Corrosion Evaluation of Penstock Contacted Area with Concrete Saddle of Hydroelectric Power Plant by use of Long Range Ultrasonic Testing Method

Fumito. Kawamura[1*], Yuki. Wada[1], Kenta. Fukuhara[2] and Koichi. Kioka[2]

[1]Yonden Consultants Inc., Takamatsu City, Kagawa, Japan
[2] Sikoku Electric Power Inc., Takamatsu City, Kagawa, Japan

[*]Fumito Kawamura: f-kawamura@yon-c.co.jp

Introduction

Structural soundness estimation is very important for safety use of long term used infrastructures. So far we have been estimated on corrosion, material strength, fracture toughness and residual strength of long term, more than 50 years used penstock in hydroelectric power plant[1][2][3][4]. The penstock contacted area with concrete saddle of hydroelectric power plant is heavy loaded and exposed to stagnant water. Fig. 1 shows one of the examples of corroded area on penstock contacted area with concrete saddle.

In the present circumstances corrosion of the relevant part is evaluated by use of ultrasonic thickness gauge from the inside of penstock.

However, this method involves danger and requires shut down of the hydroelectric power plant. Therefore, it is necessary to evaluate corrosion of the relevant part from the outside of the penstock.

In this study, we characterized the long range ultrasonic wave served our purpose by the laboratory tests and selected the long range ultrasonic wave suitable for corrosion investigation. Field tests were conducted using the selected long range ultrasonic wave to confirm the applicability to actual corrosion. The corrosion evaluation method was examined based on these results.

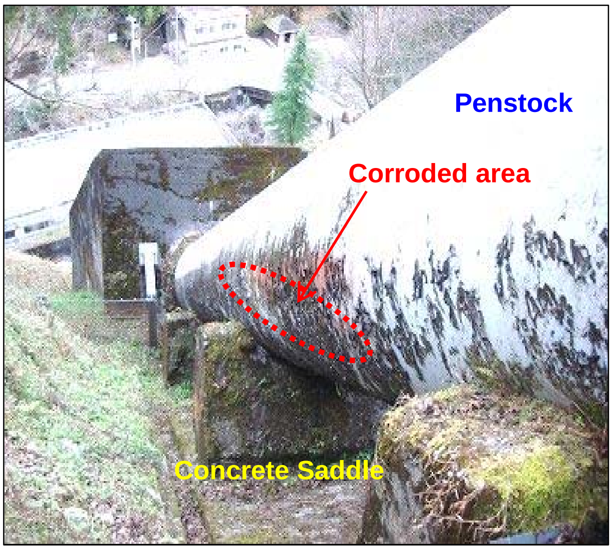

Fig.1 An examples of corroded area on penstock contacted area with concrete saddle.

Experiment

Laboratory tests were conducted to understand the ultrasonic propagation and to find suitable interference factors for three long range ultrasonic waves such as SH wave, SV wave and guided wave.

Long range ultrasonic testing was performed on the acutually corroded penstock contacted with concrete saddle.

Results and Discussion

1)Selection of long range ultrasound

The effects of inhibiting factors such as propagation distance, water, coating film and deposits were investigated for SH wave, SV wave and guided wave. As a result, it was found that the SH waves with less attenuation due to distance, less noise caused by coating and detection performance for the targeted corrosion depth[5][6].

2)Basic characteristics and optimum frequency of SH wave

Laboratory tests were conducted to understand the characteristics of each frequencies for the attenuation of SH wave distance, beam spread, the effect of coating film, the effect of water, S / N and identification of corrosion depth. The frequencies of the SH wave probe were 0.35, 0.50, 1.00 and 2.00MHz. As a result, for flaw detection of penstock contacted area with concrete saddle using SH waves, it was found to be able to apply a frequency of 0.35 MHz to 1.0 MHz with little distance attenuation good S / N.

The frequency of 0.5 MHz is found to be suitable for detection and evaluation of corrosion damage with depth of 2 mm or more.

3)Corrosion evaluation method

The evaluation of corrosion adopted the method of estimating the corrosion depth from the reflection echo height from the corrosion. Test specimens with hemispherical simulated grooves were prepared. The relationship between their reflection echo height and the reflection echo height from the actual corrosion damage occurred on the actual penstock was investigated. As a result, the relationship between reflection echo height from corrosion damage and depth per corrosion shape was clarified. Based on these facts, we prepared a calibration curve to estimate the corrosion depth. Next, the data of the corroded part collected from the actual pen stock was evaluated by use of the above-mentioned calibration curve. The true value of the corrosion depth of the actual penstock was confirmed by automatic thickness measurement from the inner side or by a depth gauge from the outer side as shown in Fig.2. The result of having evaluated corrosion depth with the prepared calibration curve is shown in Fig.3.

It is clear from Fig.3 the difference between the corrosion depth actually measured on site and the corrosion depth assumed by the calibration curve is within 1.0 mm.

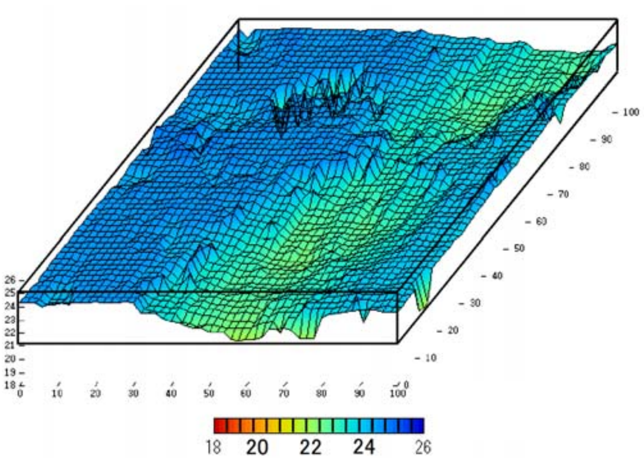

Fig.2 A semi-automatic thickness measurement result of corrosion damage of penstock.

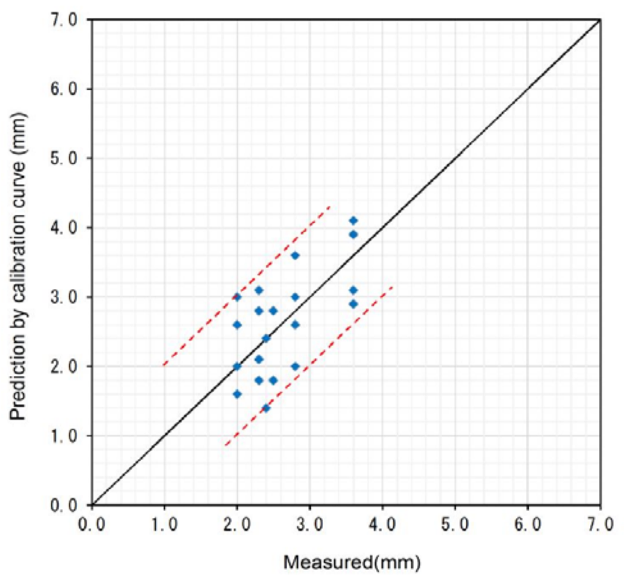

Fig.3 Relation between measured depth and predicted depth by calibration curve.

Conclusions

The following conclusions were obtained.

1) SH wave is suitable to detect corrosion damage on penstock contacted with concrete saddle.
2) The frequency of SH wave suitable for corrosion detection is 0.50MHz.
3) By use of the calibration curve obtained in this experiment corrosion depth of the actual penstock can be estimated with a certain accuracy.

References

[1] F. Kawamura, M. Miura, R. Ebara, K. Yanase, Material Strength of Long-term Used Penstock of a Hydroelectric Power Plant, *Case Studies in Structural Engineering,* 6 (2016) 103-114.

[2] F. Kawamura, M. Miura, R. Ebara, K Yanase, Analysis on Critical CTOD of Long-Term Used Penstock, *Key Engineering Materials,* 741 (2017) 57-62.

[3] F. Kawamura, Y, Wada, R. Ebara, Residual Strength Estimation of Long-Term Used Corroded Steel Plates in Hydroelectric Power Plant Steel Structures, *Journal of the Japanese Society for Strength and Fracture of Materials,* 52 (2) (2019) 23-31.

[4] F. Kawamura, Y. Wada, R. Ebara, Fracture Toughness Evaluation of Long-Term Used SS400 Welded Joint by Nondestructive Inspection, *Journal of the Japanese Society for Strength and Fracture of Materials,* 52 (3) (2019) 43-52.

[5] Y. Yokono, M. Kato, K. Nishio, Study on Detection and Quantitative Evaluation of Surface and Subsurface Flaws by Surface SH Wave, *Journal of N.D.I,* 45 (2) (1996) 136-144.

[6] Y. Imagawa, H. Noda, Y. Wkibe, Ultrasonic Guided Wave Testing System Piping, *Journal of N.D.I*, 58 (5) (2009) 186-190.