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ULTRASONIC IMAGE RECONSTRUCTION OF INTERNAL DEFECTS DERIVED BY EMAT USING TRUNCATED SINGULAR VALUE DECOMPOSITION

Yoshihiro Nishimura[1,2], Takayuki Suzuki[1,3], Katsumi Fukuda[4,5], Masatoshi Fukuta[4,6] and Eiki Ikeda[4,7]

[1] National Institute of Advanced Science and Technology, 1-2-1 Namiki Tsukuba Japan,
[2] nisimura.yoshihiro@aist.go.jp [3] suzuki-takayuki@aist.go.jp
[4] Tokyo National College of Technology, 1220-2 Kunugida Hachioji Japan,
[5] fukuda@tokyo-ct.ac.jp [6] as13605@tokyo-ct.ac.jp [7] as14602@tokyo-ct.ac.jp

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Electromagnetic Acoustic Transducers (EMATs) are used in a contact-free non-destructive testing (NDT) method using ultrasonic waves. They are useful for high-speed scanning inspected materials or for scanning high temperature materials. The time series of wave data like those derived by piezoelectric UT can be derived by EMAT,too. (Figure 1) The images of an internal defect derived by scanning the upper surface of an inspected sample is blurred because EMAT probes are usually larger than ordinary piezoelectric probes. Inverse problem-solving approaches are need for better imaging of internal defects. Suppose that an acoustic wave $f(x_0, t)$ is emitted from a EMAT probe and that the return signal $u(x_2, t)$ is observed as illustrated in Figure 2. The distribution of internal defects corresponds to that $\rho(\vec{X} + \vec{x})$ of the reflection coefficient in the inspected sample. The relation between the output signal $w(t, \vec{X})$ of the EMAT probe and the distribution of reflection coefficient $\rho(\vec{X} + \vec{x})$ from internal defects can be calculated using Equations (1) and (2). Here, $h(t, \vec{x_1})$is the response function of the probe. $\vec{X}$ is the global coordinate $(X, Y, 0)$ of the center of the probe. $\vec{x_0}$ and $\vec{x_2}$ are the local coordi-nates $(x_0, y_0, 0)$, $(x_2, y_2, 0)$ of the bottom surface of the probe. The local coordinate $(0, 0, 0)$ is the center of the bottom surface of EMAT probe. $\vec{x_1}$ is a local coordinate $(x_1, y_1, 0)$ within the inspected sample. $f(t)$ is a time series of the signal emitted from the probe. c is the velocity of an acoustic wave. Equation (1) can be expressed in a matrix equation form and $\rho(\vec{x_1})$ can be calculated from $w(t, \vec{X})$ using inverse matrix of $h(t, \vec{x_1})$. However, $h(t, \vec{x_1})$ is generally singular due to the poor precision of computation, common calculation precision is double precision. Therefore, Regularation like Truncated Singular Value Decomposition (TSVD) is required to solve Equation (1).[1]

$$w(\vec{X}, t) = \int \rho(\vec{X} + \vec{x_1}) \cdot h(\vec{x_1}, t) dx_1 dy_1 dz_1 \tag{1}$$

$$h(t, \vec{x_1}) = \int \frac{f\left(t - \frac{|\vec{x_2} - \vec{x_1}| + |\vec{x_0} - \vec{x_1}|}{c}\right)}{|\vec{x_2} - \vec{x_1}||\vec{x_0} - \vec{x_1}|} dx_0 dy_0 dx_2 dy_2 \tag{2}$$

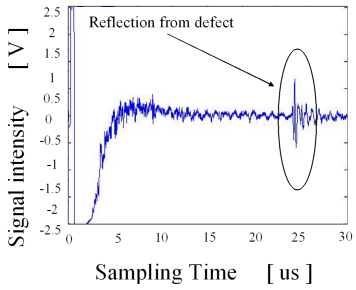

Figure 1: Reflected wave as measured

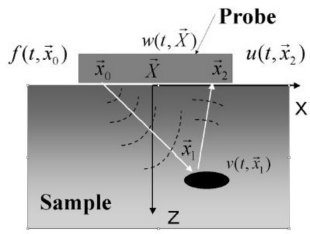

Figure 2: Propagation in a Sample

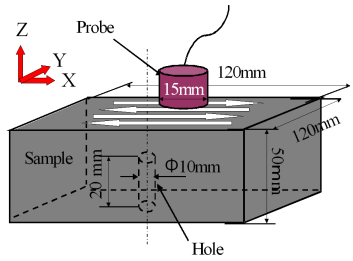

Figure 3: Probe and Sample with an Internal Defect

Figure 3 presents a sample with an internal defect used for a defect-image recontruction. Figure 4 (a-d) presents a defect model, the asreceived image, the image calculated using inverse matrix and that using TSVD. TSVD was shown to improve the quality of defect image.

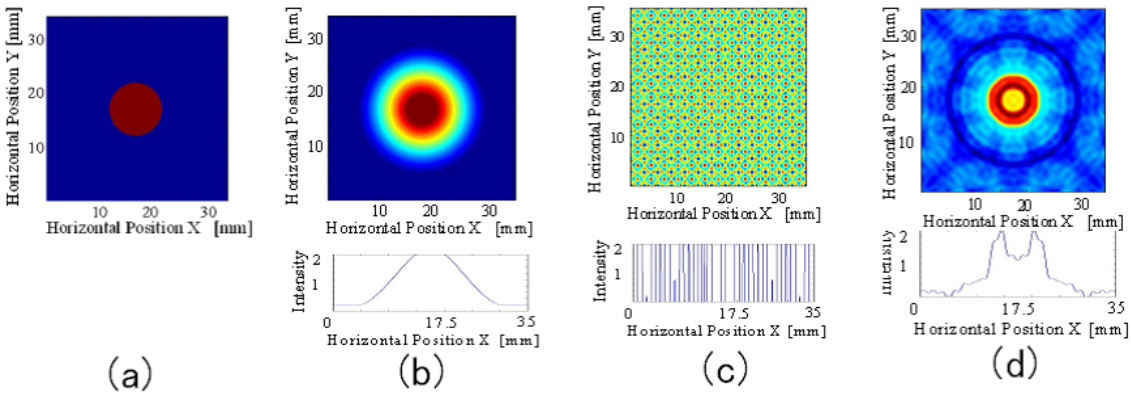

Figure 4: (a) a Defect Model. (b) Asreceived Image, (c) The image calculated using inverse matrix, (d) That using TSVD

REFERENCES

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