

Magnetic Particle Inspection

How does it work?

Magnetic particle inspection (MPI) is used for the detection of surface and near-surface flaws in ferromagnetic materials. A magnetic field is applied to the specimen, either locally or overall, using a permanent magnet, electromagnet, flexible cables or hand-held prods. If the material is sound, most of the magnetic flux is concentrated below the material's surface. However, if a flaw is present, such that it interacts with the magnetic field, the flux is distorted locally and 'leaks' from the surface of the specimen in the region of the flaw. Fine magnetic particles, applied to the surface of the specimen, are attracted to the area of flux leakage, creating a visible indication of the flaw. The materials commonly used for this purpose are black iron particles and red or yellow iron oxides. In some cases, the iron particles are coated with a fluorescent material enabling them to be viewed under a UV lamp in darkened conditions.

Magnetic particles are usually applied as a suspension in water or paraffin. This enables the particles to flow over the surface and to migrate to any flaws. On hot surfaces, or where contamination is a concern, dry powders may be used as an alternative to wet inks. On dark surfaces, a thin layer of white paint is usually applied, to increase the contrast between the background and the black magnetic particles. The most sensitive technique, however, is to use fluorescent particles viewed under UV (black) light.

MPI is particularly sensitive to surface-breaking or near-surface cracks, even if the crack opening is very narrow. However, if the crack runs parallel to the magnetic field, there is little disturbance to the magnetic field and it is unlikely that the crack will be detected. For this reason it is recommended that the inspection surface is magnetised in two directions at 90° to each other. Alternatively, techniques using swinging or rotating magnetic fields can be used to ensure that all orientations of crack are detectable.

The method of magnetisation depends on the geometry of the component and whether or not all or only part of the specimen is to be magnetised. Permanent magnets are attractive for on-site inspection, as they do not need a power supply. However, they tend only to be used to examine relatively small areas and have to be pulled from the test surface. Despite needing their own power supply, electromagnets (yokes) find widespread application. Their main attraction is that they are easy to remove (once the current has been switched off) and that the strength of the magnetic field can be varied. For example, an AC electromagnet can be used to concentrate the field at the surface where it is needed. Hand-held electrical prods are useful in confined spaces. However, they suffer two major disadvantages that can rule out their use altogether. Firstly, arc strikes can occur at the prod contact points and these can damage the specimen surface. Secondly, because the particles must be applied when the current is on, the inspection becomes a two-man operation. Bench units are fixed installations used to test large numbers of manufactured specimens of various sizes. The electrical components of a mobile unit (as described above) are incorporated in the bench unit making testing more rapid, convenient and efficient.

In some cases, MPI can leave residual fields which subsequently interfere with welding repairs. These can be removed by slowly wiping the surface with an energised AC yoke.

What will it find?

MPI is used to detect surface-breaking and near-surface flaws in ferromagnetic materials. It cannot, however, be used to detect deeply embedded flaws, nor can it be used on non-ferromagnetic materials, such as aluminium, copper or austenitic stainless steel.

Where is it used?

MPI is often used to look for cracking at welded joints and in areas identified as being susceptible to environmental cracking (e.g. stress corrosion cracking or hydrogen induced cracking), fatigue cracking or creep cracking. Wet fluorescent MPI finds widespread use in looking for environmental damage on the inside of vessels.