Eddy Current Testing of Partly Magnetic Stainless Steels

The DC saturation method for eddy current testing provides a better signal-to-noise ratio when examining partly magnetic stainless steel tubing

BY DAVID BAUER AND ANTHONY GRAVIANO

Because some stainless steels are partly magnetic, the usual method of eddy current testing using permanent magnet coils may not be the best choice since these types of coils usually don't have strong enough magnetic fields to optimize the signal-to-noise ratio for testing such products.

Theory of DC Saturation

Partially magnetic stainless steel alloys present problems during eddy current testing because the material's permeability is not constant. In terms of calibrating the equipment there is usually an increase in the background "noise" of the product because of the varying permeability, which will reduce the signal-to-noise ratio.

One method for reducing the noise and enhancing the signal-to-noise ratio is to use a coil with a permanent magnet. However, this method usually does not produce a magnetic field strong enough to achieve saturation. Saturation is defined as the degree of magnetization produced in a ferromagnetic material where the incremental permeability has been decreased substantially to almost exact unity.

A better and more reliable method to reduce the material permeability to unity is to use DC saturation, which produces a much stronger magnetic field than a permanent magnet coil. A schematic of DC saturation is shown in Fig. 1.

This technique utilizes a welding generator to impart a high current into the test coil to saturate the material. The end result of this technique is to maximize the signal-to-noise ratio, an improvement over permanent magnet coils.

Use of DC Saturation for In-Line Testing

An arrangement of a DC saturation coil used in line on the mill to test long length tubular coils is shown in Fig. 2.

The following should be noted in the typical saturation coil shown in Fig. 2:

1. An insert test coil (selected to allow the desired fill factor for the particular size tubing) slides into the main saturation housing. The housing is water cooled.
2. The insert coil can be single frequency or dual frequency.
3. An independent power supply provides the necessary amps for DC saturation.
4. Calibration is normally done by using a similar coil installed in an off-line cart with rolls and variable speed control. Using a reference standard with the desired drilled hole or

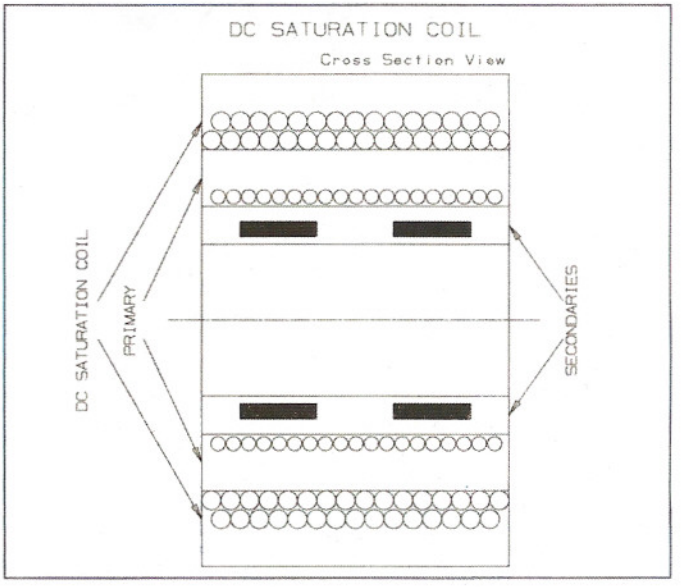

Fig. 1 — Schematic of a DC saturation coil.

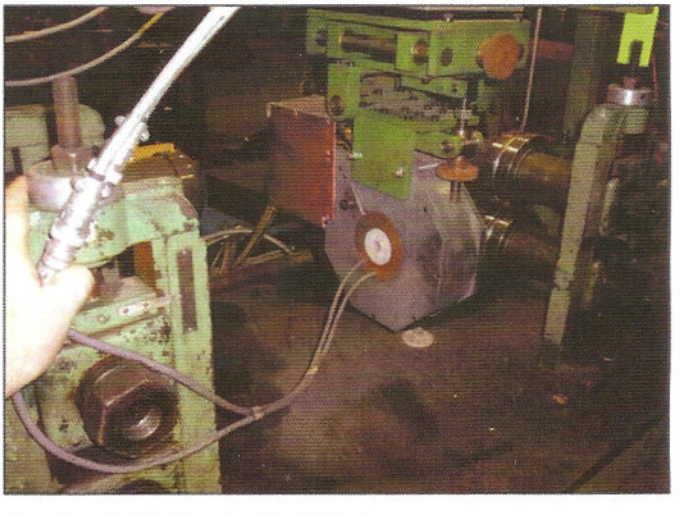

Fig. 2 — Eddy current coil platform.

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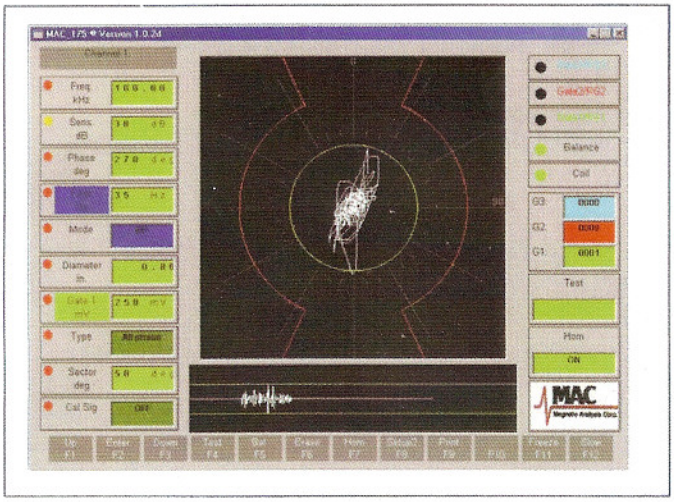

Fig. 3 — No saturation.

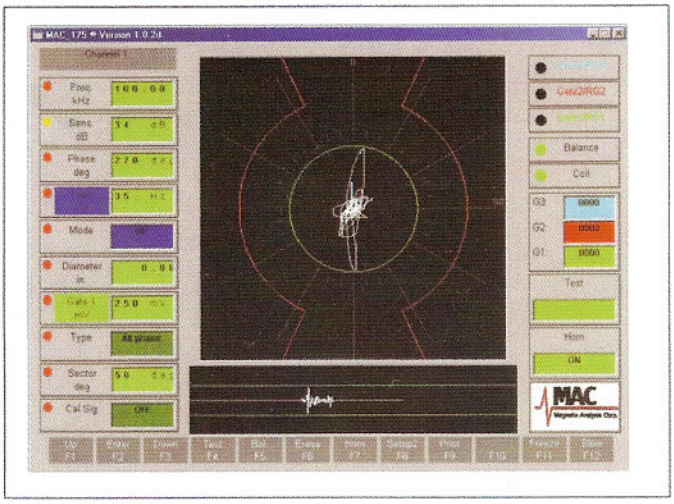

Fig. 4 — Permanent magnet.

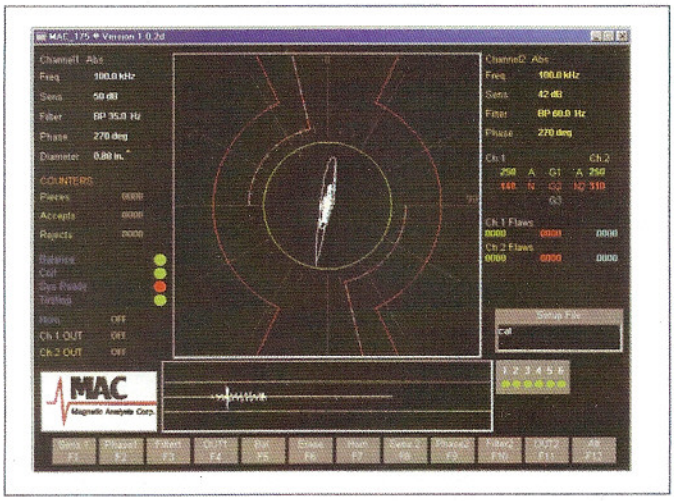

Fig. 5 — DC saturation.

EDM notches, the eddy current equipment is standardized.

5. Automatic paint sprayers are put in-line to mark any indications to be further evaluated offline.

Use of DC Saturation for Off-Line Testing

Long-length tubing is typically coiled on reels. As such, it is becoming more and more advantageous to eddy current test this product as it is being reeled. However, this presents some obvious problems for proving up indications since it usually is not possible to pull the tube back off the reel in a controlled way.

To overcome this issue, an oscillating DC saturation coil is used. Since eddy current testing requires relative motion between the test coil and the tube, it should not matter if the coil is stationary with the tubing moving or the tubing is still with the coil moving. The coil is used in the same arrangement as previously described with one important difference: if an eddy current indication is detected, the reeling apparatus automatically shuts off and the indication will be located about 6 in. to the left of the coil if the product is feeding from right to left. Then the coil is simply oscillated back and forth past the indication to perform the proofing. Typically (and for ease of calibration), the oscillating speed is set equivalent to the reeling speed. Calibration must be done in two modes: the static (normal) as well as oscillating.

Summary

A DC saturation system provides a more reliable technique for testing partially magnetic tubular products. This system provides flexibility in off-line as well as in-line testing.

Figures 3–5 show examples of DC saturation eddy current testing. The setup for all three situations of 0.849- × 0.112-in. 19D material was done at a test frequency of 100 kHz. All other conditions and parameters were kept the same except for sensitivity.

The sensitivity for each setup was set so as to have the EDM longitudinal notch (0.25 in. long × 0.0305 in. wide × 0.0112 in. deep) just break threshold. The sensitivity to do this required 38 db for no saturation (Fig. 3), 34 db for permanent magnet (Fig. 4), and 50 db for DC saturation (Fig. 5). Clearly this shows a significant signal-to-noise ratio for the use of DC saturation.❖

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