Magnetisers and Magnetising Fixtures

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As manufactured, any permanent magnet is an inert piece of metal or ceramic (ferrite), until it has been magnetised (or energised) by an appropriate external magnetic field. Special equipment have been developed to magnetise, demagnetise, stabilise and calibrate all types of permanent magnets. Though magnetising is the most commonly used term, the operation is also described as charging or energising of magnet.

In-situ magnetising

A magnet can be energised either before or after the assembly. But it is preferable to first assemble the magnet and then magnetise it in the assembly, i.e. in-situ magnetising. This is done in applications like loudspeakers, magnetoes of two-wheelers, DC motors etc. The various technical and commercial advantages of in-situ magnetising are:

1. If the magnet is magnetised first and then assembled, there will be five to ten per cent loss of flux in ferrite magnets and even more in Alnico. This is due to shift in working point along the B-H curve.
2. Magnetised magnets attract all iron-bearing impurities during handling and assembly. These impurities may adversely affect the performance of magnetic assembly.
3. If the magnets are in energised condition, then assembling becomes difficult.
4. The time and expense incurred in magnetising individual magnets is more than in-situ magnetising.

Principles of magnetisation

For magnetising the magnets as well as magnetic assemblies, the following are required:

—a magnetiser or a power supply, and

—a suitably designed magnetising fixture.

The basic purpose of any magnetiser is to supply unidirectional magnetic field of the proper magnitude, shape and time duration, to fully saturate the permanent magnets. Generally, for fully saturating the magnets, a magnetising field of little more than four times the intrinsic coercivity of that magnet's material is required. The intrinsic coercivity of the different magnet materials is given in their manufacturers' catalogues. The shape and time duration of applied magnetic field depends on the magnetising fixture design.

MAGNETISERS

There are three methods of energising the magnets: (a) by the use of permanent magnets, (b) impulse or capacitor discharge magnetisers, and (c) by the use of DC electromagnets.

By the use of permanent magnets

Permanent magnets are used for magnetising extremely small magnets of simple shapes like rods and slabs. These permanent-magnet magnetisers consist of a basic magnet,

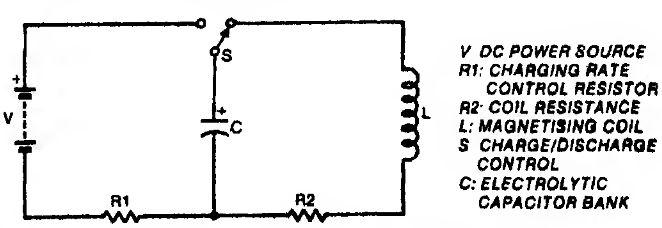

Fig. 1: General circuit for impulse or capacitor discharge magnetisers.

with high ratio of energy per unit volume and adjustable mild steel pole pieces. Thus the air gap can be adjusted to fit the magnets being energised. Due to limitations of size and shape, these magnetisers are rarely used.

Impulse or capacitor discharge magnetisers

Electrolytic capacitors are used to store the energy over a period of one to ten seconds. This energy is then rapidly discharged in some milliseconds (by a control circuit) into a magnetising fixture. The magnetising fixture produces the

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magnetic field required to energise a magnet. A high-power SCR (silicon controlled rectifier) is used to control charging and discharging of capacitors. In large capacity models, an output transformer with high-voltage primary and a high-current (low-voltage) secondary is used for electrical circuit and personnel safety.

Impulse magnetisers are rated by their capacity to deliver energy in joules (watt-seconds). The time over which the energy is delivered is determined by the impedance of fixture coil in relation to the output impedance of the magnetiser itself. Ideally, for maximum energy transfer, the output impedance of the magnetiser and the input impedance of the magnetising fixture coil should match. However, the input impedance of the magnetising fixture varies with specific fixture. Hence such a condition is difficult to obtain in practice. The amplitude of the applied magnetic field can be adjusted by varying the capacitor voltage.

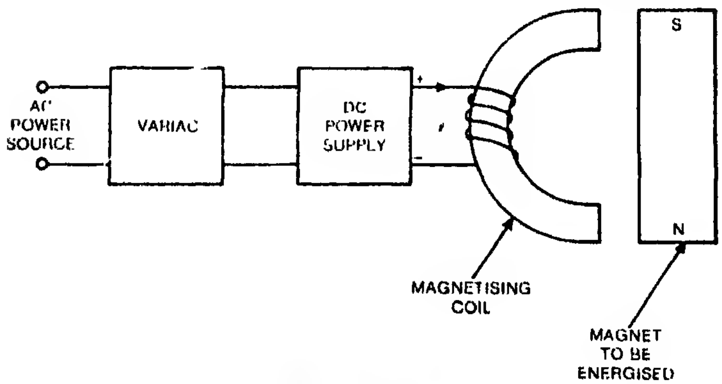

Fig. 2: Formation of DC electromagnets.

Impulse magnetisers are widely used for magnetising magnetoes of two-wheelers, loudspeakers, small DC motors etc.

DC electromagnets

These are iron-core electromagnets energised by well filtered direct current.

The high inductance of DC electromagnetic magnetisers requires a time interval of two to five seconds for the magnetic field to reach full magnitude. A substantial time is required for the field to collapse. Premature removal of the magnetised magnet is not only physically difficult but may result in partial demagnetisation. A variac is used to adjust the magnetising field strength.

Comparison of impulse magnetiser and DC electromagnetiser

In a DC electromagnet the time required for build up and collapse of the field is high. Hence, the time required for energising a magnet is more. This slows down the production rate. Impulse magnetisers take less time for magnetisation.

The power lost in heating of coil is more in DC electromagnets than in impulse magnetisers. So impulse magnetisers have better power efficiency.

DC electromagnets are better for energising large size magnets.

DC electromagnets can be used only for energising simple shaped bipolar magnets, whereas impulse magnetisers can be used for bipolar as well as multipole magnets.

The efficiency of electromagnets can be improved by controlling the time for which input current is applied. These are known as semi-continuous DC electromagnets.

DC electromagnets need forced air cooling or even water cooling. Hence, they are large sized and bulky.

MAGNETISING FIXTURES

As mentioned above, the shape and time duration of the magnetising field are important factors besides its amplitude. These two are decided by the magnetising fixture design.

A magnetising fixture essentially consists of a coil or winding of insulated copper wire or strip, a yoke of mild steel or silicon iron stampings, cooling arrangements (if needed), and pole pieces (if needed) for concentrating the magnetic field in desired shape.

Coil

Coil is the most important part of magnetising fixtures. The coil may be of single turn or multiturns, depending on the amplitude of the magnetising field required. Amplitude of the magnetising field is measured in ampere turns/metre.

The shape, size, winding pattern, resistance and inductance of coil are the important design criteria. The shape and size will depend on the magnet to be energised. The winding pattern will depend on number and positions of poles on the magnet. The resistance and inductance will depend upon the wire gauge, number of turns and the core material used.

Yoke

A yoke is used to provide path for magnetic flux and to

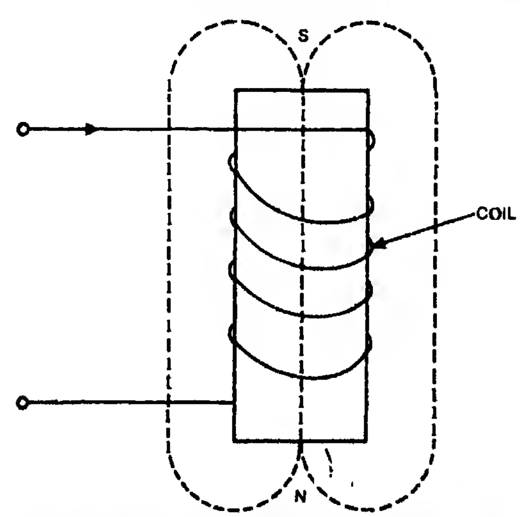

Fig. 3: Formation of north and south poles in an electromagnet.

avoid effects of stray magnetic fields. Mostly mild steel is used for the yoke and silicon iron stampings for the core. The yoke helps in heat dissipation.

The direction of current through the winding decides the direction of the magnetic field, which in turn determines the pole (north or south).

If a coil is wound around a rod-shaped magnet, and a DC current passed through it, the magnetic field produced will be shown by dotted lines as in Fig. 3. A north pole will be produced at the one end and south at the other.

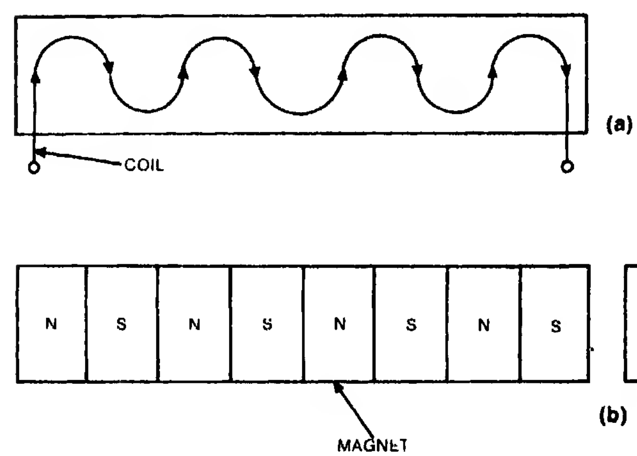

Fig. 4: Creation of multiple poles in a magnet.

If a coil is wound as shown in Fig. 4(a) in a zig-zag fashion, direction of the current in adjacent turns is opposite to each other. Hence the magnet, after magnetisation, will have multiple poles, as shown in Fig. 4(b). In all there will be six poles on the surface of the slab-shaped magnet. North and south poles will be adjacent to each other, and there will be three pairs of north and south poles.

Design considerations of the coil

The coil should be as near to the magnet as possible, so as to get the maximum possible magnetic strength.

The resistance of the coil should be high enough so as to have sufficient time duration of the magnetising field.

Spurious electrical oscillations may occur in any type of magnetiser system, depending on the relationship of the magnetiser's output impedance to the magnetising fixture's input impedance. These oscillations produce field direction reversals in the magnetising coil, which can partially demagnetise the magnet. To avoid this some guidelines are given below.

Guidelines for magnetising fixture design

1. Water cooling is desirable when more than 2-3 parts are magnetised in a minute.
2. Copper tubes can be used for water cooled fixtures.
3. Maximum possible number of turns with a thick wire should be used.
4. The entire coil can be mounted in epoxy for safety and durability.
5. When pole pieces are used, they should always be placed as close as possible to the magnet's surface.
6. As far as possible, the magnetiser should be used at the lowest possible voltage to achieve magnetic saturation. Voltages higher than necessary can cause unnecessary damage and overheating in the fixture.

Two desirable aspects of magnetisation are:

1. The less than saturation magnetisation of a magnet is not desirable because it is difficult to control with consistency. If partial magnetisation is essential, then it is better to magnetise the magnet up to saturation and then knock it down, by demagnetisation, to the desired level.
2. When oriented (anisotropic) magnets are to be magnetised, the magnetising field should be parallel to the inherent orientation of the material.

Conclusion

The scope of this article has been only to enumerate basic principles, and some practical guidelines in selection and design of an appropriate magnetisation set-up. Precise relationships to enable ready design are difficult to define due to the unique nature of each application. Setting up a good magnetising facility is an art by itself and requires experience.

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