OPTIMUM SHOT PEENING PARAMETERS TO IMPROVE FATIGUE STRENGTH OF WELDED STRUCTURAL STEELS

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ABSTRACT

Shot peening parameters were optimised by use of pneumatic shot peening methods under controlled conditions. Optimum fatigue strength values were obtained and reported in this paper for welded structural steel joints.

KEYWORDS

Tensile stress, Residual stress, Peening intensity, Coverage, Rotating bending.

1. INTRODUCTION

Heat generated welding processes often produce tensile stresses approaching the yield strenth of the material. These harmful self stresses in the heat affected zone may contribute to poor fatigue characteristics of weldments. Shot peening has been considered to be a prefered method for improving fatigue strength based on introduction of surface compressive residual stresses (Daly, 1977)

2. EXPERIMENTATION

Saturation curves were plotted and the corresponding peening intensities were determined, using pneumatic controlled shot peening. The test specimens were shot peened after applying the correction factors for determining the modified peening time.

Rotating bending fatigue strength at two million cycles to failure for different treatments : virgin, welded, shot peened and wleded-shot peened were carried out and the fatigue strength in each case was determined using stair-case method.

The details of the mechanical and chemical properties and shot peening parameters are tabulated below :

Table 1. Chemical Composition (%)

C	Mn	S	P	Si
0.12	0.20	0.023	0.026	0.10

Table 2. Welding Details

S.No.	Details	Value
1.	Type	Double V butt joint welded allaround
2.	T.G.	16 mm, 3 mm
3.	Reference	AWS proqualified joints
4.	Process	Manual, arc welding
5.	Current	100 Amp. for 3.15 mm electrode
6.	Rotation	Uniform-manually
7.	Chipping	After 1st, 2nd and 3rd run
8.	NDT	O.K.

Table 3. Mechanical Properties

S.No.	Test Condition	YS MPa	UTS MPa	%Elong	Remark
1.	Virgin	340-360	525-570	25-30	
2.	Welded		400-475		Bend test O.K.

Table 4. Shot peening parameters

S.NoParameters	Values	Remark
1.Almen strip	N or A	Variable
2.Air Pressure (P), MPa	0.4 to 0.5	Variable
3.Size of steel shot (SS), S	170,230,330,390,550	Variable
4.Nozzle dia., mm	6 and 8	Variable
5.Mass flow (m), kg/s	0.060 to 0.180	Variable
6.Stand off, mm	145	Constant
7.Reciprocating speed of nozzle, m/s	0.050	Constant
8.Rotational speed of work pc, rpm	15	Constant
9.Angle of impingement, degree	90	Constant
10.Fullway valve opening, degree	45	Constant

3. THE OPTIMISED DATA

The determined shot peening intensities were found out for the variable shot peening parameters as given in Table 5.

Table 5. Shot peening Intensities

Sl. No.	Almen strip	Pressure MPa	Shot size S	Nozzle dia mm	Mass flow Kg/s	P.I. x0.1 mm
1.	N	0.10	170	6	0.014	16*
2.	N	0.20	170	6	0.05	19
3.	N	0.30	170	6	0.079	22
4.	N	0.40	170	6	0.107	25
5.	A	0.30	170	8	0.160	34
6.	N	0.40	170	8	0.150	45
7.	N	0.50	170	8	0.980	55
8.	A	0.30	230	8	0.100	36
9.	A	0.50	230	8	0.150	63
10.	N	0.10	330	6	0.069	20
11.	N	0.20	330	6	0.089	27
12.	A	0.30	330	6	0.110	33
13.	A	0.40	330	6	0.121	35
14.	A	0.30	330	6	0.168	37
15.	N	0.10	330	6	0.113	23
16.	N	0.20	330	8	0.140	37
17.	A	0.30	330	8	0.160	38
18.	A	0.50	330	8	0.18	70
19.	A	0.30	390	8	0.170	50
20.	A	0.50	550	8	0.170	78
21.	A	0.30	550	8	0.130	60
22.	A	0.50	550	8	0.150	85

* 16A = 0.16 mm of the arc height obtained on Almen strip A.

On the basis of optimum improvement in fatigue strength and minimum surface roughness the optimised values of the shot peening intensity (PI), shot size (SS) and mass flow (m) were found to be as given below in table 6.

Table 6. Optimised shot peening parameters

S.No.	Parameter	Optimum value	Optimm Range
1.	Peening Intensity (PI)	0.38A	0.30 - 0.50A
2.	Shot size	S-330	S-330-460
3.	Mass Flow Rate	0.160 Kg/s	0.100 - 0.160 Kg/s

The modifying factors to reproduce the above peening intensities on the work-piece were determined by modifying the Almen saturation time (to = 25 sec.) to the peening time (PT) as per geometry and material of the work piece so as to produce the equivalent peening intensity on the work piece.

Table 7. Correction factors

S.No.	Factor	Value obtained	Obtained time	Modified Saturation or peening time(PT)
1.	Geometrical	CF=t1/to	t1=32 sec.	6(t1t2t3)/t / (to.to)
2.	Material	MF=t2/to	t2=14 sec.	6(32x14x8) / (25x25)
3.	Local	6.t3	t3=8 sec.	35 sec.

The improvement in fatigue strength using above parameters was found to be as in Table 8.

Table 8. Improved Fatigue Strength

Sl. No.	Steel	Endurance ratio (FS/UTS)	Test condition	Fatigue strength (MPa)	Improvement %
1.	16 mm dia	0.43	Virgin	235	0
		0.43	welded	172	-27
		0.43	Peened	288	23
		0.43	welded peened	203	-14

4. DISCUSSION

The presented optimised data can be used in service for the repair and maintenance of the welded structural steel joints

For steel if FS = 0.43 UTS, the fatigue strength level of the structural steel can be judged.

As the fatigue strength decreases upto 66% by welding then to make up this reduction from the fig. 1 the peening intensity (PI) can be obtained and this can further be adjusted nearest to those given in table 5.

Then the parameters corresponding to this adjusted inensity can be obtained from table 5.

Then the peening time can be obtained by applying the correction factors to the saturation tme to reproduce the equivalent shot peening intensity on the work piece. If UTS of the structural steel is found to be 550 MPa then its fatigue strength will be around 0.43 x 550 = 235 MPa.

Then this is again decreased by 40% (say) after welding and if it is also desired to have the fatigue strength level 15% higher after shot peening or say at 275

MPa.

Then the obtained PI from the graph corresponding to 275 MPa is 30.6 A and its adjusted value can be as 27 or 33A.

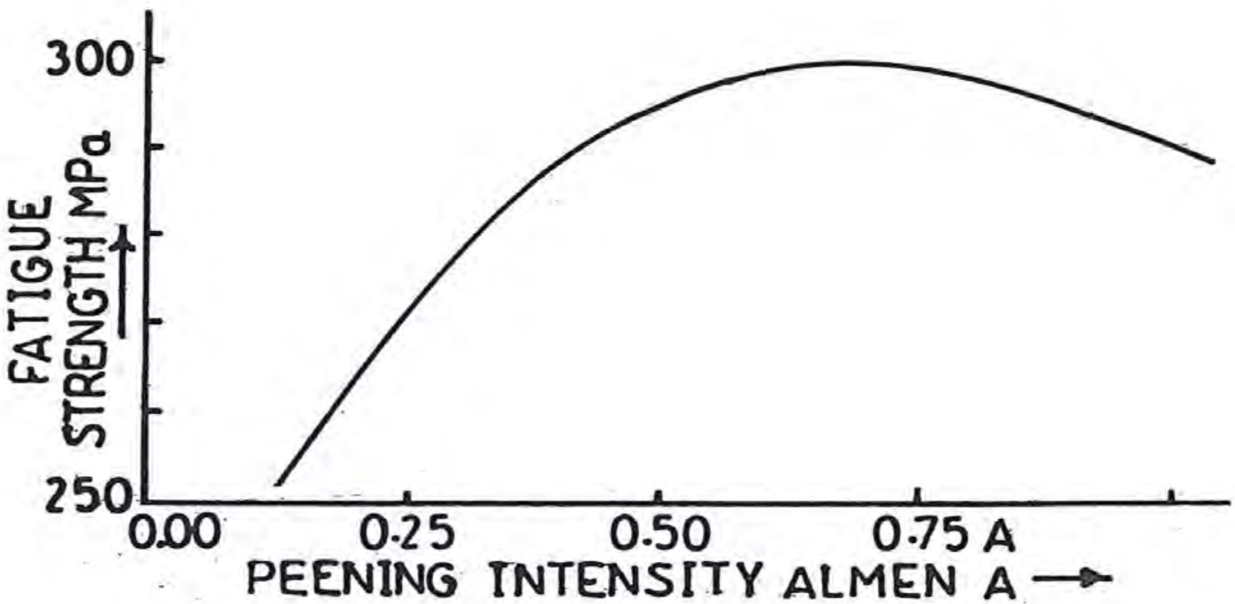

Fig. 1. Fatigue strength vs. peening intensity

Hence the parameters corresponding to 27 or 33A can be selected by modifying the saturation time which may improve the fatigue strength to nearly 270 or 280 MPa respectively.

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5. REFERENCES

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