Electromagnetic Techniques

for

Inspection of Carbon Steel Tubes

All electromagnetic techniques for the inspection of tube and pipe make the implicit assumption that the electrical and magnetic properties of the material remain constant along the length of the tube. If the technique produces signals from the tube it is assumed that they have been generated by defects such as erosion, wear, cracks or corrosion.

The assumption is often true for non-ferrous tubes but is much more questionable for carbon steel. Carbon steel tubes are generally of poorer metallurgical quality than their non-ferrous counterparts and local variations of the electrical and magnetic properties are common.

The magnetic properties, especially the ‘low field’ properties are especially sensitive to the history of the tube. The handling of the tube as it passed through the heat treatment furnace may have resulted in hot and cold spots or of differences in cooling rates at different points in the tube. Mechanical treatment or mistreatment may have caused local cold working. External magnetic fields, deliberately or accidentally applied, may have left a permanent magnetisation which varies dramatically from place to place along the tube.

Depending on the technique, these localised variations in properties may give spurious signals. There are two ways to tackle the problem, either, attempt to recognise and discount the offending signals, or, use a technique that reduces the factors producing the unwanted signals.

If pitting, wear, a support plate and a magnetic anomaly occur separately, at different points along a tube, signal recognition may be possible and discounting the unwanted signals may be an option. Unfortunately, in carbon steel tubes, corrosion is usually general and everything happens together at one and the same place. Typically, wear on the outside at a support plate, a magnetic anomaly caused by the work hardening resulting from the vibration that produced the wear and, finally, severe corrosion pitting on the inside of the tube. Distinguishing the significant from the unimportant by signal processing or recognition is very difficult in these situations.

It is possible to eddy-current inspect carbon steel tubes, the remote field system, RFEC, is one version. A low frequency excitation has to be used to obtain adequate penetration of the tube wall, and it is assumed that any residual magnetisation of the tube is uniform. Unfortunately, the low excitation frequency means slow inspection speeds if small defects are to be resolved and the inevitable ‘low field’ variations in magnetic properties can give significant and confusing spurious signals.

Because of the way in which carbon steel magnetises, local variations in magnetic properties are less if the material is fairly strongly magnetised, flux densities above about 1.2 Tesla. In magnetic particle inspection technique, this sort of level of magnetisation is advised to avoid spurious indications. Also, at this level of magnetisation, and higher, the techniques of magnetic flux leakage and the special technique used in the DINSEARCH 1-00 become reliable and efficient.

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Electromagnetic Techniques for Carbon Steel Tubes

Most heat exchangers use carbon steel tubes between 15mm and 40mm o.d. and with a wall thickness from 2mm to 4mm. The magnet to magnetise the tube wall has to go down the inside of the tube, together with the detection system, and this has to fit into a sheath which will give adequate protection in a bore that is usually very dirty and rough. There is very little space for the magnet, a fact brought home when you realise that the cross-sectional area of the hole up a 19mm tube (the bore) is not much larger than the cross-sectional area of the tube wall. To achieve the best level of magnetisation of the tube wall, permanent magnets are rarely satisfactory and electro-magnets are much better.

Because of the small amount of space available in heat exchanger tubes, the only usable detector for magnetic flux leakage systems is a pick-up coil. Two problems arise, the amplitude of the signal from a defect depends on the speed of the pull through the tube and the amplitude is very dependent on 'lift-off'. (The probe has to be a good fit in the tube, not free to rattle, and the sheath on the probe has to be thin.)

In the DINSEARCH 1-00, the tube wall is magnetised to about 1.5 Tesla and sensors on the probe respond not to the leakage flux but to the flux density within the tube wall. Where there are defects, metal missing or cracks, the flux density in the wall rises, the change can be detected and used to indicate the defect. Because the sensors work with a 35kHz carrier, there is no compromise in pull speed (unlike RFEC); because they do not depend on induced voltages, the signal is not affected by the speed of pull through the tube (unlike induced flux leakage signals); also, it turns out, the response is less affected by 'lift-off' so the probe can be smaller and it is possible to inspect tubes that are not completely clean.

The DINSEARCH 2-00 is intended for inside larger tubes and for the outside of tubes. There is more space available and defects tend to be larger. The extra space allows us to use Hall effect devices to detect the magnetic flux leakage. Hall effect devices are not speed dependent, so the DINSEARCH 2-00, like the 1-00, can travel at any convenient speed through or over the tube. The larger defects mean that we can deliberately increase the 'lift-off', and thereby reduce the effect of small variations in 'lift-off', without compromising the usefulness of the equipment. As in the DINSEARCH 1-00, controllable electromagnets ensure adequate and correct magnetisation.

The ColcheK™ system is designed for the detection and measurement of below ground corrosion in lighting columns. In lighting columns, the defects are large, typically 50% wall loss extending 50mm to 100mm along the column and spreading more than one quarter of the way round the column. Lighting columns are usually perfectly sound immediately above the corrode zone and can be seen to be so which means that this part can be used as a reference point. Because there is this reference point on each column immediately above the corrosion, because the defects are large and great accuracy in measurement is not required, a low frequency eddy-current technique is perfectly adequate.

As in all inspection, it is important that the technique is appropriate to the problem. What works well in one situation may be inappropriate in another. Our aim is to match the technique to the problem.

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