UNIFORM EDDY CURRENT PROBE WITH LITTLE DISRUPTING NOISE

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INTRODUCTION

The conventional eddy current testing using a pancake coil probe is prone to suffer from various noises generated by variations of many factors such as probe lift-off, material electromagnetic characteristics and material configurations. Thus it is very difficult for the conventional eddy current testing to detect flaws in variable areas such as weld zone and material edge. In order to detect those flaws, it is indispensable to develop new eddy current probes with little disrupting noise[1-3].

The authors have devised a new eddy current probe which is comprises of a wide tangential exciting coil and a small pick-up coil. The wide tangential coil induces uniform eddy current in the test material and the pick-up coil detects only perpendicular component of the eddy current to the uniform eddy current. The probe is unique because it is self-differential, self-nulling, and lift-off noise free in principle. The probe eliminates the influence from the disrupting objects perpendicular to the uniform eddy current because of its self-differential feature. Thus the new probe has little noise generated by disrupting objects such as weld zones and material edges.

The experimental results using the new probe have proved that the new uniform eddy current probe has a high signal-to-noise ratio compared to the conventional pancake eddy current probe when it is applied to detecting flaws in variable area of test material such as weld zone and material edge.

UNIFORM EDDY CURRENT PROBE

The uniform eddy current probe comprises of a wide tangential coil and a small pick-up coil as shown in Figure 1. The authors developed a rotating uniform eddy current probe

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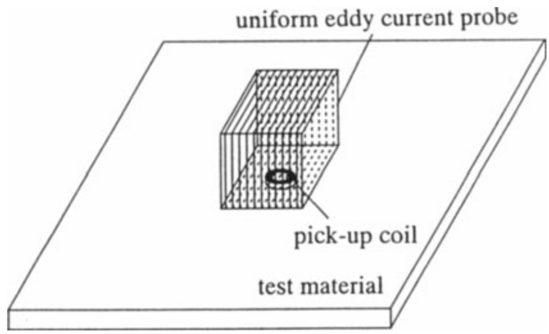

Figure 1 Uniform eddy current probe.

which was already reported[4-5]. The probe in Figure 1 uses only one of two exciting coils of the rotating uniform eddy current probe. The exciting coil generates uniform magnetic field in the conducting materials inducing uniform eddy current parallel to the exciting coil windings under the probe. The pick-up coil detects the local variations of the uniform eddy current under the probe. Each small arc of the pick-up coil winding shown in Figure 2 detects only the local eddy current component parallel to the arc. Considering a pair of small arcs opposite the line passing the coil center parallel to the eddy current, the electromotive forces at these two arcs cancel out each other, because the eddy currents under them flow in the same direction and the electromotive forces along the coil winding are induced in the opposite direction. Thus a pair of small arcs across the pick-up coil center detect only the difference between the eddy currents induced under them.

Consequently, the probe has the self-differential feature which eliminates lift-off noise. And the self-differential feature makes the probe self-nullling, eliminating the bridge balance procedure. The self-differential feature also makes the probe noise free from uniform variations perpendicular to the uniform eddy current. The authors have tried to apply the uniform eddy current probe to detecting flaws in weld zone and material edge.

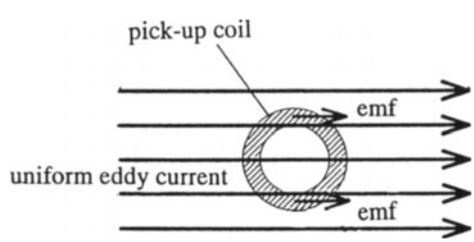

Figure 2 Self-differential feature of uniform eddy current probe.

EXPERIMENTAL RESULTS OF DETECTING FLAWS IN WELD ZONE

Figure 3 shows the weld test material of stainless steel used for the eddy current testing. The stainless plate has a weld zone at its center and the weld zone contains a electric discharge machined slit flaw of 5 mm length, 0.5 mm width, and 0.6, 1.5, 2.4 mm depths. The authors have conducted eddy current testing using a conventional pancake coil probe and uniform eddy current probes.

Figure 4 show the uniform eddy current probe arranged to flow eddy current perpendicular to the weld. The authors have conducted experiments believing the probe arrangement shown in Figure 4 is weld noise free because eddy current flows perpendicular to the weld and the pick-up coil does not generate any signal from the weld.

Figure 5 shows the eddy current testing signal obtained by a conventional pancake coil probe scanning over the weld containing a slit flaw. The three dimensional signal display

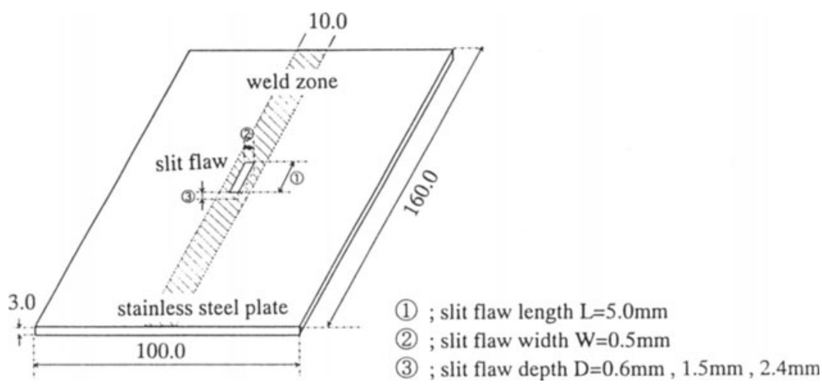

Figure 3 Weld test material with a slit flaw.

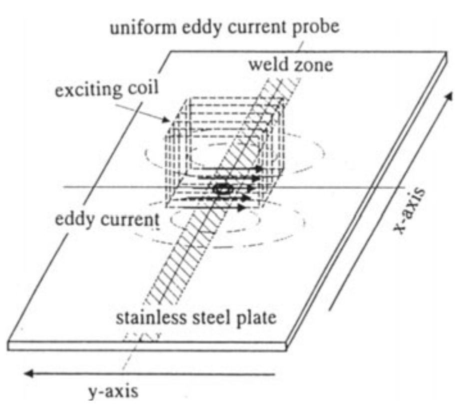

Figure 4 Uniform eddy current probe arranged perpendicular to the weld.

shows the absolute value of the signal. The test frequency is 32 kHz and the pancake coil diameter is 10 mm. The weld signal pattern is obtained when the probe is scanned perpendicular to the weld and the flaw signal pattern is obtained when the probe is scanned over along the slit flaw. The figure shows that the weld zone causes large noise and masks flaw signal. The authors do not know which variation is the cause of the noise, the material configuration or the material electromagnetic characteristics. The figure shows that conventional pancake coil probes can hardly detect flaws in weld zone.

Figure 6 shows the flaw signal and weld noise obtained by a uniform eddy current probe arranged perpendicular to the weld as shown in Figure 4. From the signal patterns, the flaw signal is larger than the weld noise. Figure 7 shows the flaw signal and weld noise obtained by a uniform eddy current probe when the pick-up coil diameter is 4 mm and the test frequency is 130 kHz. The weld noise is far smaller than the flaw signal and the flaw signal can be seen clearly. From those results, the authors think that the experimental results have shown the possibility of the uniform eddy current probe detecting flaws in weld zone.

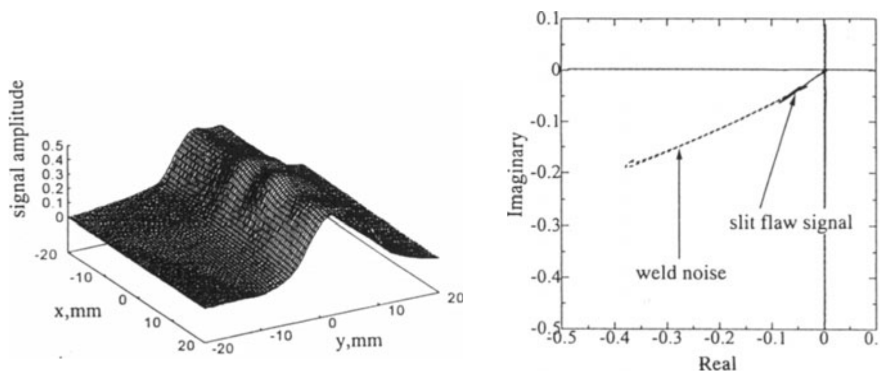

Figure 5 ECT signal of weld zone by a pancake coil probe. (Frequency : 32kHz , coil diameter : 10mm)

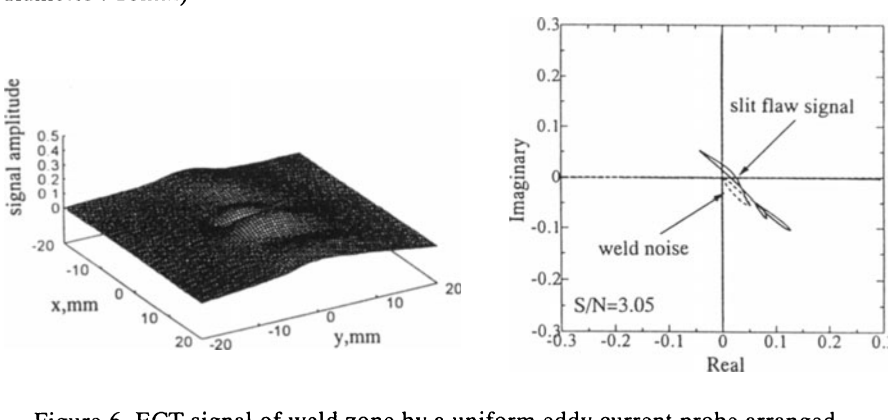

Figure 6 ECT signal of weld zone by a uniform eddy current probe arranged perpendicular to the weld. (Frequency : 32kHz , pick-up coil diameter : 10mm)

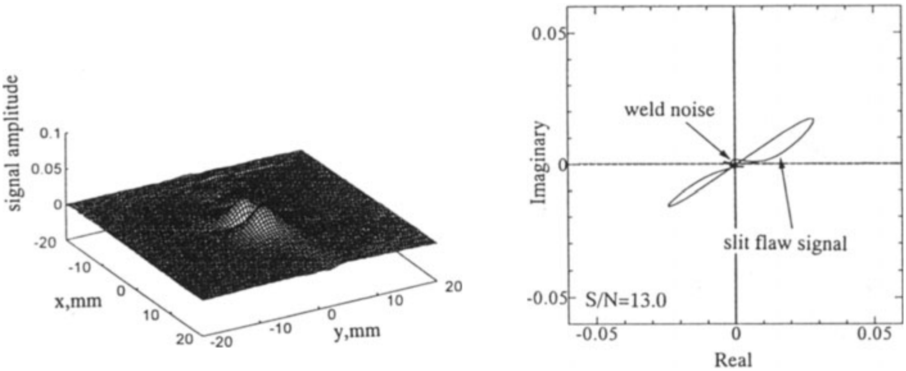

Figure 7 ECT signal of weld zone by a uniform eddy current probe arranged perpendicular to the weld. (Frequency : 130kHz , pick-up coil diameter : 4mm)

EXPERIMENTAL RESULTS OF DETECTING FLAWS AT MATERIAL EDGE

When uniform eddy current is induced perpendicular to the test material edge as shown in Figure8, the eddy current splits at the center of the exciting coil and flows parallel along to the edge. As a result, the flow of eddy current has two opposite components parallel to the edge. If a pick-up coil is positioned right under the exciting coil center and there is no flaw at the material edge, because of the self-differential feature of the probe, the pick-up coil detects only the difference of the parallel eddy current component to the edge, and the pick-up coil generates no signal. The pick-up coil generates a differential flaw signal when there is a flaw at the material edge disturbing the parallel component of the eddy current. Thus a uniform eddy current probe arranged perpendicular to the edge can detect edge flaws with little disrupting noise from the edge.

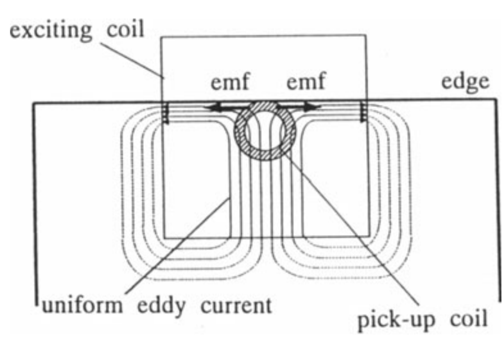

Figure 8 Eddy current induced at the edge by a uniform eddy current probe.

Figure 9 shows the test material used for the experiments of detecting edge flaws. The material is brass and the plate is 1.5 mm thick, and the slit flaw is 5 mm long, 0.5 mm wide, and 100% deep. The authors conducted experiments using many kinds of probes and Figure 10 shows two examples of them. The figure shows 30 mm wide exciting coils and a circular pick-up coil of 7 mm diameter and a rectangular pick-up coil of 7 mm sides.

Figure 11 shows the eddy current testing signal by a conventional circular pancake coil probe of 7 mm diameter. The large slope indicates the material edge noise and the convex at the center indicates the flaw signal. The edge noise pattern is obtained when the probe is scanned perpendicular to the edge and the flaw signal pattern parallel to the edge. Figure 12 shows eddy current testing signal by a rectangular coil probe of 7 mm sides. From these figures, the edge noise is quite larger than the flaw signal. Thus the conventional pancake coil probe can hardly detect flaws at material edge.

Figure 13 shows ECT signal detecting a edge flaw by a uniform eddy current probe with a circular pancake pick-up coil. Figure 14 shows the eddy current testing signal by uniform eddy current probe with a rectangular pick-up coil. The flaw signal is larger compared to the edge noise. The authors believe that the edge noise can be made much

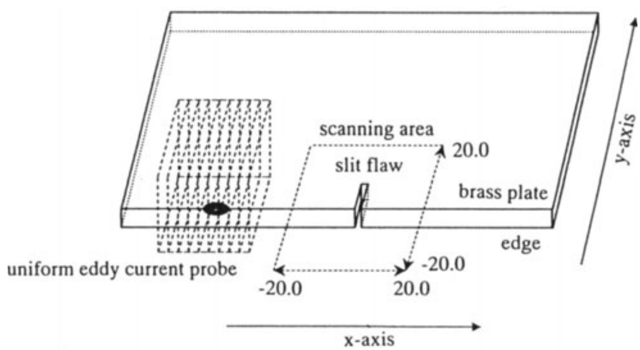

Figure 9 Test material for edge flaw detection.

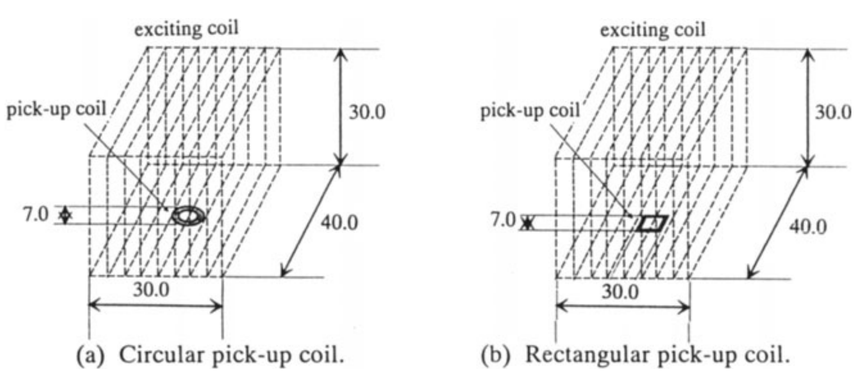

Figure 10 Uniform eddy current probes for edge flaw detection.

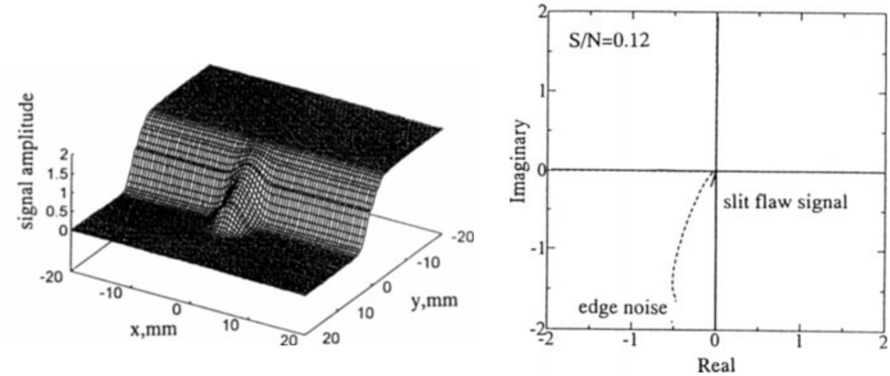

Figure 11 ECT signal of a edge flaw by a circular pancake coil probe. (Frequency : 32kHz , coil diameter : 7mm)

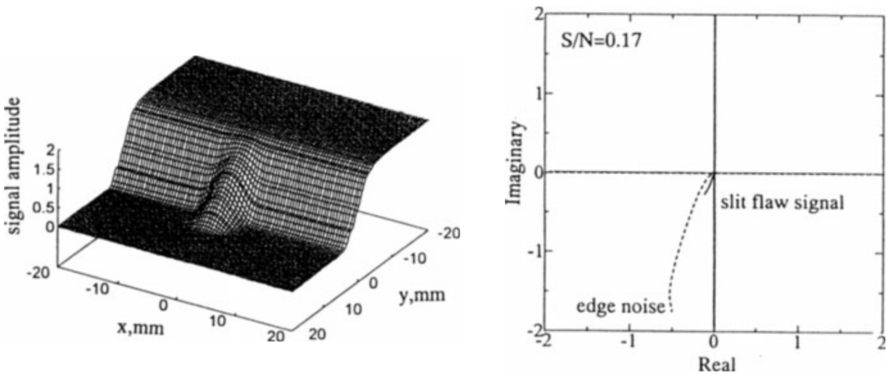

Figure 12 ECT signal of a edge flaw by a rectangular pancake coil probe. (Frequency : 32kHz , coil side : 7mm)

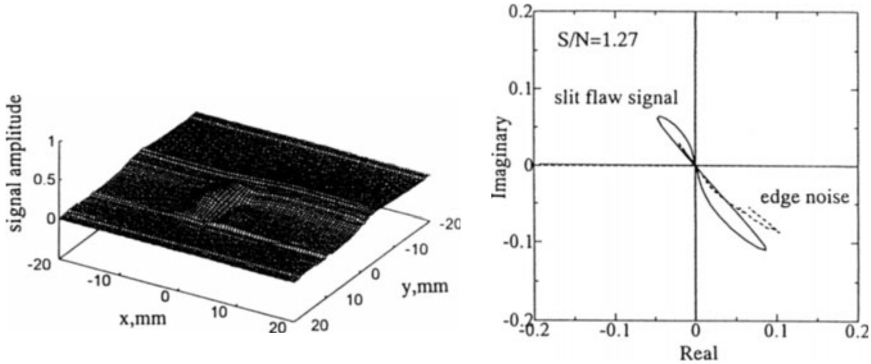

Figure 13 ECT signal of a edge flaw by a uniform eddy current probe with a circular pick-up coil. (Frequency : 32kHz , pick-up coil diameter : 7mm)

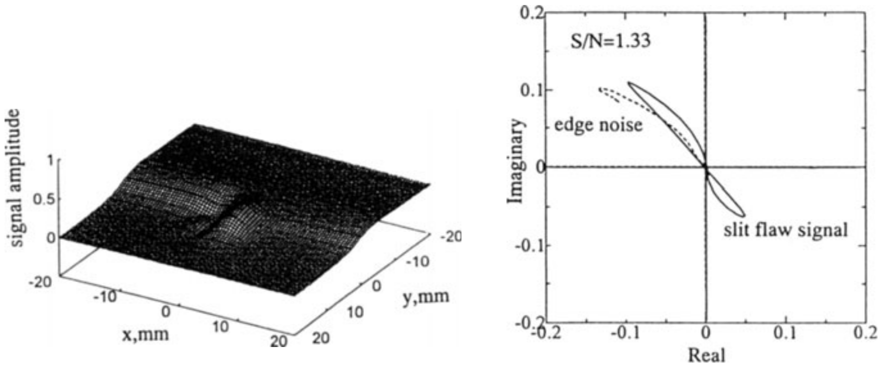

Figure 14 ECT signal of a edge flaw by a uniform eddy current probe with a rectangular pick-up coil. (Frequency : 32kHz , pick-up coil side : 7mm)

smaller by positioning the pick-up coil right under the exciting coil center. Thus the authors think that the edge flaws can be detected with far smaller disrupting edge noise by a uniform eddy current probe compared to the conventional pancake coil probe.

CONCLUSION

The eddy current probe using uniform eddy current has features of being self-differential, lift-off noise free, self-nulling, and noise free from uniform variation of test material perpendicular to the eddy current. The experimental results have shown that the probe has the possibility of detecting flaws in variable areas such as weld zone and material edge.

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