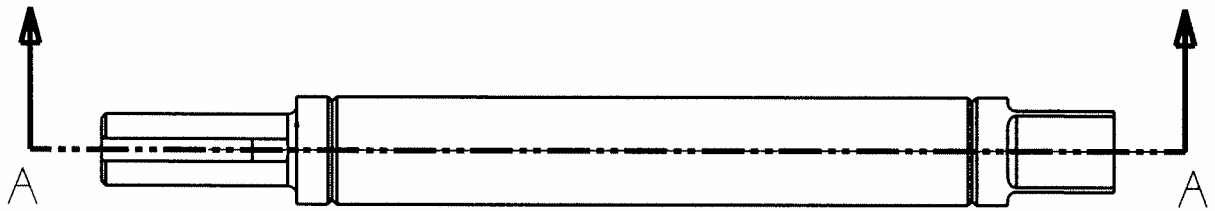
weight = 167.321lb

Inches	Kettering University MECH-300-05	
	TITLE: [redacted]_shaft_subassm	
	SIZE: A / CAGE CODE / DWG NO / REV	
	SCALE 1:8	SHEET 1 of 1

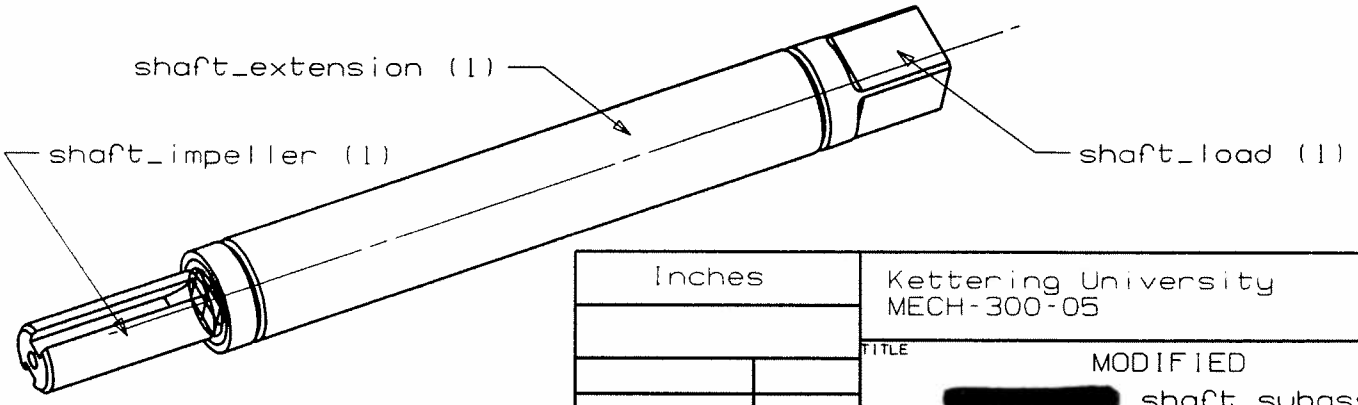
MODIFIED

REVISION HISTORY

ZONE	REV	DESCRIPTION	DATE	APPROVED



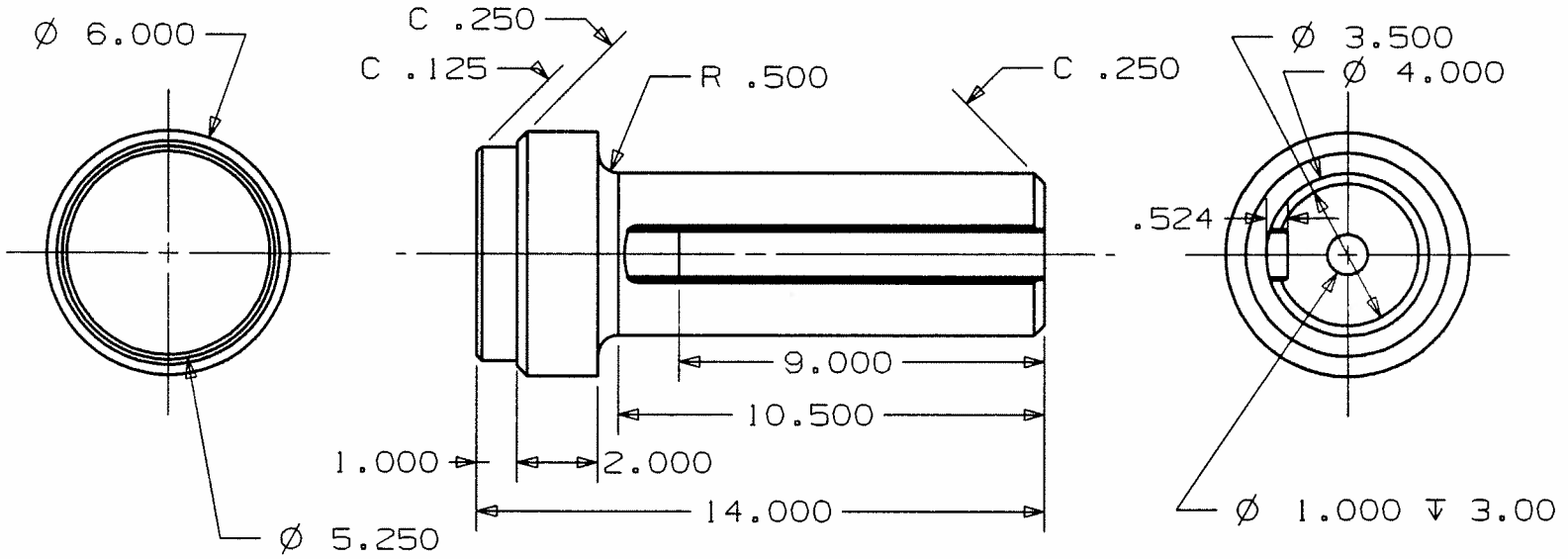
SECTION A-A

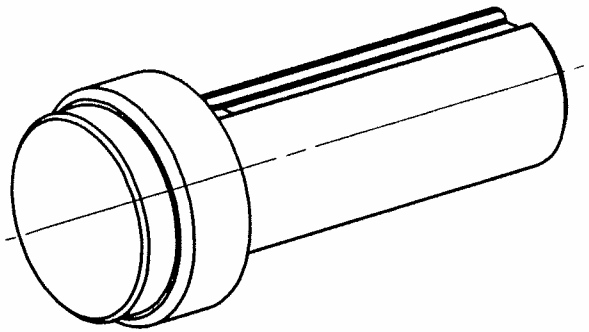


weight = 126.932lb

Inches	Kettering University MECH-300-05
	TITLE: MODIFIED [redacted]_shaft_subassm
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 1:8; SHEET 1 of 1

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED



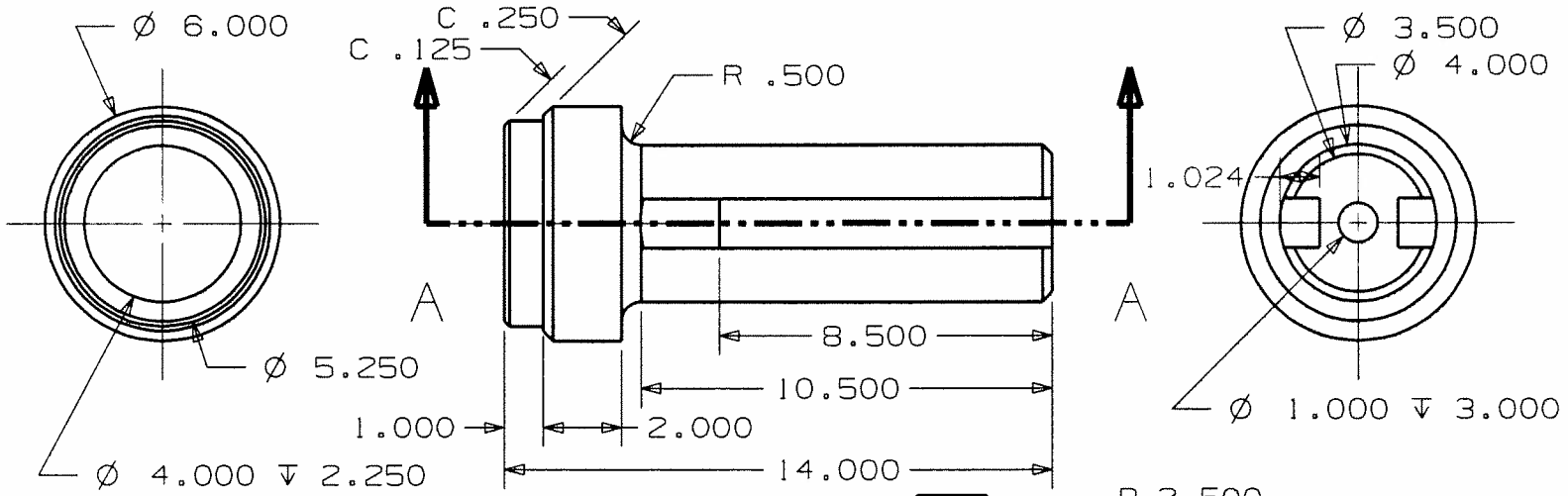


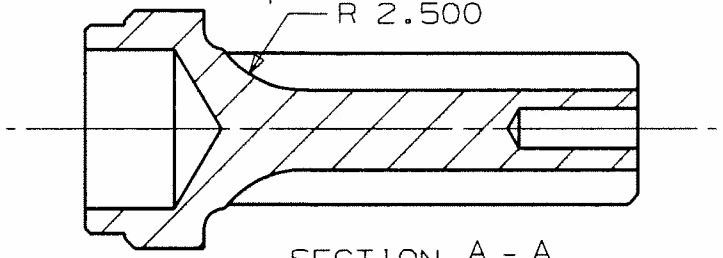
weight = 53.933

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_shaft_impeller
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 1:4; SHEET 1 of 1

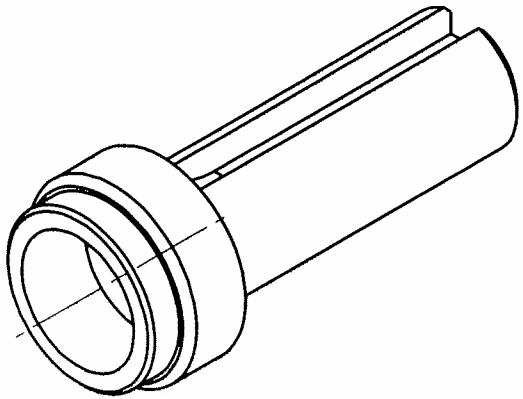
MODIFIED

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED





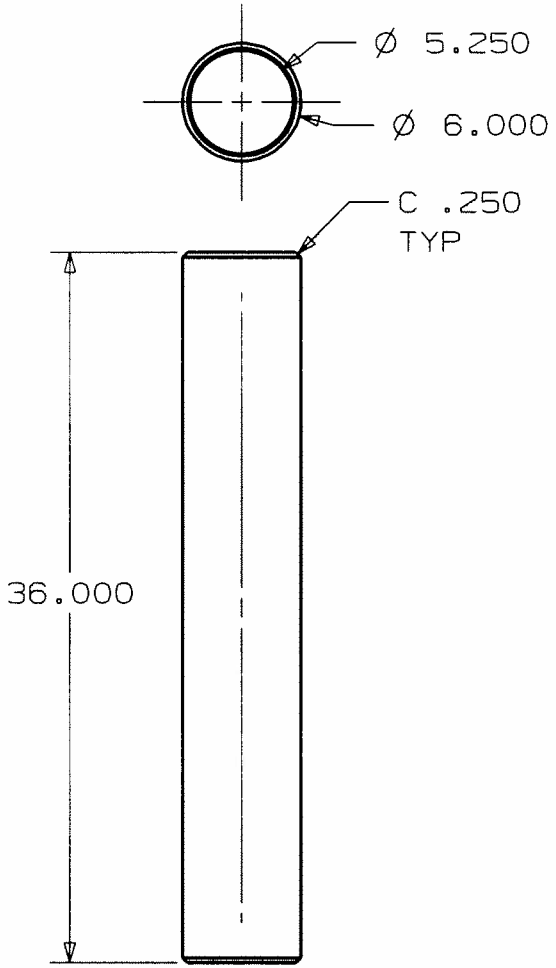
SECTION A - A

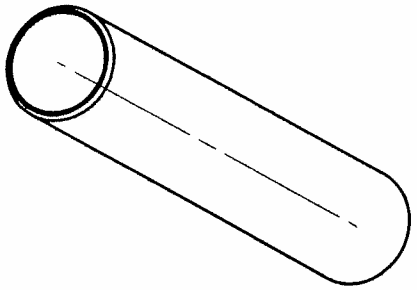


weight = 40.668 lb

Inches	Kettering University MECH-300-05
	TITLE: MODIFIED [redacted]_shaft_impeller
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 1:4; SHEET 1 of 1

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

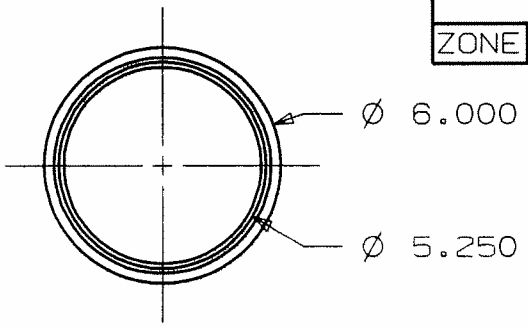


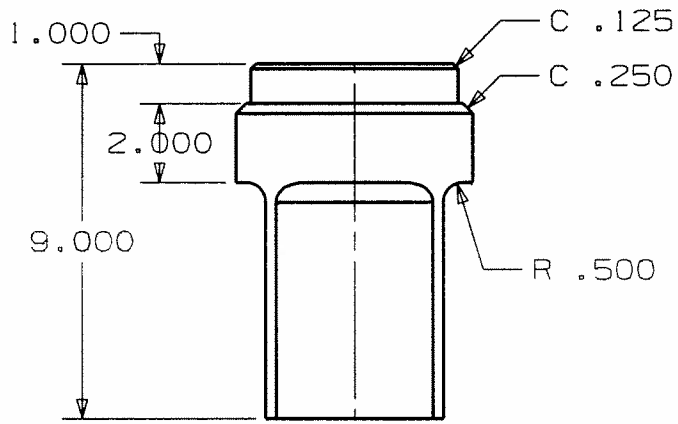


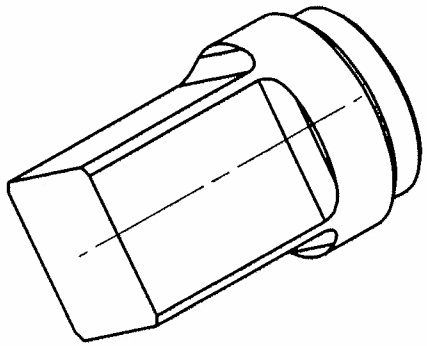
weight = 61.688

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_shaft_extension
	SIZE: A | CAGE CODE | DWG NO | REV
	SCALE 1:8 | SHEET 1 of 1

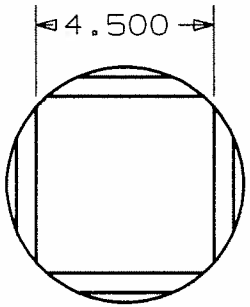
REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED







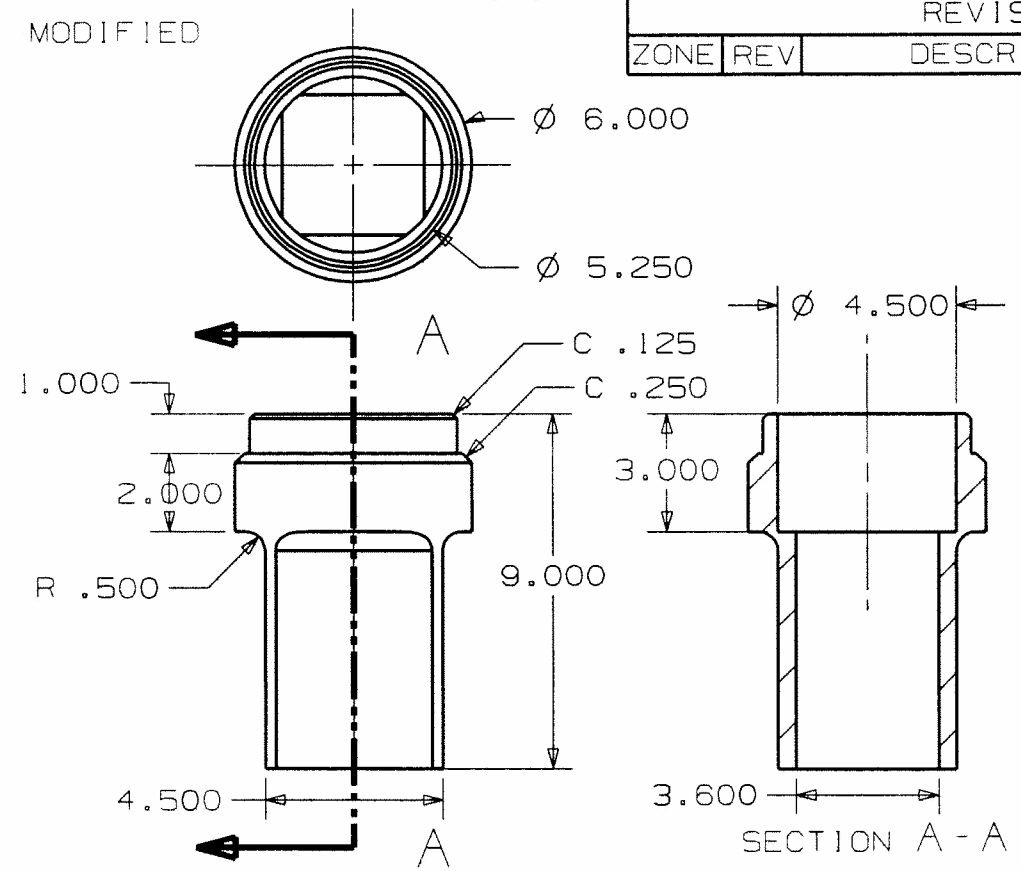
weight = 51.700 lb

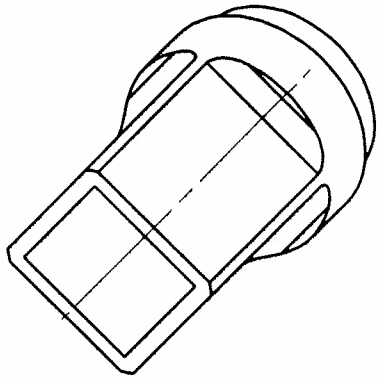


Inches	Kettering University MECH-300-05
	TITLE: [redacted]_shaft_load
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 1:4; SHEET 1 of 1

MODIFIED

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

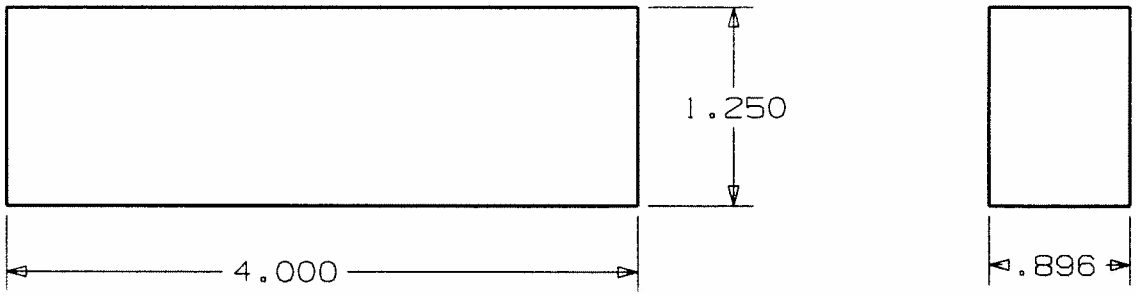




weight = 19.098 lb

Inches	Kettering University MECH-300-05
	TITLE: MODIFIED [redacted]_shaft_load
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 1:4; SHEET 1 of 1

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

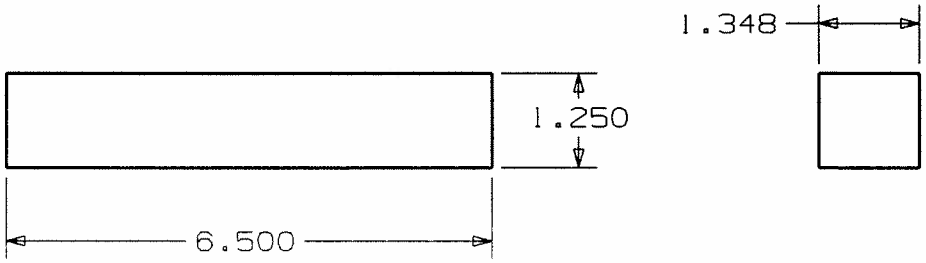


weight = 1.267 lb

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_key4
	SIZE: A; CAGE CODE; DWG NO; REV
	SCALE 1:1; SHEET 1 of 1

MODIFIED

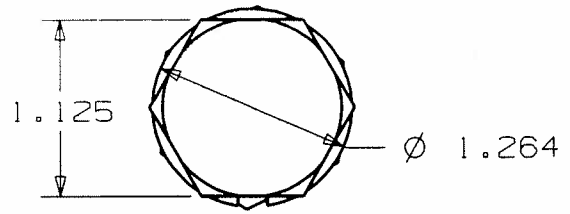
REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED

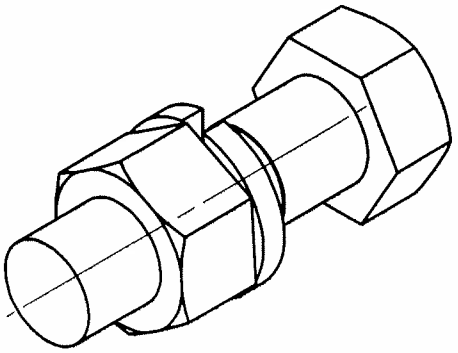


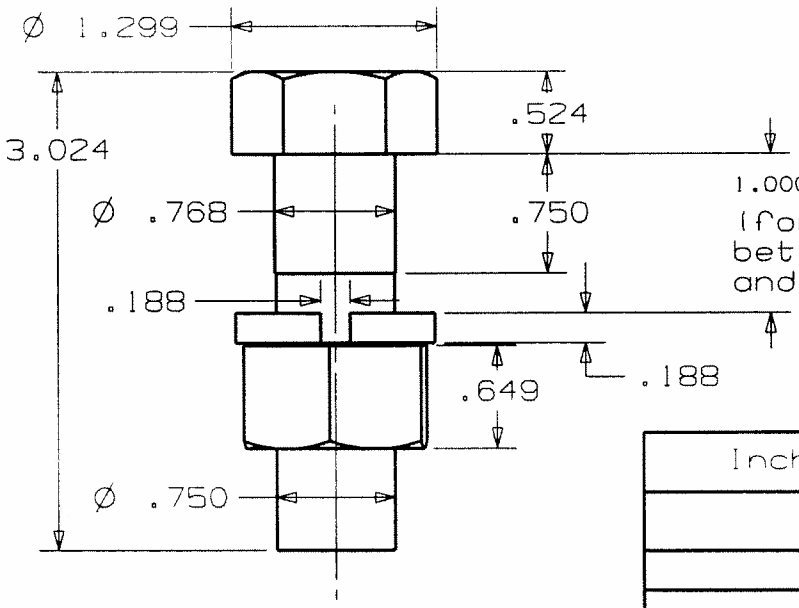
weight = 3.098 lb

Inches	Kettering University MECH-300-05
	TITLE: MODIFIED [redacted]_key4
	SIZE: A | CAGE CODE | DWG NO | REV
	SCALE 1:2 | SHEET 1 of 1

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED



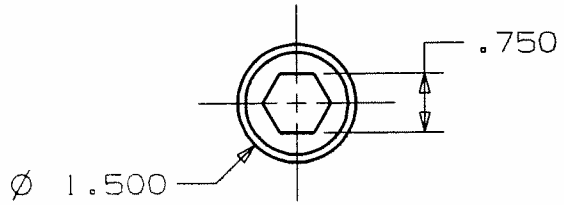


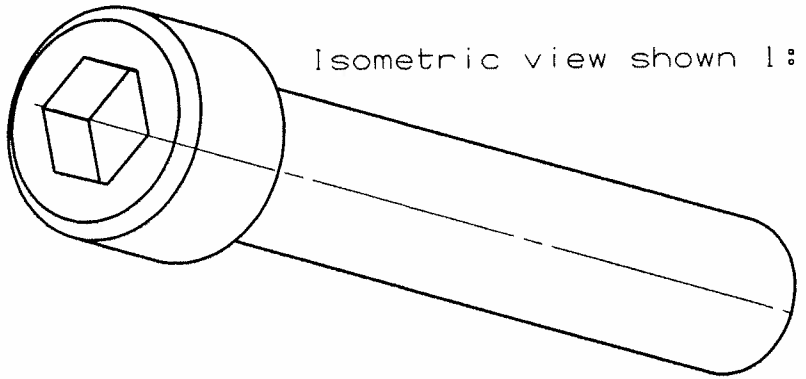


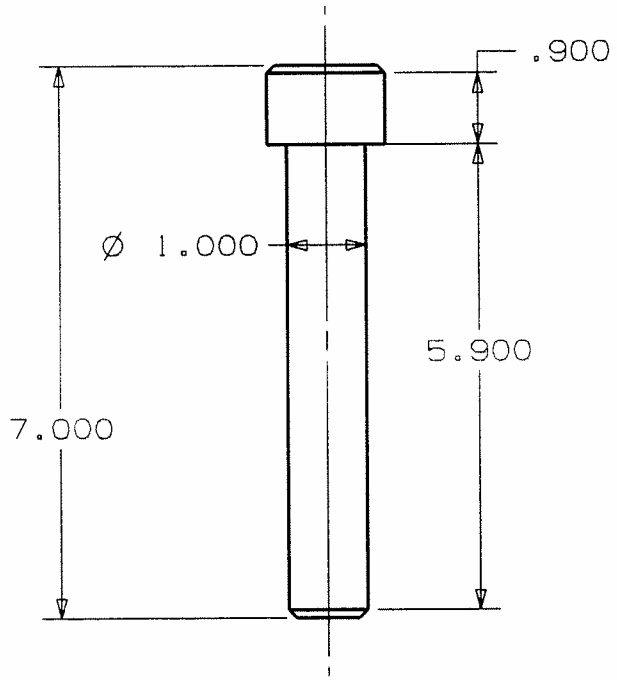
total weight = 0.642 lb

Inches	Kettering University MECH-300-05
	TITLE: [redacted]_bolt075
	SIZE: A | CAGE CODE | DWG NO | REV
	SCALE 1:1 | SHEET 1 of 1

REVISION HISTORY				
ZONE	REV	DESCRIPTION	DATE	APPROVED







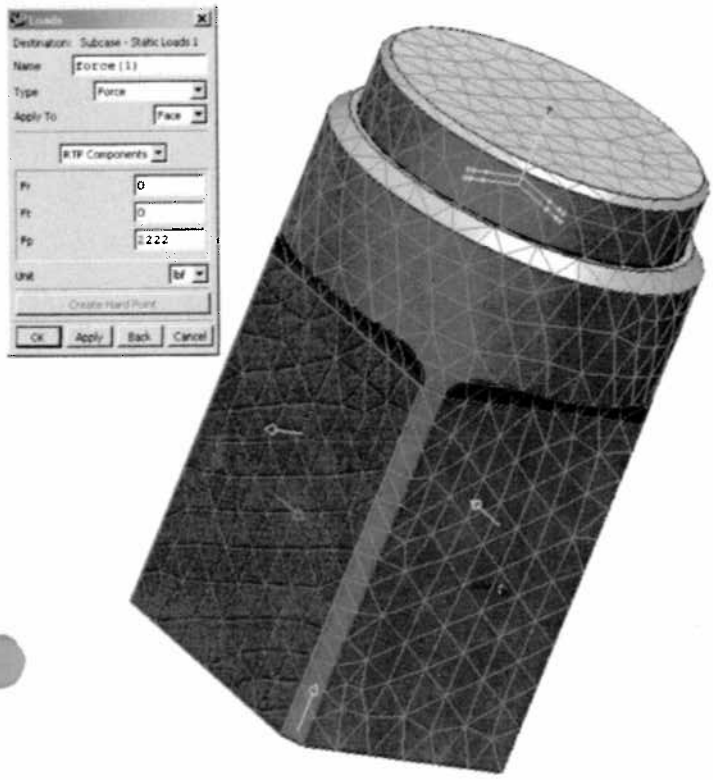
weight = 1.754 lb

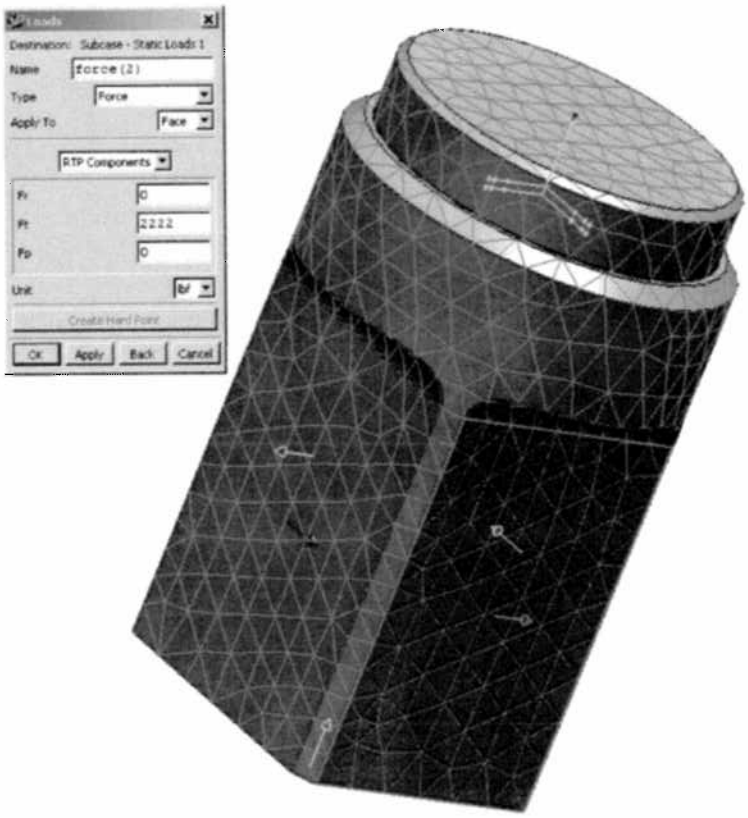
Inches	Kettering University MECH-300-05		
	TITLE: [redacted]_HexSocketHead1		
	SIZE: A	CAGE CODE	DWG NO	REV
	SCALE 1:2		SHEET 1 of 1

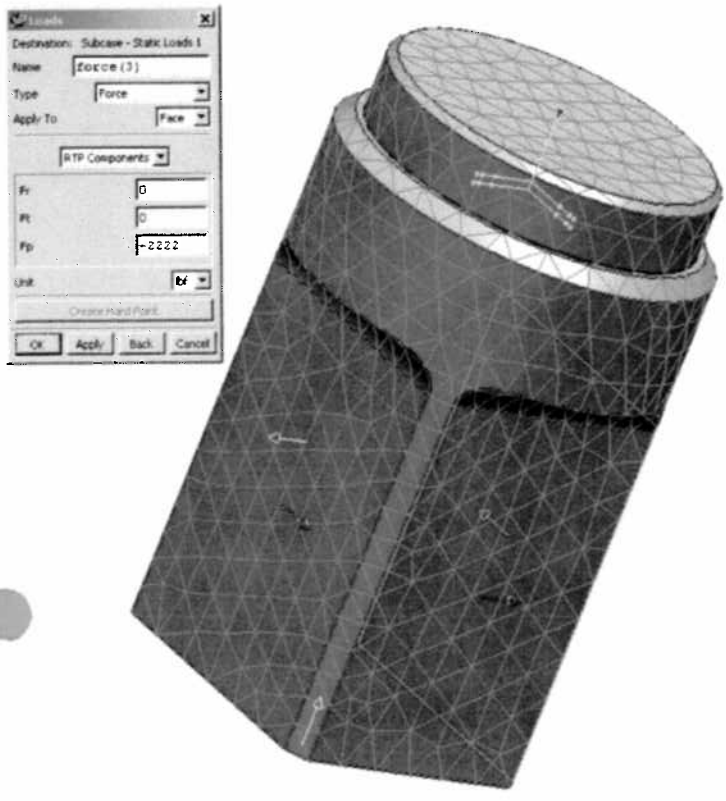
Design Analysis Report of **shaft_load**
Shaft loads and constraints
(for both unmodified and modified)
- Applications of Loads

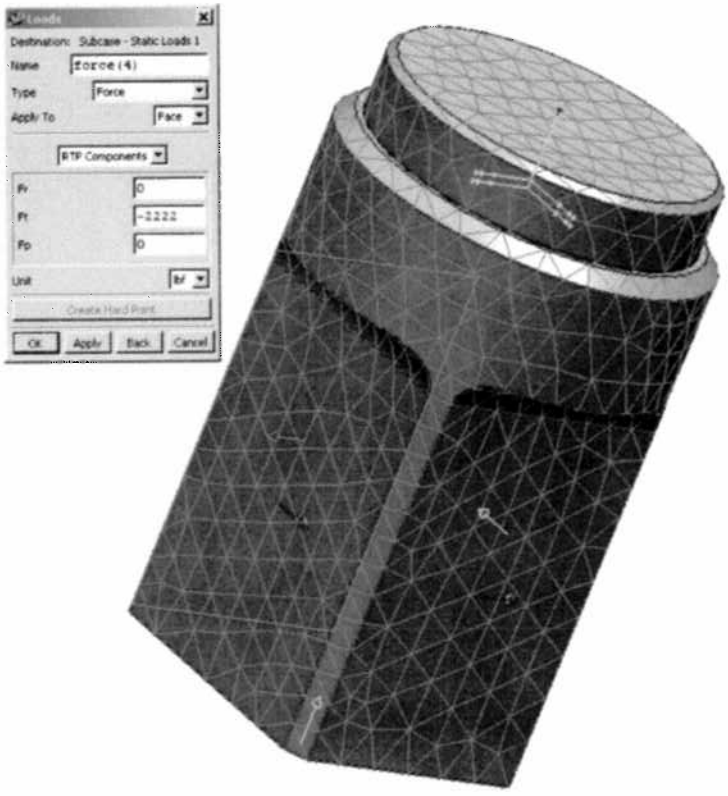
Math for applying torque on individual faces:
Distance from center to edge of face is 4.50 overall length/2 = 2.25 in

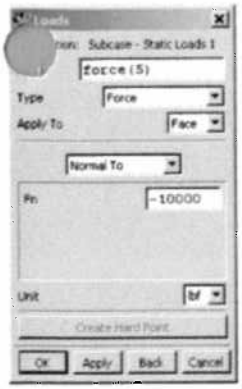
$$\frac{20{,}000\text{lbs}}{2.25\text{in} \times 4 \text{ faces}} = 2{,}222 \text{ lbs}$$



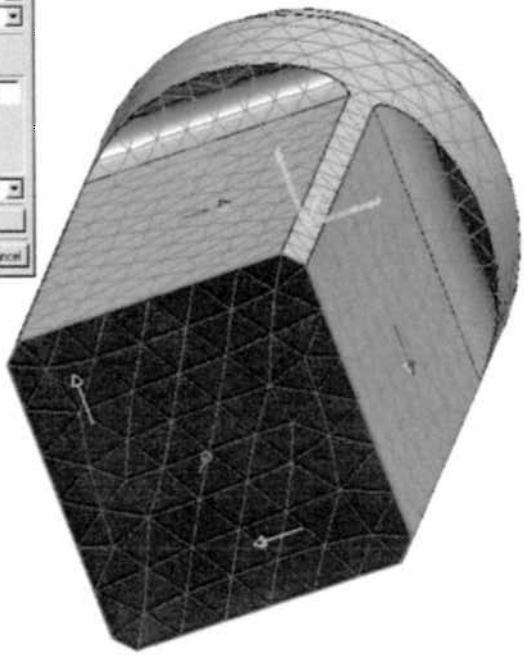


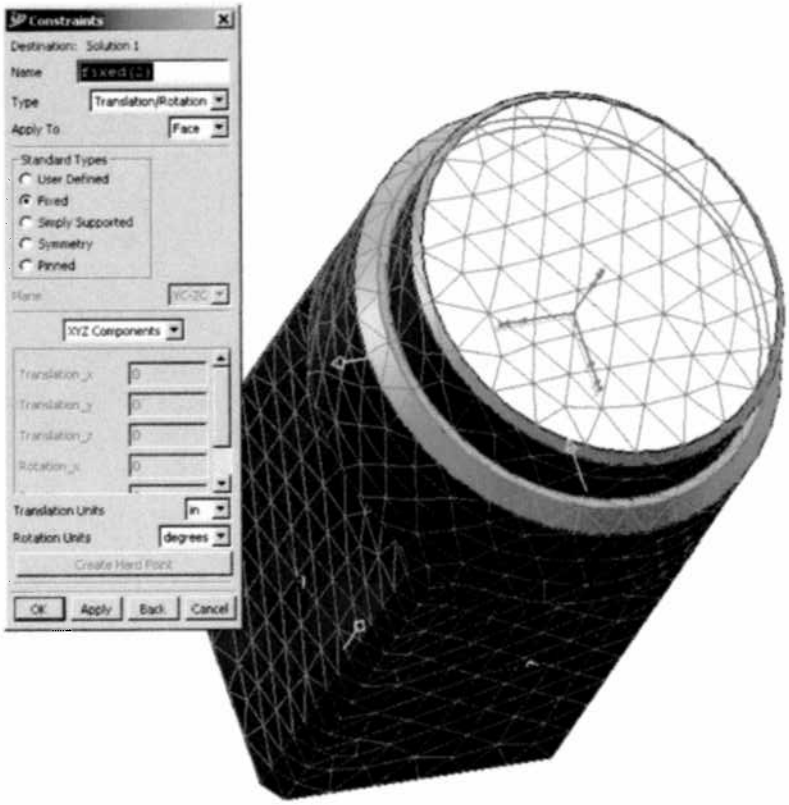






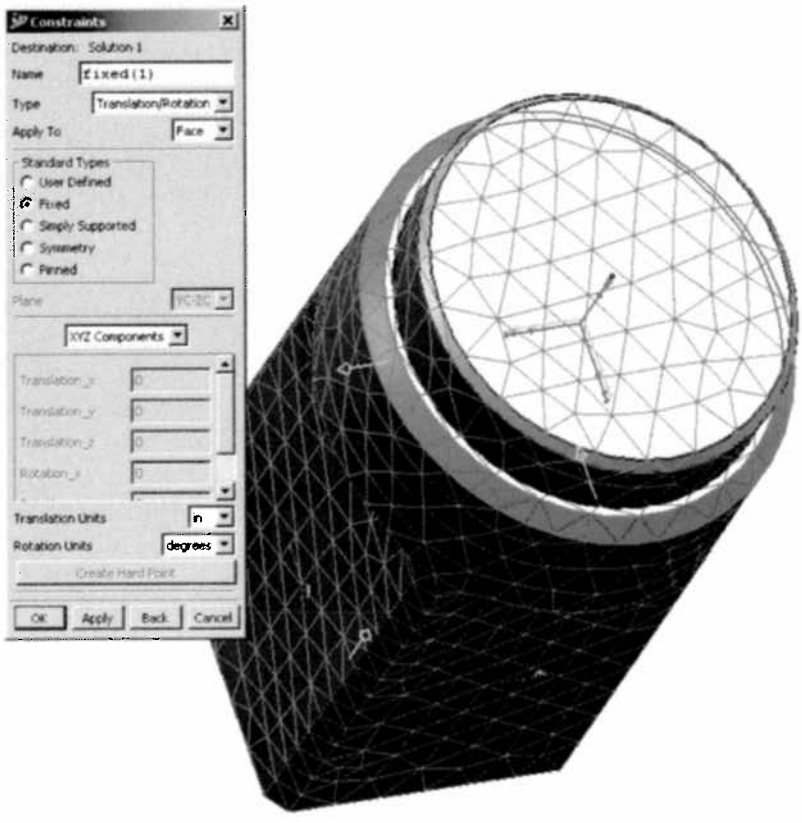
- Continuation of Applications of Loads



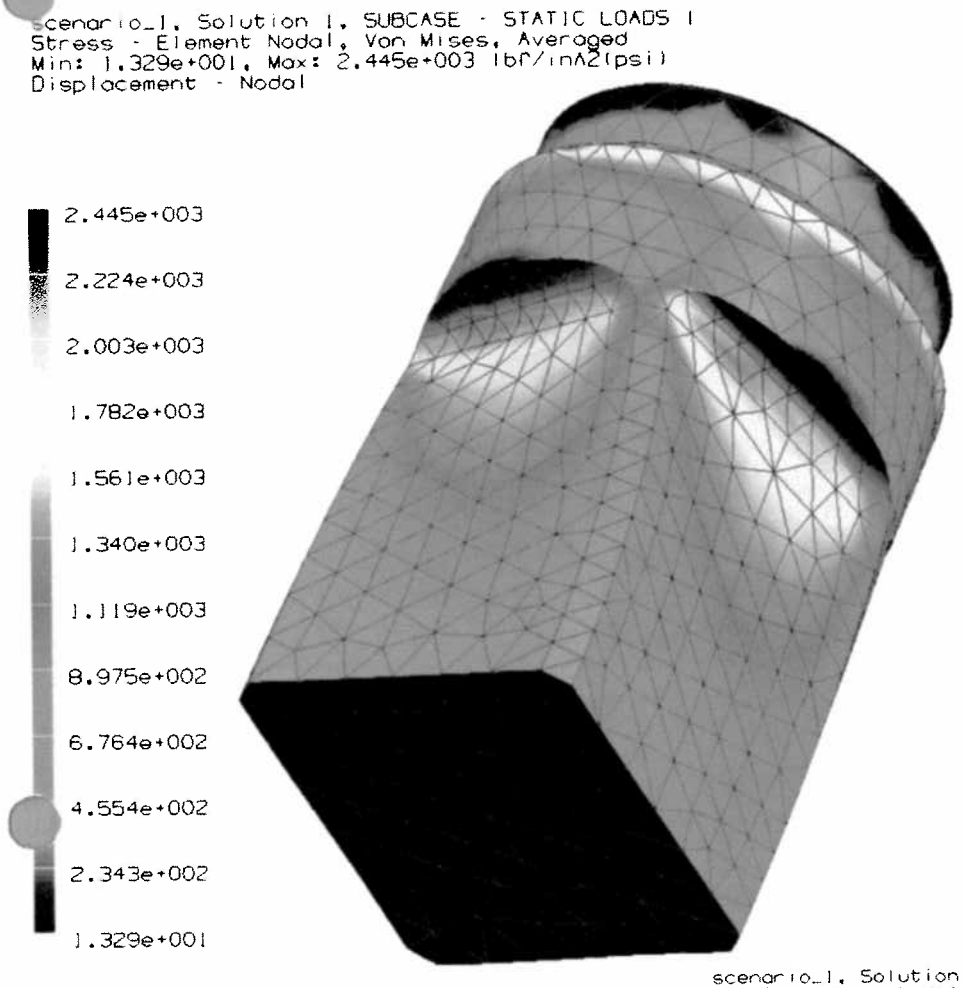


- Applications of Constraints

The part was constrained where it would have been welded to the shaft_extension.

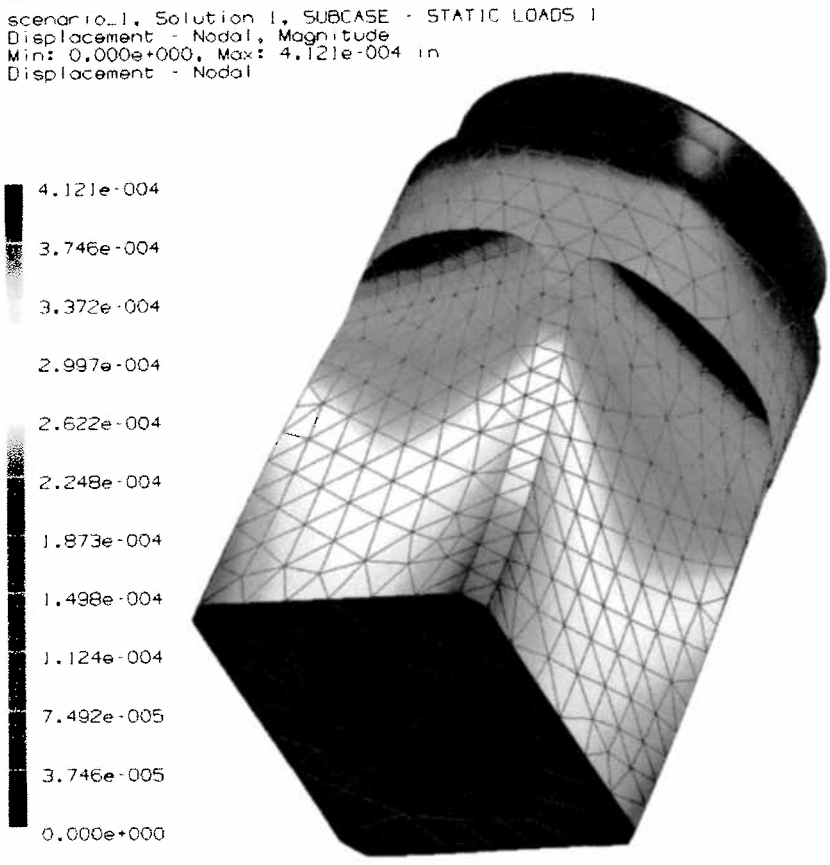


- F.E.A. results of unmodified **shaft_load**

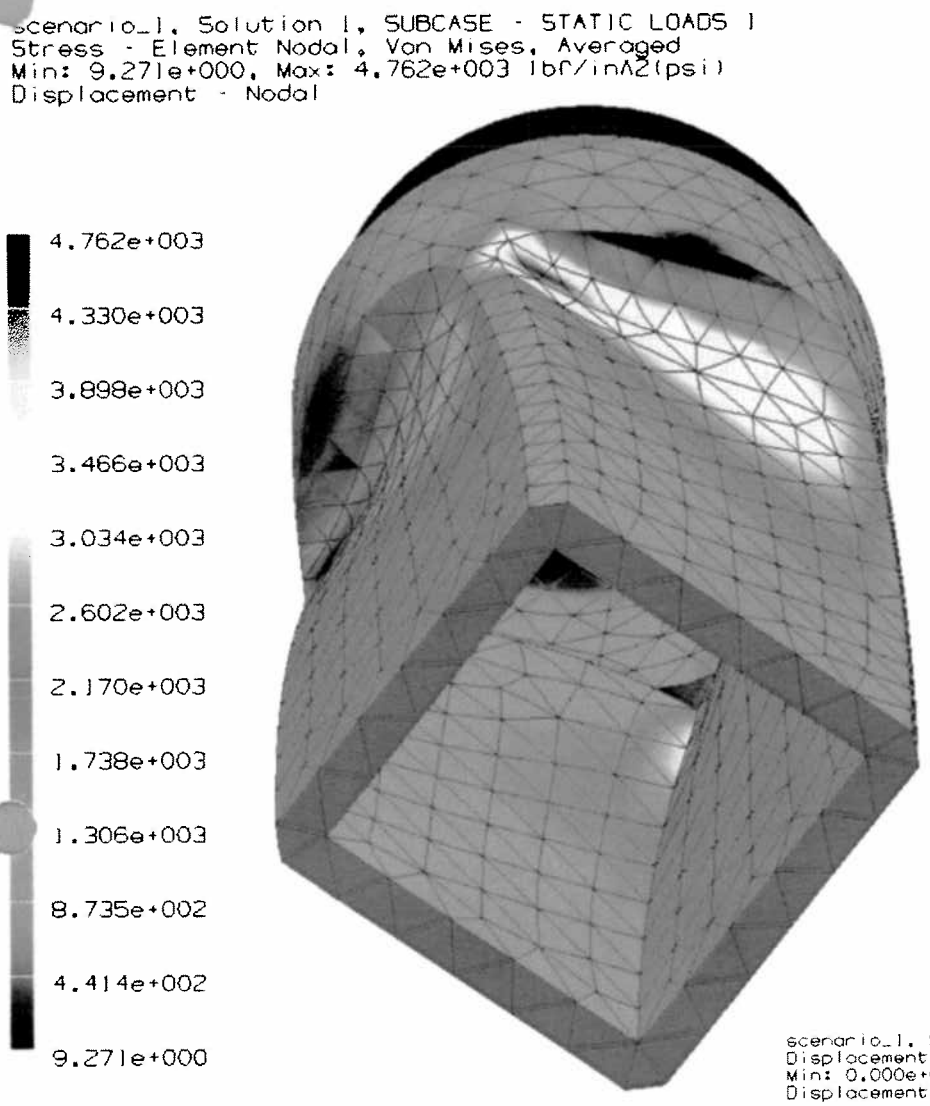


The maximum stress in this case is 2,445psi. This part is over engineered because having the yield strength of rolled steel to be 34,000psi, the safety factor of the unmodified shaft load is 13.9. Proposed changes are to remove material from the core. This should reduce cost, yet still provide sufficient strength.

NOTE: Since this program shows an over exaggeration of actual deformation the displacement results are here for your reference.



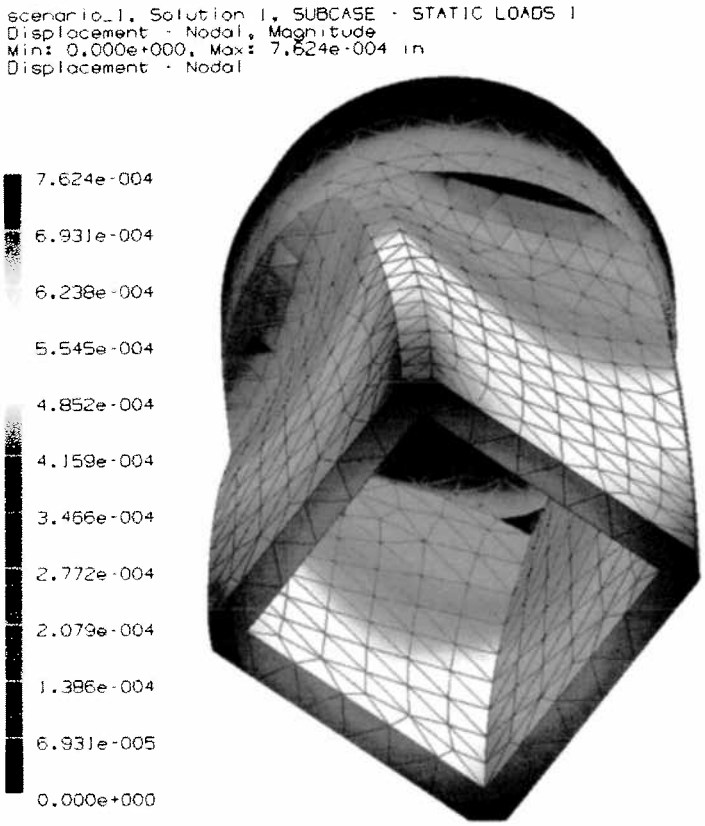
- F.E.A. results of modified **shaft_load**



The square end has a wall thickness of 0.45", and the head was a diameter of 4.5" countersunk 3.0". The part originally weighed 51.7lbs, but now weighs 19.098lbs.

The safety of factor is higher than the minimal of 4, but the stress this part will see in its lifetime will slowly wear it down, making it more brittle and more prone to failure. This is the most expensive part of the shaft subassembly to manufacture, so I want it to have a safety factor greater than 4. Keeping a decent thickness adds to the strength of the part overall, so that it lasts longer while in use. More cost could be cut with more removal of material, but more replacements would be needed.

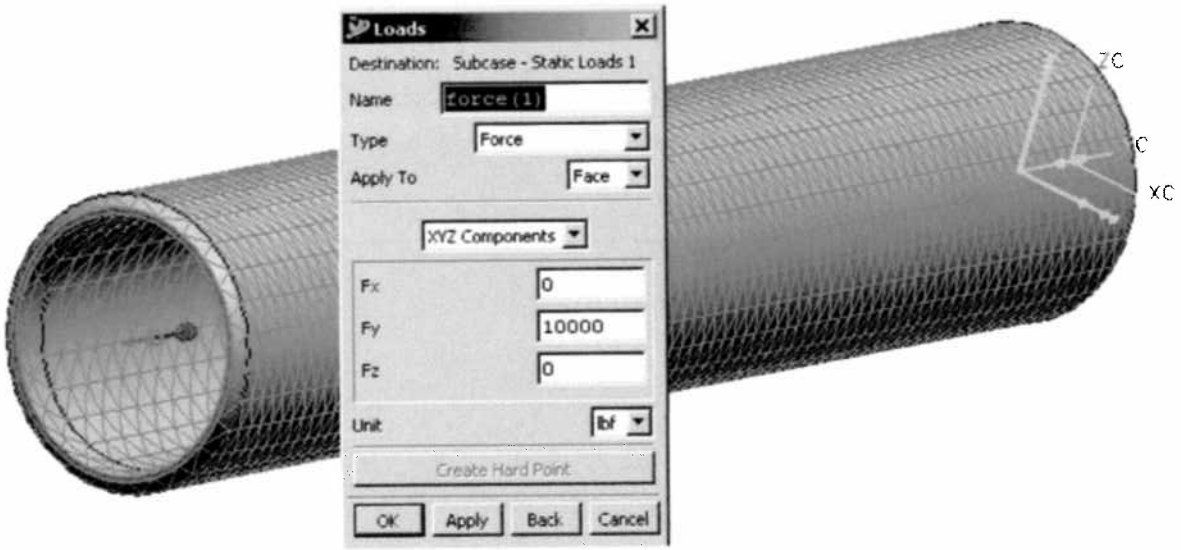
The stresses and displacements show up in the same locations with the same variations on both the original and modified parts. The only difference is that the modified part has an inner surface, so now the stresses are visible on them, where as before, the part of was over engineered with excessive material so that the stresses still penetrated the part, but were soaked up .



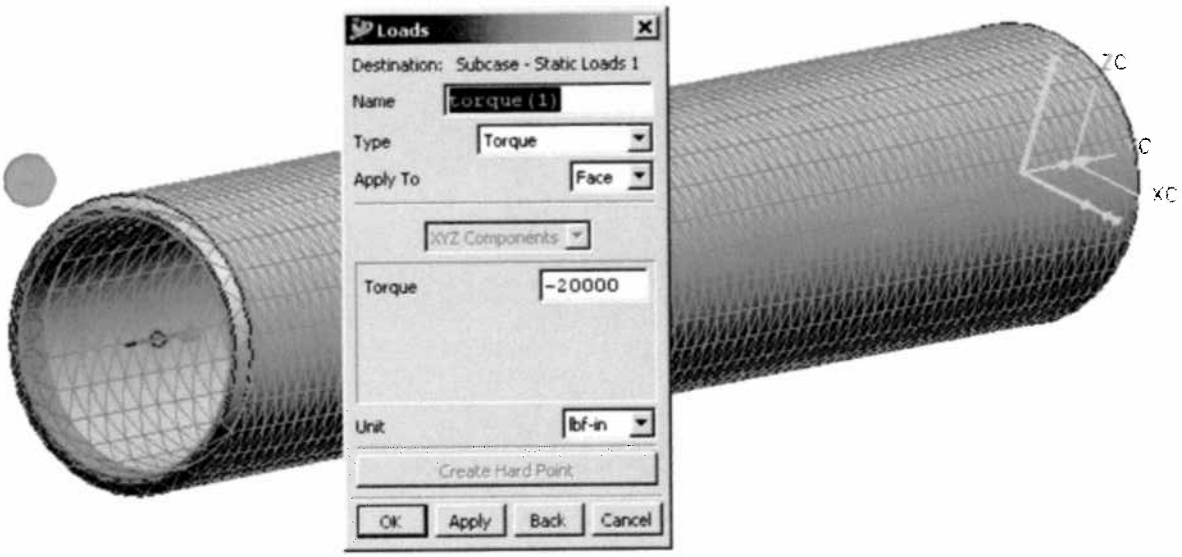
Design Analysis Report of **shaft_extension**

Shaft loads and constraints

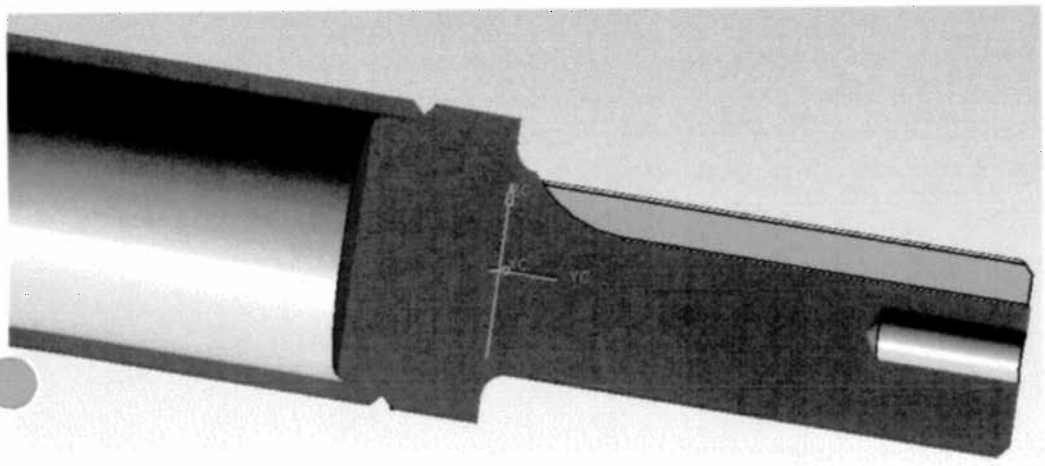
- Applications of Loads



This would be the axial load felt on the face of the extension from the shaft_load.

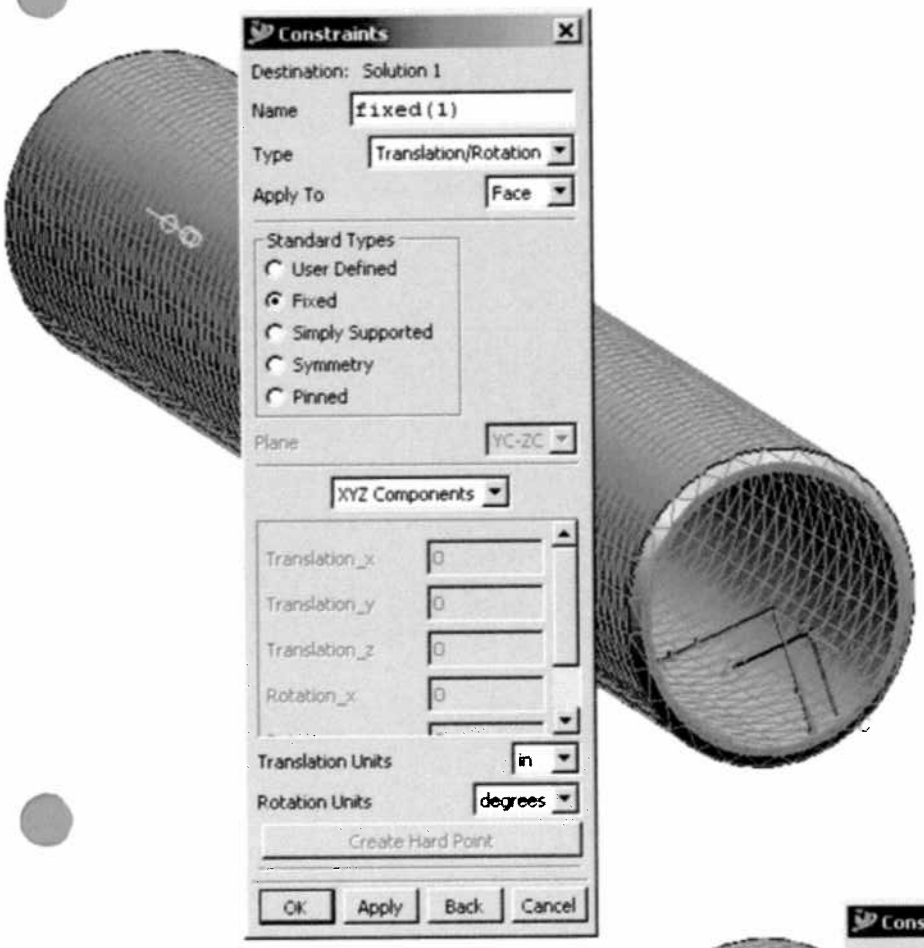


The inner face was subdivided by a datum plane offset one inch of the face on which the axial load was applied. This was to provide a more accurate F.E.A. result.



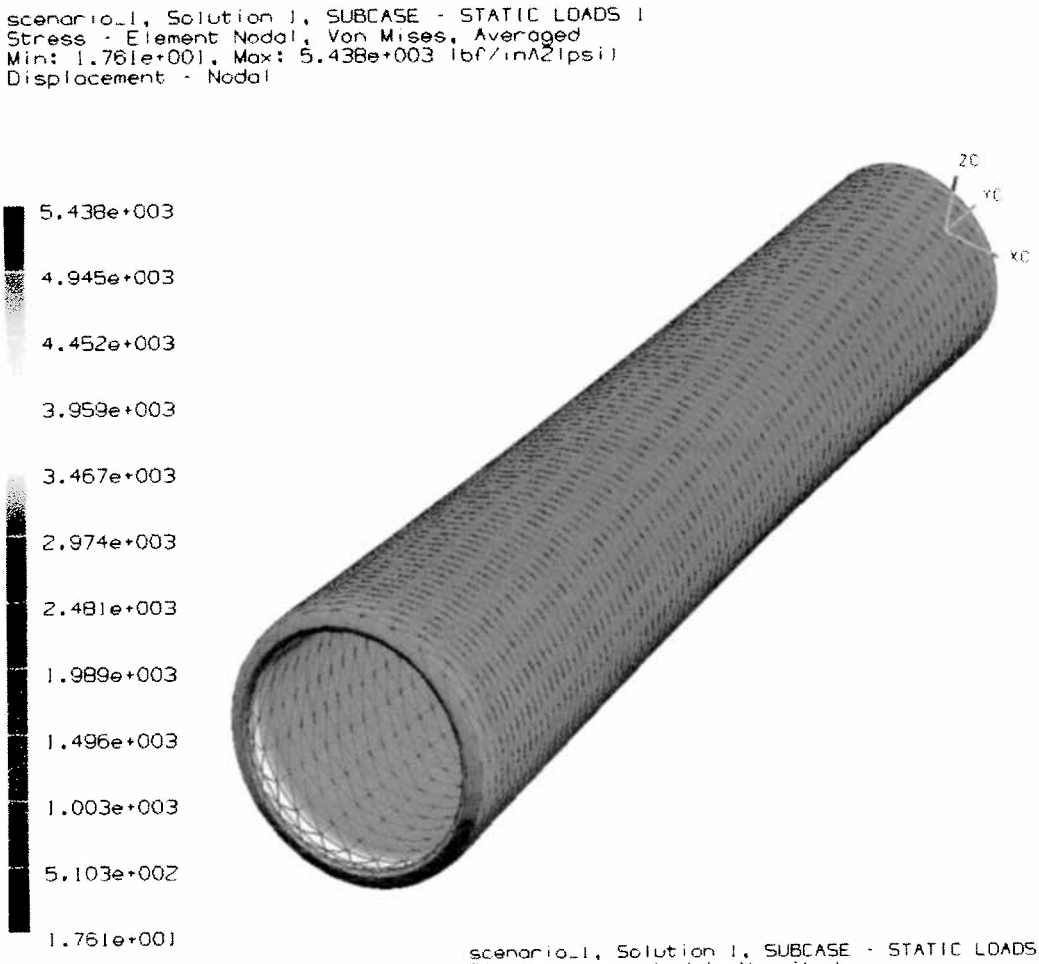
The shaft_impeller sits inside the shaft_extension. The contact to the inner face is 1" deep. This information was used to subdivide the face to apply the torque, as shown above.

- Applications of Constraints



The shaft_extension was fixed in the same way that it would have been butted and welded to the shaft_impeller.

F.E.A. results of **shaft_extension**

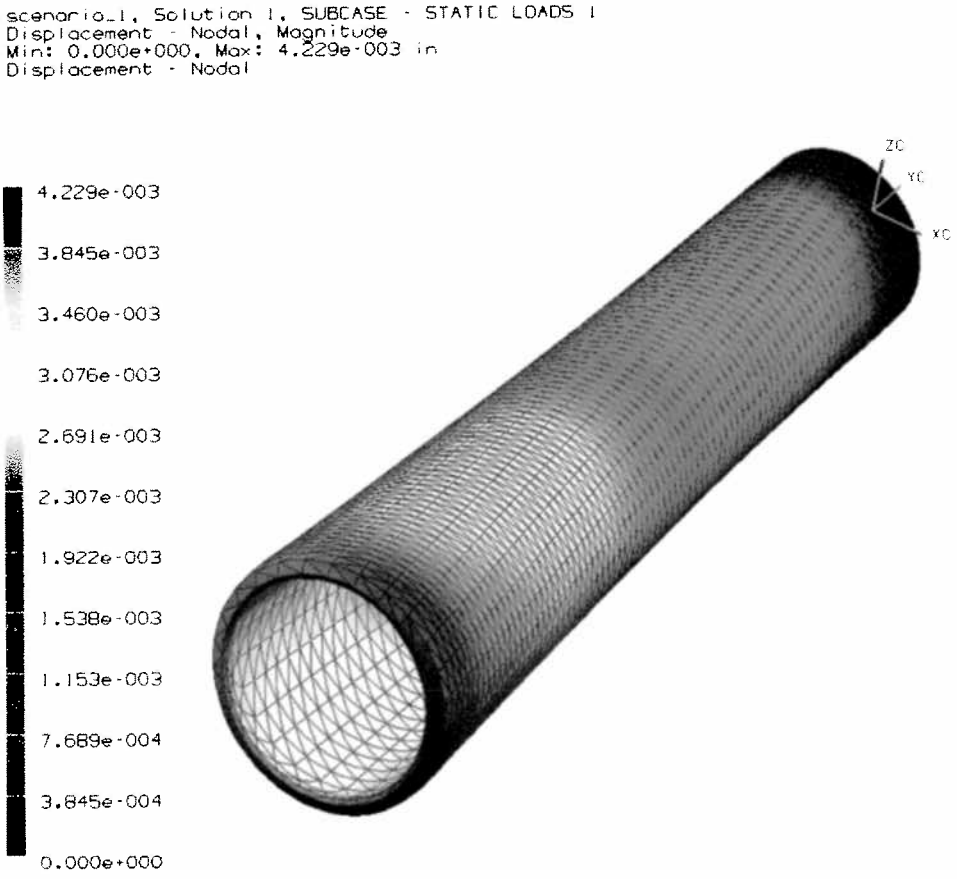


Doing Finite Element Analysis shows that this part is engineered well enough that it does not require any modifications. The factor of safety is a little over 6. The shaft_extension is such a long part compared to the others of the shaft subassembly, that its integrity is important. If the load is not applied perfectly parallel, then the extension could bend or twist when a large force is used.

It is the heaviest out of the three, weighing in at 61.688lb, but the shaft_extension is the largest.

The stress and deformation is not even despite the part being a simple cylindrical extrusion with chamfered ends. Notice how the most displacement is on the upper right end of the extension. The stress is not consistent either. If the shaft_extension was thinner, it would have a greater chance of having even more inconsistent stress and strain.

The shaft_extension will be left the way it was originally designed.

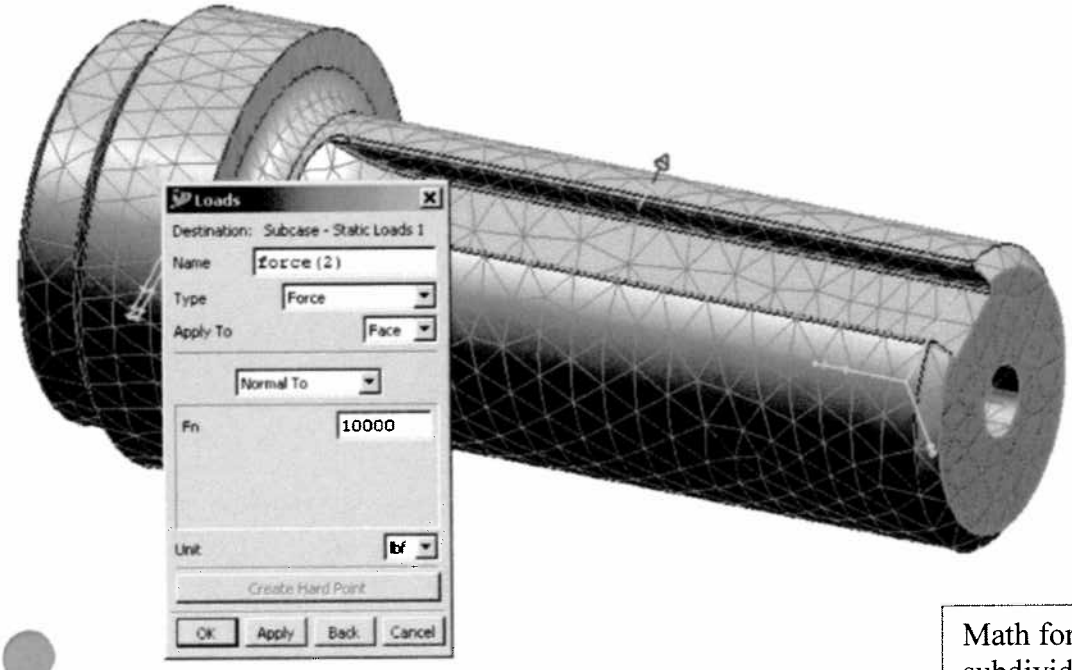


Design Analysis Report of **shaft_load**

Shaft loads and constraints

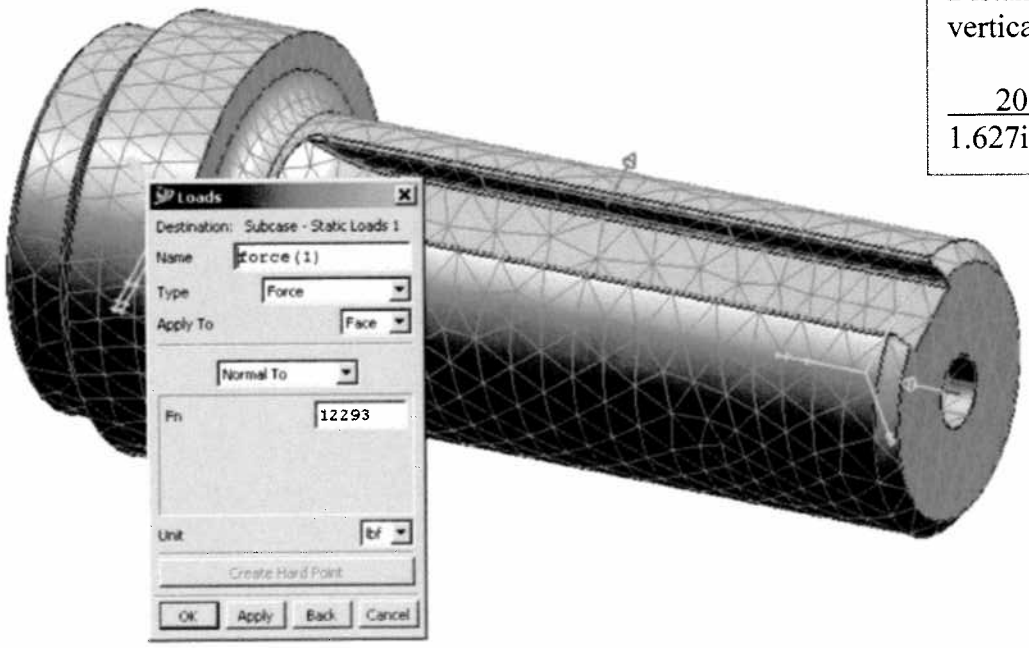
(for both unmodified and modified)

- Application of Loads



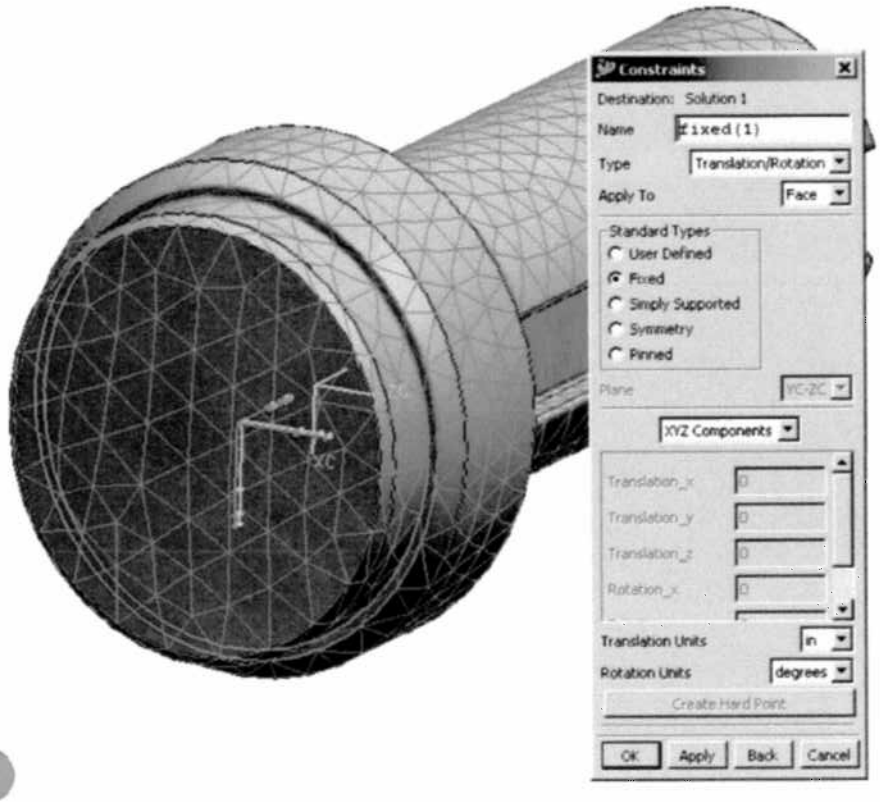
Math for applying torque on individual subdivided face in the keyway:
Distance from center to middle of vertical face is 1.627

$$\frac{20{,}000\text{lbs}}{1.627\text{in} \times 1 \text{ face}} = 12{,}293 \text{ lbs}$$



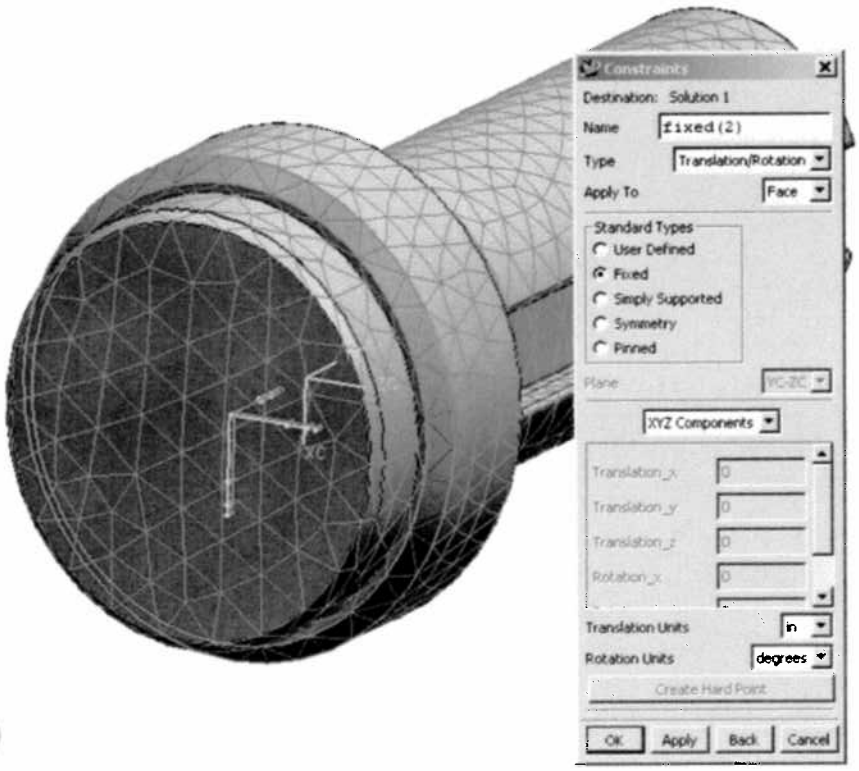
The face inside the right vertical face was subdivided using datum planes offset 3.5" from face the axial force was applied to and then 4.0" from there.

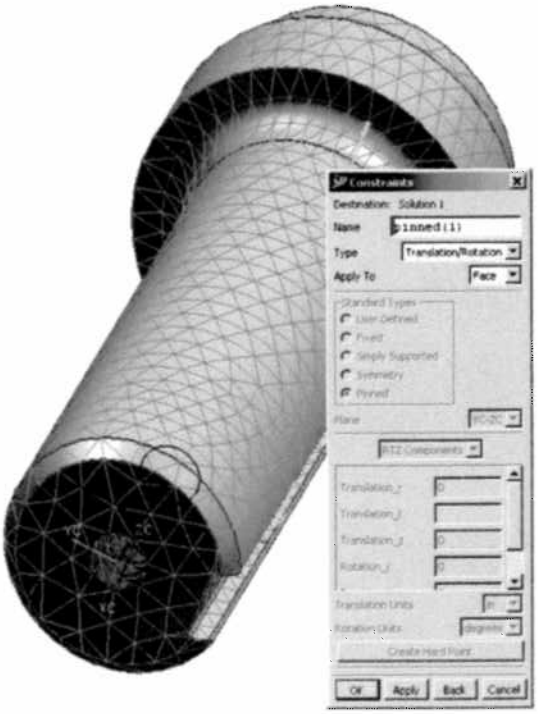
- Applications of Constraints



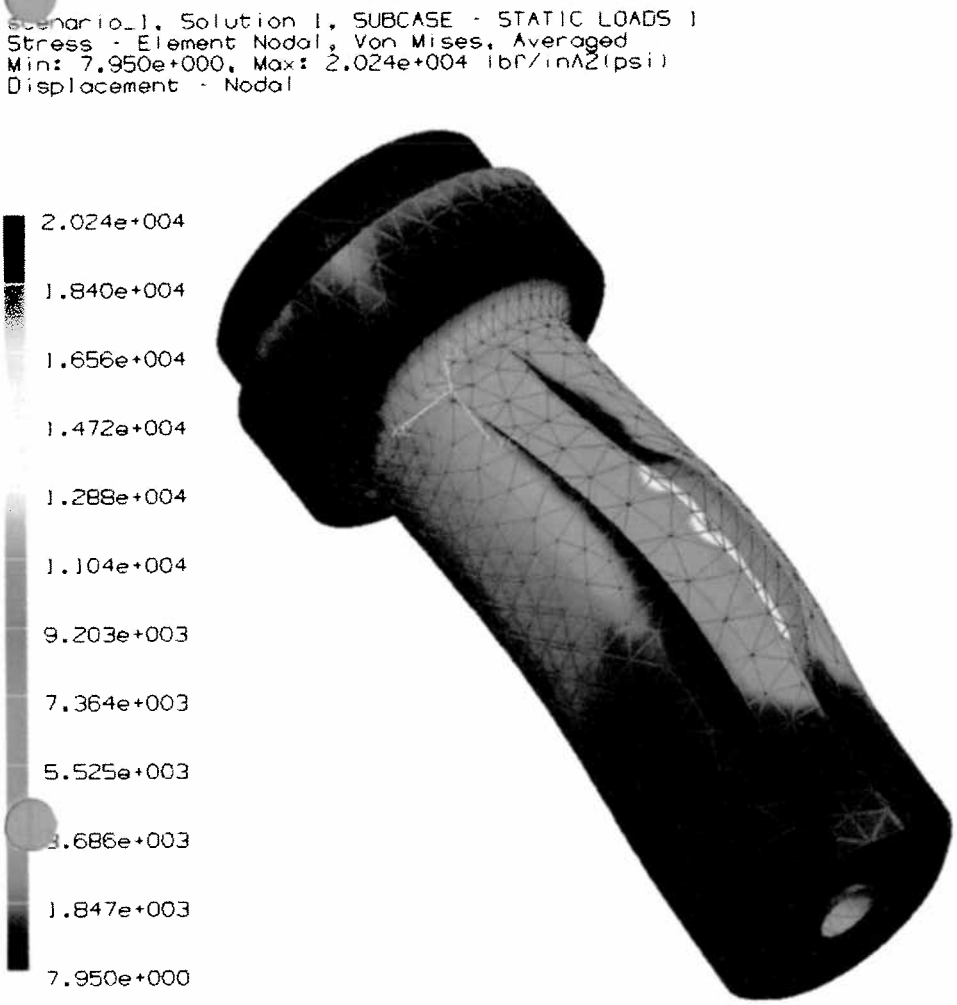
The shaft_impeller was constrained the same way as the shaft_extension, where it would be typically welded.

To get the desired result, the hole for the HexSocketHead1 was pinned, to allow rotation of this part. Otherwise, the F.E.A. results were usually just bending moments. It does still bend, but not as severe.





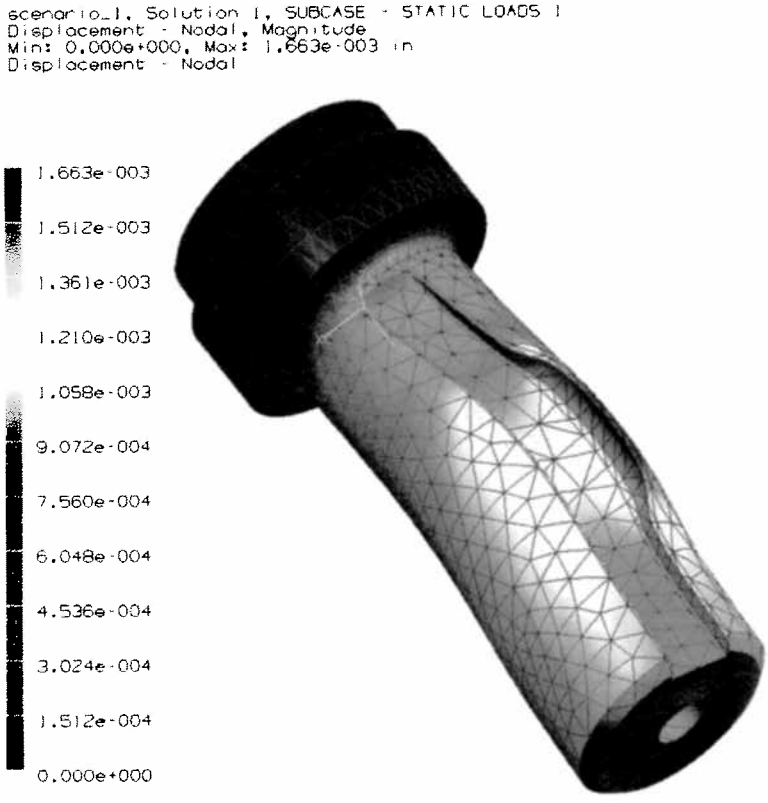
- F.E.A. results of unmodified **shaft_impeller**



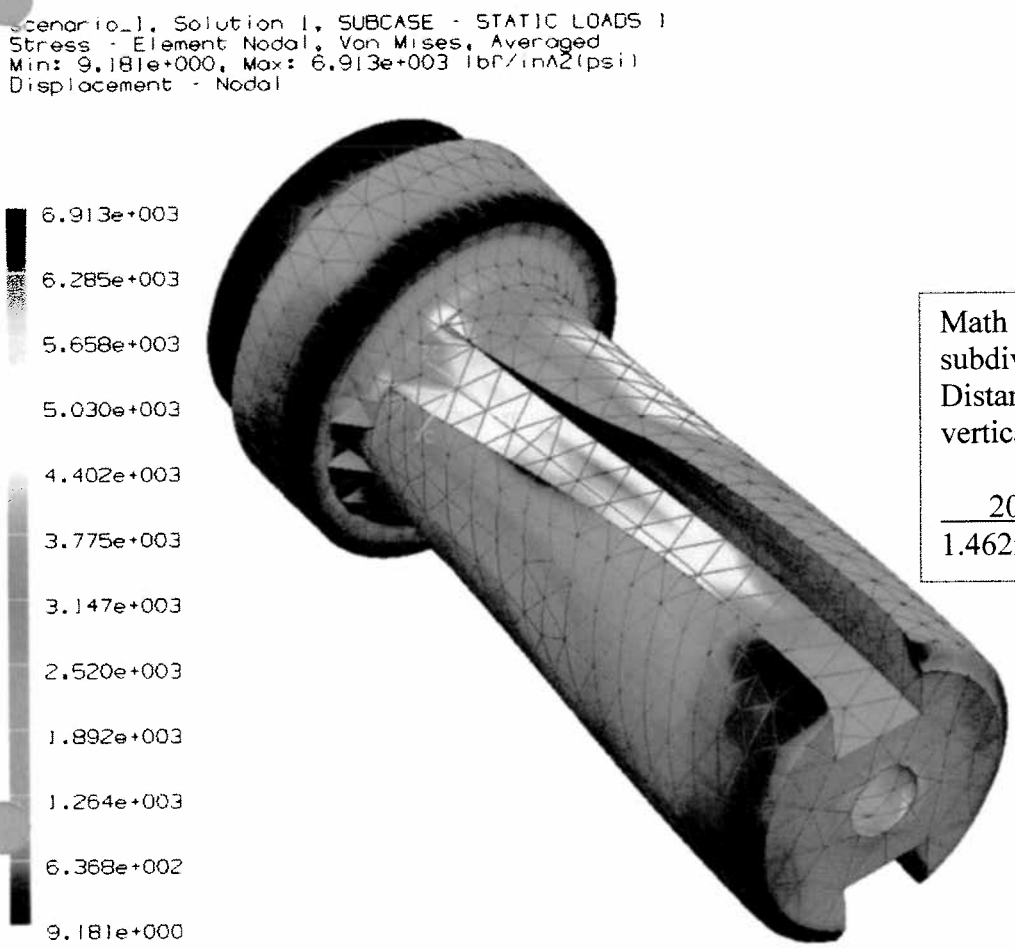
The shaft_load was over engineered, the shaft_extension was engineered well, but the shaft_impeller is under engineered. The yield strength of steel is 34,000psi. This part comes close to failing. It definitely does not fall within the safety factor of 2.

The changes to make this pass F.E.A. would be to make the key longer, and mirror the key feature to the other side.

Something that is not necessary, but should reduce weight and cost, would be a large diameter hole drilled into the head that goes no more than 3.0"
Forces do act on the head of the shaft_impeller, but they are only minimal.



F.E.A. results of modified **shaft_impeller**



The same loads and constraints were applied to the corresponding faces of the modified shaft_impeller. The only difference was the force of the torque. The key hole was made deeper, which changed one distance and added a face.

Math for applying torque on individual subdivided face in the keyway:
Distance from center to middle of vertical face is 1.462

$$\frac{20{,}000\text{lbs}}{1.462\text{in} \times 2 \text{ faces}} = 6{,}840 \text{ lbs}$$

The result is a shaft_impeller that passes with a safety factor of almost 5.
Making the keyway deeper and adding another one, takes out weight, but then it's added back in the assembly when the keys are in place. The modified shaft_impeller is 13.265lb lighter than the original.