A Brief Description of NDT Techniques

A Paper By

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Table of Contents

1 Introduction

Non-destructive Testing is one part of the function of Quality Control and is complementary to other long established methods.

By definition non-destructive testing is the testing of materials, for surface or internal flaws or metallurgical condition, without interfering in any way with the integrity of the material or its suitability for service.

The technique can be applied on a sampling basis for individual investigation or may be used for 100% checking of material in a production quality control system.

Whilst being a high technology concept, evolution of the equipment has made it robust enough for application in any industrial environment at any stage of manufacture - from steel making to site inspection of components already in service. A certain degree of skill is required to apply the techniques properly in order to obtain the maximum amount of information concerning the product, with consequent feed back to the production facility.

Non-destructive Testing is not just a method for rejecting substandard material; it is also an assurance that the supposedly good is good. The technique uses a variety of principles; there is no single method around which a black box may be built to satisfy all requirements in all circumstances.

What follows is a brief description of the methods most commonly used in industry, together with details of typical applications, functions and advantages. The methods covered are:

- Radiography
- Magnetic Particle Crack Detection
- Dye Penetrant Testing
- Ultrasonic Flaw Detection
- Eddy Current and Electro-magnetic Testing

However, these are by no means the total of the principles available to the N.D.T. Engineer. Electrical potential drop, sonics, infra-red, acoustic emission and spectrography, to name but a few, have been used to provide information that the above techniques have been unable to yield, and development across the board continues.

2 Radiography - X And Gamma

2.1 Introduction to Radiography

This technique is suitable for the detection of internal defects in ferrous and non-ferrous metals and other materials.

X-rays, generated electrically, and Gamma rays emitted from radio-active isotopes, are penetrating radiation which is differentially absorbed by the material through which it passes; the greater the thickness, the greater the absorbtion. Furthermore, the denser the material the greater the absorbtion.

X and Gamma rays also have the property, like light, of partially converting silver halide crystals in a photographic film to metallic silver, in proportion to the intensity of the radiation reaching the film, and therefore forming a latent image. This can be developed and fixed in a similar way to normal photographic film.

Material with internal voids is tested by placing the subject between the source of radiation and the film. The voids show as darkened areas, where more radiation has reached the film, on a clear background. The principles are the same for both X and Gamma radiography.

In X-radiography the penetrating power is determined by the number of volts applied to the X-Ray tube - in steel approximately 1000 volts per inch thickness is necessary. In Gamma radiography the isotope governs the penetrating power and is unalterable in each isotope. Thus Iridium 192 is used for $^{1}/_{2}$" to 1" steel and Caesium 134 is used for $^{3}/_{4}$" to $2^{1}/_{2}$" steel.

In X-radiography the intensity, and therefore the exposure time, is governed by the amperage of the cathode in the tube. Exposure time is usually expressed in terms of milliampere minutes. With Gamma rays the intensity of the radiation is set at the time of supply of the isotope. The intensity of radiation from isotopes is measured in Becquerel’s and reduces over a period of time. The time taken to decay to half the amount of curies is the half life and is characteristic of each isotope. For example, the half life of Iridium 192 is 74 days, and Caesium 134 is 2.1 years. The exposure factor is a product of the number of curies and time, usually expressed in curie hours. The time of exposure must be increased as the isotope decays - when the exposure period becomes uneconomical the isotope must be renewed.

As the isotope is continuously emitting radiation it must be housed in a container of deleted uranium or similar dense shielding material, whilst not exposed to protect the environment and personnel.

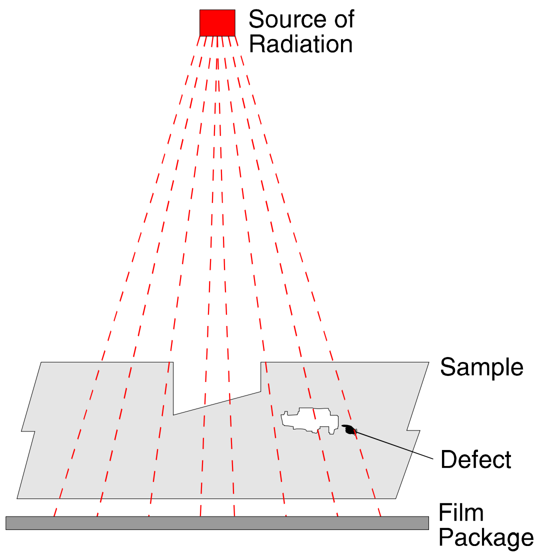
To produce an X or Gamma radiograph, the film package (comprising film and intensifying screens - the latter being required to reduce the exposure time - enclosed in a light tight cassette) is placed close to the surface of the subject.

The source of radiation is positioned on the other side of the subject some distance away, so that the radiation passes through the subject and on to the film. After the exposure period the film is removed, processed, dried, and then viewed by transmitted light on a special viewer.

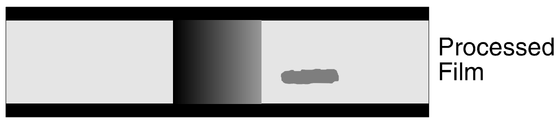
Various radiographic and photographic accessories are necessary, including such items as radiation monitors, film markers, image quality indicators, darkroom equipment, etc. Where the last is concerned there are many degrees of sophistication, including fully automatic processing units. These accessories are the same for both X and Gamma radiography systems.

Also required are such consumable items as radiographic film and processing chemicals.

2.2 An illustration of Radiography



Schematic illustration of a typical exposure arrangement for radiography. The source of radiation can be either an X-ray tube or a radioactive isotope.



The resultant radiograph shows the subject as seen from the source.

Recent developments in radiography permit ‘real time’ diagnosis. Such techniques as computerised tomography yield much important information, though these methods maybe suitable for only investigative purposes and not generally employed in production quality control.

2.3 Advantages of Radiography

- Information is presented pictorially.
- A permanent record is provided which may be viewed at a time and place distant from the test.
- Useful for thin sections.
- Sensitivity declared on each film.
- Suitable for any material.

2.4 Disadvantages of Radiography

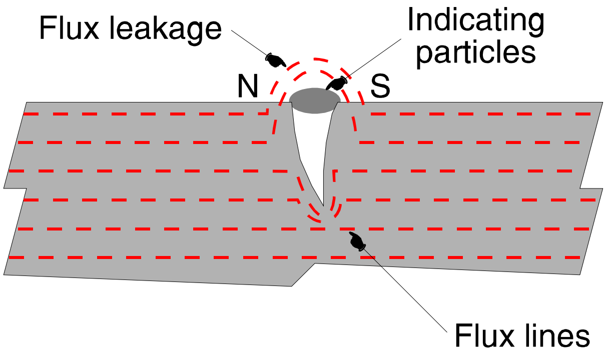
- Generally an inability to cope with thick sections.
- Possible health hazard.
- Need to direct the beam accurately for two-dimensional defects.
- Film processing and viewing facilities are necessary, as is an exposure compound.
- Not suitable for automation, unless the system incorporates fluoroscopy with an image intensifier or other electronic aids
- Not suitable for surface defects.
- No indication of depth of a defect below the surface

3 Magnetic Particle Inspection

3.1 Introduction to Magnetic Particle Inspection

This method is suitable for the detection of surface and near surface discontinuities in magnetic material, mainly ferritic steel and iron.

An Illustration of the Principle of Magnetic Particle Inspection



The principle is to generate magnetic flux in the article to be examined, with the flux lines running along the surface at right angles to the suspected defect. Where the flux lines approach a discontinuity they will stray out in to the air at the mouth of the crack. The crack edge becomes magnetic attractive poles North and South. These have the power to attract finely divided particles of magnetic material such as iron fillings. Usually these particles are of an oxide of iron in the size range 20 to 30 microns, and are suspended in a liquid which provides mobility for the particles on the surface of the test piece, assisting their migration to the crack edges. However, in some instances they can be applied in a dry powder form.

The particles can be red or black oxide, or they can be coated with a substance, which fluoresces brilliantly under ultra-violet illumination (black light). The object is to present as great a contrast as possible between the crack indication and the material background.

The technique not only detects those defects which are not normally visible to the unaided eye, but also renders easily visible those defects which would otherwise require close scrutiny of the surface.

There are many methods of generating magnetic flux in the test piece, the most simple one being the application of a permanent magnet to the surface, but this method cannot be controlled accurately because of indifferent surface contact and deterioration in magnetic strength.

Modern equipments generate the magnetic field electrically either directly or indirectly.

In the direct method a high amperage current is passed through the subject and magnetic flux is generated at right angles to the current flow. Therefore the current flow should be in the same line as the suspected defect.

If it is not possible to carry out this method because of the orientation of the defect, then the indirect method must be used. This can be one of two forms:

1. Passing a high current through a coil that encircles the subject.

2. Making the test piece form part of a yoke, which is wound with a current carrying coil. The effect is to pass magnetic flux along the part to reveal transverse and circumferential defects.

If a bar with a length much greater than its diameter is considered, then longitudinal defects would be detected by current flow and transverse and circumferential defects by the indirect method of an encircling coil or magnetic flux flow.

Subjects in which cracks radiating from a hole are suspected can be tested by means of the threading bar technique, whereby a current carrying conductor is passed through the hole and the field induced is cut by any defects. Detection of longitudinal defects in hollow shafts is a typical application of the threader bar technique.

The electricity used to generate the magnetic flux in any of these methods can be alternating current, half wave rectified direct current or full wave rectified direct current. A.C. generated magnetic flux, because of the skin effect, preferentially follows the contours of the surface and does not penetrate deeply into the material. H.W.D.C. penetrates more deeply but is inclined not to follow sharp changes in section. H.W.D.C. is useful for the detection of slightly subsurface defects. The pulsing effect of A.C. and H.W.D.C. gives additional mobility to the indicating particles. D.C. penetrates even more deeply but does not have this facility. Furthermore, demagnetising of the material after D.C. magnetising is far more difficult than after A.C. magnetising.

Normally, to ensure that a test piece has no cracks, it is necessary to magnetise it in at least two directions and after each magnetising - and ink application - visually examine the piece for crack indications.

Since this double process, which would include adjustment of the magnetising equipment controls in between each magnetising takes time it is obviously advantageous to have the facility to reduce the time required. The recent development of the Swinging Field method of multi-directional magnetising will indicate all defects, regardless of their orientation on the surface, with one magnetising shot and therefore requires only one inspection. (Please refer to our paper entitled Faster Magnetic Crack Detection using the Multi-directional Swinging Field Method).

Basically magnetic crack detection equipment takes two forms. Firstly, for test pieces which are part of a large structure, or pipes, heavy castings, etc. which cannot be moved easily, the equipment takes the form of just a power pack to generate a high current. This current is applied to the subject either by contact prods on flexible cables or by an encircling coil of cable. These power packs can have variable amperages up to a maximum of 2000 Amps for portable units, and up to 10,000 Amps for mobile equipments. Both A.C. and H.W.D.C. magnetising current is available. The indicating material is applied by means of a spray and generally the surplus runs to waste.

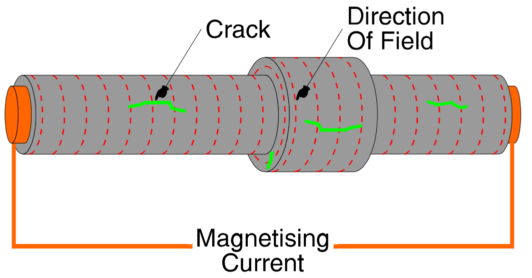
For factory applications on smaller more manageable test pieces the bench type of equipment, as represented by our EUROMAG range, is normally preferred. This consists of a power pack similar to those described above, an indicating ink system which recirculates the fluid, and facilities to grip the work piece and apply the current flow or magnetic flux flow in a more methodical, controlled manner. The work pieces are brought to the equipment and can be individually tested. Subjects up to approximately 100" long can be accommodated is such equipments and can be loaded by crane if necessary. This type of universal equipment is ideally suited to either investigative work or routine quality control testing.

These bench type equipments often incorporate a canopy to prevent direct light falling on the subject so that ultra-violet fluorescent material can be used to the best effect. The indicating particles may be suspended in very thin oil (kerosene) or water. In some circumstances the indicating medium can be applied dry.

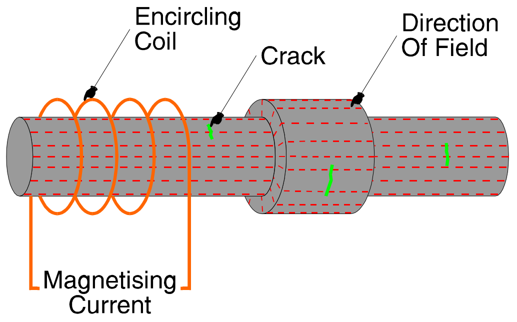
These equipments are suited to production work and in certain circumstances can be automated to the extent of loading, magnetising, inking and unloading. The work pieces still have to be viewed by eye for defect indications.

Specialised equipments are also frequently manufactured to test a particular size and type of test piece.

3.2 An Illustration of Magnetic Particle Inspection



Schematic arrangement for detecting longitudinal defects using current flow through the subject. The source of the current can be a portable / mobile power pack or, in the case of a bench unit, from the built-in power pack.



Schematic arrangement of an encircling coil for the detection of circumferential and transverse defects. The coil may be cable wrapped round loosely or wound on a former, as in a bench unit.

3.3 Advantages of Magnetic Particle Crack Detection

- Simplicity of operation and application.
- Quantitative.
- Can be automated, apart from viewing. (Though modern developments in automatic defect recognition can be used in parts of simple geometry e.g. billets and bars. In this case a special camera captures the defect indication image and processes it for further display and action)

3.4 Disadvantages of Magnetic Particle Crack Detection

- Restricted to ferromagnetic materials.
- Restricted to surface or near surface flaws.
- Not fail safe in that lack of indication could mean no defects or process not carried out properly.

4 Dye Penetrant Testing

4.1 Introduction to Dye Penetrant Testing

This method is frequently used for the detection of surface breaking flaws in non-ferromagnetic materials.

The subject to be examined is first of all chemically cleaned, usually by vapour phase, to remove all traces of foreign material, grease, dirt, etc. from the surface generally, and also from within the cracks.

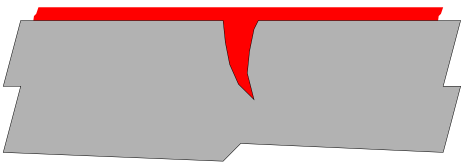
Next the penetrant (which is a very fine thin oil usually dyed bright red or ultra-violet fluorescent) is applied and allowed to remain in contact with the surface for approximately fifteen minutes. Capillary action draws the penetrant into the crack during this period.

The surplus penetrant on the surface is then removed completely and thin coating of powdered chalk is applied.

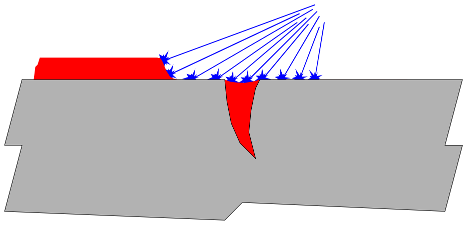
After a further period (development time) the chalk draws the dye out of the crack, rather like blotting paper, to form a visual, magnified in width, indication in good contrast to the background.

The process is purely a mechanical/chemical one and the various substances used may be applied in a large variety of ways, from aerosol spray cans at the most simple end to dipping in large tanks on an automatic basis at the other end. The latter system requires sophisticated tanks, spraying and drying equipment but the principle remains the same.

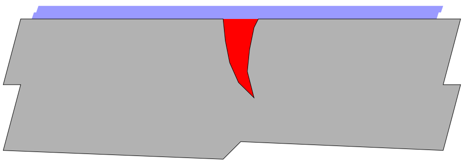
4.2 An Illustration of Dye Penetrant Testing



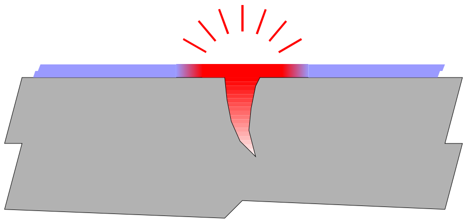
A. Penetrant applied to the surface and enters defect



B. Excess penetrant removed from surface



C. Developer powder applied to draw penetrant out of crack.



D. Accentuated indication of crack as penetrant spreads around the opening.

4.3 Advantages of Dye Penetrant Testing

- Simplicity of operation.
- Best method for surface breaking cracks in non-ferrous metals.
- Suitable for automatic testing, with reservation concerning viewing. (See automatic defect recognition in Magnetic Particle Inspection)
- Quantative.

4.4 Disadvantages of Dye Penetrant Testing

- Restricted to surface breaking defects only.
- Decreased sensitivity.
- Uses a considerable amount of consumables.

5 Ultrasonic Flaw Detection

5.1 Introduction to Ultrasonic Flaw Detection

This technique is used for the detection of internal and surface (particularly distant surface) defects in sound conducting materials.

The principle is in some respects similar to echo sounding. A short pulse of ultrasound is generated by means of an electric charge applied to a piezo electric crystal, which vibrates for a very short period at a frequency related to the thickness of the crystal. In flaw detection this frequency is usually in the range of one million to six million times per second (1 MHz to 6 MHz). Vibrations or sound waves at this frequency have the ability to travel a considerable distance in homogeneous elastic material, such as many metals with little attenuation. The velocity at which these waves propagate is related to the Young's Modulus for the material and is characteristic of that material. For example the velocity in steel is 5900 metres per second, and in water 1400 metres per second.

Ultrasonic energy is considerably attenuated in air, and a beam propagated through a solid will, on reaching an interface (e.g. a defect, or intended hole, or the backwall) between that material and air reflect a considerable amount of energy in the direction equal to the angle of incidence.

For contact testing the oscillating crystal is incorporated in a hand held probe, which is applied to the surface of the material to be tested. To facilitate the transfer of energy across the small air gap between the crystal and the test piece, a layer of liquid (referred to as 'couplant'), usually oil, water or grease, is applied to the surface.

As mentioned previously, the crystal does not oscillate continuously but in short pulses, between each of which it is quiescent. Piezo electric materials not only convert electrical pulses to mechanical oscillations, but will also transduce mechanical oscillations into electrical pulses; thus we have not only a generator of sound waves but also a detector of returned pulses. The crystal is in a state to detect returned pulses when it is quiescent. The pulse takes a finite time to travel through the material to the interface and to be reflected back to the probe.

The standard method of presenting information in ultrasonic testing is by means of a cathode ray tube, in which horizontal movement of the spot from left to right represents time elapsed. The principle is not greatly different in digitised instruments that have a LCD flat screen. The rate at which the spot moves is such that it gives the appearance of a horizontal line on the screen. The system is synchronised electronically so that at the instant the probe receives its electrical pulse the spot begins to traverse the screen. An upward deflection (peak) of the line on the left hand side of the screen is an indication of this occurrence. This peak is usually termed the initial pulse.

Whilst the base line is perfectly level the crystal is quiescent. Any peaks to the right of the initial pulse indicate that the crystal has received an incoming pulse reflected from one or more interfaces in the material. Since the spot moves at a very even speed across the tube face, and the pulse of ultrasonic waves moves at a very even velocity through the material, it is possible to calibrate the horizontal line on the screen in terms of absolute measurement. The use of a calibration block, which produces a reflection from the back wall a known distance away from the crystal together with variable controls on the flaw detector, allows the screen to be calibrated in units of distance, and therefore determination of origins of returned pulses obtained from a test piece.

It is therefore possible not only to discover a defect between the surface and the back wall, but also to measure its distance below the surface. It is important that the equipment is properly calibrated and, since it is in itself not able to discriminate between intended boundaries of the object under test and unintended discontinuities, the operator must be able to identify the origin of each peak. Further as the pulses form a beam it is also possible to determine the plan position of a flaw.

The height of the peak (echo) is roughly proportional to the area of the reflector, though there is on all instruments a control, which can reduce or increase the size of an indication - variable sensitivity in fact. Not only is party of the beam reflected at a material/air interface but also at any junction where there is a velocity change, for example steel/slag interface in a weld.

Probing all faces of a test piece not only discovers the three-dimensional defect and measures its depth, but can also determine its size. Two-dimensional (planar) defects can also be found but, unlike radiography, it is best that the incident beam impinges on the defect as near to right angles to the plane as possible. To achieve this some probes introduce the beam at an angle to the surface. In this manner longitudinal defects in tubes (inner or outer surface) are detected.

Interpretation of the indications on the screen requires a certain amount of skill, particularly when testing with hand held probes. The technique is, however, admirably suited to automatic testing of regular shapes by means of a monitor - an electronic device that fits into the main equipment to provide an electrical signal when an echo occurs in a particular position on the trace. The trigger level of this signal is variable and it can be made to operate a variety of mechanical gates and flaw warnings. Furthermore, improvements in computer technology allow test data and results to be displayed and out-putted in a wide variety of formats.

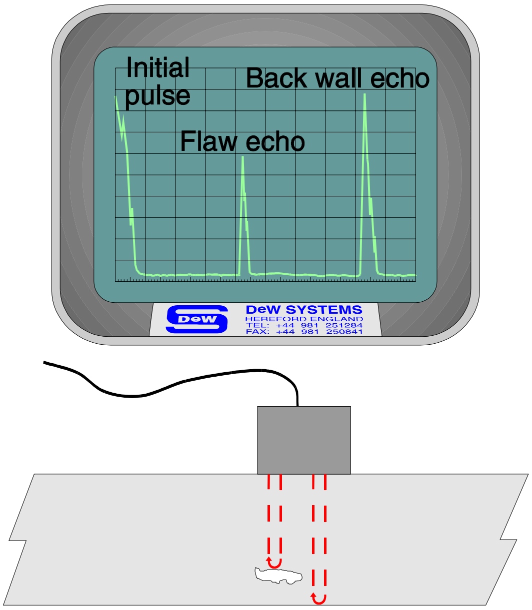
Modern ultrasonic flaw detectors are fully solid state and can be battery powered, and are robustly built to withstand site conditions.

Since the velocity of sound in any material is characteristic of that material, it follows that some materials can be identified by the determination of the velocity. This can be applied, for example in S.G. cast irons to determine the percentage of graphite nodularity.

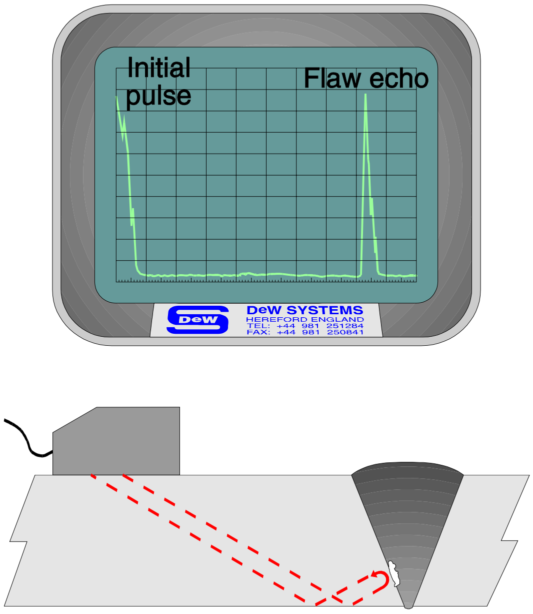
This process can also be automated and is now in use in many foundries. Typical equipment is the Qualiron.

When the velocity is constant, as it is in a wide range of steels, the time taken for the pulse to travel through the material is proportional to its thickness. Therefore, with a properly calibrated instrument, it is possible to measure thickness from one side with an accuracy in thousandths of an inch. This technique is now in very common use. A development of the standard flaw detector is the digital wall thickness gauge. This operates on similar principles but gives an indication, in LED or LCD numerics, of thickness in absolute terms of millimetres. These equipments are easy to use but require prudence in their application.

5.2 An Illustration of Ultrasonic Flaw Detection



Schematic diagram of ultrasonic detection of slag in steel section using a normal probe.



Schematic diagram of the use of an angle probe to detect defects not directly under the probe. Such as in weld inspection.

5.3 Advantages of Ultrasonic Flaw Detection

- Thickness and lengths up to 30 ft can be tested.
- Position, size and type of defect can be determined.
- Instant test results.
- Portable.
- Extremely sensitive if required.
- Capable of being fully automated.
- Access to only one side necessary.
- No consumables.

5.4 Disadvantages of Ultrasonic Flaw Detection

- No permanent record available unless one of the more sophisticated test results and data collection systems is used.
- The operator can decide whether the test piece is defective or not whilst the test is in progress.
- Indications require interpretation (except for digital wall thickness gauges).
- Considerable degree of skill necessary to obtain the fullest information from the test.
- Very thin sections can prove difficult.

6 Eddy Current and Electro-Magnetic Methods

6.1 Introduction to Eddy Current Testing

The main applications of the eddy current technique are for the detection of surface or subsurface flaws, conductivity measurement and coating thickness measurement. The technique is sensitive to the material conductivity, permeability and dimensions of a product.

Eddy currents can be produced in any electrically conducting material that is subjected to an alternating magnetic field (typically 10Hz to 10MHz). The alternating magnetic field is normally generated by passing an alternating current through a coil. The coil can have many shapes and can between 10 and 500 turns of wire.

The magnitude of the eddy currents generated in the product is dependent on conductivity, permeability and the set up geometry. Any change in the material or geometry can be detected by the excitation coil as a change in the coil impedance. The most simple coil comprises a ferrite rod with several turns of wire wound at one end and which is positioned close to the surface of the product to be tested. When a crack, for example, occurs in the product surface the eddy currents must travel farther around the crack and this is detected by the impedance change. See Fig.1.

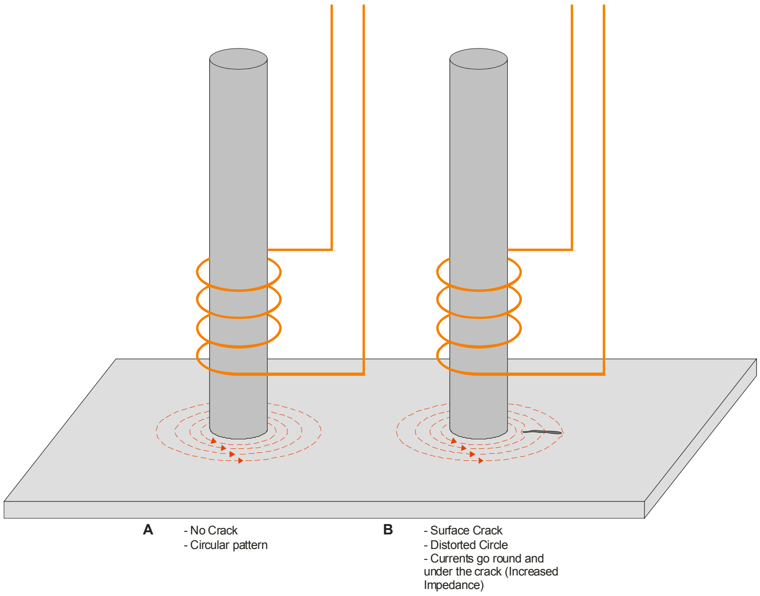


Figure 1 - Coil with single winding

Coils can also be used in pairs, generally called a driven pair, and this arrangement can be used with the coils connected differentially. In this way 'lift off' (distance of the probe from the surface) signals can be enhanced. See Fig.2.

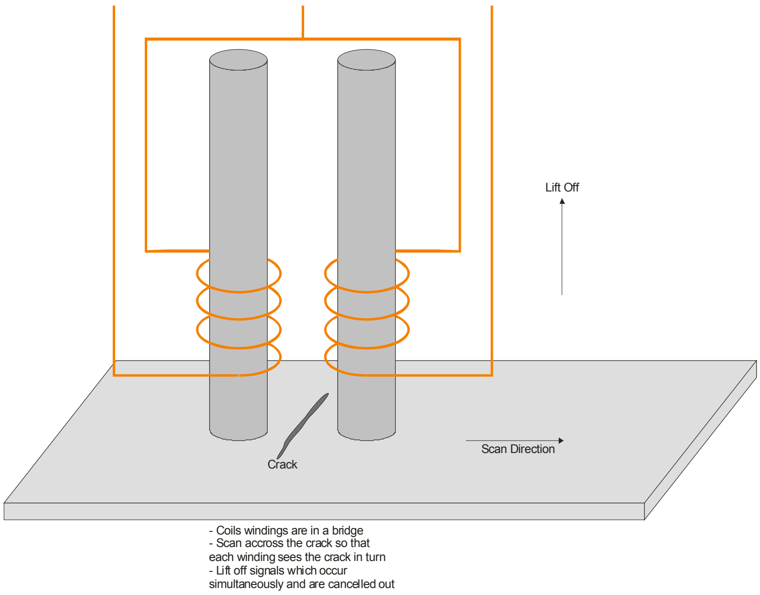


Figure 2 - Coil with two windings, known as a driver pair or differential probe

Coils can also be used in a transformer type configuration where one coil winding is a primary and one (or two) coil windings are used for the secondaries. See Fig.3.

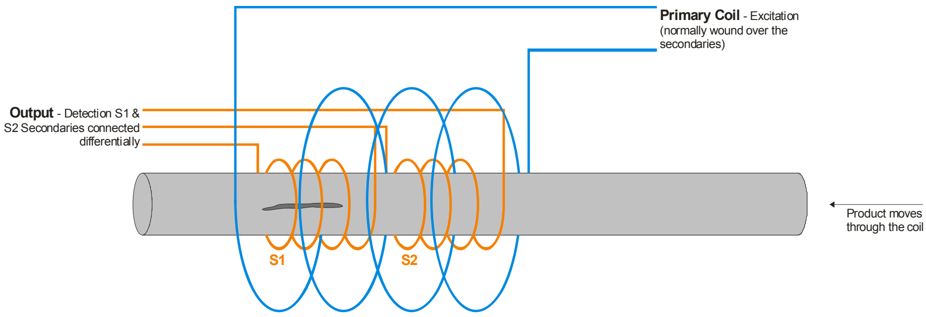


Figure 3 - Transformer type coil with 3 windings

The detected eddy current signals contain amplitude and phase information and which can be displayed on CRT type displays – non digital displays. Signals can be displayed as the actual, i.e. absolute signal, or with appropriate electronics, only a signal change is displayed. The best results are obtained where only one product parameter is changes, e.g. the presence of a crack.

In practice changes in eddy current signals are caused by differences in composition, hardness, texture, shape, conductivity, permeability and geometry. In some cases the effects of the crack can be hidden by changes in other parameters and unnecessary rejection can occur. However, the coils can be selected for configuration, size and test frequency in order to enhance detection of cracks, conductivity, metal loss etc. as required.

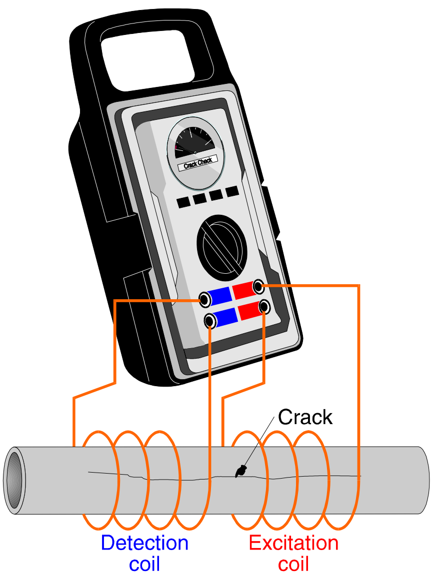
The depth to which the eddy currents penetrate a material can be changed by adjusting the test frequency – the higher the frequency, the lower the penetration; however, the lower the frequency, the lower sensitivity to small defects. Larger coils are less sensitive to surface roughness and vice versa. The latest electronic units are able to operate a wide range of coil configurations in absolute or differential modes and at a wide range of frequencies.

For surface testing for cracks in single or complex shaped components, coils with a single ferrite cored winding are normally used. The probe is placed on the component and 'balanced' by use of the electronic unit controls. As the probe is scanned across the surface of the component the cracks can be detected. See Fig.1 Where surfaces are to be scanned automatically the single coil windings are suitable only if the lift off distance is accurately maintained. Generally differential coil configurations are used with higher speed scanning systems where lift off effects, vibration effects, etc. can be cancelled out to an acceptable extent. See Fig.2. Tubes, bar and wire can be inspected using an encircling coil and these usually have a coil configuration with one primary and two secondaries connected differentially. See Fig.3.

Most eddy current electronics have a phase display and this gives an operator the ability to identify defect conditions. In many cases signals from cracks, lift off and other parameters can be clearly identified. Units are also available which can inspect a product simultaneously at two or more different test frequencies. These units allow specific unwanted effects to be electronically cancelled in order to give improved defect detection.

The eddy current test is purely electrical. The coil units do not need to contact the product surface and thus the technique can be easily automated. Most automated systems are for components of simple geometry where mechanical handling is simplified.

6.2 An Illustration of Eddy Current Testing Equipment



Schematic illustration of eddy current testing of drawn tube for longitudinal defects.

6.3 Advantages of Eddy Current Testing

- Suitable for the determination of a wide range of conditions of conducting material, such as defect detection, composition, hardness, conductivity, permeability etc. in a wide variety of engineering metals.
- Information can be provided in simple terms: often go/no go. Phase display electronic units can be used to obtain much greater product information.
- Extremely compact and portable units are available.
- No consumables (except probes – which can sometimes be repaired).
- Flexibility in selection of probes and test frequencies to suit different applications.
- Suitable for total automation.

6.4 Disadvantages of Eddy Current Testing

- The wide range of parameters which affect the eddy current responses means that the signal from a desired material characteristic, e.g. a crack, can be masked by an unwanted parameter, e.g. hardness change. Careful selection of probe and electronics will be needed in some applications.
- Generally tests restricted to surface breaking conditions and slightly sub-surface flaws.

7 Non-Destructive Testing Methods & Applications

Material	Flaw Type						
	Surface Cracks & Flaws	Sub-Surface Cracks & Flaws	Internal Flaws & Discontinuities	Lack of Bond or Lack of Fusion	Non-Metallic Inclusions - Slag, Porosity	Material Quality	Laminations, Thickness Measurement
Ferrous Forgings & Stampings	M.T.	M.T. U.T.	R.T. U.T.		R.T. U.T.		U.T.
Ferrous Raw Materials & Rolled Products	M.T.	M.T. U.T.	U.T.		M.T. U.T.		U.T.
Ferrous Tube & Pipe	M.T. E.T.	M.T. U.T.	U.T.	U.T.	M.T. U.T.		U.T.
Ferrous Welds	M.T. U.T.	U.T.	R.T. U.T.	R.T. U.T.	R.T. U.T.		U.T.
Steel Castings	M.T.	M.T. U.T.	R.T. U.T.		R.T. U.T.		U.T.
Iron Castings	M.T.	U.T. E.T.	U.T.		R.T. U.T.	U.T.	U.T.
Non-Ferrous Components & Materials	P.T. E.T.		R.T. U.T.	U.T.	P.T. U.T.		U.T.
Ferrous Components Finished	M.T.	U.T. E.T.	R.T. U.T.	U.T.	M.T. U.T.		U.T.
Non-Ferrous Components Finished	P.T. E.T.	U.T. E.T.	R.T. U.T.		U.T. E.T.		U.T.
Aircraft Ferrous Components	R.T. M.T. E.T.	M.T. U.T.	R.T. U.T.	U.T.	M.T. U.T.		U.T.
Aircraft Non-Ferrous Components	R.T. P.T. E.T.	R.T. U.T.	R.T. U.T.	U.T.	P.T. U.T.		U.T.

R.T. - X or Gamma Radiography
P.T. - Dye Penetrant
E.T. - Eddy Current
M.T. - Magnetic Particle Inspection
U.T. - Ultrasonic

Aerospace Industry	Testing components including aero-engine, Landing gear and air frame parts during production
Aircraft Overhaul	Testing components during overhaul including aero-engine and landing gear components
Automotive Industry	Testing Brakes-Steering and engine safety critical components for flaws introduced during manufacture. Iron castings – material quality. Testing of diesel engine pistons up to marine engine size.
Petrochemical & Gas Industries	Pipe-Line and tank internal corrosion measurement from outside. Weld testing on new work. Automotive LPG tank testing
Railway Industry	Testing locomotive and rolling stock axles for fatigue cracks. Testing rail for heat induced cracking. Diesel locomotive engines and structures.
Mining Industry	Testing of pit head equipment and underground transport safety critical components.
Agricultural Engineering	Testing of all fabricated, forged and cast components in agricultural equipment including those in tractor engines.
Power Generation	Boiler and pressure vessel testing for weld and plate defects both during manufacturing and in subsequent service. Boiler pipe work thickness measurement and turbine alternator component testing.
Iron Foundry	Testing ductile iron castings for metal strength on 100% quality control basis.
Shipbuilding Industry	Structural and welding testing. Hull and bulkhead thickness measurement. Engine components testing.
Steel Industry	Testing of rolled and re-rolled products including billets, plate sheet and structural sections.
Pipe & Tube Manufacturing Industry	Raw plate and strip testing. Automatic ERW tube testing. Oil line pipe spiral weld testing.