Survey of a wireless NDT service for a nuclear piping wall thinning defect

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1. Introduction

The wireless sensor network has been issued for several years. The nuclear power plants all around world have adapted many kinds of sensor technologies for inspections and diagnostics of main instruments. Even though wireless sensor is more useful than wired-sensor, wireless sensor based applications haven't been used in nuclear power plants because of the authorization of a jamming, an electromagnetic interference and so on.

A wireless sensor uses a battery for its operations, but this battery can't be used for a long haul. It causes a battery change problem.

There aren't any wireless sensor based NDT for a piping wall thinning part. We will describe a method of how to develop it in this paper.

2. Problem of the wireless NDT in the piping wall thinning

2.1 Battery problem

There are various NDT methodologies. We can classify them as a passive NDT and an active NDT. The active NDT uses oscillators but the passive NDT does not. The ultra sonic NDT has UT sensors and a UT signal generator/ receiver. The UT sensors shoot ultra sonic signals and collect the reflected ultra sonic signals. In the case of the vibration NDT, the vibration only has a vibration signal acquisition module. We can classify the ultra sonic NDT as an active NDT. The vibration NDT can be included in the passive NDT.

When we want to make an active NDT system that is based on wireless technology, we must integrate a sensor, a pulser and a receiver in one united body and implement a wireless communication circuit in it. We call that sensor a united sensor.

The active NDT systems need a high electric power to generate a oscillator and to transfer the collected radio signal.

The power supply is a core issue in every wireless sensor network. It is more critical in the active NDT systems because of the oscillator.

The active NDT system treats a mass data acquisition and transmission. It uses a high electric power to transfer the acquisition data.

Sometimes, the transmission ratio in the ultra sonic NDT is more than MByte/sec. The electric power consumption in the data transmission will bring out a short-term battery change problem.

The mass data transmission problem is connected directly to the battery problems in the wireless sensor network.

2.2 Ultra sonic NDT for wall thinning

It is known that the ultra sonic measurement is adequate to measure the thickness of a pipe that is made of carbon steel or stainless steel. The ultra sonic technology is used in a nuclear power plant to measure the thickness of the main loop piping system.

It is proven that the ultra sonic measurement in the pipe wall thinning parts is not correct. The use of a pipe causes its corrosion. When a corrosion is generated in a pipe, the speed of the ultra sonic that penetrates the pipe is lower than the original pipe. The same situation occurs in the reflection time.

When we apply the ultra sonic technology to the piping wall thinning parts, we can identify the thickness of the used pipe is growing as time passes. Figure 1 shows the problem that we mentioned above.

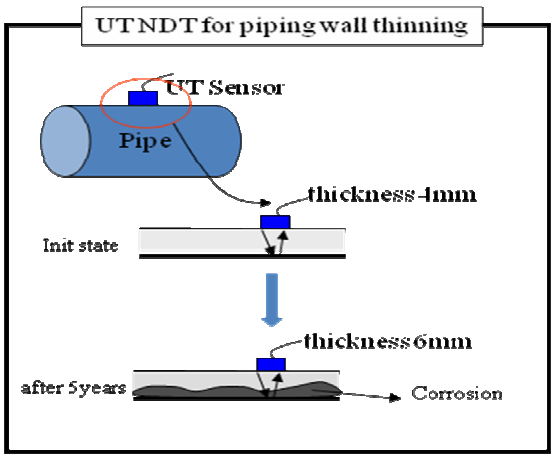

Figure 1. Problem of ultra sonic NDT for piping wall thinning

3. New methodology for piping wall thinning

3.1 PEC(Pulsed Eddy Currents)

The eddy currents are excited in a conductor by passing an alternating current through a coil in close proximity to the conductor. The AC current is time-

harmonic and sinusoidal in nature and gives rise to eddy currents of a similar nature.

In contrast, PEC are excited by means of a non-sinusoidal coil current. In most systems a steady-state current is allowed to persist for some time before the waveform is repeated. The length of this steady state period is usually made sufficiently long such that any eddy-current signals have completely decayed away[1][2].

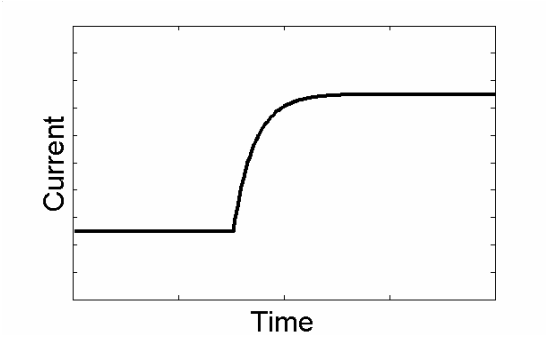

Figure 2. Typical PEC waveform

By tracing the entire penetration sequence via the voltage induced across the coil, we can derive three unique signal values at three different times. PEC penetrates its induced current into the target materials deeper than the traditional eddy currents. In this way, the new measurement technique - known as Pulsed Eddy Current technology - overcomes the limitation of the traditional design. All three parameters can be measured: the distance, the electrical resistivity and the thickness.

PEC technology provides accurate measurements - limit of the resolution is 0.02μm. The ultra sonic NDT for a piping wall thinning has the problem of a corrosion, but PEC is free from it.

3.2 Data division

The material to be measured affects the amplitude and phase change of the electromagnetic field, yielding two parameters.

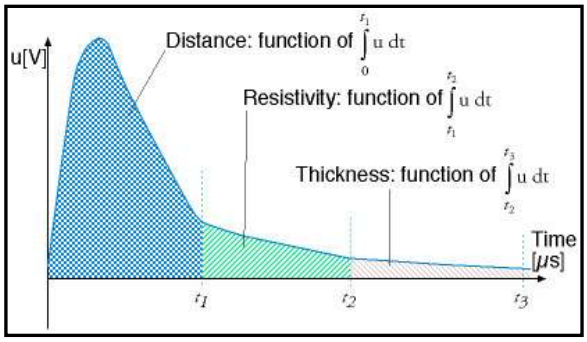

Figure 3. Three parameters of PEC

But to measure dimensions, for example, the thickness of a plate, three parameters must be taken into account: (1) the distance between the coil and the work-piece, (2) the electrical resistivity, and (3) the thickness of the metal plate, strip or bar.

We can extract the thickness information from the output signal and greatly reduce the data transmission time. We want to obtain the thickness information only. Thus we made an united PEC sensor module. It includes a data separation facility. It separates the thickness data from the data acquisition circuit in the module. It transfers the information(less than 0.5 Kbyte) to the remote data acquisition center[3].

4. Conclusion

A piping wall thinning defect inspection is a very important process in nuclear power plants. It is impossible to inspect all pipes based on wired sensors. A sensor network is a proper approach to inspect them.

The wireless sensor, battery and data transmission are obstacles to develop the wireless inspection for the piping wall thinning defect.

PEC is a good methodology to improve these problems. It provides us with several merits in the power consumption, data transmission and wireless communication. The piping wall thinning defect inspection is not executed frequently because the wall thinning progresses are very slow. But the battery problem is not clearly solved. The life of the battery that will be used in the united sensor is finite.

The battery problem is one of the most critical fields in the sensor network. Many methodologies such as the clustering topology control and an energy harvesting skill has been developed to improve it.

Fortunately, there is an useful energy source to charge a battery in nuclear power plants. It is radioactive energy. The atomic cell can replace a traditional battery.

Acknowledgement

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