# ENHANCEMENT OF FATIGUE PROPERTY OF TINI SHAPE MEMORY ALLOY WIRE BY ULTRASONIC SHOT PEENING

K. Takeda[1], D. Uemura[2] and K. Hattori[3]

[1]*Aichi Institute of Technology, 1247 Yachigusa, Yakusa-cho, Toyota, Japan*
[2]*Sinfonia Technology Co., Ltd., Shiba NBF Tower, 1-30, Shibadaimon 1-chome, Minato-ku, Tokyo, Japan*
[3]*Toyo Seiko Co., Ltd., 3-195-1 Umaganji, Yatomi, Japan*

*e-mail: k-takeda@aitech.ac.jp*

## 1. Introduction

In the practical applications using the shape memory alloy (SMA), the fatigue property is one of the most important subjects in view of evaluating functional characteristics of SMA elements. In a general way, the fatigue life can be enhanced by the ultrasonic-shot peening (USP). This USP process does not depend on the material shape. The fatigue life can be improved by USP due to induce the compressive residual stress on the surface layer and modify the surface properties. In this study, the rotating-bending fatigue life, the compressive residual stress and the fracture surface of TiNi SMA wire treated by USP was investigated.

## 2. Rotating-bending fatigue life

The relationships between bending strain amplitude $\varepsilon_a$ and number of cycle to failure $N_f$ obtained by the rotating-bending fatigue test under a constant frequency $f$ = 150 cpm at room temperature are shown in Fig 1. The bending strain amplitude $\varepsilon_a$ was obtained from the bending strain on the surface of the specimen at the fracture point. As can be seen in Fig. 1, the smaller the bending strain amplitude, the longer the fatigue life is. The effect of the USP to the fatigue life of SMA is large in the small strain and slight in the large strain. The fatigue life with the coverage of 1000% is longer than that of 2000% and 4000%.

## 3. Compressive residual stress

The distributions of compressive residual stress of as-received and USP-treated SMA wire in the surface layer are shown in Fig. 2. As can be seen in Fig. 2, in the USP-treated wire, the larger the depth from the surface, the smaller the compressive residual stress is. In the same depth from the surface, the larger the coverage, the larger the compressive residual stress is. In the case of the USP-treated wire with coverage of 2000% and 4000%, the compressive residual stress cannot be measured around the surface. The structure on the surface may become the amorphous.

## 4. Fracture surface

SEM photographs of a fracture surface for the USP-treated wire with coverage of 2000% and 200% are shown in Fig. 3 (a) and (b), respectively. As can be seen in Fig. 3 (a) and (b), the initiation point of the fatigue crack occurs both on the surface and at the inside with USP-treated wire. In the USP-treated wire with coverage of 200%, the initial fatigue crack appears at the surface in the all specimen. The percentages of the initiation point of the fatigue crack on the fracture surface of as-received and USP-treated wires are shown in Table 1. The larger the coverage, the larger the percentage in the case of the surface is.

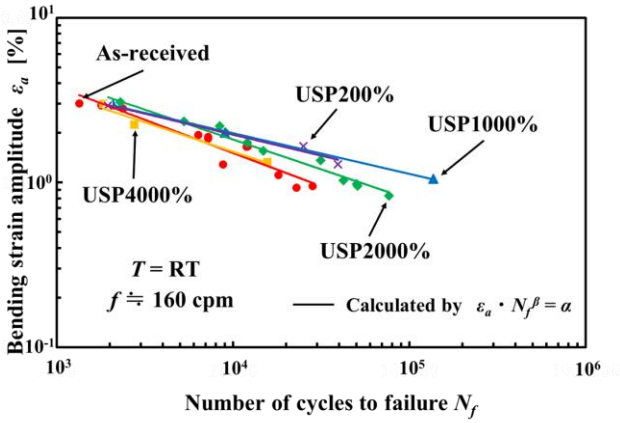



Fig. 1 Relationship between bending strain amplitude $\varepsilon_a$ and the number of cycle to failure $N_f$ obtained by the rotaing-bending fatigue test

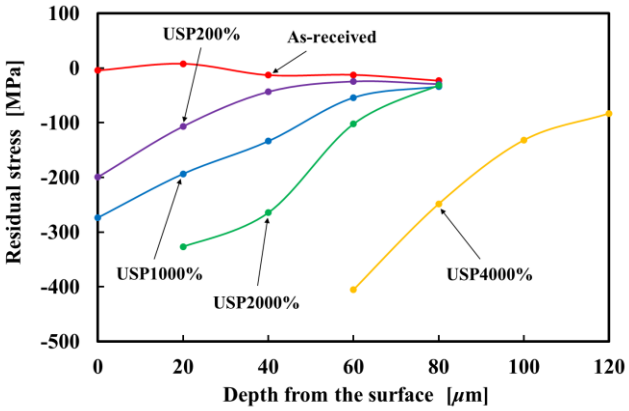
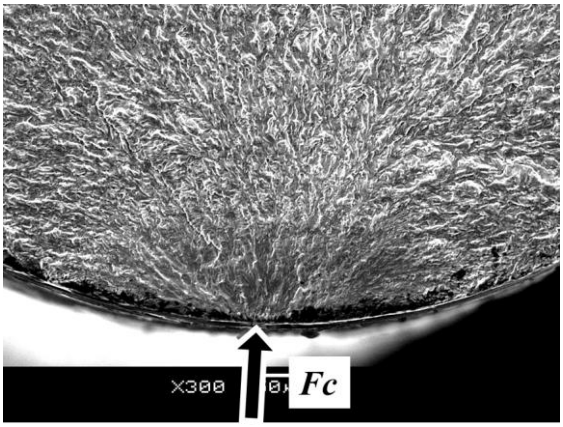
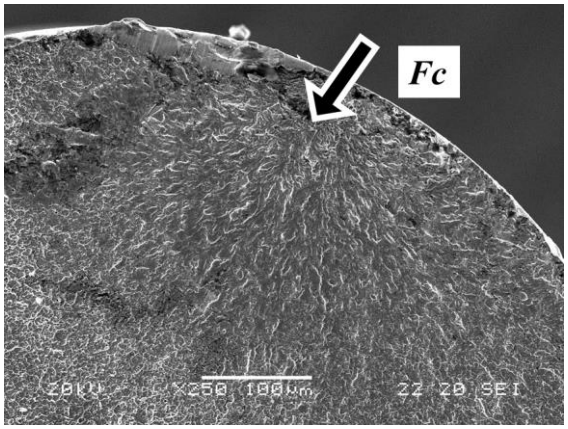



Fig. 2 Distributions of the compressive residual stress around the surface of as-recieved and USP-treated SMA wire




(a) USP-treated with coverage of 2000%




(b) USP-treated with coverage of 200%

Fig. 3 The initiation point of the fatigue crack of the USP-treated wires

Table 1 Percentages of the initiation point of the fatigue crack

| Coverage conditions | Surface | Inside |
|---|---|---|
| As-received | 100% | 0% |
| USP200% | 0% | 100% |
| USP1000% | 33% | 67% |
| USP2000% | 50% | 50% |
| USP4000% | 67% | 33% |

## 5. Conclusions

The influence of USP to the rotating-bending fatigue life and the initiation point of the fatigue crack of SMA wire was investigated. The effect of the compressive residual stress to the fatigue life of USP-treated SMA wire was discussed. The results obtained are summarized as follows.

(1) The effect of the USP to the fatigue life of SMA is large in the small strain and slight in the large strain.
(2) In the case of the USP-treated wire with coverage of 2000% and 4000%, the compressive residual stress cannot be measured around the surface. The structure on the surface may become the amorphous.
(3) In the initiation point of the fatigue crack, the larger the coverage, the larger the percentage in the case of the surface is.