Regression Analysis of Markl Girth Butt Weld Data

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The following data was taken from Markl's 1952 paper which provides the fatigue test results of girth butt weld data. AutoCAD was used to scale the image in the X & Y axes such that each axis conformed to the log values. Following this step, circles were drawn over each data point as shown in Figure 1. Finally, the center point of each circle was determined from AutoCAD thereby providing the log value of cycles and stress.

Data points taken from Markl's fatigue set are provided in Table 1. Note that the results include fatigue tests with and without backing rings.

Once the data was in electronic format, several curves were fit to the data set (see Page 2). The best fit to the data was a linear fit. Two cases were analyzed: failures with and without backing rings and only failures without backing rings. The following conclusions can be made:

1. In both cases, the original Markl equation for failure stress range (S=490*N^-0.20) was not consistent with the regression analysis results.
2. The regression analyses suggest a slightly steeper slope of m = 4.47 instead of Markl's m = 5.0.
3. The regression analysis indicates a higher coefficient of 557.2 ksi instead of 490.0 ksi.
4. The data set without backing rings indicates a slightly higher life with a fatigue coefficient of 608 ksi vs. 557 ksi for the combined data set.

In addition, a best fit FSRF calculator was used to determine the FSRF for use with the ASME low carbon steel design curves. The results of this analysis are included on Page 3. Again, two cases were analyzed: data with and with backing rings, and only data without backing rings. Some conclusions on the best fit FSRF results:

1. The ASME mean curve and Markl's data set appear to have different slopes.
2. The best fit FSRF was 2.43 for the combined data set and 2.58 for the data without backing rings.
3. The FSRF for the combined data set is slightly lower than the FSRF for only data without backing rings. This is in contrast to the regression analysis but could be due to the greater number of data points for tests with backing rings, or could be due to increased strengthening of the weld joint due to the presence of the backing rings.

Regression analysis for data including "various backing rings" and "no backing rings":

METHOD	Ao	A1	So	Se	R^2
1. Linear	12.8099	-4.6649	0.00	0.2203	0.8756
2. Non-Linear	12.8099	-4.6649	0.0000	0.2203	0.8756
2. Langer	7.6668	-2.0000	20.0000	0.3103	0.8518

BEST FIT EQUATIONS USING EQ 2.0

Linear	:	Sf = [557.2090 * Nf^(1/-4.6649)]
Non-Linear	:	Sf = [557.2090 * Nf^(1/-4.6649)] + 0.0000
Langer	:	Sf = [6813.9666 * Nf^(1/-2.0000)] + 20.0000

Regression analysis for data including only "no backing rings":

METHOD	Ao	A1	So	Se	R^2
1. Linear	12.3120	-4.4220	0.00	0.1731	0.9022
2. Non-Linear	12.3120	-4.4220	0.0000	0.1731	0.9022
2. Langer	7.5863	-2.0000	20.0000	0.2482	0.8718

BEST FIT EQUATIONS USING EQ 2.0

Linear	:	Sf = [608.4999 * Nf^(1/-4.4220)]
Non-Linear	:	Sf = [608.4999 * Nf^(1/-4.4220)] + 0.0000
Langer	:	Sf = [6210.8351 * Nf^(1/-2.0000)] + 20.0000

Best fit FSRF For data including "various backing rings" and "no backing rings":

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Best Fit FSRF       = 2.4300
Standard Error      = 0.1161 (see Note #3 below)
r^2                 = 0.8756
Number Data Points = 52
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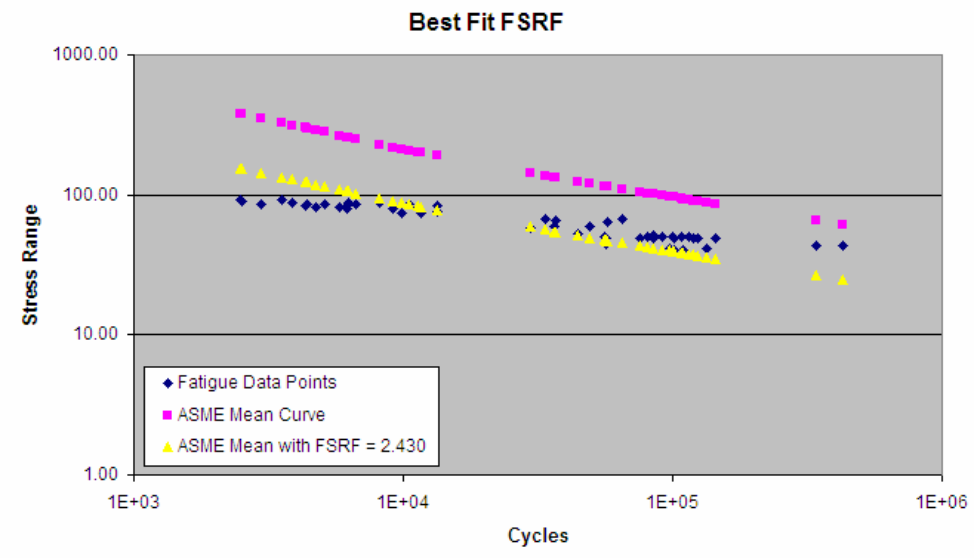

Best fit FSRF for data including only "no backing rings":

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Best Fit FSRF       = 2.5800
Standard Error      = 0.0942 (see Note #3 below)
r^2                 = 0.9022
Number Data Points = 17
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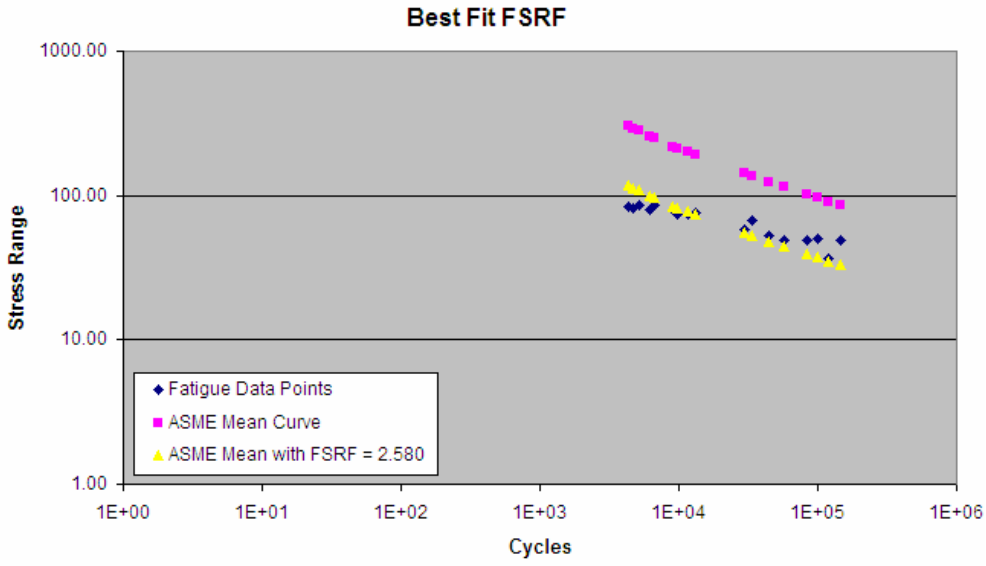

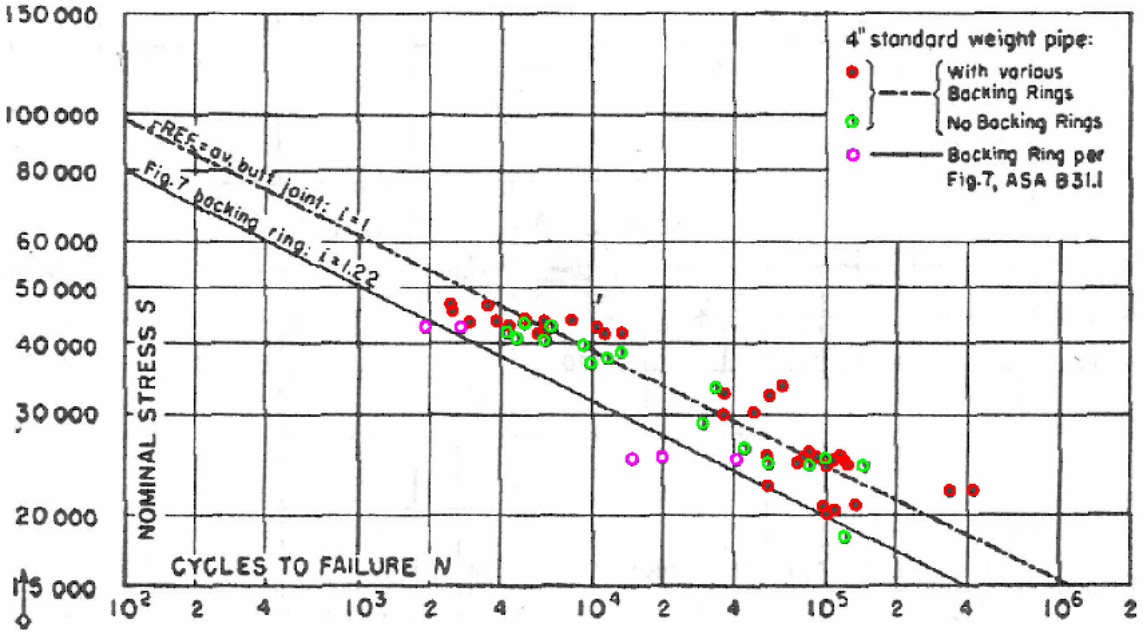

Figure 1 – Markl's girth butt weld test data (1952)

Table 1 – Markl Girth Butt Weld Data

		Log(Sa)	Log(N)	Nominal Alternating Stress	Failure
	Description	psi	cycles	(psi)	Cycles
1	various backing rings	4.6683	3.3929	46591	2471
2	various backing rings	4.656	3.4012	45290	2519
3	various backing rings	4.6362	3.4747	43271	2983
4	various backing rings	4.665	3.552	46238	3565
5	various backing rings	4.6381	3.5904	43461	3894
6	various backing rings	4.6303	3.6447	42687	4413
7	various backing rings	4.6155	3.7662	41257	5837
8	various backing rings	4.6196	3.7922	41649	6197
9	various backing rings	4.6381	3.7943	43461	6227
10	various backing rings	4.6394	3.9122	43591	8170
11	various backing rings	4.6276	4.0197	42423	10464
12	various backing rings	4.6159	4.0525	41295	11285
13	various backing rings	4.617	4.1276	41400	13415
14	various backing rings	4.5112	4.5652	32449	36745
15	various backing rings	4.474	4.562	29785	36475
16	various backing rings	4.4773	4.6925	30012	49261
17	various backing rings	4.5079	4.7588	32203	57385
18	various backing rings	4.5244	4.8138	33450	65133

19	various backing rings	4.4022	4.747	25246	55847
20	various backing rings	4.3493	4.7506	22351	56312
21	various backing rings	4.3896	4.877	24524	75336
22	various backing rings	4.3992	4.906	25073	80538
23	various backing rings	4.4087	4.9283	25627	84781
24	various backing rings	4.3994	4.9614	25084	91496
25	various backing rings	4.3841	5.0031	24216	100716
26	various backing rings	4.3944	5.0347	24797	108318
27	various backing rings	4.4018	5.0624	25223	115452
28	various backing rings	4.3931	5.0792	24723	120005
29	various backing rings	4.3858	5.0937	24311	124079
30	various backing rings	4.3131	4.9882	20564	97320
31	various backing rings	4.3	5.0047	19953	101088
32	various backing rings	4.307	5.0377	20277	109069
33	various backing rings	4.3159	5.1275	20697	134122
34	various backing rings	4.341	5.5304	21928	339156
35	various backing rings	4.341	5.6303	21928	426874
36	no backing rings	3.6347	4.6186	41553	4312
37	no backing rings	3.6753	4.6081	40560	4735
38	no backing rings	3.7092	4.6341	43063	5119
39	no backing rings	3.7931	4.6053	40300	6210
40	no backing rings	3.8222	4.6295	42609	6640
41	no backing rings	3.9614	4.5963	39473	9150
42	no backing rings	3.9938	4.5645	36686	9858
43	no backing rings	4.0653	4.5734	37446	11623
44	no backing rings	4.1247	4.5832	38300	13326
45	no backing rings	4.4726	4.4595	28807	29689
46	no backing rings	4.5275	4.5217	33243	33690
47	no backing rings	4.6508	4.4156	26038	44751
48	no backing rings	4.7534	4.3895	24519	56676
49	no backing rings	4.9284	4.3857	24305	84801
50	no backing rings	4.9985	4.3975	24975	99655
51	no backing rings	5.0793	4.2603	18210	120033
52	no backing rings	5.1596	4.3849	24261	144411
53	fig 7 backing rings	4.6289	3.2847	1926	42550
54	fig 7 backing rings	4.6274	3.4363	2731	42403
55	fig 7 backing rings	4.3966	4.1709	14822	24923
56	fig 7 backing rings	4.4002	4.2989	19902	25130
57	fig 7 backing rings	4.3957	4.6172	41419	24871