Structural Analysis

Joy Arnold

Flexure Idealization



- Deleted epoxy holes (not structurally important)
- Replaced face on counterbored holes (not structurally important)
- Removed lips at top and bottom of flexure (not structurally important)
- Removed bottom 3 holes (only there to reduce mass)
- Trimmed sides of body leading up to top radius to make split body easier
- Kept fillets since they could impact movement and stress concentrations

Flexure FEM



 Split body and used 3D swept mesh for each split body since the flexure is a complex shape and would not be represented well by a 2D mesh.

Enclosure Idealization



- Removed all fillets on walls of object in order to midsurface
- Removed protruding cylinder in body (not structurally important)
- Made top of enclosure (with holes for connection) flesh with walls for better mesh and since overhang was not structurally important.
- Made all four walls even and flesh to each other for mid surfacing.
- Removed holes on bottom of enclosure (not structurally important)

Enclosure FEM



- Mid surfaced walls of enclosure and made 2D mesh since simple rectangular geometry
- Did tetrahedral mesh of connection points for flexure due to complex and unsymmetrical geometry.
- Did 3D swept mesh since complex geometry that would not be represented well in 2D.

AFT Plate Idealization





- Made top of AFT Plate flat and removed center hole in order to more easily mesh since the circular ring did not seem structurally essential for this assembly
- Made bottom of AFT Plate (with holes for connection) flesh with walls for better mesh and since overhang was not structurally important.
- Removed small holes in 3D geometry since did not seem structurally important.

AFT Plate FEM



- Mid surfaced walls of AFT Plate and made 2D mesh since simple rectangular geometry
- Did 3D swept mesh of the rest of the body since complex geometry that would not be represented well in 2D.

Constraints and Bolted Connections



- Used fixed constraints for bottom of flexures
- Used bolted connections (nut and bolt) to connect AFT Plate to enclosure.
- To connect flexure to enclosure: created spider connections (face to midpoint) in holes of flexure and enclosure and connected those through node to node connection.

Solution Parameters

Solution	Parameter	s2			¢	>>
Modeling (Object					1
Name	Solution Parameters2					
Label	10					
Properties						1
Card Name	PARAM					
A-B				· · · · · · ·		^
C-D		ALPHA2			¢	
E-F		Real		0.0000		
G-H		Imaginary		0.0000		
M-N	- K-L		NO	•	•	
- O-P		ALTSHAPE	0		\$	
Q-R		AMPCZ	1e-06	•		
- S-T		ASCOUP	YES	•	•	
U-V		ASING	0		•	
W-Z		AUNITS	1			
User Defined		Additio	1		(W)	
		AUTOADJ	YES		•	
		AUTOMPC	NO	•		
		AUTOSEEL	NO	•	\	
		AUTOSPC	Default	•	•	
		AUTOSPCR	NO	-	•	
		AUTOSPRT	YES	•		
		BAILOUT	0			
		BDMNCON	2		•	
		BETA		^	•	
		Real		0.3333		
						100

• Bailout = 0

Simulation Objects





- Glued 2D mesh of AFT plate to 3D swept mesh (face to face gluing using WELD conditions)
- Glued 2D mesh of enclosure to 3D swept mesh (face to face gluing using WELD conditions)

Simulation Objects





- Glued tetrahedral mesh to 2D walls of enclosure (face to face gluing using WELD conditions)
- Added non-structural mass to FEM: the difference between FEM mass and original assembly mass (approx .14kg)

Modal Results

1

3

MODAL EFFECTIVE MASS FRACTION

MODE	FREQUENCY	REQUENCY		T2		Т3	
NO.		FRACTION	SUM	FRACTION	SUM	FRACTION	SUM
1	3.857389E+02	9.167393E-01	9.167393E-01	6.601360E-03	6.601360E-03	1.882118E-04	1.882118E-04
2	4.323752E+02	4.183047E-05	9.167811E-01	2.681497E-04	6.869510E-03	3.235244E-01	3.237126E-01
3	5.058278E+02	6.977391E-03	9.237585E-01	8.780091E-01	8.848786E-01	7.679358E-06	3.237203E-01
4	5.529793E+02	2.545111E-04	9.240130E-01	1.484602E-03	8.863632E-01	1.249758E-01	4.486961E-01
5	7.871940E+02	7.963356E-06	9.240209E-01	3.946326E-04	8.867578E-01	4.115851E-02	4.898546E-01
6	8.420052E+02	1.410463E-05	9.240351E-01	7.386557E-05	8.868317E-01	1.078981E-01	5.977527E-01
7	8.972222E+02	1.125045E-05	9.240463E-01	2.766701E-05	8.868594E-01	8.121982E-02	6.789725E-01
8	9.376367E+02	2.872422E-04	9.243335E-01	5.891322E-03	8.927507E-01	5.014480E-04	6.794740E-01
9	1.021849E+03	2.490148E-05	9.243584E-01	1.516877E-02	9.079194E-01	2.131944E-02	7.007934E-01
10	1.071698E+03	2.226768E-04	9.245811E-01	6.715180E-04	9.085910E-01	8.642079E-02	7.872142E-01

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SUBCASE 1

MODAL EFFECTIVE MASS FRACTION

FREQUENCY	R1		R2		R3	
_	FRACTION	SUM	FRACTION	SUM	FRACTION	SUM
3.857389E+02	5.251490E-03	5.251490E-03	6.757747E-01	6.757747E-01	5.138258E-04	5.138258E-04
4.323752E+02	1.304714E-05	5.264537E-03	3.094610E-03	6.788693E-01	6.006701E-06	5.198325E-04
5.058278E+02	6.964801E-01	7.017446E-01	4.587150E-03	6.834564E-01	7.369720E-03	7.889553E-03
5.529793E+02	2.587290E-03	7.043319E-01	4.174061E-05	6.834982E-01	4.973801E-06	7.894527E-03
7.871940E+02	2.979386E-02	7.341257E-01	2.890062E-02	7.123988E-01	2.876811E-04	8.182208E-03
8.420052E+02	2.876660E-02	7.628923E-01	2.658055E-02	7.389793E-01	2.582573E-03	1.076478E-02
8.972222E+02	3.027312E-02	7.931655E-01	1.128789E-02	7.502672E-01	8.399985E-03	1.916477E-02
9.376367E+02	9.120269E-03	8.022857E-01	2.709252E-06	7.502699E-01	7.499294E-01	7.690942E-01
1.021849E+03	2.412146E-02	8.264072E-01	1.237449E-03	7.515074E-01	1.623503E-02	7.853292E-01
1.071698E+03	2.515975E-03	8.289232E-01	7.324457E-03	7.588319E-01	5.518485E-04	7.858810E-01
	FREQUENCY 3.857389E+02 4.323752E+02 5.058278E+02 5.529793E+02 7.871940E+02 8.97222E+02 9.376367E+02 1.021849E+03 1.071698E+03	FREQUENCY R1 S.857389E+02 5.251490E-03 4.323752E+02 1.304714E-05 5.058278E+02 6.96480HE-01 5.529793E+02 2.587290E-03 7.871940E+02 2.979386E-02 8.972222E+02 3.027312E-02 9.376367E+02 9.120269E-03 1.021849E+03 2.412146E-02 1.071698E+03 2.412146E-02	FREQUENCY R1 FRACTION SUM 3.857389E+02 5.251490E-03 5.251490E-03 4.323752E+02 1:304714E-05 5.264537E-03 5.058278E+02 6:964801E-01 7.017446E-01 5.529793E+02 2.587290E-03 7.043319E-01 7.871940E+02 2.979386E-02 7.341257E-01 8.420052E+02 2.87660E-02 7.628923E-01 8.972222E+02 3.027312E-02 7.931655E-01 9.376367E+02 9.120269E-03 8.022857E-01 1.021698E+03 2.515975E-03 8.289232E-01	FREQUENCY R1 FRACTION SUM FRACTION R2 3.857389E+02 5.251490E-03 5.251490E-03 6.757747E-01 4.323752E+02 1.304714E-05 5.264537E-03 3.094610E-03 5.058278E+02 6.964801E-01 7.017446E-01 4.587150E-03 5.529793E+02 2.587290E-03 7.043319E-01 4.174061E-05 7.871940E+02 2.979386E-02 7.341257E-01 2.890052E-02 8.420052E+02 2.876606E-02 7.628923E-01 2.658055E-02 8.972222E+02 3.027312E-02 7.931655E-01 1.128789E-02 9.376367E+02 9.120269E-03 8.022857E-01 2.709252E-06 1.021849E+03 2.515975E-03 8.289232E-01 7.34457E-03	FREQUENCY R1 FRACTION SUM FRACTION SUM 3.857389E+02 5.251490E-03 5.251490E-03 6.757747E-01 6.757747E-01 4.323752E+02 1.3904714E-05 5.264357E-03 3.094610E-03 6.788693E-01 5.0582782E+02 6.964801E-01 7.017446E-01 4.587150E-03 6.834564E-01 5.529793E+02 2.587290E-03 7.043319E-01 4.174061E-05 6.834564E-01 7.871940E+02 2.97936E-02 7.341257E-01 2.890662E-02 7.13988E-01 8.420052E+02 2.876660E-02 7.628923E-01 2.658055E-02 7.38793E-01 8.972222E+02 3.027312E-02 7.931655E-01 1.12879E-02 7.592672E-01 9.376367E+02 9.120269E-03 8.022857E-01 2.709252E-06 7.592699E-01 9.376367E+03 2.412146E-02 8.264072E-01 1.23749E-03 7.515074E-01 1.071698E+03 2.515975E-03 8.28232E-01 7.324457E-03 7.558319E-01	FREQUENCY R1 FRACTION SUM R2 FRACTION R2 SUM R2 FRACTION R3 SUM R3 FRACTION R3 SUM 3.857389E+02 5.251490E-03 5.251490E-03 6.757747E-01 6.757747E-01 5.138258E-04 4.323752E+02 1.394714E-05 5.264537E-03 3.094610E-03 6.786798E-01 6.006701E-06 5.058278E+02 6.954801E-01 7.017446E-01 4.587150E-03 6.834546E-01 7.969720E-03 5.529793E+02 2.587290E-03 7.043319E-01 4.174061E-05 6.834546E-01 4.973801E-06 7.871940E+02 2.979386E-02 7.341257E-01 2.890062E-02 7.123988E-01 2.876801E-06 8.972222E+02 3.027312E-02 7.931655E-01 1.128789E-02 7.502672E-01 8.399985E-03 9.376367E+02 9.120269E-03 8.022857E-01 2.709252E-06 7.502699E-01 7.499294E-01 1.021849E+03 2.515975E-03 8.282923E-01 7.237449E-03 7.518439E-01 1.625508E-02 1.071698E+03 2.515975E-03 8.282923E-01 7.324457E-03 7.588319E-01 5.518485E-04

Primary modes highlighted (largest fractions)

Modal Shape



Modal shape of a primary mode (mode 1).