Oersted Technology

About Magnets

General Background

Modern magnets are far more powerful than those of only a few years ago, which has greatly increased their usefulness in a wide range of products. Magnets are usually shipped from the factory to a manufacturer in the unmagnetized state. There are a number of reasons for this. There are legal restrictions on the shipping of active magnets. They may affect instruments, destroy nearby delicate equipment, and erase magnetic tape and disk memory information. Larger masses of magnets can be dangerous to personnel, causing objects to fly at high speed, and pinching or crushing body parts. In addition, magnetized magnets attract some kinds of dirt particles, and they are extremely difficult to clean once they have become contaminated. The new types of magnets can be made and used in extremely thin sections, and materials are often brittle. Once they are magnetized, additional forces are caused, which could greatly increase breakage in shipment. For these reasons, it is usually preferred to magnetize magnets in place in the final product, or just before assembly.

Older magnet materials could often be magnetized by such means as exposing them to a fixed magnetic field caused by other magnets, focused through a steel pole structure, or by using a short time duration current (perhaps a second) of rectified AC current directly from the power lines into a fixture of many turns (and high inductance), among other techniques. The newer high-coercivity magnets are much more resistive to demagnetizing effects, and are correspondingly much harder to magnetize.

The method used is to send a very short (perhaps a thousandth of a second) pulse of electric energy at very high voltage and current, through a fixture which converts the electric pulse into a magnetic pulse. Whenever electric current flows through a wire, a magnetic field is set up in a circular field (no poles) around the wire, the direction of the field being at right angles to the direction of current. By properly shaping wire conductors, often with steel (or other magnetically permeable) pole material used both to support the wires, and also to help concentrate and direct the magnetic flux, a fixture can be made which holds the part and causes it to assume the required magnetic pole pattern. The currents in the fixture are usually so high that it would overheat, burn out its insulation, and even melt or vaporize the wire, if the power were allowed to be on too long. The magnetization of the part is accomplished in an extremely short time, once the required coercive field is attained (millionths of a second), and so the field does not need to be present very long. This is fortunate, since otherwise the extremely high currents needed to produce the required field could not be achieved in the space available.

If a number of magnets are placed together, they tend to line up end-to-end. In a magnet, individual atoms (or small groups of atoms) also tend to line up within small regions called DOMAINS, producing tiny local magnetic regions. In an unmagnetized part, these domains exist everywhere, but they have fields which point in different directions, and they cancel each other out so that the average resulting field is zero.

When the part is magnetized, these domains are caused to align in the direction of the coercing field. Some of the domains are more difficult to align than others, and so some small degree of magnetization may be reached at a low field, and more at a higher one, until all the domains have turned (or reformed) in the direction of the external field. In magnetically "soft" materials, such a low carbon steel, as soon as the external field is removed, some or all of the domains go back to a field-canceling jumble of directions. In magnetically "hard" permanent materials, however, most or all of the domains remain aligned, resulting in a net external magnetic field.

Many modern magnet materials are said to be ANISOTROPIC, meaning that they have a preferred axis of magnetic field, built-in during manufacture. The part may be magnetized in either direction along this axis, north-south or south-north. The part is extremely resistant to magnetizing in any other direction, however. Many of these materials are easier to magnetize the first time, from the virgin state, than they are to remagnetize again in the opposite direction. For this reason, if a part made of material with these characteristics must be remagnetized, it would be aligned in the fixture in the same way that it was originally magnetized, not north pole to south pole, and so on.

Magnetizer Operation

The magnetizer (magnetizing pulse generator) consists of a power supply operating off line AC current which produces DC current at a very high voltage, at moderate current levels. The current is then stored in a bank or banks of capacitors. In order to insure proper operation, both the value of the capacitance and charge voltage must be matched to the fixture which is in use. A switch capable of carrying very high currents is then closed to allow the magnetizing pulse to flow. In Oersted Technology products these are SCR (silicon controlled rectifier) solid-state devices, fast-acting and with very little voltage drop or lost power. The load fixture stores energy in its magnetic field, and behaves electrically like a nonlinear inductance. If the inductance is high enough, the current would surge forward, then slow up, stop, and reverse direction, which is called ringing. Reversed current in the fixture would be disastrous, because it would destroy the capacitors and also partially demagnetize the part. Reversed current into the capacitors is blocked by separate diodes (which only conduct electrical current in one direction), one for each bank. If the current were to be abruptly cut off in the fixture, however, the voltage across the fixture would rise to a very high value, until it forced a path to dissipate the stored energy. That would destroy the electrical insulation of the fixture, burn out the blocking diodes, or possibly cause a fire or endanger the operator. Instead, a large diode (the freewheeling, or "flyback" diode) is provided to allow the energy to continue out one side of the fixture winding and back in the other, until it is dissipated safely in the electrical resistance of the fixture.

Many magnetizer designs use line-frequency transformers to obtain the high charging voltage. Oersted Technology uses a high-frequency design instead which saves weight and space. It also results in even charging, so that the capacitor banks are charged faster for the same maximum line current, with less stress on the capacitors.