

Failure theories applied at critical point in the hub-assembly



Below in the table are given the temperatures and strains as a function of time at the critical location (Gage 13) on the hub surface when the trunnion-hub assembly is immersed in liquid nitrogen. The strain is measured using a 45° rosette. Strain gage A is located along the radial direction and strain gage C is along the hoop direction.

Apply the failure theories discussed in class and calculate the factor of safety

- **Maximum stress**
- **Maximum strain**
- **Von-Mises**
- **Beltrami**
- **Octahedral**

Remember the strength of steel changes as a function of temperature as given in Table 2. So account for this phenomenon while applying the failure theories. Summarize the factor of safety results obtained from the above failure theories.

Table 1: Strain and temperature at Gage 13 location

TIME	TEMPERATURE	STRAIN - A	STRAIN - B	STRAIN - C
	°F	10 ⁻⁶	10 ⁻⁶	10 ⁻⁶
0:00:00	76.670	17.131	38.408	96.834
0:00:32	-51.516	111.023	119.318	218.509
0:01:05	-81.032	198.077	243.523	308.454
0:01:39	-98.935	337.131	290.239	458.710
0:02:11	-112.945	412.325	345.234	535.710
0:02:44	-124.764	329.804	361.540	602.149
0:03:17	-139.202	328.992	403.272	627.262
0:03:50	-155.587	266.971	476.784	727.091
0:04:23	-179.963	227.907	545.046	842.550
0:04:56	-213.936	188.148	554.839	962.914
0:05:29	-265.008	274.233	660.997	1120.539
0:06:02	-274.504	206.003	600.260	1095.058

0:06:35	-280.257	142.667	543.347	1058.986
0:07:08	-284.320	110.287	507.332	1025.088
0:07:41	-287.006	67.571	463.857	992.376
0:08:14	-289.867	30.592	425.405	960.724
0:08:47	-292.100	5.781	393.370	928.650
0:09:20	-293.502	-16.995	364.813	896.815
0:09:53	-294.429	-37.443	336.068	858.668
0:10:26	-295.434	-46.914	318.310	830.799
0:10:59	-296.219	-56.088	300.849	796.744
0:11:33	-296.819	-52.679	292.021	767.730
0:12:06	-297.345	-50.132	284.851	739.656
0:12:38	-297.796	-48.091	267.457	704.232
0:13:11	-298.060	-39.971	252.547	669.136
0:13:45	-298.514	-40.430	229.414	640.580
0:14:17	-298.816	-37.252	218.557	607.023
0:14:50	-299.157	-35.424	200.233	571.036
0:15:23	-299.537	-33.864	187.759	536.224
0:15:56	-299.499	-37.905	177.238	508.772
0:16:29	-299.955	-34.008	162.425	478.465
0:17:02	-300.221	-29.450	150.432	441.980
0:17:36	-300.374	-34.140	137.105	412.444
0:18:09	-300.679	-32.364	118.011	387.939
0:18:41	-300.870	-29.768	120.608	359.218
0:19:14	-301.023	-25.459	120.241	326.453
0:19:48	-301.214	-7.750	109.171	267.507
0:20:20	-301.367	5.557	95.136	228.275
0:20:53	-301.597	19.764	67.611	180.590
0:21:27	-301.904	31.639	41.712	138.493
0:22:00	-302.134	35.784	14.919	112.775
0:22:32	-302.365	33.097	-5.034	79.506
0:23:05	-302.788	33.400	-19.479	62.900
0:23:39	-302.981	32.070	-24.765	43.582
0:24:11	-302.942	32.336	-29.895	31.976
0:24:44	-303.212	35.516	-33.550	14.291
0:25:17	-303.212	27.242	-45.779	3.860
0:25:51	-303.367	30.140	-51.153	-11.587
0:26:24	-303.482	22.873	-63.095	-26.408
0:26:56	-303.598	19.204	-68.562	-39.788
0:27:30	-303.831	23.021	-67.983	-43.885
0:28:03	-303.792	15.729	-77.071	-55.491
0:28:35	-303.792	17.528	-82.826	-64.123
0:29:08	-303.831	15.466	-83.088	-69.781
0:29:42	-304.063	12.813	-88.978	-78.908
0:30:15	-304.140	12.649	-93.098	-83.747
0:30:48	-304.295	11.244	-98.818	-91.985

0:31:20	-304.140	8.332	-100.650	-98.493
0:31:54	-304.257	7.908	-101.794	-98.917
0:32:27	-304.295	2.970	-107.810	-103.134
0:33:00	-304.451	3.725	-109.572	-109.572
0:33:33	-304.412	0.749	-115.065	-112.188
0:34:06	-304.412	1.828	-116.504	-115.065
0:34:39	-304.645	0.626	-114.109	-116.986
0:35:12	-304.606	1.245	-118.165	-124.278
0:35:45	-304.684	-5.390	-125.158	-127.315
0:36:18	-304.645	-4.410	-123.819	-132.450
0:36:51	-304.956	-8.283	-126.252	-132.366
0:37:24	-304.723	-5.289	-125.777	-134.408
0:37:57	-305.034	-5.563	-126.769	-138.996
0:38:30	-305.189	-6.955	-130.678	-142.186
0:39:03	-305.228	-9.093	-130.298	-140.008
0:39:36	-305.228	-7.295	-132.816	-147.200
0:43:36	-305.345	-5.909	-131.790	-143.657
0:47:36	-305.423	-6.063	-133.382	-145.969
0:51:36	-305.423	-15.415	-139.496	-147.048
0:55:36	-305.501	-15.929	-140.729	-149.359
0:59:36	-305.618	-14.540	-139.340	-150.847
1:03:36	-305.618	-16.698	-142.576	-152.286
1:07:36	-305.696	-13.254	-139.852	-152.438
1:11:36	-305.579	-13.564	-140.163	-155.266
1:15:36	-305.618	-16.339	-139.340	-159.837
1:19:36	-305.657	-13.717	-141.394	-155.059
1:23:36	-305.735	-15.308	-142.625	-155.930
1:27:37	-305.813	-14.381	-143.496	-155.722
1:31:37	-305.813	-15.100	-143.136	-156.082
1:35:37	-305.735	-16.747	-142.265	-160.605
1:39:37	-305.852	-16.434	-143.751	-161.731
1:43:37	-305.813	-15.460	-144.215	-155.722
1:47:37	-305.891	-15.610	-146.523	-156.951
1:51:37	-305.891	-14.891	-144.725	-159.469

Table 2: Yield strength of cast steel as a function of temperature

Temperature	Yield Strength
°F	ksi
-250	86
-150	62
-50	50
0	45
50	40