Experimental Determination of Fatigue Strength as Related to Peening Intensity and Specimen Thickness

Michael M. Woelfel
Potters Industries, Inc.
Hasbrouck Heights, NJ U.S.A.

ABSTRACT

In this study, hardened steel specimens of different thicknesses are peened to different Almen intensities, and then tested to destruction or run-out in fully-reversed bending. Several specimens are tested at each of several stress levels to establish significant results. From the data, S-N curves are established showing the improvement in fatigue strength for each condition.

KEY WORDS

Shot Peening, Fatigue Strength, Almen Intensity, Thickness

INTRODUCTION

The basic function of shot peening is to improve the fatigue life or strength of cyclically-stressed metal components. This is achieved by generating, via the peening process, a shell or skin of plastically deformed material around the peened part. Although rarely more than a few thousandths of an inch thick, this peened skin, which is in a state of high residual compressive stress (self-stress), resists the nucleation and propagation of micro-cracks at the part surface.

Improved fatigue resistance takes two forms:

1. Increase in the number of cycles of stress reversal before failure (fatigue life) and,
2. Increase in fatigue strength, which is defined as the load or stress below which fatigue failure does not occur.

Much research in the past has been concerned with fatigue life improvement, and reports of increases of 500 or 600% are not uncommon. Perhaps of more interest to the typical design engineer would be fatigue strength. This would allow the design of a component that, at least theoretically, would not fail in fatigue.

Control of the shot peening process has been and is currently based on Almen intensity, a procedure well covered in the literature. Although this is a convenient way to monitor the process, it may not be the best predictor of a fatigue strengh. In the past, (see references (1), (2) and (3)), work has been done to assign an optimum Almen intensity to each cross-sectional thickness. It is the purpose of the present study to replicate this previous work, and most particularly to determine the correlation between Almen intensity and fatigue strength for differing specimen thicknesses.

EXPERIMENTAL DETAILS

Several hundred specimens were machined from AISI 1075 stock, in three different thicknesses (1/8", 3/32" and 1/16") and heat treated (through-hardened and drawn) to a hardness of 41-42 HRC. The specimens were triangular in shape, designed for uniform extreme-fiber stress in fully-reversed cantilever bending. Each specimen thickness was then peened in a direct-pressure blast cabinet, as follows:

Peening Media	- glass beads 300-425 micrometer
Nozzle diameter	- 0.25 in. (6.4mm)
Metering orifice	- 0.125 in. (3.2mm)
Nozzle distance and angle	- 6 in. (150mm), 90^o
Saturation	- 130 per cent
Almen intensities	- 4A, 7A, 11A

Approximately 200 specimens were tested at stress levels ranging downward from 50% of yield strength of the material. About 25% of the specimens were tested to run-out (approx. 2.5 x 10^6 cycles) to establish the flat portion of the S-N curve, and thus determine fatigue strengths.

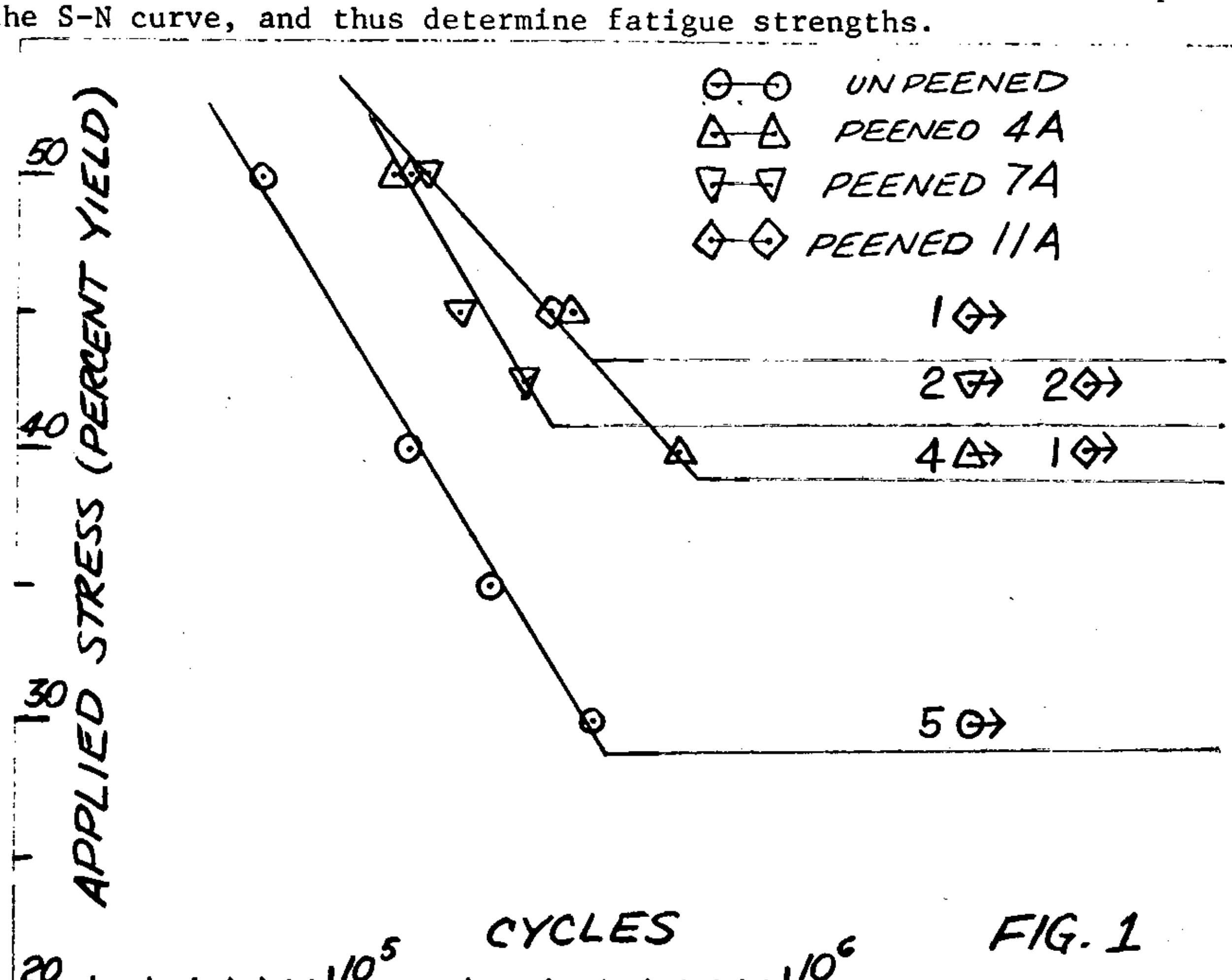

FIG. 1

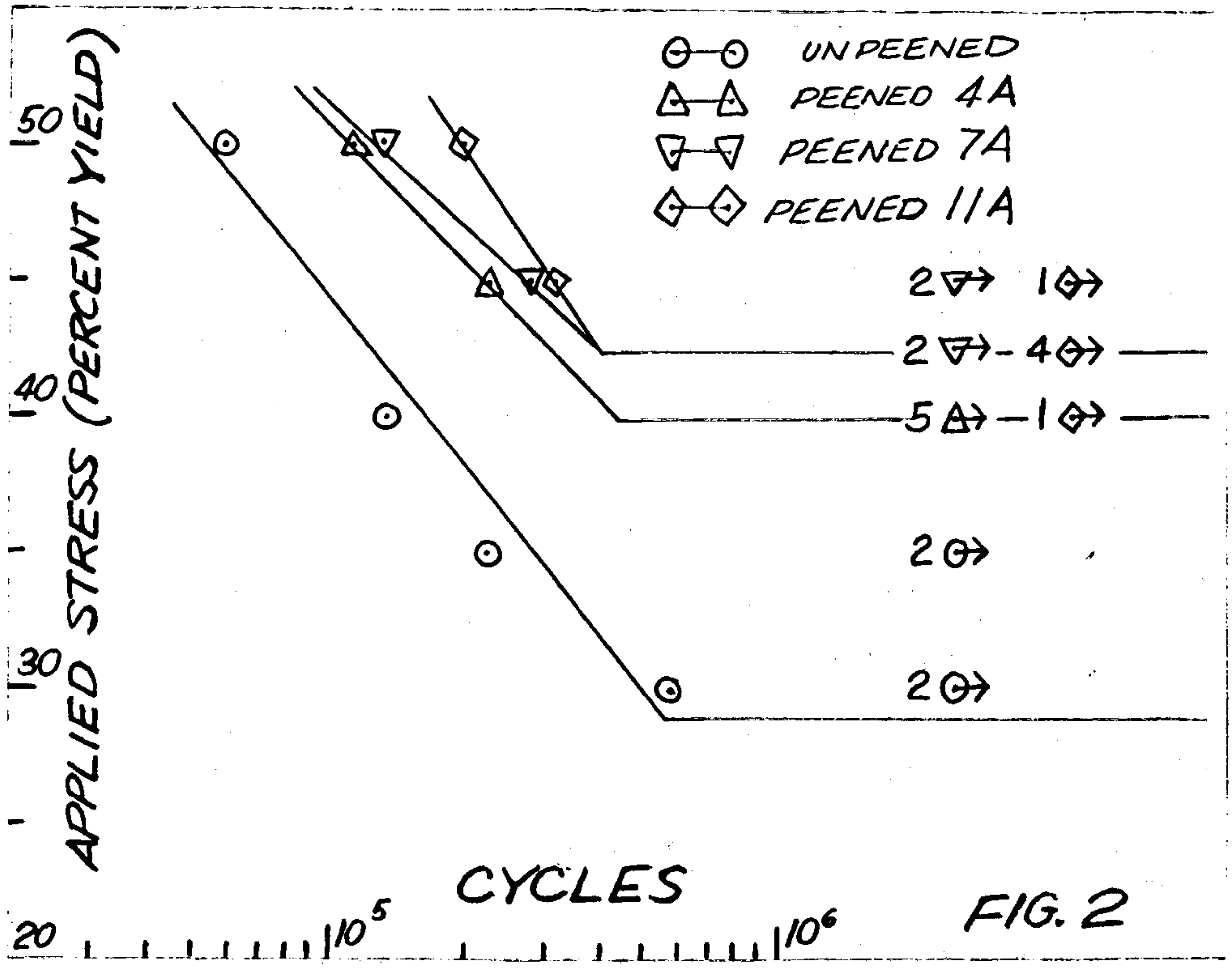
UNPEENED
PEENED 4A
PEENED 7A
PEENED 11A
2 1
2 - 4
5 - 1
2
2
APPLIED STRESS (PERCENT YIELD)
50
40
30
20
CYCLES
10^5
10^6

FIG. 2

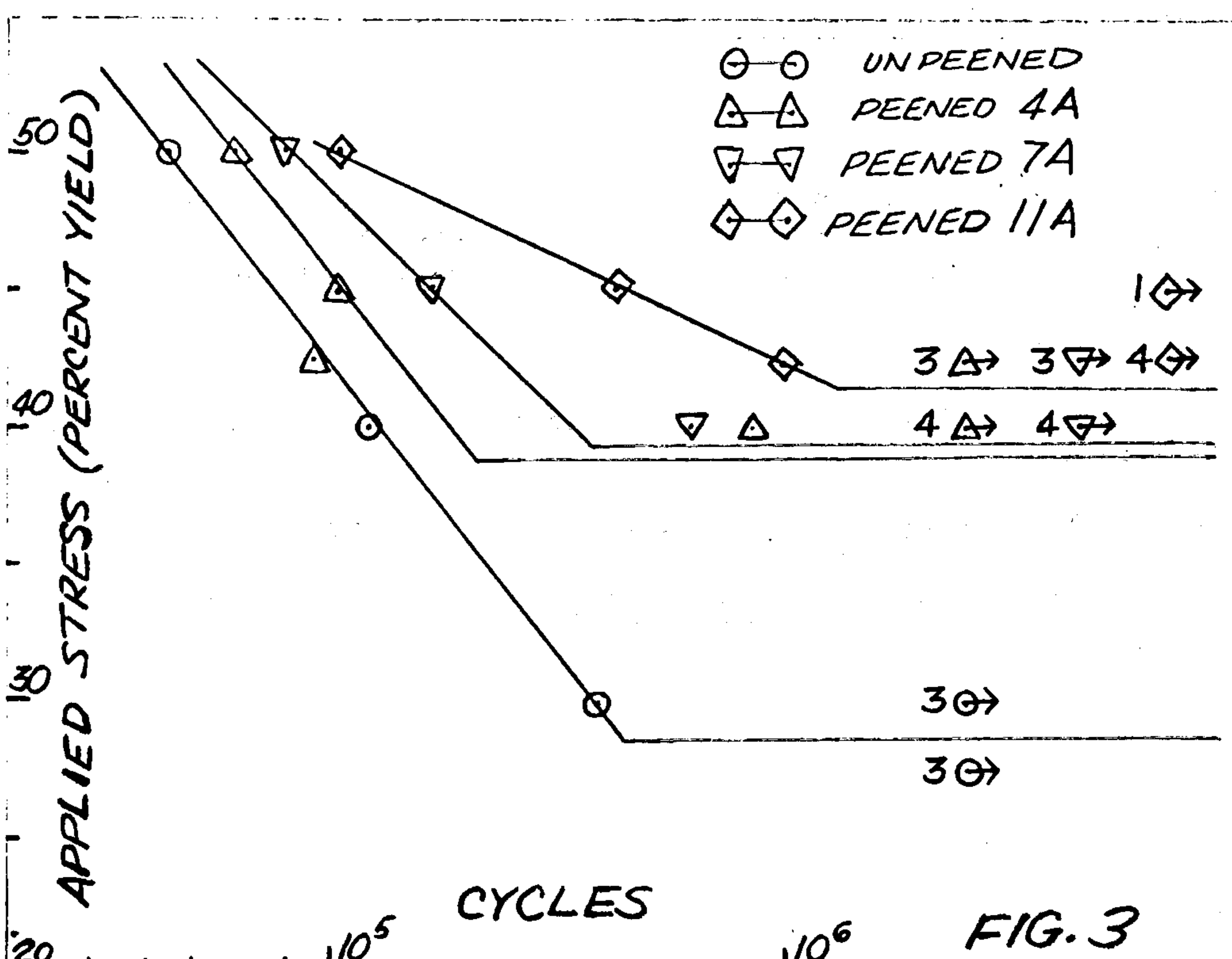
UNPEENED
PEENED 4A
PEENED 7A
PEENED 11A
1
3 3 4
4 4
3
3
APPLIED STRESS (PERCENT YIELD)
50
40
30
20
CYCLES
10^5
10^6

FIG. 3

DISCUSSION

Figures 1, 2 and 3 present the results obtained for specimens of 1/16" (1.59mm), 3/32" (2.38mm) and 1/8" (3.18mm) cross-section, respectively. Curves are shown for specimens peened to each of the three pre-selected Almen intensities, and for heat-treated but unpeened specimens. It is of interest to note that all failures occurred below 10^6 cycles. All specimens exceeding 10^6 cycles were eventually terminated without failure, some as high as 6 to $10 \cdot 10^6$ cycles. The number shown beside each runout indicates the number of specimens achieving run-out at that stress level. Each failure point is the arithmetical mean of several failures at that point. Note that the control (unpeened) specimens all exhibited identical S-N curves.

CONCLUSIONS

1. The increase in fatigue strength due to peening in this test program ranges from 35% to 50%. In each case, the higher Almen intensities produced somewhat higher fatigue strengths.

2. The similarity of the control (unpeened) curves attests to the validity of the test procedure.

3. For the material tested, approximately one million cycles represents a run-out.

4. Further testing will expand the range of thicknesses tested, and also investigate the effects of increased coverage and variation in media diameter.

ACKNOWLEDGEMENTS

The author wishes to acknowledge with gratitude the assistance of Mr. Ronald Schmidt, Impact Specialist, and Mr. Andrew Wasowicz, Senior Technician, both of Potters Industries, Inc., Research Laboratory.

REFERENCES

1. Straub, J.C. Shot Peening in Gear Design, AGMA 48th Annual Meeting, June 1974

2. Straub, J.C. Shot Peening in Spring Design, SPRINGS, October 1966

3. Military Specification, Shot Peening of Metal Parts, MIL-S-13165B, December 1966