

## Application Note #0110 Eddy Current Thread Checking Signature Analysis

### Description:

Giving your customers the perfectly machined hole used in an automated assembly process.

### Motivation:

Perfectly drilled, tapped or countersunk holes are required in today's automated assembly processes. An improperly dimensioned hole has the potential to stop a production line. This can have catastrophic consequences to the profits of a highly automated manufacturing facility.

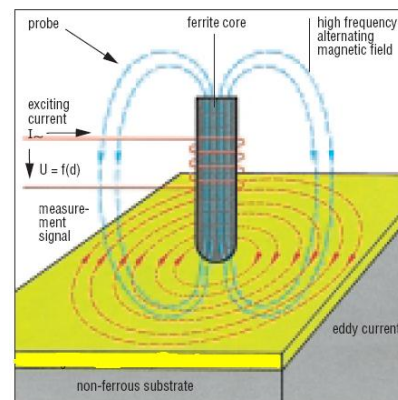
### Solution:

While it is possible to pull parts from the production line and manually check the threads with a gauge, this method doesn't always work in a high speed assembly line. Furthermore, with today's high quality standards and potentially large penalties for shipping defective parts, there is a clear need to automate inspection so that every defective component can be found and removed from the production line.

Automated inspection systems can verify that components have proper dimension and material properties, (i.e. countersunk is present, threads presence, correct thread depth, hole diameter, porosity, etc.). In the past, this type of inspection has been typically done by vision systems, which are a challenging and expensive proposition. The data in this article shows that an approach using an eddy current sensor, with a precision displacement probe to monitor its position can be a low cost alternative for high speed part inspection.

For non-ferrous conductive components, eddy current technology is the sensor of choice. (This article is based on using an Eddy current sensor on an aluminum part. For ferromagnetic components, inductive sensors should be use). Eddy current sensors produce an electro-magnetic field that emanates from the sensor to a diameter equal to approximately 3 times the sensor diameter. The oscillating field induces eddy currents in the surface of a conductive material that engages the field. The influence of the resulting eddy current field on the coil field is proportional to the distance between the coil and conductive "Target" material.

By inserting an appropriately sized eddy current sensor into a machined hole, an analog voltage proportional to the radial distance between the sensor and the hole surface is produced. Plotting the eddy current sensors output voltage with respect to the distance the probe is inserted into the hole, generates a waveform that can be used to determine the quality of the hole. Since probe output voltage is affected by probe positioning and



Eddy Current Method

changes in the base material, both of these parameters need to be tightly controlled to ensure measurement accuracy. Eddy current sensors are also not affected by water, oil or dust.

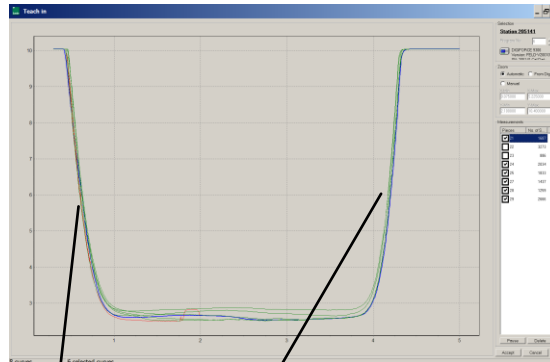
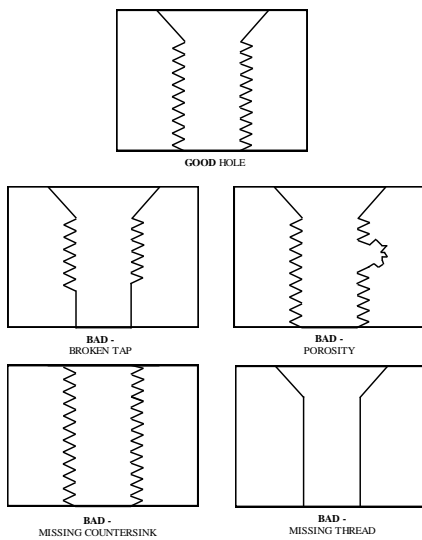


Figure 1

Waveform shows the profile of a correctly machined hole. Eddy current displacement into the hole (X axis) versus the sensor's output voltage is plotted.

Reference waveforms were captured from several correctly drilled, tapped and countersunk holes (figure 1). By comparing waveforms from other inspected parts to our reference waveform, we can detect and remove from the shipment components with typical defects as shown in the diagrams and figures below.

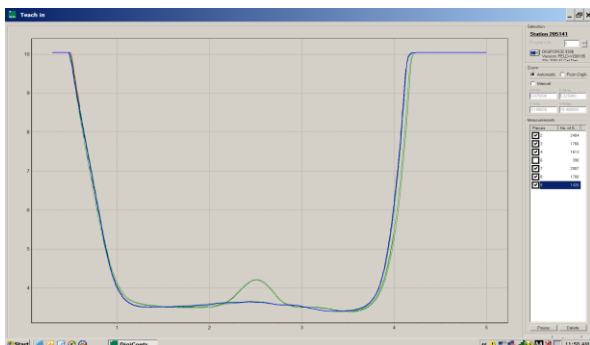
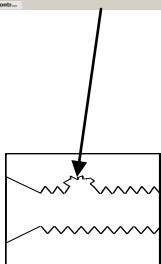


Figure 2

This hole profile waveform shows a porosity defect in the base metal. A porosity defect causes the curve to spike. The blue profile is our reference waveform.



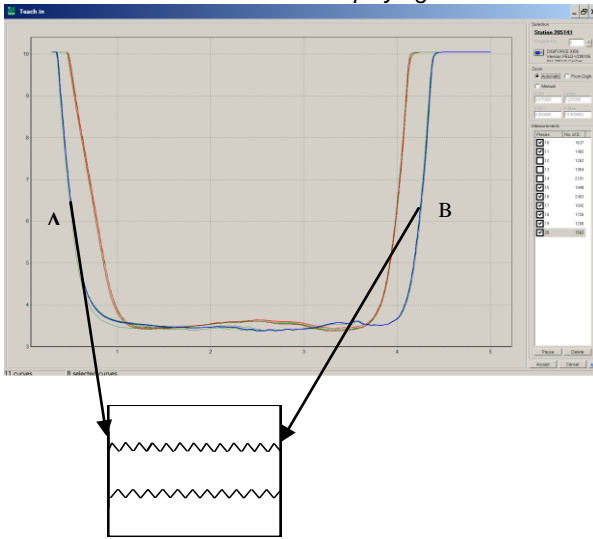


Figure 3

This hole profile waveform shows two defects. Tapped hole is missing the countersink, so the curve is shifted left and has steeper slope (A), and also the part is thicker so the curve is shifted right (B). The red curve is our reference curve profile

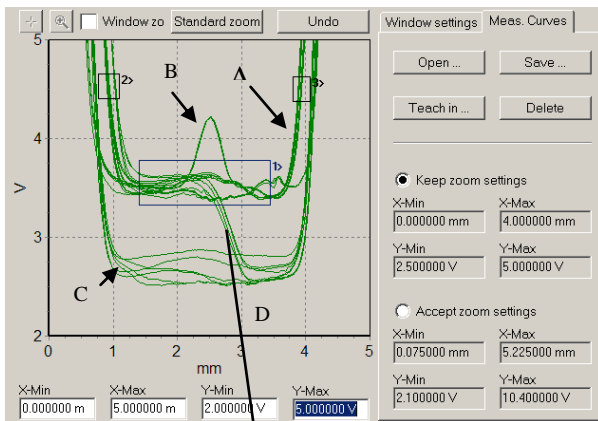
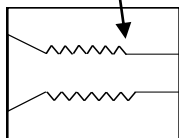
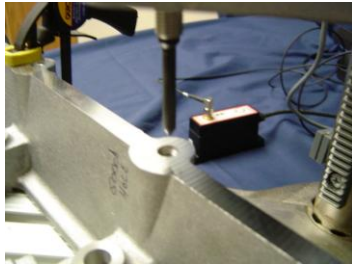


Figure 4 shows multiple hole profile waveform faults.

A - Waveforms of holes tapped and countersunk correctly.  
 B - Waveforms show hole with porosity fault.  
 C - Waveforms show holes missing taper and threads.  
 D - Waveforms show holes made with a broken tap.



Graphing multiple faulty hole waveforms over a plot of a good hole waveform is a monitoring strategy that can be used to quickly detect common anomalies. Defective components can be found by using alarm functions that require the waveform to enter and exit a region of the graph in a defined way.



In the example shown above, the three alarm functions require the signal to enter from the top and exit from the bottom (alarm function 2>), enter from the left and exit from the right, (alarm function 1>) or enter from the bottom and exit from the top, (alarm function 3>). If these alarm function requirements are met, the part is properly machined.



Dependent on the type of sensor used, other parameters that can be measured include the distance of the first thread to top of the block, countersunk slope, thread length, part thickness and a wide range of other common physical properties.

*Complete Thread Detection System Requirements:*

- 1) Eddy Current probe and signal conditioner used during testing.
- 2) Displacement sensor used for monitoring the position of the eddy current probe.
- 3) Process monitoring system used for data collection, alarm and plot generation.

