BEHAVIOUR OF SHOT PEENED ELECTRON BEAM WELDED STAINLESS STEEL PLATE SAMPLES UNDER COMBINED REVERSE TORSIONAL AND BENDING CYCLIC STRESS

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ABSTRACT

For further knowledge of fatigue behaviour of materials and welded joints under combined stress fatigue, fatigue testing equipment was necessary to develop. The desired equipment could apply cyclic torque and bending deflections to the test specimen. It could allow independent and easy adjustment of mean and amplitude values of each type of deflection. Mechanism was capable of providing adjustable phase shift between torque and bending cycles. Arrangements were provided for measurement of angle of twist and deflection. Shot peening was found to be benefitial even under combined bending and torsional fatigue. The improvement in fatigue life was upto 100%.

KEY WORDS

Combined stress fatigue, Adjustable Amplitude of cyclic torque and bending deflections, Adjustable mean torque and bending deflection phase shift Shot Peening, Electron beam welding, Notch effect on σ_e endurance limit of chrom steel blading material.

INTRODUCTION

Electron beam welding has become a proven industrial process. As the power density in the beam is very high, 10^5 watt per sq. cm. is quite normal, depth to width ratio of 10:1 can be easily achieved.

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It produces narrow heat affected zone and low distortion. As machined parts can be welded directly eliminating the necessity of complicated machining and casting. This results is substantial reduction in cost of production. Electron beam welding is mostly carried out in vacuum the purity of the weld remains high. This enables to weld reactive materials by electron beam welding.

To get a deep penetration weld electron beam has to be focussed at half the job depth. Focussing the beam at the bottom or top of the job produces bed quality welds. For partial penetration welds root defects can be minimized if the weld speed is low. To carry out deep penetration weld with a narrow beam it is important to have extremely good alignment between the job and the beam. This stringent condition can be relaxed if beam is given a small oscillation. Most of our welds were carried out with beam oscillation.

The 10 KW Electron beam welder was used at 38.9 KV, 250MA, 19cms/min parameters for welding test pieces at BARC Trombay.

MECHANISM USED FOR COMBINED BENDING AND TORSIONAL FATIGUE LOADING:

The mechanism invented and used for design and development of combined stress fatigue testing machine was as shown in **Fig. 1** Variable eccentric drive with slider was used for adjustable vertical deflection of specimen. The vertical movement of the specimen was transmitted through a reck to gear drive using four gears as shown in the plan of Fig. 1. The gear drive provided simultaneous twist along with vertical deflection to the fixed end of the specimen through a segment gear. Arrangements have been provided to change gear train for getting different gear ratio for changing the amplitude of twist and phase shift. Fatigue specimen had been designed along with holding arrangement to provide ease of loading and unloading. Fatigue failure had been ensured for welded joints at the minimum gauge section. The above mechanism for combined stress is first of its kind development at Amir Tanks & Vessels Indore in collaboration with MACT, Regional Engg. College, Bhopal.

A combined bending and torsional fatigue testing machine was earlier design on four bar mechanism at Stanford University California by Fuchs [1,2].

EXPERIMENTAL WORK

Influence of Shot Peening on Combined Bending and Torsional fatigue behaviour was experimentally investigated.

Shot used	-	5.330 (0.8 mm dia steel shots)
Peening Intensity		0.25A
Coverage		200%

It was observed that fatigue life was increased from 50 to 100% after Shot Peening.

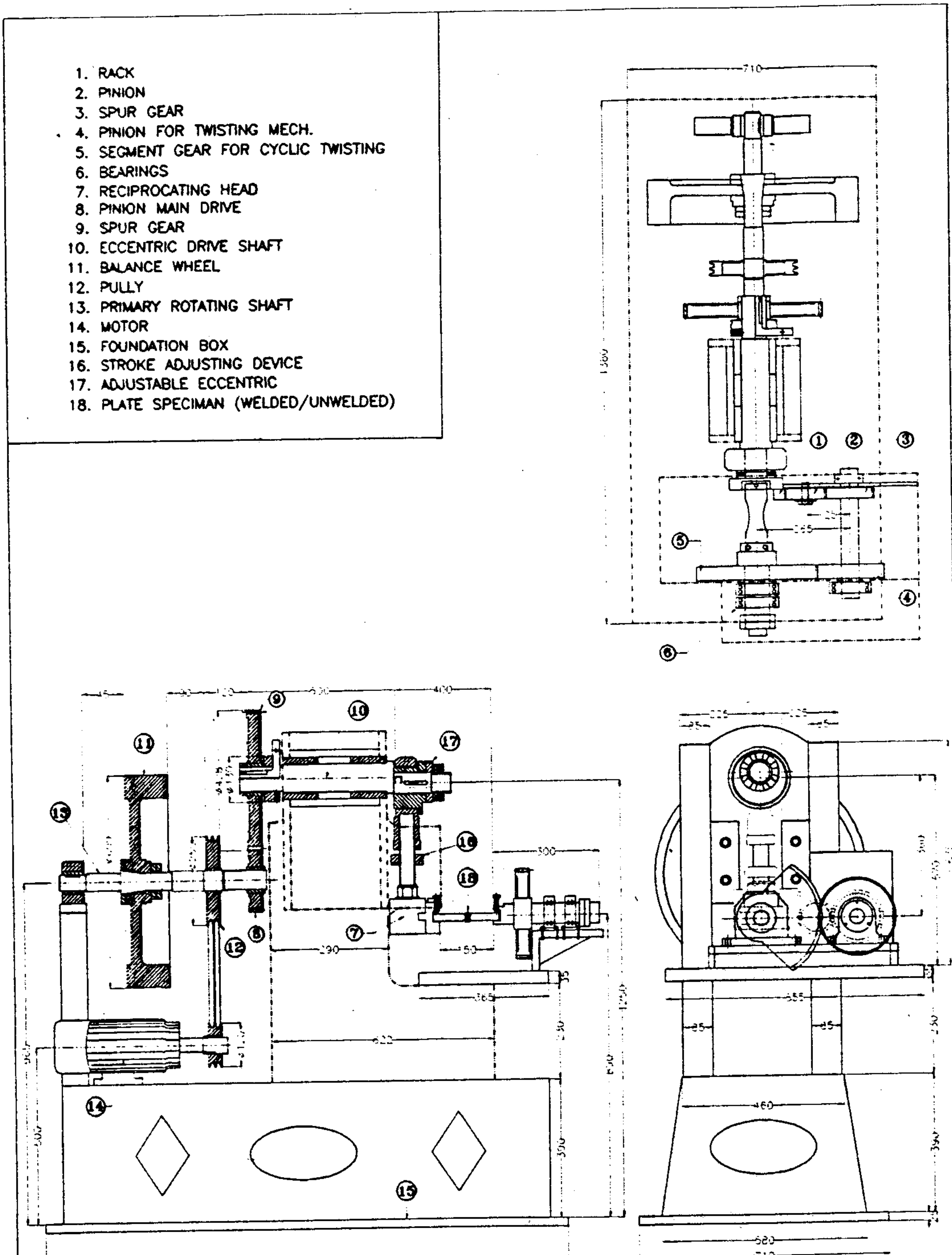
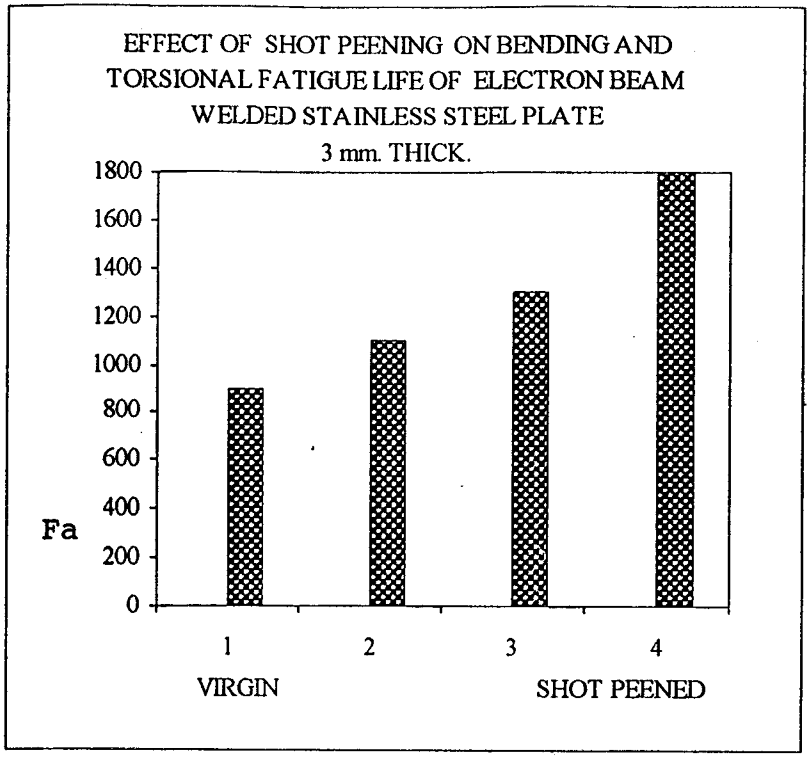


Fig.1. THE MECHANISM OF INDUCING COMBINED BENDING AND TORSIONAL FATIGUE LOADING/ TESTING MACHINE

The Bar Chart for fatigue life of origin and shot peened specimen under combined bending and torsional fatigue is shown below:-



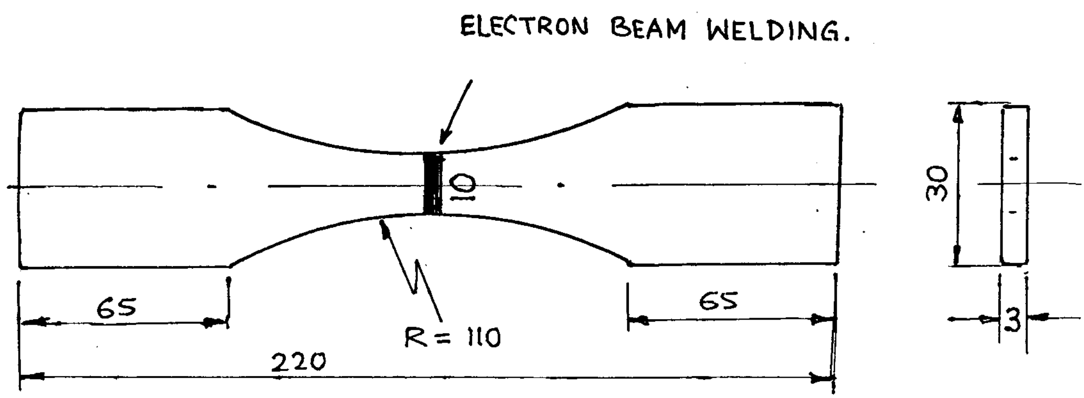
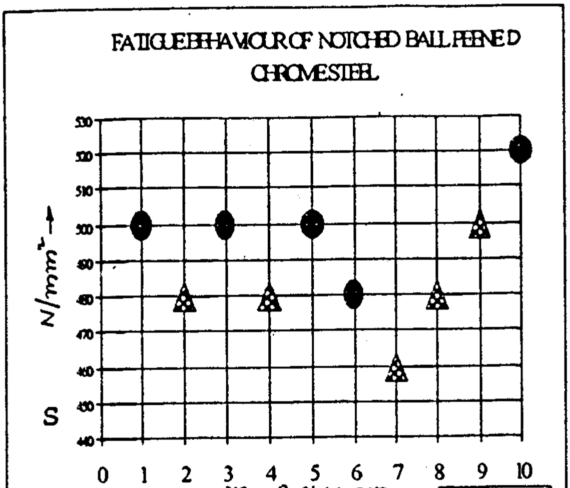


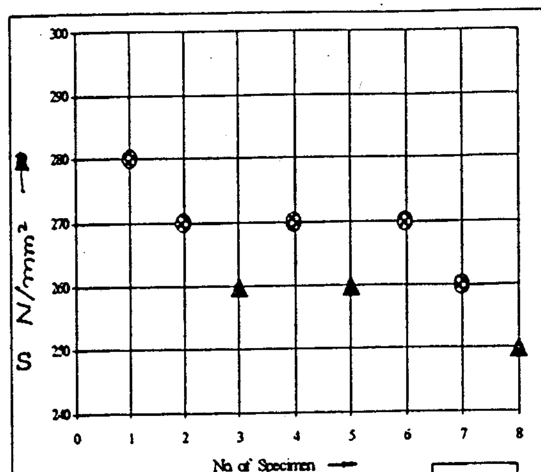
Fig. Details of Plate specimen used for Bending Torsional fatigue studies

In addition to above tests chrome steel of blading quality was also tested for rotating bending reversed fatigue loading for high cycle fatigue. Effect of notch and notch with shot peening on fully reversed fatigue behaviour was studied.

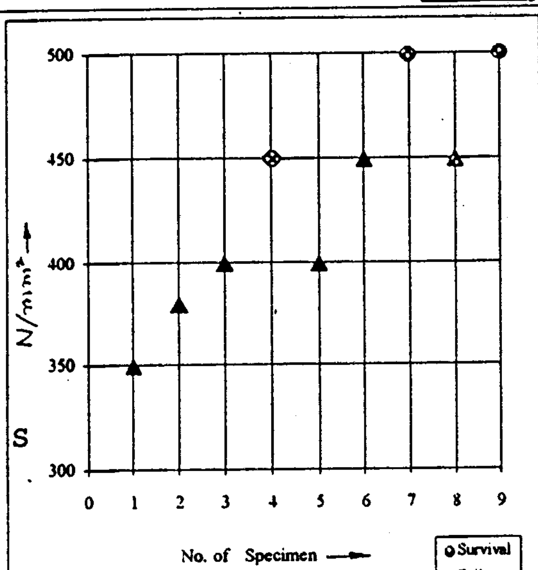
Stair case data for various tests were as follows:



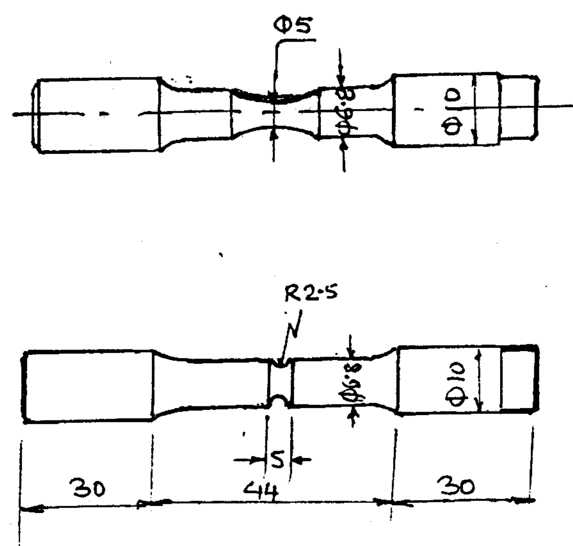
Mean fatigue limit of Virgin Chrome Steel



Mean fatigue limit of Notched Virgin Chrom Steel



Mean fatigue Limit of Ball Peened Chrome Ball



UN NOTCHED AND NOTCHED SPECIMENS

Mean fatigue limit of Virgin chrom steel was calculated by stair case data using the following equation [3,4].

$$\sigma_e = \sigma_0 + \bar{x} \; (A/N \pm 1/2)$$

σ_0 = Lowest stress level where survival occurred.
$\bar{x}$ = Fixed interval by by which stress level was increased or decreased.

$A = \sum i \times Ni$ = $\sum$ stress interval x No. of survival. $N = \sum Ni$

Mean fatigue limit of unnotched specimens was found to be = 493 N/mm^2
Similarly mean fatigue limit of notched samples found to be σ_e = 260 N/mm^2

The fatigue strength reduction factor = 493/260 $\approx$ 1.9
Mean fatigue limit of Ball peened notched specimen = 400.5 N/mm^2

Fatigue strength reduction factor of notched Ball peened specimen was = 493/400 $\approx$ 1.2

RESULTS AND DISCUSSIONS:

The combined bending and torsional fatigue testing machine designed and developed has performed well. The deflection and strain measuring system gave accuracy with in limits.

It was observed that shot peening enhances combined bending & torsional fatigue life of electron beam welded 3mm thick ss plate by hundred percent even through no stress rel;ieving was provided after welding. The loading was of high strain low cycle type and shot peening has proved to be benefitial even under combined bending and torsional fatigue.

In order to study the influence of ball peening on chrome steel turbine blade rotating bending plain and notched specimen were ball peened. Notch radii used was as per root radii of blade. Ball peening reduced the fatigue strength reduction factor from 1.9 to 1.2 and fatigue strength was increased by 54%. Ball peening with 3.1 mm Steel bearing ball proved to be quite effective in attaining requisite residual stress distribution. The increase in fatigue strength of blading steel was due to the presence of residual compressive stress.

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