A COMPARISON OF THE EFFECT OF PEENING USING CUT WIRE AND CAST STEEL SHOT ON FATIGUE PERFORMANCE OF 7010-T7651 ALUMINIUM ALLOY PLATE.

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ABSTRACT

Cut wire shot offers a significantly longer media life than cast steel shot which may therefore offer a cost advantage. Because of its tighter size distribution, cut wire shot could produce a more consistent depth of compression, which may be reflected in an improved fatigue performance.

In order to evaluate the potential of conditioned cut wire as an alternative to cast steel shot, rotating bending test specimens in 7010-T7651 were shot peened with each media to normal production intensity and fatigue tested under the same conditions.

The use of conditioned cut wire shot did not show any significant improvement in the fatigue performance of typical Airbus spar/rib material. Evaluation of peening with an improved conditioning standard of cut wire (SCCW) showed a significant improvement in fatigue performance compared to the baseline cast steel test specimens peened under the same conditions.

INTRODUCTION

Cut wire shot potentially offers a significantly longer media life than cast steel shot for peening. There could therefore be some cost benefit in changing from cast steel to this media. Because of the tighter size distribution of cut wire shot, it might be assumed that a more consistent depth of compressive layer could be produced. This may benefit the fatigue performance of the aircraft components we produce.

In order to consider any change in material or processing, which may affect the performance of aircraft components, it is necessary to evaluate the implications in a qualification programme. Normally, the performance of components is assessed by carrying out full scale testing, such as the major fatigue test. The results from these tests are then used to certify the aircraft and define the maintenance and inspection schedules. Because it is not practical or economic to repeat these tests, it is essential that we can demonstrate that the fatigue performance is at least as good as that obtained with our existing processing standard used for these full scale tests before it can be considered for use in production.

PROCEDURE

Material

It was agreed that test specimens would be produced from aluminium alloy 7010-T7651 plate, a material used extensively in the manufacture of Airbus wings.(1,2)

Test specimen

A simple plain toroidal fatigue specimen with a stress concentration factor, K_t of 1.0, Fig.1, was selected to assess the relative effect of peening with the alternative media on the fatigue life.(1,2)

PROCEDURE continued

Shot Peening

Saturation peening was carried out in accordance with British Aerospace Airbus Limited process specification ABP 1-2028 to give a minimum coverage of 100% at an Almen intensity of 0.008"A using either :-

MIL-S-851 Type I (HRC 45-55), S230 size, cast steel shot, or
MIL-S-851 Type III , CW-23, conditioned carbon steel cut wire.

see Table 1.

The peening method used was similar to that applied to fasteners used on Airbus aircraft. The test specimens were placed in a fixture ref. Fig.2and then peened using a single 1/4" nozzle with a stand-off of 5.5" and a translational speed of 2.5 in/s. The test specimens were given one pass, and then rotated through 90° and peened again, a further seven times to ensure adequate coverage.
Finally, test specimens were decontaminated in 60%v/v nitric acid.(1,2)

Fatigue Testing

The shot peened test specimens were subjected to rotating bending fatigue testing with single point loading in accordance with BS 3518 Part 2.(1,2)

RESULTS

This programme of work was carried out in two stages.
Initial work was undertaken with specimens peened using conditioned cut wire from Taydor and compared with baseline of test specimens peened with cast steel shot.

Results from the initial testing (3) ref. Table 2 indicated that the lives of the shot peened specimens were adversely affected by the change in peening media from cast steel to conditioned cut wire. The mean life of these cut wire specimens being 1,234,220 cycles, which is significantly lower than that obtained for the cast steel shot (1,642,920 cycles).

These results were unexpected and contrary to our previous experience (4), consequently the shape of the cut wire used was then closely examined.
It was then agreed that the lower fatigue life of the specimens peened using cut wire could be related to the condition of the cut wire used in these initial tests. It was therefore decided to evaluate a more spherical conditioning standard of cut wire media in the second stage of this work.

Josef Frohn was selected from a number of suppliers considered suitable as sources of this spherically conditioned cut wire (SCCW) because of the high degree of roundness of their media and the availability of their product within the project timescales.

In order to relate the test results for the SCCW to those obtained for the cast steel specimens tested in the first stage of this work, it was agreed that the fatigue tests would be carried out using the same alternating stress. However, the first three specimens tested (CS6, CS7 and SCCW1) exhibited extremely high fatigue lives (around 4,000,000 cycles).

Consequently, the alternating stress was increaased to 230 MPa for the remaining test specimens. Results of the second stage fatigue testing (5) ref. Table 2 indicate that the use of spherically conditioned cut wire is at least as good as cast steel.

DISCUSSION

From the initial fatigue results ref. Table 1, specimen CS3 gave an unrepresentative early failure due to initiation at a region of folded material on the peened surface (4). This initial data, omitting the result for CS3, gives a mean life of 1,234,420 for conditioned cut wire and 1,920,350 for cast steel tested under the same conditions, ref. Fig.3. This indicates that peening with this conditioning standard of cut wire could adversely affect the fatigue life compared to peening with cast steel shot.

The results from the folowing specimens were omitted from the investigation of the second stage results :-

Test specimens CS6, CS7 and SCCW1 were tested to a lower alternating stress level than that used for the remaining specimens.

Specimen SCCW9 was classed as an extreme observation or outlier by our analysis software.

Specimens CS11 and CS12 were peened after the other specimens used in the second stage and show batch to batch variability, having significantly higher lives than the other specimens tested under the same conditions.

Analysis of the remaining results from the second stage testing gave a mean life for SCCW of 2,307,638, at least as high as that obtained for cast steel which was 1,471,367, ref. Fig.3.

CONCLUSIONS

This test programme has demonstrated that the conditioning standard of the cut wire does have a significant effect on the fatigue performance of the peened components. Approval of spherically conditioned cut wire media has only been given after introduction of controls to ensure that the media is conditioned, as a minimum, to the standard used in the second stage of this testing.

CONCLUSIONS continued

Concerns have been generated regarding the differences in fatigue performance obtained. A simple test specimen geometry and a straightforward procedure has been used throughout. It may therefore be reasonable to attribute these differences to variations in the peening process. In consequence, we have reviewed our control of the process application in order to ensure a repeatable standard of saturation peening.

REFERENCES

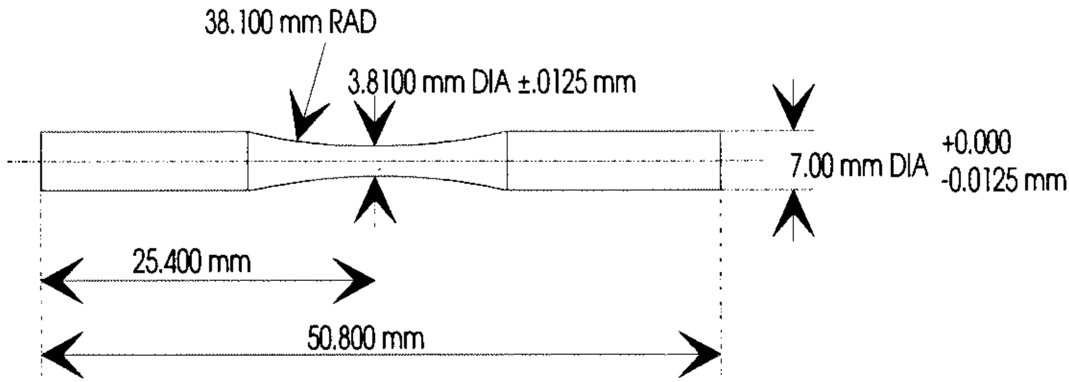
1. P E Edwards - Qualification of conditioned carbon steel cut wire shot (MIL-S-851 Type III) for saturation peening Airbus parts. (Ref. GEN/B44/82755)

2. P E Edwards - Further work for qualification of conditioned carbon steel cut wire shot (MIL-S-851 Type III) for saturation peening Airbus parts. (Ref. GEN/B4402/83129)

3. M G Burns - Qualification of conditioned carbon steel cut wire shot for saturation peening Airbus parts - stess corrosion and fatigue testing. (Ref. B23/94/1439)

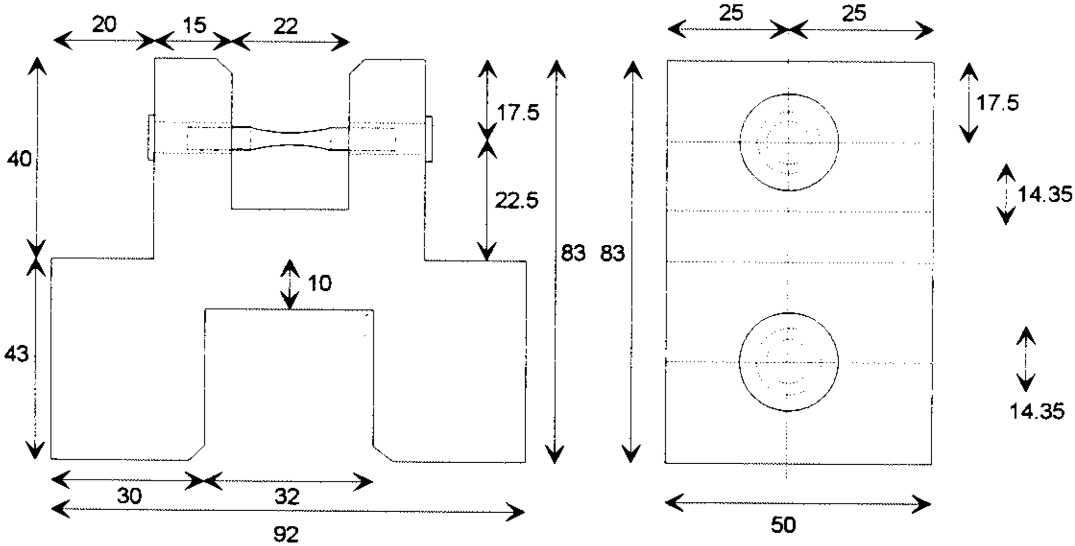
4. R A Collins - Fatigue assessment of alternative peening media (Ref. GEN/B5607/63898)

5. MET Test certificate No W095055 (Feb 1995)



Not to scale

Figure 1 - Plain Toroidal Fatigue Specimen



ALL DIMENSIONS IN mm

NOT TO SCALE

Figure 2 - Peening Test Jig

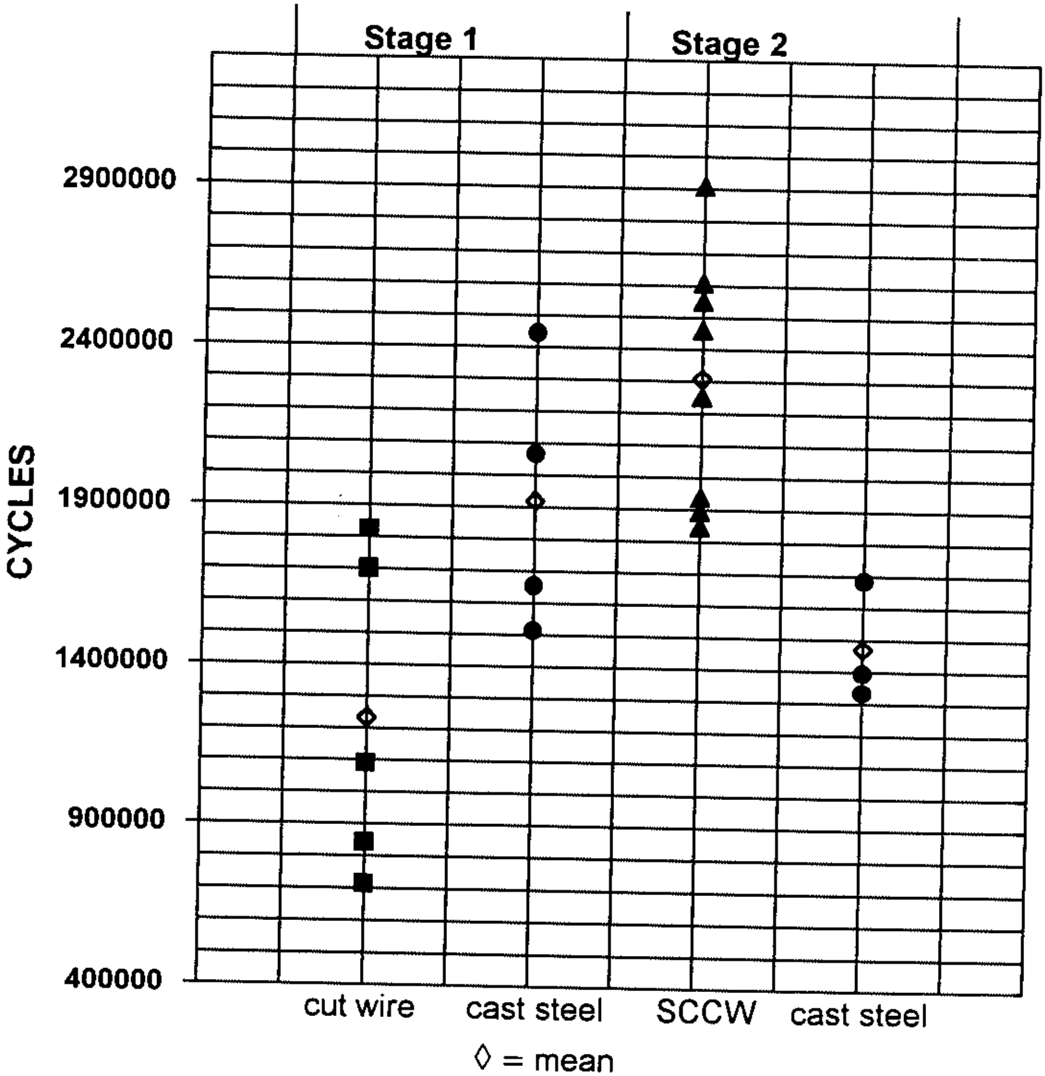


Figure 3 - Fatigue Test Results

MEDIA	SIZE	NO OF TEST SPECIMENS	STRESS AMPLITUDE (MPa)	MEAN STRESS (MPa)
CAST STEEL (CS1-CS5)	S230	5	200	0
CUT WIRE (CW1-CW5)	0.6 mm	5	200	0
CAST STEEL (CS6-CS7)	S230	2	200	0
SPHERICALLY CONDITIONED CUT WIRE (SCCW1)	0.6 mm	1	200	0
CAST STEEL (CS8-CS12)	S230	5	230	0
SPHERICALLY CONDITIONED CUT WIRE (SCCW2-10)	0.6 mm	9	230	0

Table 1 - Test Matrix

MEDIA	IDENT.	STRESS AMPLITUDE (MPa)	MEAN STRESS (MPa)	CYCLES
CUT WIRE	CW1	200	0	1090600
	CW2	200	0	841900
	CW3	200	0	1823000
	CW4	200	0	714100
	CW5	200	0	1701500
CAST STEEL	CS1	200	0	2067600
	CS2	200	0	2443300
	CS3	200	0	533200
	CS4	200	0	1514200
	CS5	200	0	1656300

Table 2 - Initial Fatigue Results

MEDIA	IDENT.	STRESS AMPLITUDE (MPa)	MEAN STRESS (MPa)	CYCLES
CAST STEEL	CS6	200	0	4409100
	CS7	200	0	3769000
	CS8	230	0	1394300
	CS9	230	0	1686600
	CS10	230	0	1333200
	CS11	230	0	3091600
	CS12	230	0	3238700
SPHERICALLY CONDITIONED CUT WIRE	SCCW1	200	0	3797900
	SCCW2	230	0	1847400
	SCCW3	230	0	1938700
	SCCW4	230	0	2551800
	SCCW5	230	0	2908000
	SCCW6	230	0	1894900
	SCCW7	230	0	2607500
	SCCW8	230	0	2459700
	SCCW9	230	0	4563900
	SCCW10	230	0	2253100

Table 3 - Second Stage Fatigue Results