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Corrosion sensor for the pipe with wide area coverage
高エリアカバレッジの配管腐食センサ

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1. Introduction

Currently, there are many kinds of ultrasonic diagnostic apparatus in the markets, and they are used for the detection of damage arising in the metal body and so on in various situations. With the some of them, we can get clear images of very high precise position and shape of a hole, they are used to identify the location of the hole caused by corrosion or erosion on the pipe at plant diagnosis. For example, there is a diagnostic apparatus to be used to scan manually on the pipe with the ultrasonic transmitter and receiver module[(1)]. During patrolling the plant in periodic inspections, it is used by an inspector who can perform a manual scan all over the pipe in order to identify the location of the hole. It has been used over many years in the industry and has very high reliablity, but it requires troublesome task. On the other hand, there is an another type of diagnostic apparatus with an array of many ultrasonic devices which operate as phased array[(2,3)]. The obtained image is very clear and identification of the hole is very easy, but there is a problem in cost.

In general, corrosion is categorized into two types, the general corrosion and the localized corrosion. In the case of localized corrosion, it is very difficult to predict the occurrence, and there is no appropriate monitoring device for it. In order to treat the localized corrosion, it should be predicted when and where it will happen. So it is necessary to constantly monitor but monitoring equipment mentioned above is not suitable for such applications. As an apparatus for performing the monitoring at all times, there is an ultrasonic thickness meter of the pipe wall with wireless communication[(4)]. In principle, it can measure the thickness just only beneath the detector, so it can not be used in the needs to predict where the corrosion will happen. Also, there is a monitoring device using ultrasonic guided wave[(5)]. It is characterized by detecting a position of the hole in relatively accurate over a wide range.

In the field of the actual plant, when a dangerous corrosion leading to an accident is found, it is necessary to replace the pipe on which corrosion occurs. In this case it is not necessary to specify the precise position of the hole caused by the localized corrosion, and position measurement is sufficient enough resolution for replacing the pipe in most cases. Therefore, it is useful in practice that by monitoring widely with as few sensors as possible, for example, one sensor unit informs the operator which pipe a dangerous corrosion occurs on, quickly.

In this study, it is intended to develop a sensor with wide area coverage, and it can extract information about approximate position of the hole caused by the corrosion or erosion at the expense of an accuracy and a resolution of shape and position measurement. This is the first report of the proposed corrosion sensor for the pipe. The basic simulation and experimental results are provided.

2. Numerical simulation and discussions

As mentioned above, since it is an object to detect the approximate position of the dangerous hole, which is assumed to be deeper hole than the specific value, at a low cost as possible, the target of this study is to detect the approximate position and the depth of the hole from the propagation time and the amplitude of the received signal. In order to evaluate the basic characteristics, the numerical simulation of ultrasonic transmitting and receiving characteristics was carried out with ultrasonic analysis software ComWAVE (ITOCHU Techno-Solutions Co.). **Fig.1** is the numerical model for basic evaluation of the effect of reflect angle, depth and diameter of a hole on received wave signal. The material properties, the model dimensions and the boundary conditions are also expressed on **Fig.1**. The results of the numerical simulation are shown on **Fig.2**.

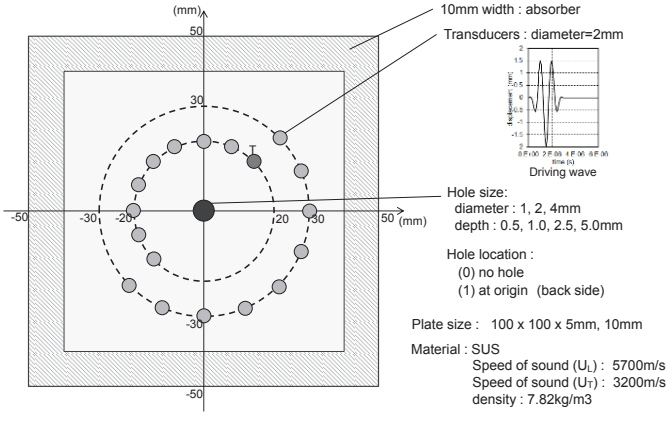
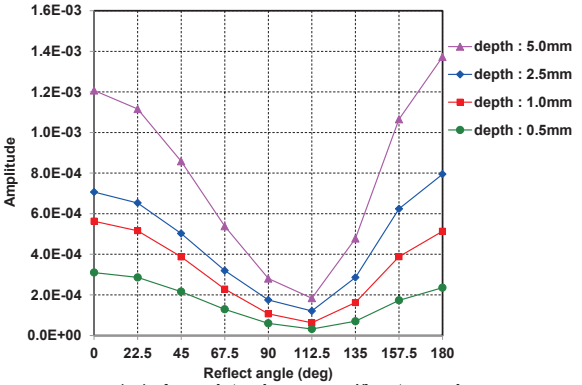
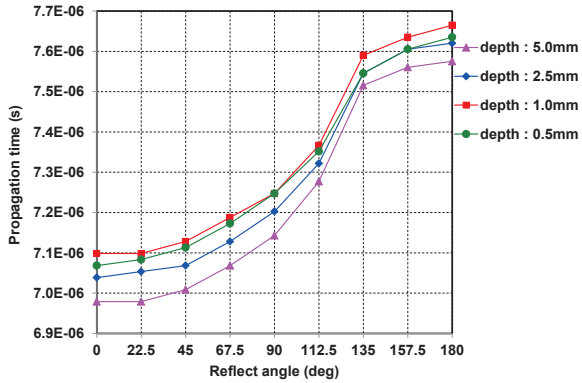


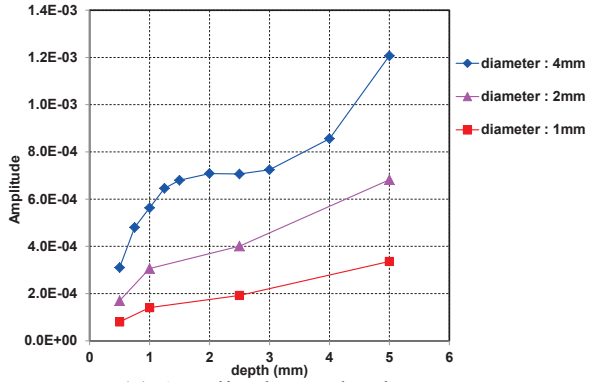
Fig.1 Basic simulation model



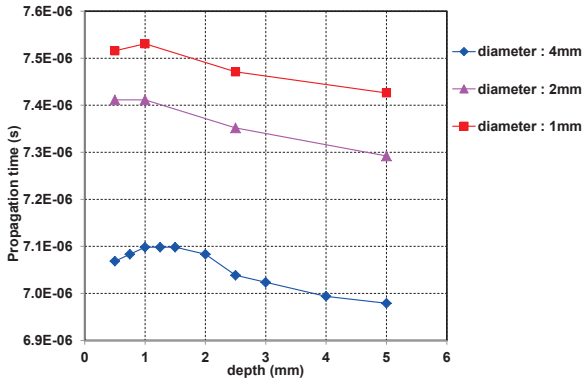
(a) Amplitude vs. reflect angle
(diameter:4mm, distance:40mm)



(b) Propagation time vs. reflect angle
(diameter:4mm, distance:40mm)



(c) Amplitude vs. depth
(angle:0deg, distance:40mm)



(d) Propagation time vs. depth
(angle:0deg, distance:40mm)

Fig.2 Results of simulation

From these, the following considerations are obtained.

- Both amplitude and propagation time depend on the reflect angle, depth and radius of a hole.
- Each parameter has quite different effect on these signals.
- The amplitude sensitivity on the depth of a hole is quite low level at the center of plate thickness.
- But the propagation time sensitivity has the opposite feature.
- From this point of view, it is understandable that the combined method of the amplitude and the propagation time is required.
- The depth of a hole can be detected with combining amplitude and propagation time.
- On the other hand, the diameter of a hole is difficult to detect only by amplitude and propagation time.
- The depth is more important parameter than the diameter on corrosion issue. So, the results are good enough.
- These results show that it is also difficult to distinguish between the deep and small-area hole, and the shallow and large-area hole.

3. Conclusions

It is concluded that position and depth of hole are obtained by propagation time and amplitude of received signals. The experimental result will be demonstrated at the conference in December.

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