LABORATORY EXPERIMENT 3 MAGNETIC PARTICLE INSPECTION

OBJECTIVE: To investigate the magnetic particle inspection method for the detection and sizing of surface and sub-surface flaws in magnetic materials. To explore the various techniques and equipment available for magnetic particle inspection.

MATERIALS:
High current power supply and prods
Electromagnetic yoke
Electromagnetic Inspection coil
Wet horizontal inspection system
Gauss Meter
Pie-Field Gauge
Magnetic particle powder
10 steel specimens with saw slots
11 steel weld bars
2 weld specimens
1 piston
Flawtech Specimens (bolt M382, pipe flange M366, eye hook M484, gear M319)

SAFETY: Electrical Shock Hazard – High electrical current flows between the two prods and between the headstock and tailstock of the wet horizontal system. This current will take the path of least resistance, which should be through the metallic sample. However, do not touch the contact points when current is flowing and the metal path is absent.
Eye and Skin Hazard – The solution used in the wet horizontal system is petroleum based and could damage the eye and dry-out the skin. Eye protection and protective gloves must be worn when using the wet horizontal system. The Ultraviolet lights used in this lab are filtered to remove harmful wavelengths. However, the intense ultraviolet light can cause eye media to fluoresce. This condition called ocular fluorescence is temporary but should be avoided by not looking directly at the UV light or its reflection.
Strong Magnetic Field – The equipment produces a strong magnetic field that can interfere with the function of pacemakers, watches, magnetic data storage media and other electro/mechanical devices.

INSTRUCTIONS: Document the results by provide a sketch showing the location of any indications produced on any of the test specimens.

Electromagnetic Yoke or Permanent Magnets. Produce a magnetograph to develop an understanding of the direction and strength of the magnetic field. Dust magnetic particles on top of a piece of paper while the two magnet poles are held under the paper. Change the distance between poles and note the variations in magnetic field strength. Use what was learned about the direction and strength of the magnet field inspect the welded plate sample and the piston. Use the pie-field indicator to determine the direction of the field and whether enough flux is present to produce an indication.

Electromagnetic Coil. Use the coil to inspect the crane hook, the bolt specimen and the piston. Experiment with the gauss meter to determine if anything can be learned about the magnetic field (direction, peak strength position, AC or DC). Make use of the notched shim attached to the surface of the crane hook to judge the direction of the field and determine if its strength is adequate to produce an indication.

High Current Power Supply and Prods. Define the optimum test parameters and develop an understanding of the magnetic field produced with the pods by testing the specimens containing the known artificial discontinuities (the specimens with black tape placed over the small saw slots). Use the parameters and techniques developed to produce indications from the known discontinuities to inspect the weld certification specimens.

Wet horizontal inspection system
Verify that the solution contains the proper concentration of particles by measuring the amount of settled particles in the graduated, pear-shaped centrifuge tube. An acceptable concentration is between 0.15 and 0.25% of total volume of the solution. Also verify that the solution is not contaminated by looking for layering in the solution. Perform an overall system check using the Ketos ring. Record the number of indications produced at 1,400, 2,500 and 3,400, and compare to the number of indications required by ASNT E1444. Repeat the testing using AC current to investigate the difference in depth of penetration between A/C and D/C (remember to demagnetize the Ketos ring between the tests). Perform an inspection on the pipe fitting and gear using the central conductor and the coil. Attempt to measure with a Gauss meter the strength of the circular field produced with the central conductor and the longitudinal field produced with the coil.

PROCEDURE: The inspections shall be performed in general accordance with ASTM E1444-01, Standard Practice for Magnetic Particle Examination. The general procedures for each of the inspection techniques is provided below. Refer to the specification if additional information is necessary.

Dry Particle Inspection with the Electromagnetic Yoke and Coil

1. Verify that the test specimens are demagnetized using the field meter or Gauss meter.
2. Select magnetic particles of a color that provides high contrast against the surface being inspected.
3. When a yoke is used, place the magnetic poles on the surface of the sample in a position that will cause any flaws present to produce maximum disruption of the magnetic field. When the coil is used, orient the test component in a position that will induce a magnetic field in a direction that will cause any flaws present to produce maximum disruption of the magnetic field.
4. Apply the electrical current to produce a magnetic field. Start with a fairly weak field and increase until the reference notches produce an indication. If “whiskers” form at the edges of the part, the magnetizing force is too strong and should be reduced.
5. Lightly dust the area under examination with the particles.
6. With the magnetizing force still applied, lightly blow on the surface remove particles that are not held in place by a flux leakage field.
7. Inspect the region under examination for areas where the magnetic particles are clustered together to form an indication.
8. Repeat with inspection with the magnetic flux oriented in an orthogonal direction.
9. Demagnetize the samples placing them is a strong, AC driven magnetic field and slowly withdrawing them from the field.
10. After demagnetization, use the Gauss meter or field gauge to confirm that the residual magnetic field is less than 3 G at all locations on the part. Repeat the demag process if the field is above 3 G.
11. Clean the samples by wiping with a damp cloth to remove residual particles and drying thoroughly.

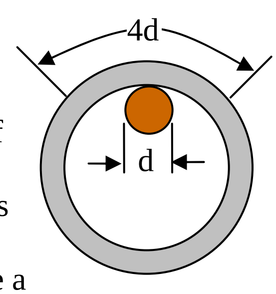
Dry Particle Inspection with High Current Power Supply and Prods

1. Verify that the test specimens are demagnetized using the field meter or gauss meter.
2. Select magnetic particles of a color that provides high contrast against the surface being inspected.
3. Place each in the specimens in a vice.
4. Press the prods firmly against the surface of that specimen and apply the electrical current. Start with a fairly weak field and increase until the reference notches produce an indication. If “whiskers” form at the edges of the part, the magnetizing force is too strong and should be reduced.

5. Lightly dust the area under examination with the magnetic particles
6. With the magnetizing force still applied, lightly blow on the surface remove particles that are not held in place by a flux leakage field.
7. Inspect the region under examination for areas where the magnetic particles are clustered together to form an indication.
8. Repeat with inspection with the magnetic flux oriented in an orthogonal direction.
9. Demagnetize the samples placing them is a strong, AC driven magnetic field and slowly withdrawing them from the field.
10. After demagnetization, use the Gauss meter or field gauge to confirm that the residual magnetic field is less than 3 G at all locations on the part. Repeat the demag process if the field is above 3 G.
11. Clean the samples by wiping with a damp cloth to remove residual particles and drying thoroughly.

<u>Fluorescent Particle Inspection with the Wet, Horizontal Inspection System (wet, continuous technique)</u>

1. Verify that the test specimens are demagnetized using the field meter or gauss meter.
2. Allow the solution to flow for several minutes to assure that the particles are well distributed in the solution.
3. Position the sample in the equipment
    a. When using the contacts (head shot) to induce a circular magnetic field:
        - Unlock, move, and relock the tailstock so that the test component will fit between it and the headstock.
        - Hold the component against the tail stock and use the foot peddle to trip the pneumatic ram to clamp the component between the copper contacts (watch the fingers).
    b. When using a central conductor to induce a circular magnetic field:
        - Put the 1” copper bar through the center of the test component and clamp the bar between the headstock and tailstock as explained in “a.”
        - Rotate the sample so that the region of interest is adjacent to the copper bar. The effective region of examination is four time the diameter of the central conductor as shown in the illustration.



    c. When using the coil is used to induce a longitudinal field:

- Slide the coil away from the headstock and center it over the region to be inspected.
- The test component can be laid on the inside surface of the coil, left suspended on the central conductor or left clamped between the headstock and tailstock.

4. Set the machine to contacts when performing a head shot or when using a central conductor, and to coils when using the coil.
5. Select AC when inspecting for surface defects and DC when inspecting for surface or near-surface defects.
6. Adjust the current to a low initial setting.
7. Let the solution gently flow over the surface. Stop the flow just an instant prior to applying the magnetizing force.
8. As soon as the flow of solution has been stopped, immediately apply the magnetizing current by pushing the bar on the front of the machine. Apply the current in three bursts lasting 0.5 second.
9. Examine notched shim under ultraviolet light to see if the magnetic field strength was adequate to produce an indication. If no indication is produced by the IQI, increase the current setting; reapply the particle solution; and the magnetizing force until an indication is visible. Note: To arrive at a target current level, adjustment must be made by increasing the current setting in small increments and monitoring the amp meter when the current is applied. If the current setting is overshot by a significant amount, the sample must be demagnetized before testing at a lower current setting.
10. Visually inspect the surface under ultraviolet light for areas where the particle cluster and fluoresces brighter than the background.
11. Rotate the sample and repeat the inspection until all areas have been inspected within the effective region of examination.
12. Demagnetize samples by setting the equipment to the AC mode, setting the amperage at least as high as the highest setting used during the inspection, and then pressing and holding in the demag. button until the amperage degrades to zero. Parts that have a circular magnetic field shall be magnetized in the longitudinal direction before demagnetization.
13. After demagnetization, use the Gauss meter to confirm that the residual magnetic field is less than 3 G at all locations on the part. Repeat the demag process if the field is above 3 G.
14. Depress the foot switch to release the clamping pressure, and remove the part from the equipment.
15. Clean the samples by wiping with a damp cloth to remove the residual particles and drying thoroughly.

DISCUSSION:

Discuss the results of the field strength measurements of the longitudinal and the circular magnetic field. From your observations with these measurements, explain why it is good practice to start the inspection with specimens that are in the demagnetized state. Also explain why it is good practice to establish a longitudinal field in the part prior to demagnetization.

Discuss the Ketos ring data. Comment on the relationship between the applied current and the number of indications produced. Compare the results obtained using DC with those obtained using AC and explain the reason for any differences.

Comment on the location and orientation of the flaws that were detected in the weld, hook, gear and piston samples, and the type and orientation of the magnetic field that was used to detect them. Explain the relationship between the field direction and the orientation of an elongation flaw that leads to an optimum response. Note any difficulties that were encountered or shortcomings of any of the inspection techniques.

Comment on your experience using the prods and explain why their use is not allowed when inspecting critical components.

Identify a few reasons why the magnetic particle inspection method is sometime preferred over liquid penetrant inspection. Also comment on how the dimensions and depth of a subsurface discontinuity will affect the indication produced.