Shot peening effect on pieces manufactured by 3D printer

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Introduction

3D printing, also known as additive manufacturing (AM), refers to various processes used to synthesize a three-dimensional object. Nowadays, AM systems are employed in many kinds of industries, such as the aerospace and automotive industries. In these industries, the raw materials that are most frequently used to manufacture pieces by 3D printer are aluminium alloy powder, titanium alloy powder and MS1 powder.

However, there is little literature about applying shot peening processes to 3D printing material. Therefore, we investigated the effect of shot peening on 3D printing material.

This experiment aims to verify if the fatigue strength of the specimens manufactured in MS1 material by 3D printing is improved after shot peening, which kind of layer direction structure (vertical or horizontal) has better resistance, and what the peening effect is for small and large size shot media.

Methodology

Specimen

In this study, the chosen material was the MS1 powder. Ms1 is a typical welding repair material for die. Table 1 shows chemical composition of MS1.

Table 1.

Ni	Co	Mo	Ti	Al	Cr	Cu	C	Mn	Si	P	S	Fe
17 -19	8.5 -9.5	4.5 -5.2	0.6 -0.8	0.05 -0.15	≦ 0.5	≦ 0.5	≦ 0.03	≦ 0.1	≦ 0.1	≦ 0.01	≦ 0.01	Bal.

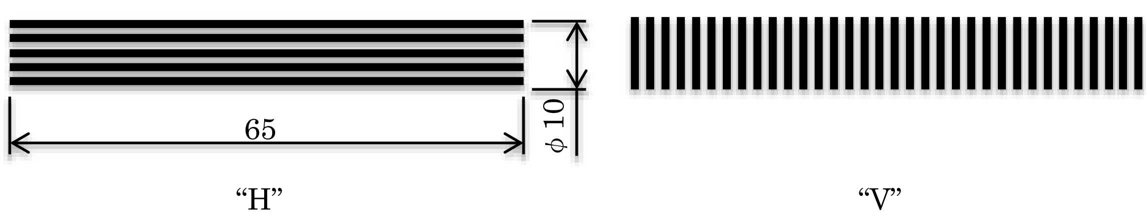


Fig.1 Direction of printing

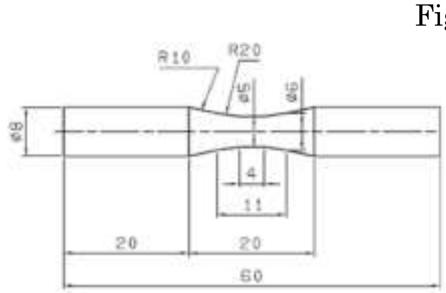


Fig.2 Shape of specimen

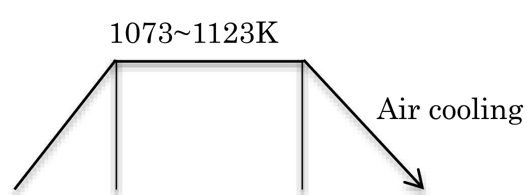


Fig.3 Heart pattern of solution heat treatment

A piece manufactured by EOS system. MS1 material was used for3D printing. Specimens have porosity and layers with mono direction structure. In this study two types of specimens were used, one with vertical direction structure (referred to as V) and one with horizontal direction structure (referred to as H)(Fig.1). After 3D printing, the specimens were machined (Fig.2). Thereafter, specimens are applied solution heat treatment that is indicated Fig.3.

Shot peening condition

In the shot peening process two sizes of shot media were used. The first one was ϕ 0.1mm and the second one was ϕ 0.6mm. After shot peening, the specimens were submitted to a rotating bending fatigue strength test.

Symbol and shot peening condition are shown Table 2.

Direct air type shot peening machine ware used. Specimens were exposure shot stream form upper side during rotating as 30rpm. The photograph (Fig. 4) shows inside of shot peening machine that was made by SINTOKOGIO.

Table 2.

Item/Symbol	○	●	△SP-S	▲SP-S	□SP-L	■SP-L
Laminating direction	H	V	H	V	H	V
Shot media	-		SBM100T		SB-6	
Media diameter	-		100 μ m		600 μ m	
Media hardness	-		HRC40-50		HRC45-50	
Air pressure	-		0.2MPa			
Coverage	-		300%			
Arc height	-		0.216mmN		0.376mmN	

Fig. 4 Projection method

Evaluation method

Hardness distribution, residual stress distribution, microstructure observation, fatigue strength are evaluated. Rotating bending fatigue test was selected in order to evaluate fatigue strength. Fatigue test carry out at room temperature. Rotating velocity is 3000rpm.

Result and discussion

Material

Micro structure was observed by micro scope before and after solution heat treatment. Before the heat treatment, the laminated structure clearly appeared. On the other hand, after heat treatment, the laminated structure becomes slightly improving.

Fig. 6 shows harness distribution of specimen before and after heat treatment. Before heat treatment, the hardness of both materials is higher comparison with after heat treatment. The hardness is less than 300HV after heat treatment.

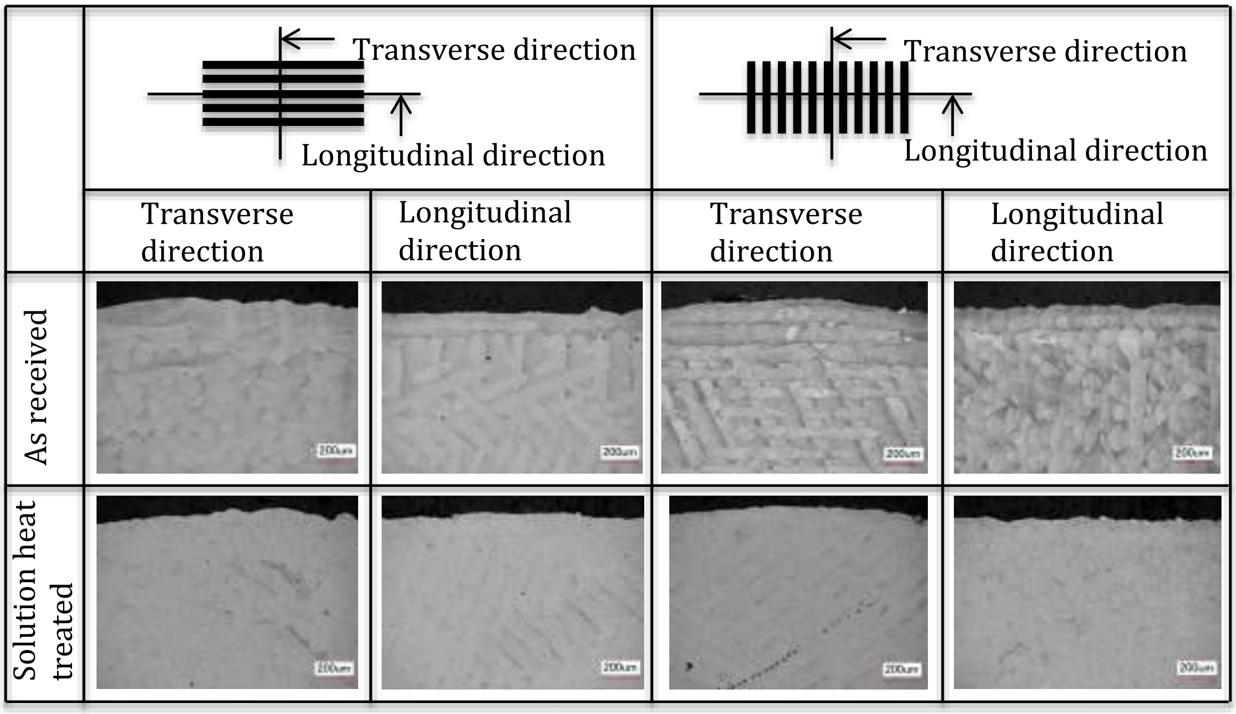
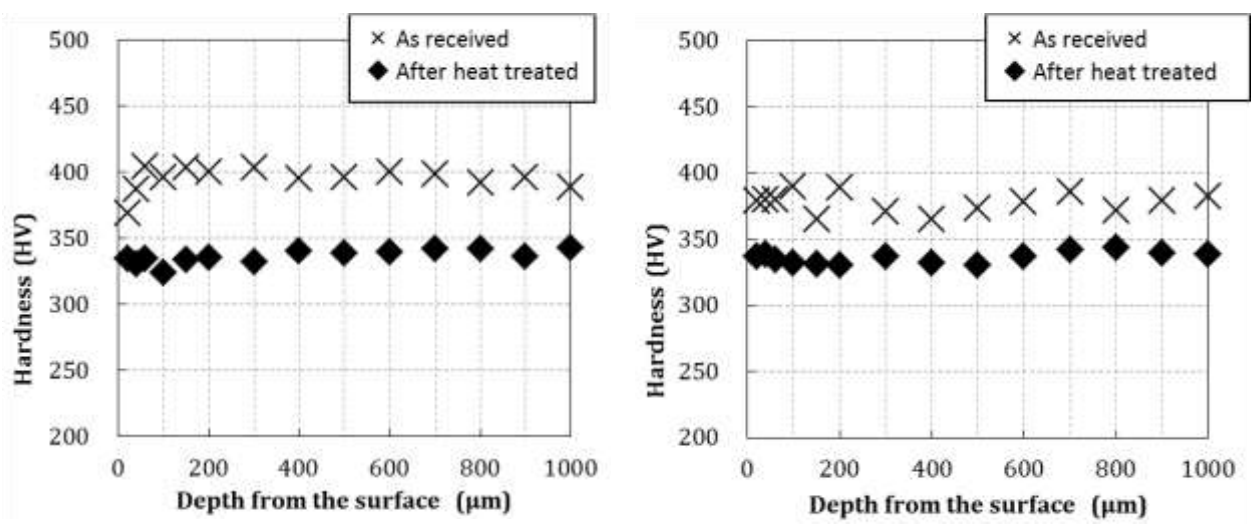


Fig. 5 Micro structure (Before and after heat treatment)



H V

Fig. 6 Hardness distribution (Before and after heat treatment)

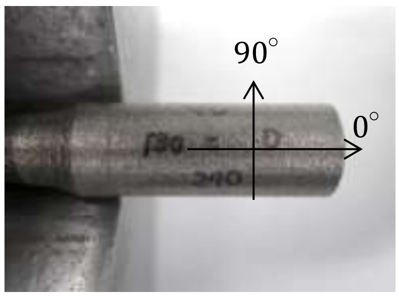
Residual stress

Residual stress was measured by 2 directions (Fig. 7). One is measured along the longitudinal direction (0°).More one is measured along the transverse direction (90°).

Fig. 8 shows distribution of residual stress. In case of H material, distributions of residual stresses are similar on both measuring direction. On the other hand, in case of V material, we can see the different as deeper side of residual stress. The residual stress of 90° are higher than result of 0° as V material. Those are indicated by circle.

Fatigue strength

Fig.9 shows S-N curve that was obtained through a rotating bending fatigue test. Shot peened materials have better fatigue properties than non-peened materials.



※Residual stress were measured by 2 direction. One is meared along the longitudinal direction (0°).
More one is measured along the transverse direction(90°).

Fig. 7 Measuring direction of residual stress

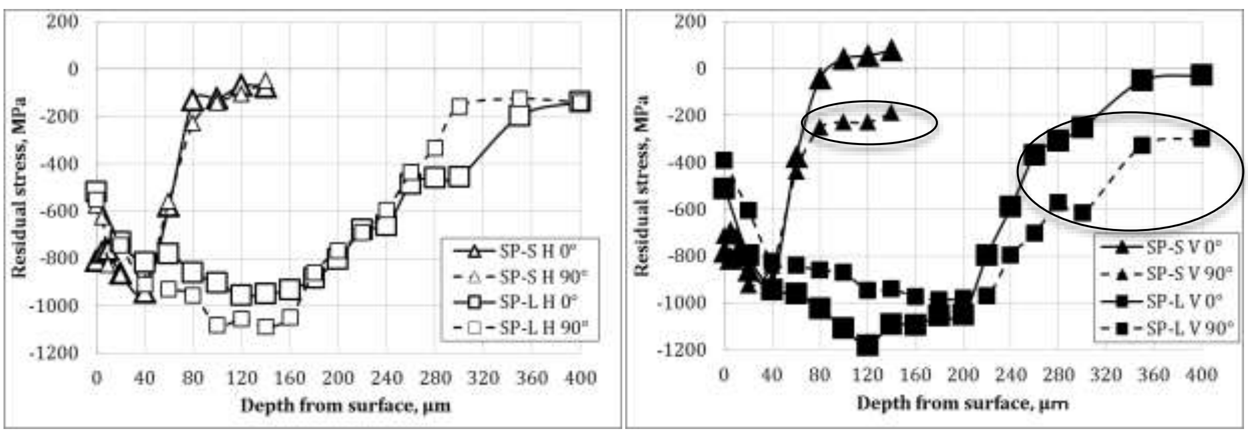


Fig. 8 Distribution of residual stress

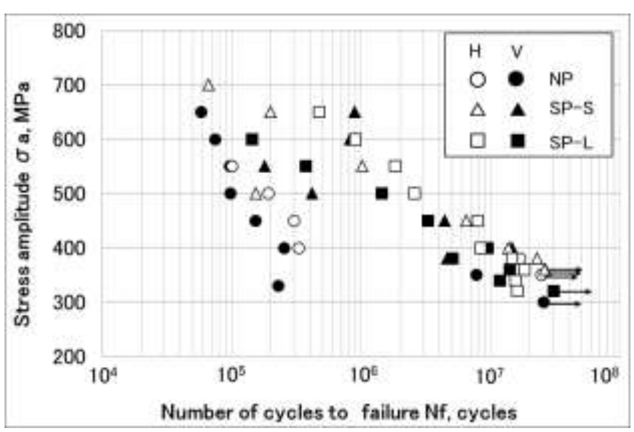


Fig. 9 S-N curve