1Pb-45

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 231-232
6-8 December, 2010

Effects of Ultrasonic Cavitation Peening with a Block Type Horn Scanning on Residual Stress of Metal Surface.

ホーン走査による金属材料表面への超音波キャビテーションピーニング

Masayuki Nakagawa[1†], Isamu Kudo[2], Hiroji Muto[2], Yasuomi Watanabe[2] ([1]Industrial Research Institute of Niigata Pref.; [2]ADVAN ENG. co., ltd.)
中川　昌幸 [1]，工藤　勇 [2]，武藤　浩二 [2]，渡部 豈臣 [2] ([1] 新潟県工業技術総合研究所; [2] アドバンエンジ株式会社)

1. Introduction

Cavitation often occurs in liquid when the local pressure of the liquid decreases intensively. It is known that high impact pressure is induced at a moment when the bubbles collapse and stable continuous cavitation can be generated by ultrasonic wave irradiation in liquid.

It has been reported that the high impact pressure caused by micro jet which occurs when a cavitation bubble collapse could reach about 1 GPa[1] which is intensive enough to deform metallc material such as stainless steel. We have investigated the new surface treatment process , the intensive impact pressure caused by ultrasonic cavitation applying on metallic surface to introduce compressive residual stress such as shotpeening.

Shotpeenig is well known process to introduce compressive residual stress which is effective for improving fatigue strength. However, surface roughness become worse because dimples produced by hard shots collision cover the surface. Relationship between compressive residual stress and surface roughness is trade-off for improving fatigue strength since a lot of defects in surface layer are also induced by shots collision approximately in proportion with surface roughness. It is thought that the cavitation process has advantage to improve fatigue life of devices, furthermore for the small parts and thin films, because it can introduce compressive residual stress on surface and inhibit production of surface defects simultaneously.

We have already reported that the process of irradiating ultrasonic wave in water could effectively generate the cavitation and successfully introduced the compressive residual stress on the surface of various metalic material[2] , for example , austenitic stainless steel such as SUS304, which has the problem of stress corrosion cracking (SCC) in many devices.

In this study, we tried to apply the "ultrasonic cavitation peening" to larger plane surface by scanning a block type horn. A block type horn with same resonant frequency as the ultrasonic transducer was designed by FEA. The distribution of compressive residual stress introduced by the ultrasonic cavitation peening with the horn scanning holizontally pallarell with the surface at a adequate speed was mesured by XRD stress measuring method at certain intervals to evaluate homogeneity of the processed surface.

2. Experimental

Ultrasonic wave of frequency 19.5kHz was oscillated with an ultrasonic transducer and was irradiated to the specimen surface fixed on a sufficiently heavy jig in water of 25℃ using a block type horn shown in **Fig.1**. The horn material is SUS303 stainless steel. **Fig.2** shows the schematic of an experimental set-up. The axial vibration direction of the horn is vertical to the specimen surface. The peak-to-peak amplitude of the horn tip face measured at the position of the center and near one edge vs. output level of the amplifier of ultrasonic vibration is shown in **Fig.3**. In Fig.3 it is confirmed that P-P amplitude increase with output level of amplifier. It tends that edge amplitude is a little larger than center amplitude. In this study we carried out scanning ultrasonic cavitation peening with amplifier output level of 5.

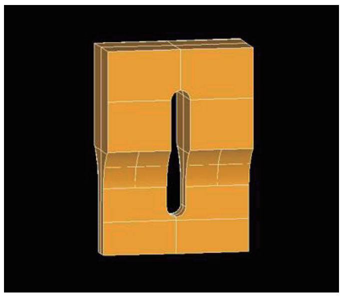
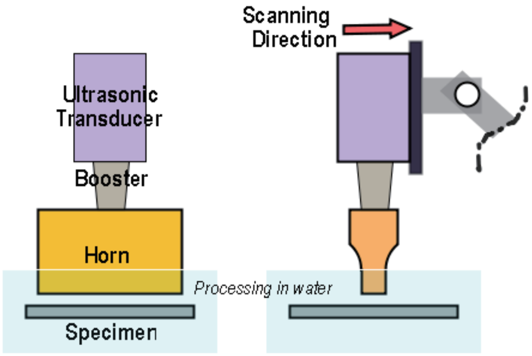


Fig. 1　Schematic of a block type horn.
(Size of the tip face is 92mm(W)x15mm(L))

The specimen was rolled plate of 18-8 stainless steel (SUS304) and size of 120mm ×100mm and 3mm thick. The processed area was about 92(W)mm×100(L)mm. The width of 92mm and length of 100mm were determined by the width

e-mail:mnakagaw@iri.pref.niigata.jp

of the horn and scanning distance pallarell with scanning direction respectively.



(front) (side)

Fig. 2 Experimental set-up.

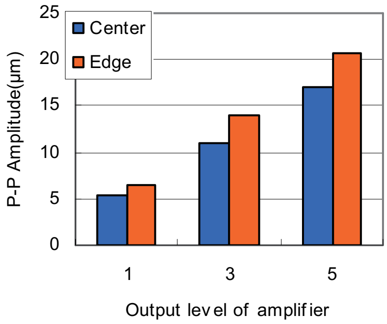


Fig. 3 The peak-to-peak amplitude of the horn tip face measured at the position of the center and near one edge vs. output level of the amplifier of ultrasonic vibration.

3. Results and Discussion

Fig.4 shows mesurement points on the specimen which range just half of the processed area. **Fig.5** shows the distribution of residual stress on the processed surface peened with two scanning patterns. The patternA, B were scanning speed of 6mm/min, 1scan, 12mm/min, 2scan respectively. They are equivalent conditions because mean time of processing by area is same.

Inside of the processed area, compressive residual stress increases much larger than no-processed surface of -20MPa. However value of compressive stress of some mesurement points along “Y-4” are lower than other points. It is thought that the measurement points along “Y-4” are located near the boundary line of the horn scanning area where cavitation may be unstable. Distribution of compressive residual stress measured at the points except ”Y-4” is a little inhomogeneous, but compressive stress value of any points reach over -350MPa.

3. Conclusion

Compressive residual stress which improve fatigue life could be introduced by the ultrasonic cavitation peening with a block type horn scanning for larger area than that with a step horn fixed. The compressive stress value of whole processed area reached over -350MPa. However larger compressive residual stress such as value of -600MPa was introduced at some indefinite local points. Increasing numer of scanning can achieve larger compressive residual stress being introduced and homogeneous distribution of residual stress.

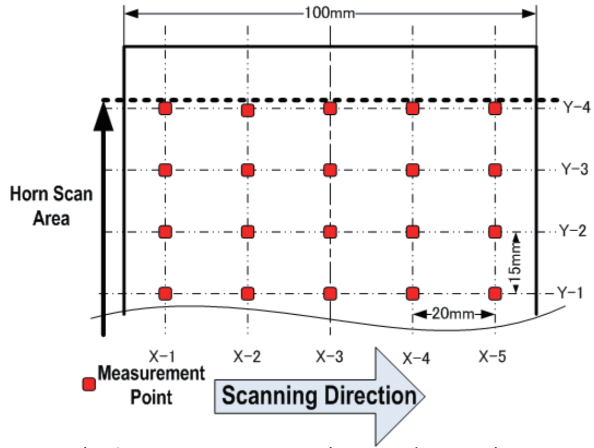
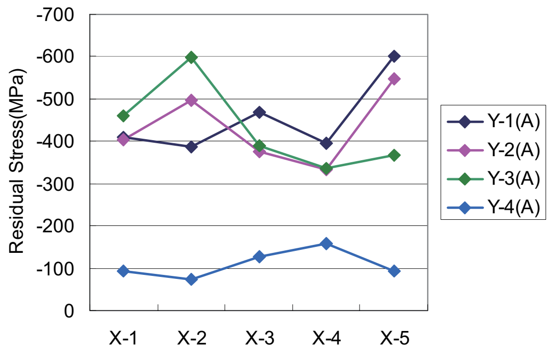
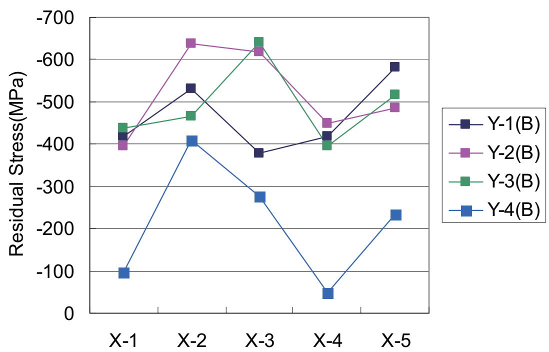


Fig.4 Measurement points on the specimen.



(PatternA)



(PatternB)

Fig. 5 Distribution of residual stress on the processed surface.

References

1. T. Okada Y. Iwai, H. Ishimaru and N. Maekawa : Jpn. JSM(A) **58** (1992)1489.

2.M.Nakagawa, T.Watanabe: Jpn. JWS. **22**(2004) 587.