APPLICATION

Thread Detection Using Inductive Sensors

Detecting the presence of threads in a hole is easy to automate using inductive sensing technology. There are however, some sources of error that when understood, enhance the reliability of inductive thread detection.

Inductive displacement sensors are typically used to detect the distance between the sensor face and target. Circuit designs are optimized to utilize the electromagnetic field that extends out in front of the sensor. Application guides warn of conductive material in the radial portion of the field around the sensor causing erroneous changes in the output, and recommend removing any conductive material within a 3X sensor diameter area that is not the target.

Just the opposite is true when using inductive sensors for thread detection. The sensor is inserted into the threaded hole and it is the radial portion of the electromagnetic field that engages the target, in this case the threaded surface of the hole. Instead of concern over non-target material in the radial portion of the field, the concern is with non-target material in front of the sensor. This could be a work surface, clamping surface or the bottom of a blind tapped hole.

RANGE

The electro-magnetic field produced by the sensor extends radially from the OD of the sensor the same distance as it extends axially from the face of the sensor. The published measurement range for a given sensor in a normal displacement application is based on the output being linear to a given specification.

The field extends much farther than that of the published range. As Kaman's thread detection sensors are intended for go-no-go applications, the field beyond the published range is still useful. As a rule of thumb, it is best to keep the gap between the OD of the sensor and the ID of the tapped hole to less than 75% of the sensor OD.

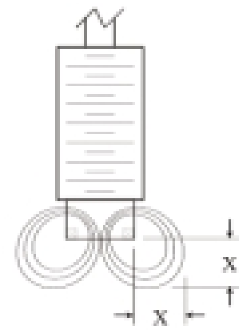


Figure 1. The actual size of the magnetic field varies with each sensor design. As a rule of thumb, the field of any unshielded inductive sensor radiates from the face of the sensor, and radially from the OD of the sensor about the same amount. The distance X is equal to approximately 75-100% of the diameter of the sensor tip.

Based on the actual sensor design, the field can radiate axial behind the face of the sensor. The distance is a function of the individual sensor design.

RESOLUTION/HYSTERESIS

For thread detection, resolution can be a critical issue. A low-end prox sensor with low resolution/high hysteresis can use up a lot of the overall error budget. Saving on the sensor cost can result in added cost for high accuracy fixturing and positioning equipment. On the other hand, a high resolution/low hysteresis sensor can save both in the overall cost of implementation, and in higher reliability through simplified mechanics.

RADIAL POSITION ERRORS

Ideally, the sensor should be concentric with the tapped hole when detecting threads using inductive technology. As the sensor moves off center in the hole, half of the field moves closer to the threads, while half the field moves farther away from the threads. Because the inductance curve is not a straight line, it flattens out the farther you get from the sensor, the change in inductance from the portion of the field moving closer to the threads is greater than the change in inductance from the portion of the field moving farther away from the threads resulting in an output decrease. The decrease in output from this type of motion is not linear, and decreases rapidly the closer the sensor gets to the threads.

Assume the sensor was taught tapped and untapped with the sensor perfectly concentric in the tapped hole. The untapped voltage was logged at 4.375 volts and the tapped voltage at 4.775 volts. This would provide a delta of 400 millivolts. Assume the switch point in the sensor is set at the average of the two values, 4.575 volts. Now assume the sensor is installed in a thread detection application with a radial insertion repeatability of say +/- 0.015" and a 0.015" eccentricity results in a decrease in the output of 125 millivolts. This reduces the difference between the set point and an untapped hole to 75 millivolts. Probably sufficient, but still much less than the 200 millivolts if the sensor could be placed exactly concentric with the tapped hole.

Of note, the larger the gap between the sensor and the tapped hole, the less the magnitude of output change due to eccentricity.

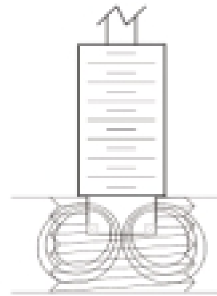


Figure 2. When the thickness of the tapped material is sufficient to engage the entire length of the magnetic field, axial insertion repeatability is not critical.

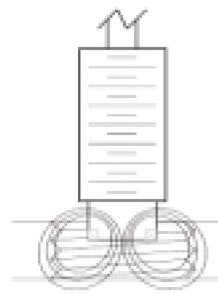


Figure 3. When the tapped hole is in relatively thin material, axial insertion repeatability is critical. As the sensor changes position axially, more or less of the field engages the target changing the output of the system.

AXIAL POSITION ERRORS

As the sensor is inserted into the tapped hole the output begins to decrease until the field behind the sensor face is fully engaged by the ID of the hole. At that point, continued insertion does not result in a change in output. At some point, based on material thickness, the sensor field extending in front of the sensor face will begin to leave the tapped hole. The output at this time will start to increase, and if the sensor could be inserted completely through the hole, the output would return to the initial value before insertion began. As long as the thickness of the tapped material is sufficient to engage the entire axial length of the electromagnetic field, there is little concern. The thinner the material gets, the more precise and repeatable the insertion depth needs to be to eliminate variations in the sensor output due to non-repeatability of insertion depth.

DETERMINING THE RADIAL AND AXIAL REPEATABILITY SPECIFICATIONS

It is best to determine this empirically. The fixturing needs to be able to independently adjust the sensor relative to the tapped hole sample in the X, Y & Z axes.

1) Adjust the Z-axis such that the sensor face is located axially in the hole as close to the same depth as it will be in the actual application. Adjust the X-axis until the output is maximized. Adjust the Y-axis until the output is maximized. The sensor has now been electrically centered in the tapped hole. Note that there may be a dead zone in the exact center. By extending the sensor in both directions and noting the position for a given output value, the difference can be split and the adjustment made to center the hole.

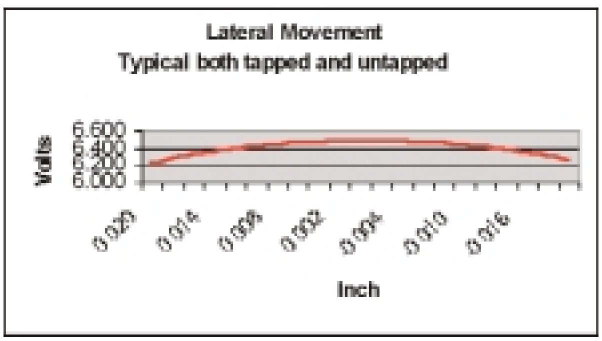
2) Plot the output in 1 to 2 mil increments as you displace the sensor radially in the tapped hole. Either the X or Y-axis can be adjusted to do this. Continue taking data until the sensor has moved radially at least twice as far as the antici-

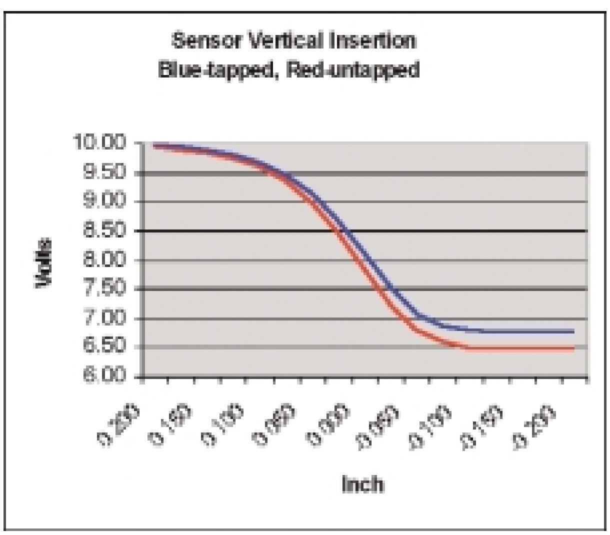
pated radial insertion repeatability you believe you can achieve.

3) Center the sensor radially, and position the sensor axially at the position it will be during operation. Plot the output in 1 to 2 mil increments as you displace the sensor axially within the hole. Continue taking data in both axial directions until the sensor has moved at least twice as far as the anticipated axial insertion repeatability you believe you can achieve.

4) Repeat steps 1-3 with an untapped hole sample.

5) Analyze the data to determine the optimum delta between the tapped and untapped holes and the errors from axial and radial displacement to determine the repeatability requirements for the sensor in the application. Remember that if anything changes in the material or dimensions, the process should be repeated.





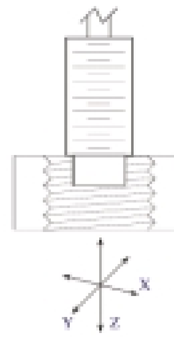


Figure 4. To properly determine repeatability specifications it is best to use a 3-axis micrometer adjustable stage to position either the threaded sample or the sensor.

CONCLUSIONS

The cost of an individual sensor is typically a small portion of the overall cost of implementing an automated check or inspection. Consider the cost of the instrumentation required and the cost of implementation. Fixturing, installation, debug, and total production down time during implementation should be included. Weighing all these factors will result in the most cost effective solution to automated inspection implementation.

When using inductive sensors to detect the presence of threads in a hole, bench characterization is invaluable. Understanding the error sources and magnitude of their contribution to the overall error budget will minimize implementation and debug time.

Total error includes the repeatability of:
- The sensor output
- Axial insertion
- Radial insertion

Sensor repeatability can be taken from the manufacturer's data sheet. It is a good practice to verify this value through testing.

Axial and radial insertion data, derived as described in this app note, is used to set design specifications for the part and sensor handling mechanisms.

Inductive displacement sensors from Kaman Instrumentation are ideal for the typical metal forming environment. Inductive sensors are unaffected by grease, grime or cutting fluids. Contact Kaman's applications engineering group for further information and assistance.

WHY KAMAN?

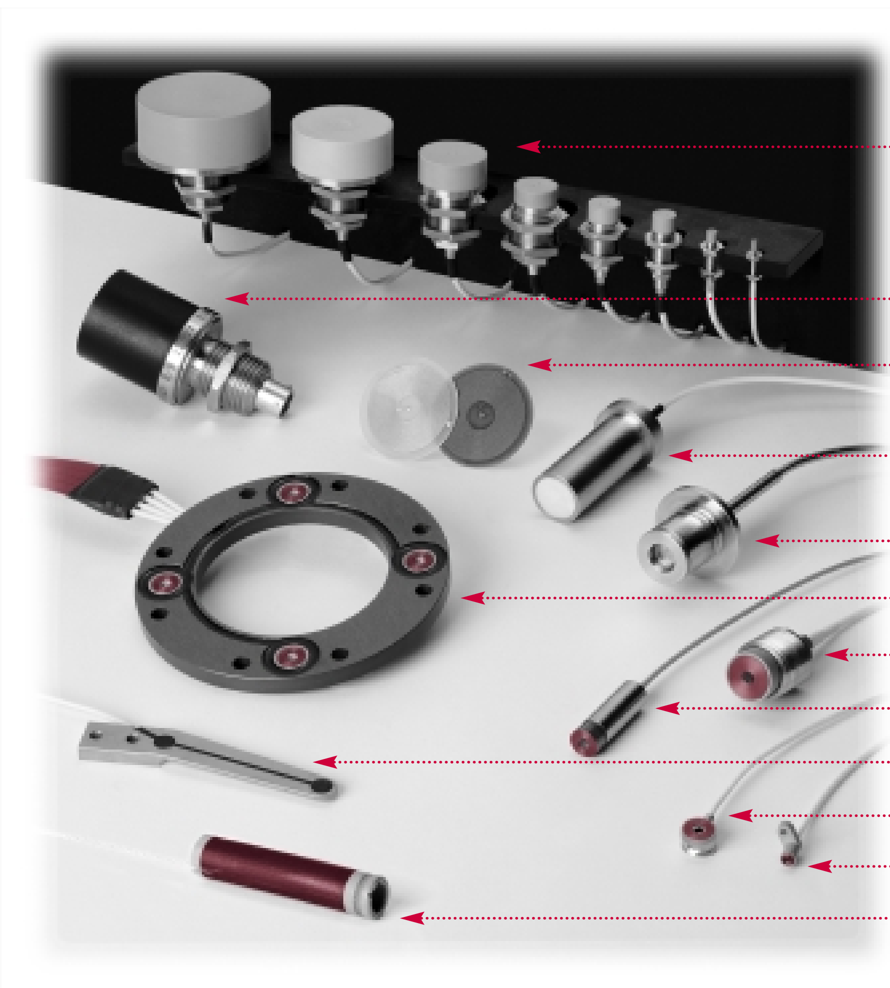
Experience. Kaman Instrumentation has over 30 years of experience with noncontact position measurement techniques. We bring you the best in advanced sensor technology and signal conditioning electronics.

Custom systems. We specialize in custom solutions to difficult problems, and we'll work with you to develop a system for your particular application.

Advanced technology. Kaman's sensors are based on eddy current technology, providing measurements that are

- very stable and repeatable;
- ideal for metal targets;
- unaffected by humidity, dust, and other contaminants;
- resistant to harsh environments.

CHOOSE A STANDARD SENSOR OR WE'LL DESIGN ONE WITH YOU.



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