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Advances In Eddy Current Array Sensor Technology

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Abstract

Eddy Current array technology can be an extremely useful tool for increasing productivity and detection capabilities for surfaces. Typical surface inspection techniques such as Dye Penetrant methods, require chemicals and development time, whereas an eddy current technique can be done cleanly and nearly instantly with no chemical clean up afterwards. New probe technology makes flexible arrays easier and cheaper to use, and eddy current systems and software easier to apply to new testing requirements, and simple enough for entry level technicians to learn and operate. The outcome is better, more uniform test with a digital record. And since the eddy current arrays are tunable to a particular defect type or size, the Probability of Detection (POD) increases dramatically for the defects of interest compared to manual single channel eddy current inspection, while decreasing the likelihood of false defect calls.

This paper will describe some of the technology available for using Eddy Current Array as a test solution, as well as some sample applications.

1. Introduction

The capabilities of Eddy Current hardware and software have improved dramatically. Digital systems can manipulate data as it is being collected to enhance the Probability of Detection (POD) of target defects in ever increasing difficult test criteria. Data can be stored and used for reference for future tests.

The gains in capabilities in hardware and software has made in possible to use Eddy Current technology in new and powerful ways. One new way to apply Eddy Current technology is in using arrays to cover large areas, where in the past a single Eddy Current coil would be mechanically manipulated over a large or complex geometric shape. Arrays can be developed custom-fitted to complex shapes or span large areas to make testing faster and with higher POD.

This paper presents a method of making inexpensive Eddy Current sensor arrays. The most common NDT tests performed are surface tests such as dye penetrant or magnetic particle technologies. The use of Eddy Current arrays can make many of these tests better, faster and more repeatable.

2. Eddy Current Sensor

Eddy Current sensor technology has evolved along with available hardware and software. For instance, very small sensors can be built by using microscopes and precision tools. Using automatic winding machines to make coils results in greater uniformity of coils over hand wound techniques. Eddy Current sensors can be made to operate in many different ways: bridge, transmit-receive, absolute, differential and cross-wound. But all are still essentially the same; wire wound coils concept that have been in use since the beginning of Eddy Current NDT.

3. Typical Coil Sensor Limitations

When designing a sensor for new application the primary criterion is detection capability or sensitivity to the target defects in the given material and geometry. However, consideration must be given to other test scenario aspect such as environment, temperature of operation, wear protection, size and material, for example. Often the applications that cannot be solved are constrained by a specification not related to sensitivity. For example, a coil can be made to detect a specific flaw size on a given surface but it might be impossible to make a housing small enough to get the probe on the part of interest.

The biggest limitations for wire wound coil probes are mechanical as a result of the coil is a rigid assembly. Coils can be shaped to a certain extent to fit complex geometries but they are not flexible. The coil or coil array also occupies a volume, which must be enclosed in a protective housing.

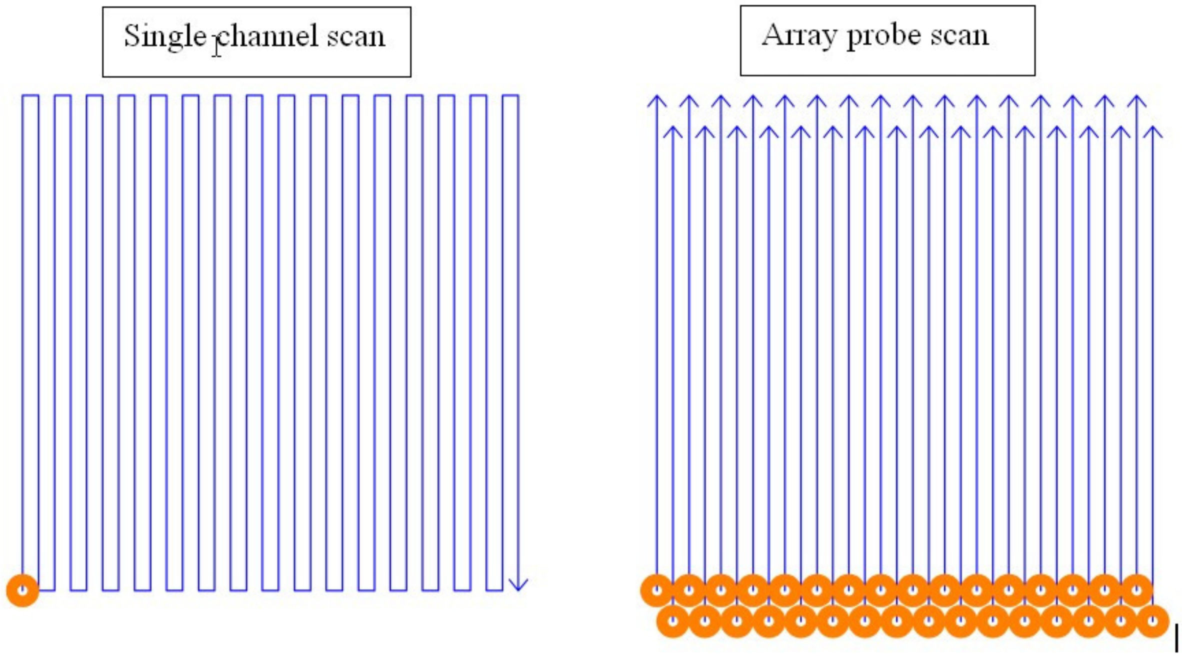
Another consideration is cost associated with manufacturing wound coil Eddy Current sensors.. Making a single coil can be inexpensive, but if the coil has to match other coils in an assembly with very precise specifications with tight tolerances, costs can increase dramatically.

4. Eddy Current Arrays

The biggest evolution in Eddy Current sensor technology is Eddy Current arrays. Eddy Current array technology increases productivity and detection capabilities for surface inspection. The inspection of large surfaces has always been problematic due to the low Probability of Detection (POD), for the defects of interest, if the inspection is done manually or by the complexity and cost associated with scanner and fixture. Inspection times can be long and therefore costly, or present a bottleneck in a production environment. Visual surface techniques like dye penetrant, fluorescent penetrant or magnetic particle require development time, can mean production of chemical wastes, and provide data that can only be recorded by photograph. In many cases the repeatability of the test is highly operator dependent.

Eddy Current array techniques can be done cleanly and nearly instantly without the need of complex scanner or chemical clean up afterwards. The outcome is a better, more uniform test with a digital record. Since the resolution of Eddy Current arrays is a design parameter (application specific) a known surface coverage with a known sensitivity and resolution results in a dramatically increased Probability of Detection (POD) for the defects of interest compared to manual single channel Eddy Current inspection.

Examples of a surface scan with a single channel probe vs. array probe



Single channel scan	Array probe scan
-Time consuming -Need scanning devise to ensure proper coverage <u>Scan time ex:</u> 32 scan line of 10" at 1" per sec. = 5.3min	-Faster -No need of scanner (but compatible if needed) -May require only basic one axis encoding (which can be built in the probe) <u>Scan time ex:</u> 32 scan line of 10" at 1" per sec. = 10sec.

Arrays have been made from conventional coils and are therefore subject to the same limitations of single channel coils. Cost to manufacture can be significant. If a standard single channel pencil main cost is the manufacture of the coil itself, than a multi coil sensor will have incrementally greater cost of manufacture, which limits the range of applications where this technology can be economically used.

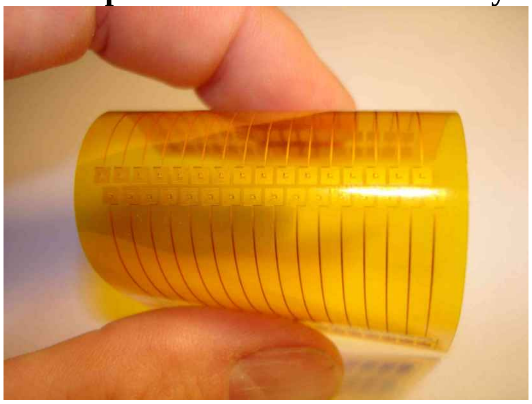
Often test problems include a requirement to follow a varying surface profile such, as an airfoil surface. Arrays can be made flexible; but because each individual sensor themselves are not, there is always a limit past which coils will be less effective, or the wire will start to fail.

5. New sensor technologies to overcome barriers

Advances in electronics manufacturing, especially in the sector of flexible printed circuit boards, have been used to develop a new type of Eddy Current sensor. These are often referred to as film coils or etch coils. These coils are manufactured using a GE patented process in a similar fashion to electronic PCBs. The result is a very thin and flexible coil that can work as a conventional Eddy Current coil. The design possibilities are endless. Coils can be designed to work in every operating mode (absolute, differential, transmit-receive…) and size. They can be made as single coil or as arrays.

There are many advantages to film coils but probably the most important ones are for arrays. Existing array probe technology can results in probes to costly for a particular application. Using film technology will make arrays easier and therefore less expensive to manufacture. The reduced coil-to-coil variations realized with etch coils, as opposed to conventionally wound coils permits a far more uniform test with equal sensitivity across all coils. Flexible probes, the inspection of parts with sharp corners and radii, field replacement of coils, and compact design are other key features that this technology allows.

Example of a 32 channel film array



6. Conclusion

Probe design complexity and cost for large or complex surfaces is great reduced using GE propriety film technology. The use of this technology with multi-frequency multi-channel Eddy Current systems and appropriate software has the potential to increase POD and greatly enhance speed of test in single channel Eddy Current tests using where the probe is mechanically manipulated over a surface. Film array technology can dramatically decrease the cost of manufacture of probes and become an economic alternative to time and resource consuming dye penetrant, magnetic particle and fluorescent penetrant surface tests, and can provide a digital record for reporting and archiving.