Eddy Current Inspection of Steel Wire

(Application Example Follow-up)

Application Report AP240806-2

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Introduction and Objective

After I wrote application report AP240806 that describes the steps I took to inspect a 1.6mm steel wire for flaws, I felt challenged to develop a high-frequency encircling coil in the Uniwest U20 housing-style that could be used in the production of larger diameter wires.
After doing a bit of math and designing an appropriate bobbin for a differential reflection coil, we built the U20-2-HF 2.0mm encircling coil.
It turned out to be a bit better than estimated, with a center-frequency of 1 MHz and a frequency range of 20 kHz to 2 MHz. The following describes how the coil performed with the 1.6mm steel wire.

Setup

The encircling coil and setup are shown in figures 1 and 2

Fig. 1 Encircing coil U20-2HF 2.0mm

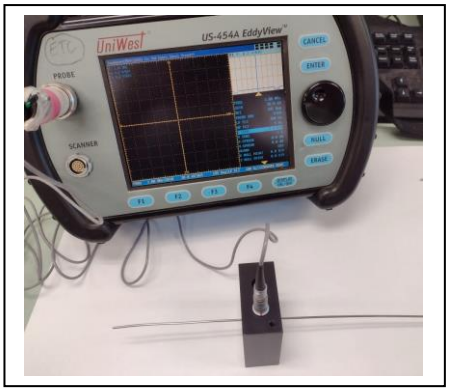

Fig. 2 Equipment setup

Additionally, I used a 0.030 inch (0.76mm) endmill to create man-made holes (fig. 3) in the “Good Wire” (the smallest diameter endmill I had available).

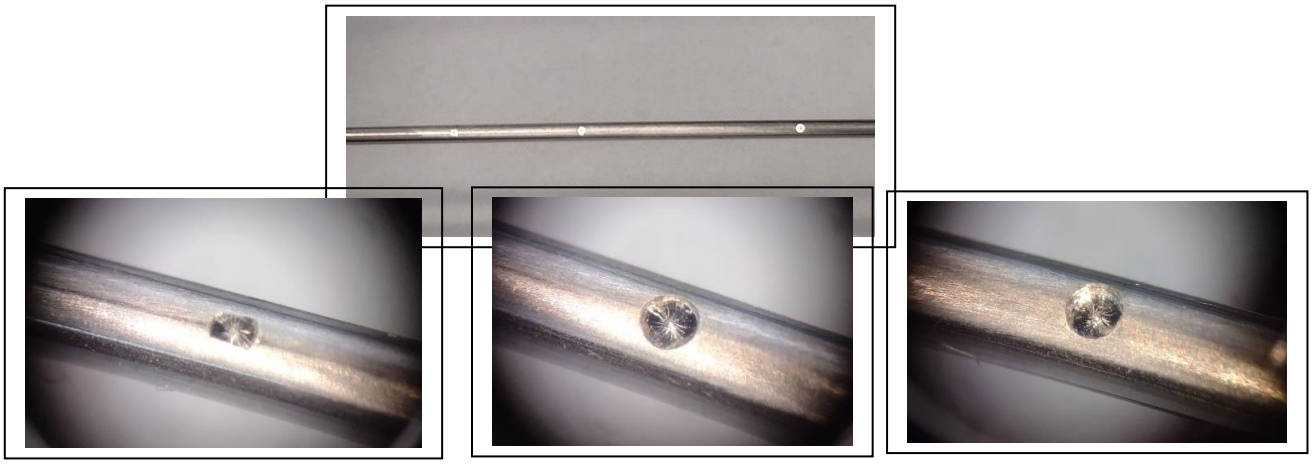

Fig. 3 Man-made holes in good wire, small 0.003” deep, medium 0.007” deep, large 0.015” deep

Results

Let's look at the responses from the three holes in the Good Wire at 1 MHz (fig. 4), shown in figures 5 through 8.

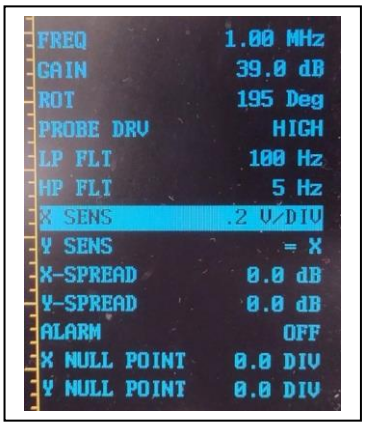

Fig. 4 Instrument settings

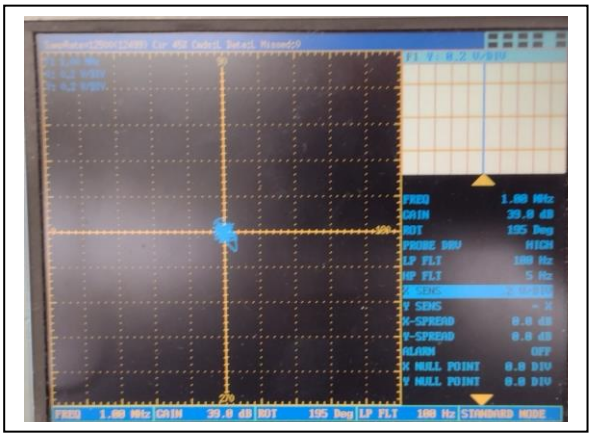

Fig. 5 Signal response, Good Wire w/o flaws

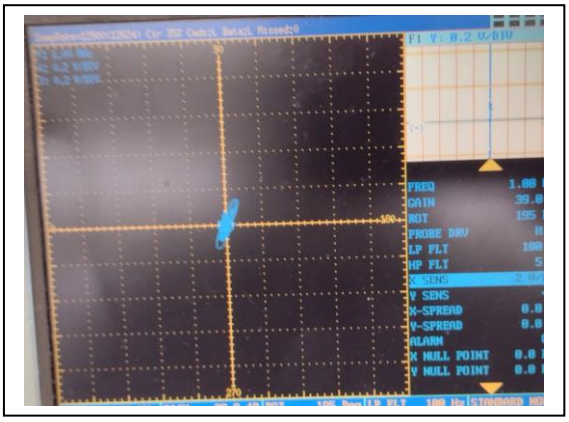

Fig. 6 Signal response, small hole

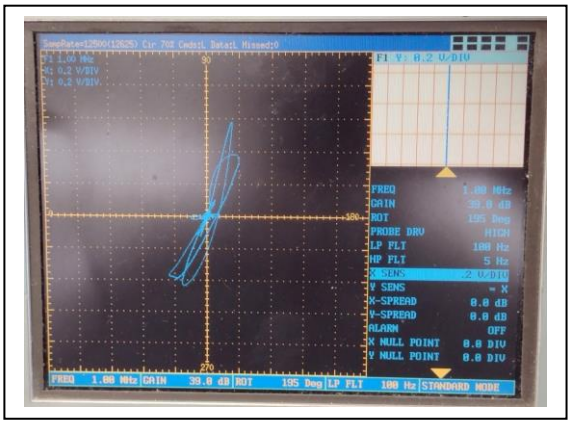

Fig. 7 Signal response, medium hole

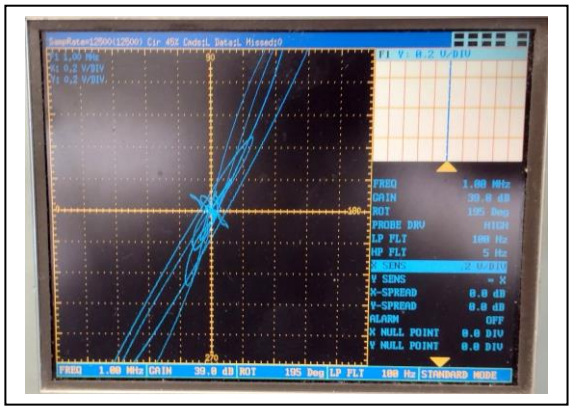

Fig. 8 Signal response, large hole

Figure 9 shows the responses from the holes in strip-chart format.

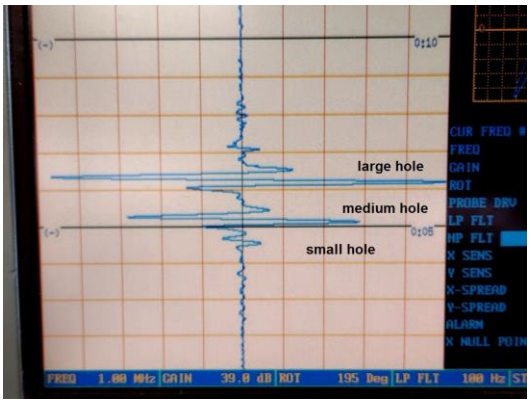

Fig. 9 Chart display of signal responses

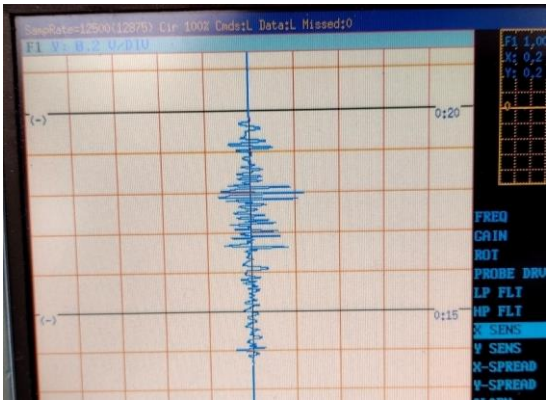

Fig. 10 Signal responses from “Bad Wire”

Unfortunately, in order to get the response of the large hole to show up reasonably small in the display, I had set the instrument gain a bit too low. As a result, the flaws in the “Bad Wire” appear too small (fig. 10).

By increasing the gain close to the value in the original report we can see the flaws in the “Bad Wire” a bit better (figures 11 to 14).

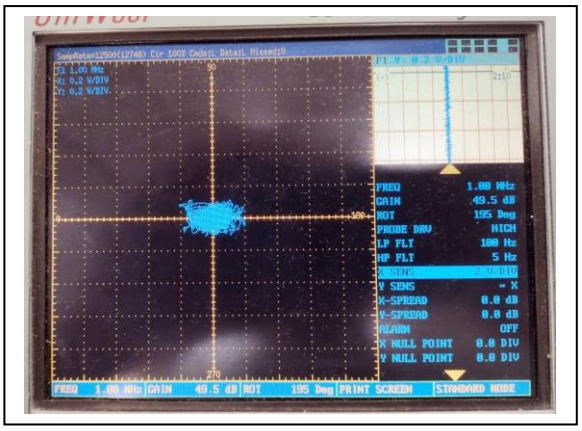

Fig. 11 Signal response, Good Wire

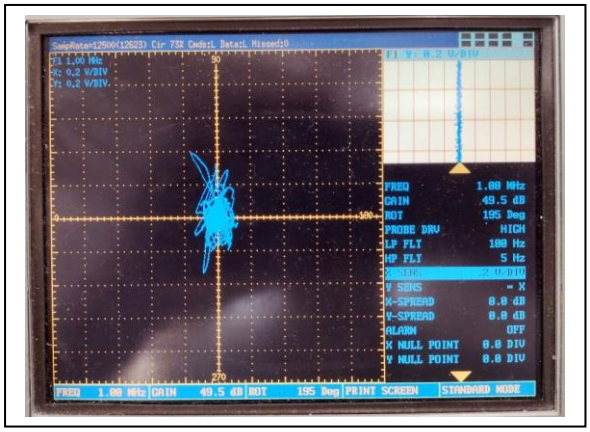

Fig. 12 Signal response, Bad Wire, small flaws

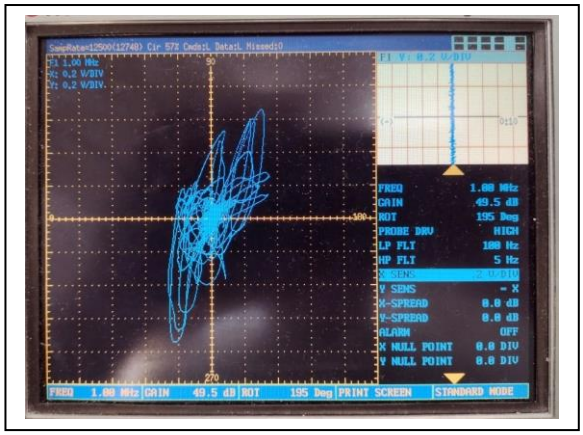

Fig. 13 Signal response, Bad Wire, med flaws

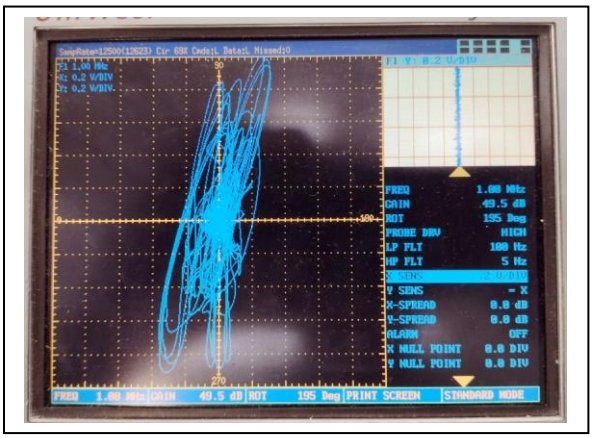

Fig. 14 Signal response, Bad Wire, large flaws

Conclusion

Comparing the signal responses shown above to the responses from the U3 encircling coil in the original report we can see that we obtain equivalent results even though the actual coil diameter is slightly larger.

The U20-2HF has a broader frequency range than the U3 coil configuration and is more suitable for inspecting larger diameter wires.

Clearly holes made with a 0.030 inch diameter endmill are not representative of the flaws in the Bad Wire. Holes made with a 0.010 inch endmill would have been more representative.

Please note that the Final Remarks in the original report still hold!

Kennewick WA, USA, 21. August 2024