

PIPER SEMINOLE –PA-44TWIN ENGINE AIRCRAFT







05/04/05

ENLARGED VIEW OF GUSSETPiper



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05/04/05



FINITE ELEMENT MODEL OF PA 44



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FINITE ELEMENT MODELING PIPEr DETAILS OF PA 44 ENGINE MOUNT

- Tube clusters and gussets are modeled using plate elements for thin walled structure.
- Portion of the tube clusters connecting leg area are modeled using beam elements.
 - This simplifies the model by reducing number of plate elements and still retaining stiffness properties.
- The end of the beam elements are connected to tubes by rigid body elements

FINITE ELEMENT MODELING PIPEr DETAILS OF PA 44 ENGINE MOUNT

- Rigid body elements are used to transfer forces between beam and plate elements
- Loads and boundary conditions are applied according to static test conducted previously
- The model is analyzed using NASTRAN for Windows®, version 2002
- The results are plotted using FEMAP®, which is the pre and post processor of the FEM package

Proposed gusset cluster (critical area in Red)



05/04/05



Current gusset cluster (critical area in Red)





Principle Stresses in the area of the proposed piper gussets with no gussets on the model The max stress is 108 Ksi



05/04/05







Principle Stresses in the area of proposed **Piper** gussets with current production gussets in the model The max stress is 104 Ksi



05/04/05





Principle Stresses in the area of proposed gussets with two sets of gussets in the model The max stress is 57 Ksi



05/04/05





Von Mises Stresses in the Cluster located below proposed gussets with two additional sets of gussets in the model The max stress is 91.5 Ksi

Element 49533 - PLATE Property 12 - Untitled Material 1 - Untitled Plate Top VonMises Stress = 91493.55 Node 2209 = 42654.03 Node 1844 = 75505.23 Node 51563 = 77800.43 Node 51553 = 53608.77 5937

47500

2375

11875

-11875

-23750

-83125

05/04/05

Summary Of Predicted Raised Piper Principle Tensile Stress

	Proposed Gusset area (Ksi)	Current production gusset area (Ksi)
Stresses with no Gussets	108	142
Stresses with one set of Gussets	104	107
Stresses with two set of Gussets	57	66

UPPER HALF OF THE ENGINE MOUNT



FEM Analysis of PA 44 Engine Mount

05/04/05

LOWER HALF OF THE ENGINE MOUNT IN COMPRESSION



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Direct Stress Comparisons

- 45% reduction in stresses in the proposed cluster of gusset addition versus no gusset design
- 28% reduction in stresses in the current production gusset cluster set
- Transfer of load path from proposed gusset area to the clusters right below it should be investigated



95000

4750

71250

Principle Stresses in the area of proposed gussets with three gusset sets The max stress is 59 Ksi

> Element 20160 - PLATE Property 1 - Untitled Material 1 - Untitled Plate Top MajorPrn Stress = 58979.79 Node 21157 = 29390.09 Node 21158 = 50539.54 Node 21160 = 51259.72 Node 21159 = 27569.05

Output Set: MSC/NA3TRAN Case 5 Contour: Plate Top MaiòrPrn Stress

05/04/05

Principle Stresses in the area of current production gusset set with three gusset sets

The max stress is 65 Ksi

Element 24271 - PLATE Property 1 - Untitled Material 1 - Untitled Plate Top MajorPrn Stress = 65108.23 Node 25225 = 48784.06 Node 25224 = 27385.05 Node 25226 = 29118.03 Node 25227 = 50747.41

Oxtput Set: MSC/NASTRAN Case

05/04/05

Von Mises stresses in the area of third set of gussets with three total gusset sets The max stress is 52 Ksi

Element 48988 - PLATE Property 11 - Untitled Material 1 - Untitled Plate Top VonMises Stress = 52349.73 Node 50999 = 23764.97 Node 50998 = 35199.64 Node 50898 = 48184.84 Node 50899 = 43473.08

Julput Set: MSQ/NASTRAD Con

05/04/05



Von Mises stresses in the area of fourth cluster with three gusset sets The max stress is 83 Ksi



05/04/05



Major Principle stresses in the area of Proposed added gusset with four gusset sets The max stress is 57 Ksi



Dutplit Set: MSC/NASJAAN Case 5

05/04/05

Major Principle stresses in the area of current production gusset set with four gusset sets The max stress is 67 Ksi

> Element 24271 - PLATE Property 1 - Untitled Material 1 - Untitled Plate Top MajorPrn Stress = 66995.03 Node 25225 = 50183.24 Node 25224 = 28174.98 Node 25226 = 29964.34 Node 25227 = 52208.15



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Von Mises stresses in the area of third set of gussets with four gusset sets The max stress is 51 Ksi

Element 48888 - PLATE Property 11 - Unitied Material 1 - Unitied Plate Top VorMises Stress = 50714.42 Node 50939 = 2005.24 Node 50939 = 3005.24 Node 50939 = 3005.24 Node 50939 = 4397.3.22 Node 50939 = 42318.37

Output Set: MSCXN/ASTRAN Case 5

05/04/05

Von Mises stresses in the area of fourth set of gussets with four gusset sets The max stress is 51 Ksi

Element 20160 - PLATE Property 1 - Untitled Material 1 - Untitled Plate Top VonMises Stress = 50053.55 Node 21157 = 29722.21 Node 21158 = 43164.79 Node 21159 = 43579.69 Node 21159 = 33932.04

Output Set: MSC/NASTRAN Case 5 Contour: Plate Top Von Mises Stress

05/04/05



Observations

- Addition of third set of gussets reduces the Von Mises stress at that cluster
- Increases the stresses to the fourth cluster
- Addition of fourth set of gussets reduces the stresses in that cluster
- Upper half clusters increase in stress with the addition of the lower 2 sets of gussets

Stresses at different clusters Piper

	Upper Half		Lower Half	
	Proposed Gusset area, Max Principle Stress (Ksi)	Current Gusset area, Max Principle Stress (Ksi)	Third Cluster, Max Von Mises Stress (Ksi)	Fourth Cluster, Max Von Mises Stress (Ksi)
Stress with no Gusset	108	142	93	84
Stress with one set of Gusset	104	107	90	86
Stress with two set of Gusset	57	67	91	85
Stress with three set of gusset	59	65	52	83
Stress with four set of Gusset	57	67	51	51

Conclusions



- The Finite Element Model peak predicted stress correlates to the location of service cracking observed
 - This validates the FEM to substantiate this product enhancement
- Reduction in production stresses in the upper cluster failing cluster with added gussets
- Reduction in production stresses in all clusters with added gussets.
- Upper half clusters are subjected to tensile loading and the lower half to compressive for critical fatigue design condition.
- The Load path movement is predictive using FEM
 FEM Analysis of PA 44 Engine Mount



Recommendations

- Addition of gussets to the next cluster in the load path
- Improving welding process to reduce the heat affected zone
- Conduct a fatigue test to study the fatigue loads and life of the mount