EFFECT OF ULTRASONIC SHOT PEENING ON THE FATIGUE CHARACTERISTICS OF WELDED STS304 FOR ROLLING STOCK

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Abstract. Fatigue fracture of structures can be easily expected if the structures have heat affected zone, i.e. welded part. However, the fatigue characteristic and durability can be improved by applying shot peening process because it induces the compressive residual stress on the surface of structures.

In this paper work, the effects of ultrasonic peening on the fatigue life of the step in rolling stock are investigated. STS304 welded specimens are used for this study. Conventional shot peening process is also accomplished to compare with ultrasonic peening(CSP). To obtain S-N data, the bending fatigue test was done for conventional shot peened and ultrasonic peened specimens with the same Almen intensity. Compressive residual stress is also measured to find the factors improving the fatigue life.

The results show that the fatigue life for ultrasonic shot peened specimens increases tremendously by comparing with the fatigue life of unpeened specimen.

Keywords: Ultra Shot Peening(USP), STS304, SEM, Compressive Residual Stress, Rolling Stock

Introduction

Fatigue fracture of welded parts in rolling is a serious problem during operation (See Fig. 1). Welding zone is usually weak because there are not only possible welding defects but also Heat Affect Zone (HAZ). Therefore, post heat treatment or hammering after welding is needed to prevent accidental fatigue fracture.

Various kinds of surface treatment methods have been studied[(1-2)] to improve the endurance and fatigue characteristics. Shot peening process is a well known technology for surface treatment and can prevent unexpected ruptures from taking place in machinery parts or structures[(3-7)]. Recently, USP(Ultrasonic Shot Peening) and RPUP(Rotating Pins Ultrasonic Peening) have been studied to improve the durability of structural parts.

Fig. 1 Fatigue fracture in the step of rolling stock due to repeated load.

Ultrasonic technique such as USP has no dust cause of operating and is easier to carry than conventional shot peening. In addition, it has an advantage to be able to have same effect in short time with shot peening as it can give much energy in short time due to using high frequency. It is especially effective on the rolling stock to have small region applied and repair frequently. And, it is more economical than shot peening because it is unnecessary for USP to withdraw shot ball after peening. For that reasons, it has enough value to be research.
The objective of this paper is to research the improvement in the characteristics of fatigue from applying the USP process and shot peening to the welded parts of STS304 for manufacturing rolling stocks introduce advantage of USP compared with shot peening.

EXPERIMENT

Material tested in this paper is STS304 which is used for the step of rolling stock. Chemical composition of the material and welding condition are shown in Table 1 and 2, respectively. Mechanical properties are as follow: yield strength = 206MPa, Tensile strength = 520MPa, Elongation = 40%.
The specimen shown in Fig. 1 was machined by CNC after TIG A/C butt welding was conducted precisely on the plate with 400mm×50mm. Shot peening was performed by a 0.8mm cut wire rounded shot ball. Shot peening velocity was 50m/s and peening time was 11 minutes. Fatigue test was accomplished by the bending fatigue test machine (J.T. TOHSI, FIS-10) with a capacity of 10N-m.

Table 1 Chemical composition of material

Composition	C	Si	Mn	P	S
SWRH 72A	0.69 ~ 0.76	0.15 ~ 0.35	0.03 ~ 0.90	0.03↓	0.03↓

Table 2 Welding conditions of specimen

Welding type	Machine	Welding rod	Shielding gas	Voltage	Ampere	Remark
GTAW	Inverter TIG 300A	Y308, 2.0mm	100% Ar	220V	100A	3Pass

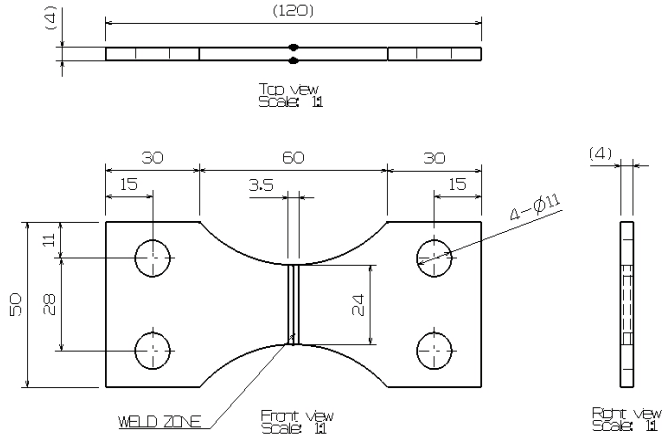

Fig. 2 Specimen configuration

Fig. 3 Ultrasonic peening process

In order to perform the fatigue test, stresses were modulated by the changes in torques, displacements and torsion angles.

Ultrasonic peening process was done by portable ultrasonic peening machine as shown in Fig. 3. The ultrasonic peening machine is a pin type whose diameter is 2.0mm. The specimens were treated as 38μm of amplitude (potentiometer indicator: 4) for 30sec of peening time.

RESULTS AND DISCUSSION

Figure 4 shows S-N data for unpeened, shot peened, and ultrasonic shot peened specimens. The results for USP and shot peened specimens show that the fatigue life tremendously increases by peening. For unpeened specimen, the average fatigue life is 7.7×10^3 cycles under high stress amplitude, i.e. 400MPa. Fatigue lives of shot peened and ultrasonic shot peened specimens are 1.1×10^5 and 4.0×10^5 cycles under the same stress amplitude, respectively. The fatigue life of ultrasonic shot peened specimen is higher than that of shot peened specimen in low cycle fatigue region. In high cycle fatigue region, i.e. under low stress amplitude, the fatigue lives for shot peened and ultrasonic shot peened specimens increase similarly by comparing with the fatigue life of unpeened specimen.

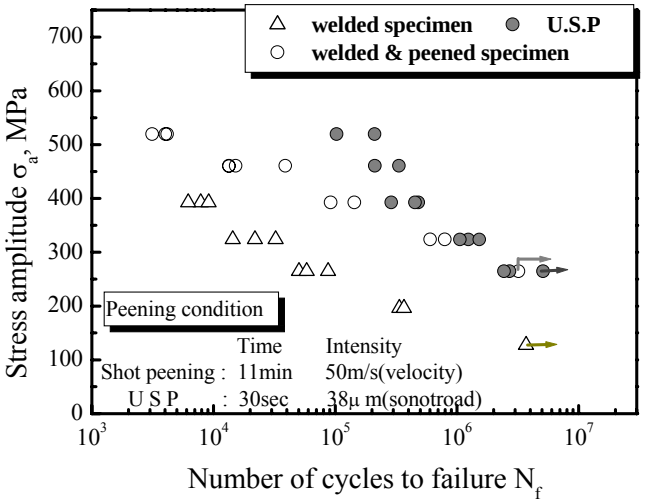

Fig. 4: Fatigue life data depending on peening types

Figure 5 shows the compressive residual stresses of unpeened, shot peened, and ultrasonic shot peened specimens. Compressive residual stress of shot peened specimen is higher than that of ultrasonic shot peened specimen in general. But the compressive residual stress of ultrasonic shot peened specimen is higher than that of shot peened specimen in fatigue fracture region, which is within 1mm to 6mm from the center of welded part. Hence, the fatigue life of ultrasonic shot peened specimen is higher than that of shot peened specimen.

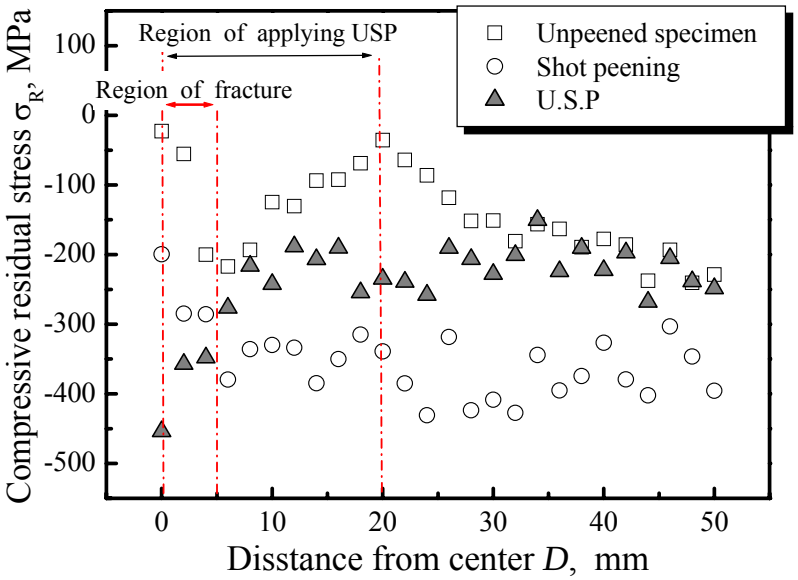

Fig. 5 Compressive residual stresses for USP and shot peened specimens

CONCLUSIONS

From the present research work about the effect of ultrasonic shot peening on the fatigue characteristics of welded STS304 for a rolling stock, the conclusions can be summarized as follows:

In high cycle fatigue region, the fatigue lives for shot peened and ultrasonic shot peened specimens increase similarly by comparing with the fatigue life of unpeened specimen. But in low cycle fatigue region, the fatigue life of ultrasonic shot peened specimen is higher than that of shot peened specimen.

The fatigue life of ultrasonic shot peened specimen is higher than that of shot peened specimen because the compressive residual stress of ultrasonic shot peened specimen is higher than that of shot peened specimen in fatigue fracture region.

To understand the ultrasonic peening effects in detail, more parametric studies about ultrasonic peening will be needed in the future.

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