آزمون ذرات مغناطیسی

Magnetic Particle Testing (MT)

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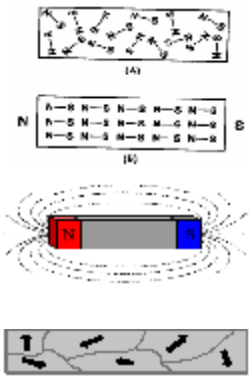
آزمون ذرات مغناطیسی (MT)

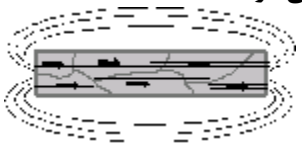
- مغناطیس نمودن قطعه و اعمال ذرات فرومغناطیس بر آن
- ظاهر شدن ترکهای سطحی در اثر نشت شار مغناطیسی

مبانی MT

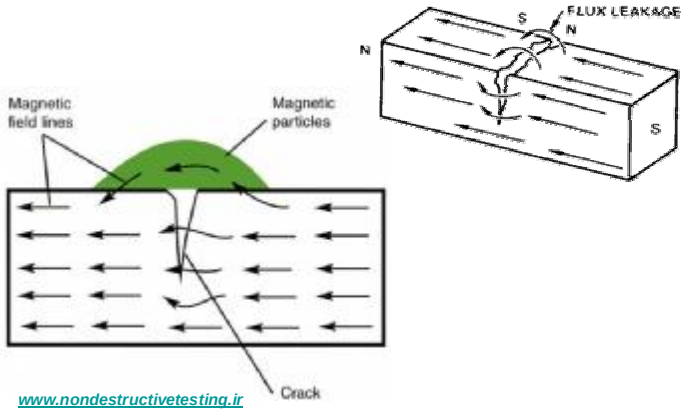


ü مولکولهای مواد فرومغناطیس دوقطبی هستند.

ü خطوط شار مغناطیسی در داخل و خارج قطعه تشکیل می گردد.



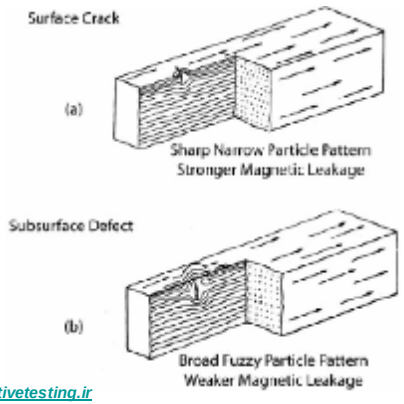
اصول آزمون ذرات مغناطیسی (MT)



مزایای MT

- Accurate and reliable
- Simple to operate
- Indications are produced directly on the surface of the part
- Little training needed for operators
- Almost no limitation on size or shape of the part being tested
- Works well through thin coatings of paint, or other nonmagnetic coverings such as plating
- Detects cracks filled with foreign material
- Provides some crack depth information
- Low cost
- Forgiving of mistakes
- Some subsurface sensitivity
- Lends itself well to automation

عیوب سطحی و زیرسطحی



رفتار مغناطیسی مواد

- **دیامغناطیس (Diamagnetic)**: حساسیت منفی نسبت به مغناطیس شدن، کمی دفع می شوند (مس، طلا، نقره، آب)
- **پارامغناطیس (Paramagnetic)**: حساسیت مثبت کمی نسبت به مغناطیس شدن دارند (آلومینیم، تنگستن، گاز اکسیژن)
- **آنتی فرومغناطیس (Anti-ferromagnetic)**: مشابه پارامغناطیس ولی مثل آن وابسته به حرارت نیست (اکسیدهای نیکل، کروم و کبالت)
- **فرومغناطیس (Ferromagnetic)**: زیر درجه حرارت کوری **(Curie)** به سرعت مغناطیس می شوند (آهن، نیکل، کبالت)
- **فری مغناطیس (Ferrimagnetic)**: زیر درجه حرارت نیل **(Neel)** به سرعت مغناطیس می شوند **(magnetite, maghemite**

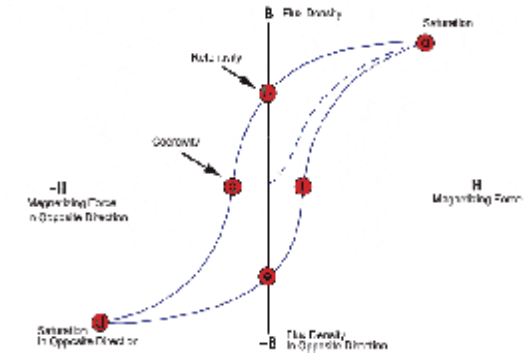
محدودیتهای MT

- Requires ferromagnetic material
- Only detects surface-breaking and near-surface cracks
- For maximum sensitivity the surface should be thoroughly cleaned and dried
- Demagnetization is often necessary
- Exceedingly large currents are sometimes required for the testing of very large castings or forgings
- Can heat and burn highly finished parts at the points of electrical contact
- Individual handling of parts for magnetization is often necessary
- Contact with the surface is sometimes required
- Some parts require multiple inspections

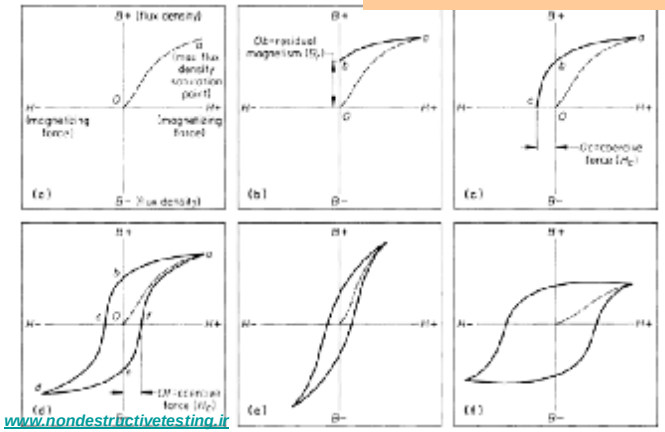
مراحل انجام آزمون

- آماده سازی سطح
- مغناطیس کردن قطعه
- اعمال ذرات
- انجام بازرسی
- مغناطیس زدایی قطعه
- تمیز کردن قطعه

منحنی هیسترزیس



منحنی هیسترزیس



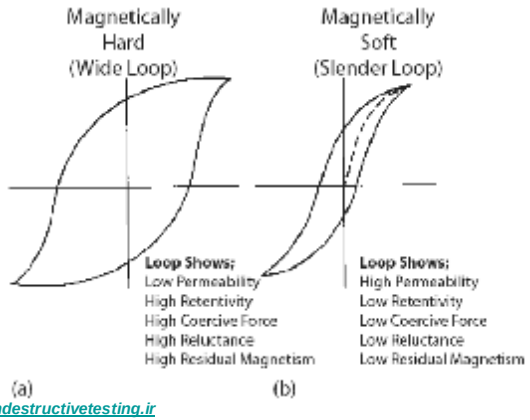
منحنی هیسترزیس

As shown in Fig. (a), starting at the origin (*O*) with the specimen in the unmagnetized condition and increasing the magnetizing force in small increments, the flux in the material increases quite rapidly at first, then more slowly until it reaches a point beyond which any increase in the magnetizing force does not increase the flux density. This is shown by the dashed (virgin) curve *Oa*. In this condition, the specimen is said to be magnetically saturated.

When the magnetizing force is gradually reduced to zero, curve *ab* results (Fig. b). The amount of magnetism that the steel retains at point *b* is called residual magnetism, *Br*.

When the magnetizing current is reversed and gradually increased in value, the flux continues to diminish. The flux does not become zero until point *c* is reached, at which time the magnetizing force is represented by *Oc* (Fig. c), which graphically designates the coercive force, Hc, in the material. Ferromagnetic materials retain a certain amount of residual magnetism after being subjected to a magnetizing force. When the magnetic domains of a ferromagnetic material have been oriented by a magnetizing force, some domains remain so oriented until an additional force in the opposite direction causes them to return to their original random orientation. This force is commonly referred to as coercive force.

مواد مغناطیسی نرم و سخت

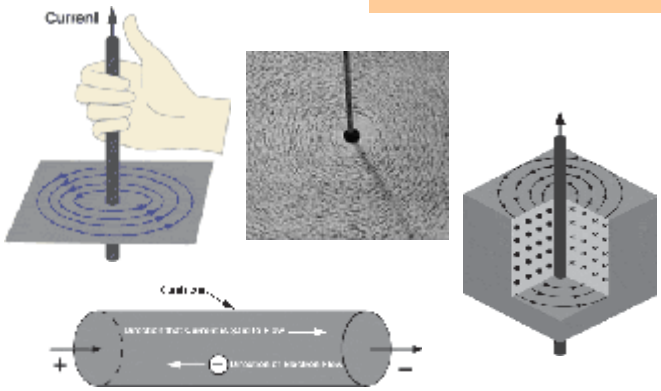


منحنی هیسترزیس

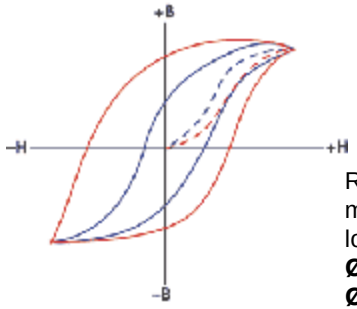
As the reversed field is increased beyond c, point d is reached (Fig. d). At this point, the specimen is again magnetically saturated. The magnetizing force is now decreased to zero, and the de line is formed and retains reversed-polarity residual magnetism, Br, in the specimen. Further increasing the magnetizing force in the original direction completes the curve efa. The cycle is now complete, and the area within the loop abcdefa is called the hysteresis curve.

The definite lag throughout the cycle between the magnetization force and the flux is called hysteresis. If the hysteresis loop is slender (Fig. e), the indication usually means that the material has low retentivity (low residual field) and is easy to magnetize (has low reluctance). A wide loop (Fig. f) indicates that the material has high reluctance and is difficult to magnetize.

الکترومغناطیس



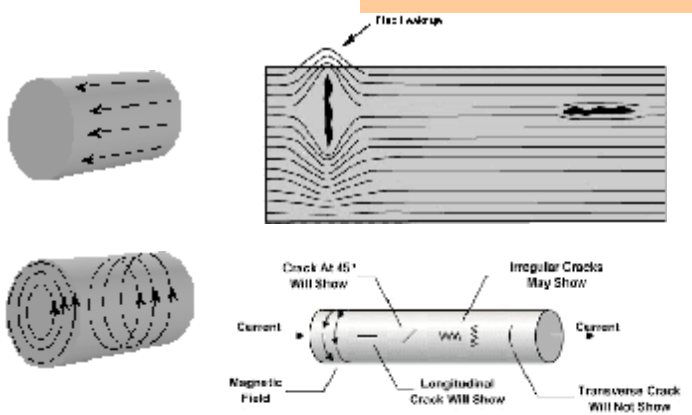
مواد سخت و نرم مغناطیسی



Relative to other materials, a material with a wider hysteresis loop has:

- Lower Permeability
- Higher Retentivity
- Higher Coercivity
- Higher Reluctance
- Higher Residual Magnetism

جهت میدان مغناطیسی و تشخیص عیوب



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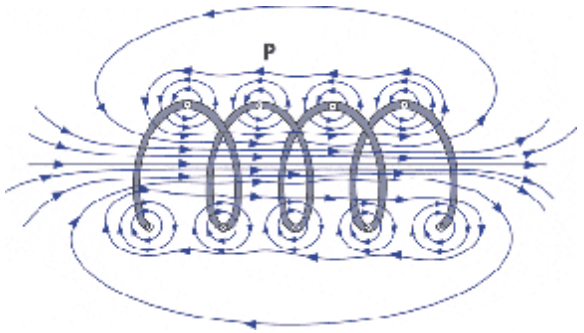
میدان مغناطیسی سیم پیچ



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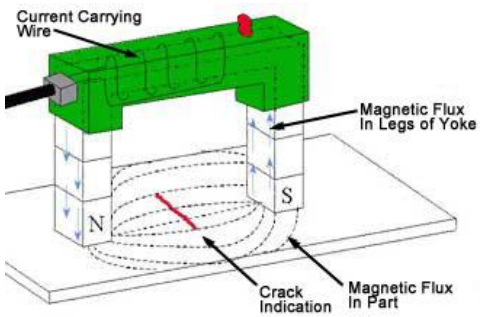
مغناطیس کردن مواد (غیرمستقیم)



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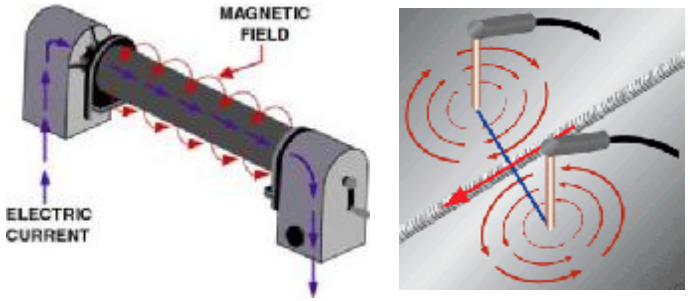
مغناطیس کردن مواد (مستقیم)



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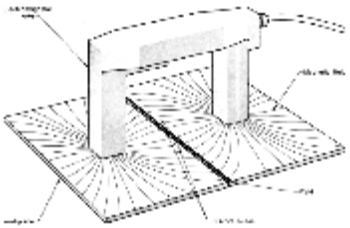
یوغ مغناطیسی (Yoke)

- مغناطیس دائم
- الکترومغناطیس



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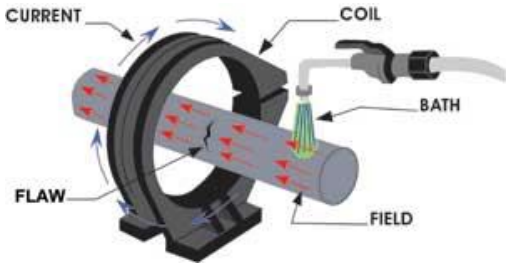
مغناطیس کردن مواد (غیرمستقیم)



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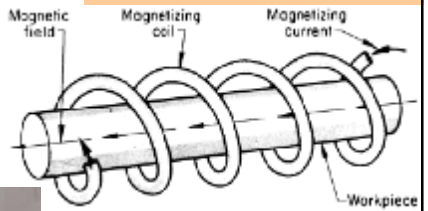
سیم پیچ (Coil)



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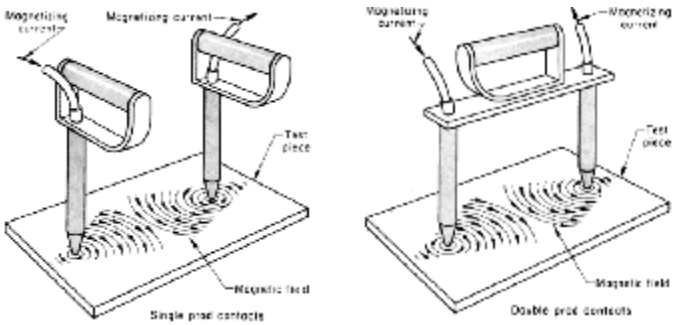
اتصال قلمی (Prod Contacts)



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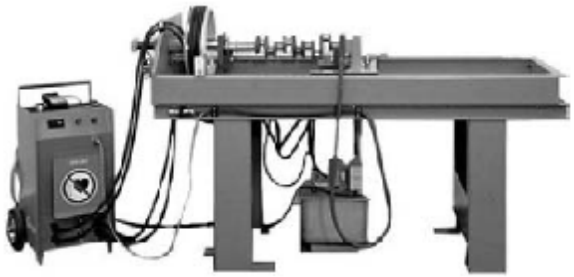
میز آزمون ذرات مغناطیسی (MT)



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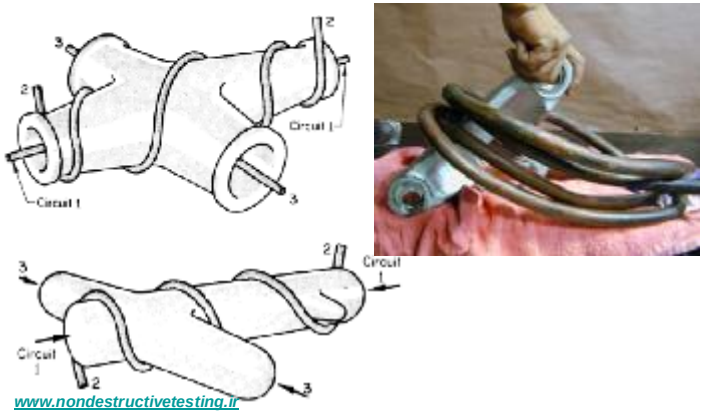
کابل رسانا (Conductive Cable)



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مغناطیس زدایی

It is often inconvenient to heat a material above it curie temperature to demagnetize it, so another method that returns the material to a nearly unmagnetized state is commonly used. Subjecting the component to a reversing and decreasing magnetic field will return the dipoles to a nearly random orientation throughout the material. This can be accomplished by pulling a component out and away from a coil with AC passing through it. The same can also be accomplished using an electromagnetic yoke with AC selected. Also, many stationary magnetic particle inspection units come with a demagnetization feature that slowly reduces the AC in a coil in which the component is placed.

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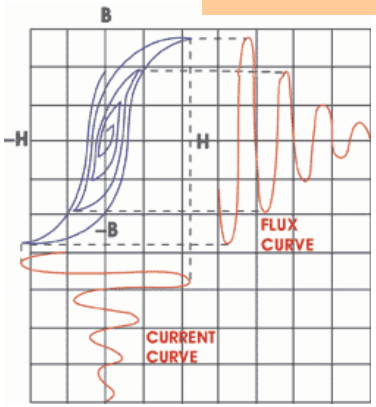
مغناطیس زدایی



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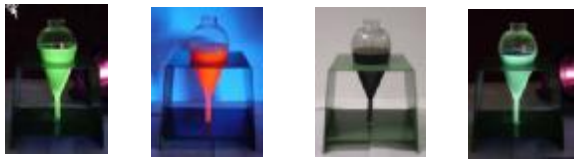
انواع ذرات مغناطیسی

- **فلورسنت** - زیر نور UV بازرسی انجام می شود. ذرات به رنگهای سبز، زرد، قرمز و صورتی
- **رنگی** - با یک ماده رنگی پوشش داده شده اند. ذرات بـه رنگهای سیاه، قرمز، زرد و خاکستری
- **ذرات دو منظوره** - هم توسط نور مرئی و هم نـور UV قابل رویت هستند

انواع ذرات مغناطیسی

- **خشک** - به صورت پودر
- **تر** - معلق در آب یا ماده نفتی رقیق



مثالهایی از MT با ذرات مرئی

Indication of a crack in a saw blade

مثالهایی از MT با ذرات مرئی

Indication of cracks in a weldment

مثالهایی از MT با ذرات مرئی

Indication of cracks running between attachment holes in a hinge

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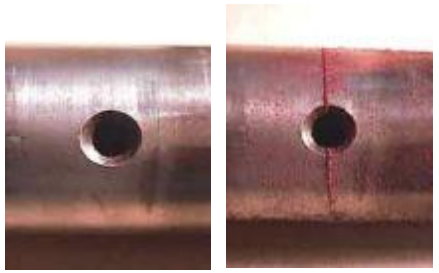
مثالهایی از MT با ذرات مرئی



Before and after inspection pictures of cracks emanating from a hole

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مثالهایی از MT با ذرات فلورسنت

Magnetic particle wet fluorescent indication of a crack in a bearing

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مثالهایی از MT با ذرات فلورسنت

Magnetic particle wet fluorescent indication of cracks at a fastener hole

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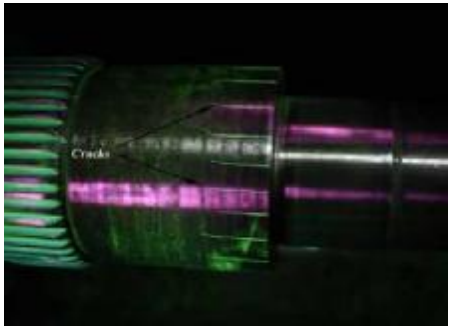
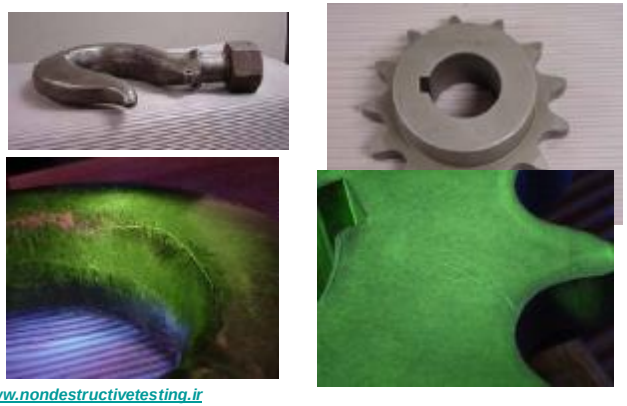
مثالهایی از MT با ذرات فلورسنت



Magnetic particle wet fluorescent indication of cracks in a drive shaft

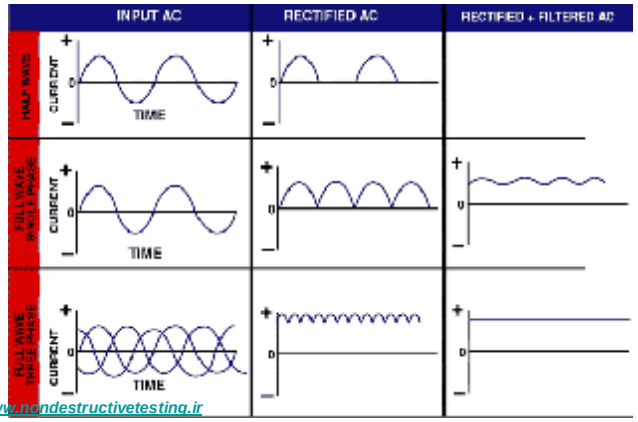
مثالهایی از MT با ذرات فلورسنت



انواع جریان الکتریکی

- جریان DC (دیگر استفاده نمی شود)
- جریان AC تک فاز
- جریان AC سه فاز
- جریان AC سه فاز یکسو شده - مشابه DC عمل می کند
- جریان AC تک فاز یکسو شده کامل
- جریان AC تک فاز نیمه یکسو شده

انواع جریان الکتریکی



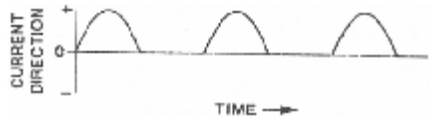
DC

Direct current (DC) flows continuously in one direction at a constant voltage. A battery is the most common source of direct current. As previously mentioned, current is said to flow from the positive to the negative terminal. In actuality, the electrons flow in the opposite direction. DC is very desirable when inspecting for subsurface defects because DC generates a magnetic field that penetrates deeper into the material. In ferromagnetic materials, the magnetic field produced by DC generally penetrates the entire cross-section of the component. Conversely, the field produced using alternating current is concentrated in a thin layer at the surface of the component.

انواع جریان الکتریکی

- جریان **AC**: آزمون عیوب سطحی

- جریان یکسو شده: عیوب زیرسطحی



Rectified Alternating Current

Clearly, the skin effect limits the use of AC since many inspection applications call for the detection of subsurface defects. However, the convenient access to AC, drives its use beyond surface flaw inspections. Luckily, AC can be converted to current that is very much like DC through the process of rectification. With the use of rectifiers, the reversing AC can be converted to a one directional current.

AC

Alternating current (AC) reverses in direction at a rate of 50 or 60 cycles per second. In the United States, 60 cycle current is the commercial norm but 50 cycle current is common in many countries. Since AC is readily available in most facilities, it is convenient to make use of it for magnetic particle inspection. However, when AC is used to induce a magnetic field in ferromagnetic materials, the magnetic field will be limited to narrow region at the surface of the component. This phenomenon is known as the "skin effect" and occurs because induction is not a spontaneous reaction and the rapidly reversing current does not allow the domains below the surface time to align. Therefore, it is recommended that AC be used only when the inspection is limited to surface defects.

Full Wave Rectified Alternating Current (FWAC) (Single Phase)

Full wave rectification inverts the negative current to positive current rather than blocking it out. This produces a pulsating DC with no interval between the pulses. Filtering is usually performed to soften the sharp polarity switching in the rectified current. While particle mobility is not as good as half-wave AC due to the reduction in pulsation, the depth of the subsurface magnetic field is improved.

Half Wave Rectified Alternating Current (HWAC)

When single phase alternating current is passed through a rectifier, current is allowed to flow in only one direction. The reverse half of each cycle is blocked out so that a one directional, pulsating current is produced. The current rises from zero to a maximum and then returns to zero. No current flows during the time when the reverse cycle is blocked out. The HWAC repeats at same rate as the unrectified current (60 hertz typical). Since half of the current is blocked out, the amperage is half of the unaltered AC. This type of current is often referred to as half wave DC or pulsating DC. The pulsation of the HWAC helps magnetic particle indications form by vibrating the particles and giving them added mobility. This added mobility is especially important when using dry particles. The pulsation is reported to significantly improve inspection sensitivity. HWAC is most often used to power electromagnetic yokes.

Three Phase Full Wave Rectified Alternating Current

Three phase current is often used to power industrial equipment because it has more favorable power transmission and line loading characteristics. This type of electrical current is also highly desirable for magnetic particle testing because when it is rectified and filtered, the resulting current very closely resembles direct current. Stationary magnetic particle equipment wired with three phase AC will usually have the ability to magnetize with AC or DC (three phase full wave rectified), providing the inspector with the advantages of each current form.