Ryan Dunn
A15600858

SE 160A: Project 2 Write Up

1. A spinning engine rotor blade...

a.) Calculate the A- and B-Basis allowable strength properties.

Given that E = 16.0*10^6 (16.0 Msi) and v = 0.31, G can be found by $G = \frac{E}{2(1+\nu)}$. This gives a G value of 6.106870229*10^6 (6.10687 Msi). Plugging the given inputs into the Input file and running my matlab code (SE160A_2_Dunn_Ryan.m) provides the following outputs for A-Basis and B-Basis:

2.) Allowable Strengths

Variable	Description	A-Basis	B-Basis	Units
σ_T*	Allowable Tension	100.6667	105.3333	Ksi
σ_C*	Allowable Compression	-103.3333	-107.3333	Ksi
τ*	Allowable Shear	63.3333	66.6667	Ksi
τ*	Allow Shear Tresca (Mixed)	51.0000	53.1667	Ksi

b.) Calculate the Margin of Safety (MS) using the Tresca, Rankine, and Von Mises failure theories for both the A- and B-Basis allowable strength properties.

Margin of Safety (MS)

Minimum Margin of Safety		Rankine	Tresca*	Von Mises
MS_{min} (A)	Min Margin of Safety (A Bas	0.1185	0.1185	0.1185
MS_{min} (B)	Min Margin of Safety (B Bas	0.1704	0.1704	0.1704

c.) Scale the stress state so that (MS = 0) for the B-Basis strength properties based upon the Von Mises failure theory.

Applied Stress State for (MS=0) - B Basis

Variable	Description	Von Mises	Units
σ_{xx}	Normal Stress - x	105.3333	Ksi
σ_{yy}	Normal Stress - y	0.0000	Ksi
σ_{zz}	Normal Stress - z	0.0000	Ksi
τ_{yz}	Shear Stress - yz	0.0000	Ksi
τ_{xz}	Shear Stress - xz	0.0000	Ksi
τ_{xy}	Shear Stress - xy	0.0000	Ksi

2. Engineers at the aircraft engine company of problem (#1) are investigating the use of new nano-material technology to alter the stress state of the spinning rotor blade for the purpose of increasing the MS.

a.) What is the MS if the spinning blade stress state is altered to (...stress state...) Use B-basis allowables and the von Mises Failure Criteria.

For this stress state, B-basis does not pass the von Mises Criteria because it produces a -0.2149 margin

Margin of Safety (MS)

Minimum Margin of Safety	Ran	Von Mises
MS_{min} (A)	Min Margin of Safety (A Bas	-0.2497
MS_{min} (B)	Min Margin of Safety (B Bas	-0.2149

Allowable Strengths

Variable	Description	B-Basis	Units
σ_T*	Allowable Tension	105.3333	Ksi
σ_C*	Allowable Compression	-107.3333	Ksi
τ*	Allowable Shear	66.6667	Ksi
τ*	Allow Shear Tresca (Mixed)	53.1667	Ksi

b.) What is the MS if the spinning blade stress state is altered to (...stress state...) Use B-basis allowables and the von Mises Failure Criteria.

However, in this stress state, the B-Basis did pass using von Mises Criteria because it produces a +0.1704 margin

Margin of Safety (MS)

Minimum Margin of Safety	Rank	Von Mises
MS_{min} (A)	Min Margin of Safety (A Basi	0.1185
MS_{min} (B)	Min Margin of Safety (B Basi	0.1704

Allowable Strengths

Variable	Description	B-Basis	Units
σ_T*	Allowable Tension	105.3333	Ksi
σ_C*	Allowable Compression	-107.3333	Ksi
τ*	Allowable Shear	66.6667	Ksi
τ*	Allow Shear Tresca (Mixed)	53.1667	Ksi

Table 1: Strength Properties for Ti-6Al-4V (solution treated) - Experimentally Measured

Property	A-Basis	B-Basis	S-Basis	Units
σ_{Ty}	136	143	145	Ksi
σ_{Tu}	151	158	160	Ksi
σ_{Cy}	-140	-150	-150	Ksi
σ_{Cu}	-155	-161	-165	Ksi
σ_{Sy}	86	89	91	Ksi
σ_{Su}	95	100	100	Ksi

3. A uniform bar is subjected to an axial force and a shear force. Students apply four strain gage rosettes along the bar length and then measure strains (a, b, c).

	Rosette Type			*Measured Strains (μ in/in)*		
(#)	θ_a	θ_b	θ_c	ε_a	ε_b	ε_c
1	0°	45°	90°	1000.0	600.0	-300.0
2	0°	60°	120°	1000.0	241.5	-191.5
3	0°	60°	120°	946.7	362.6	-259.3
4	0°	60°	120°	1033.5	123.7	-107.2

a.) Calculate the structural strains (xx, yy, xy) for the four gages.

Plugging in the values of strain for the rosette types above, and assuming the gage is orientated at 0 degrees, My matlab code produces the following results:

Gage #1

Variable	Description	Value	Units
ε_{xx}	normal strain (x)	1000.000	µ in/in
ε_{yy}	normal strain (y)	-300.000	µ in/in
γ_{xy}	shear strain	500.000	µ in/in

Gage #2

Variable	Description	Value	Units
ε_{xx}	normal strain (x)	1000.000	µ in/in
ε_{yy}	normal strain (y)	-300.000	µ in/in
γ_{xy}	shear strain	499.985	µ in/in

shear strain is negligible ~500 micro in/in

Gage #3

Variable	Description	Value	Units
ε_{xx}	normal strain (x)	946.700	µ in/in
ε_{yy}	normal strain (y)	-246.700	µ in/in
γ_{xy}	shear strain	718.108	µ in/in

Gage #4

Variable	Description	Value	Units
ε_{xx}	normal strain (x)	1033.500	µ in/in
ε_{yy}	normal strain (y)	-333.500	µ in/in
γ_{xy}	shear strain	266.620	µ in/in

b.) It was suspected that maybe the 3rd and 4th gages were orientated incorrectly since their results did not closely matched the strain gage (#2) results. A visual examination revealed that both gages were incorrectly positioned, but the observed angle could not be determined. Calculate the mis-alignment angle of gages (#3) and (#4).

To answer this, we must draw the correct mohr circle for strain gages 1 and 2. From my matlab code for case 1 and 2, the principal strains are found to be: ep1 = -346.419 and ep2 = +1046.419

The center is found by taking the average of these two values which is +350. Then, we draw the circle by plotting the points of gages #1 and 2. (strain-xx, shear strain /2). After this we find the following points:

	(x,y) coord in micro-in/in	angle produced from center (350,0)
Center	(350,0)	
Gages #1 and #2	(1000,250)	arctan(250/(1000-350)) = 21.037511025421818 degrees
Gage #3	(946.7, 359.054132409028)	arctan(359.054/(946.7-350)) = 31.036714321560599 degrees
Gage #4	(1033.5, 133.310177155885)	arctan(133.310177155885/(1033.5-350)) = 11.036444090371834 degrees

As we know, rotation on the Mohr circle is positive in the CCW direction and the angle on the circle is double the actual rotation angle. So,

Gage #3 rotation = 1/2*(alpha3 – alpha1) = 4.999601648069390 degrees
~5.000 degrees (CCW by convention)
and
Gage #4 rotation = 1/2*(alpha4 – alpha1) = -5.000433467524992 degrees
~ -5.000 degrees (CW by convention

A diagram of my work has been attached on a separate page explaining my visuals.

<u>Gage #3</u> rotation from expected (α_1)

$\Delta\alpha = \frac{1}{2}(\alpha_3 - \alpha_1) \approx \boxed{+5.000°}$ (CCW)

Gage #4 rotatation from expected (α_1)

$\Delta\alpha = \frac{1}{2}(\alpha_4 - \alpha_1) \approx \boxed{-5.000°}$ (CW)