Experience in the Demagnetization of Large Objects

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Abstract—The residual magnetization of parts may cause negative effects: in aircraft, it yields a substantial compass error and the unexpected actuation of automatic elements, while during electrical welding on major pipelines, it does not allow one to obtain a high-quality weld. The designs, techniques, and devices intended for demagnetization of large objects, which are difficult to demagnetize using conventional means, are proposed.

Key words: residual magnetization, demagnetization, aircraft, ball bearings, main pipelines.

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Ferromagnetic articles can be magnetized in the process of their production and operation. During their manufacturing, articles are magnetized during polishing on a magnetic plate, electric welding, high-frequency hardening of parts by induced high-frequency currents, and during displacement of articles with electromagnetic cranes. Minor sections of aircraft and helicopters are magnetized in the process of operation during magnetic testing. There are cases where aircraft were magnetized by magnetic fields of lightning, with practically all ferromagnetic parts being magnetized in this case. Major pipelines are magnetized in the process of diagnosis with internal flaw detectors.

Residual magnetization can harmfully affect a magnetized article during its use. For example, when a magnetized blank is turned, chips are attracted to the cutter, thus damaging the surface of the article to be processed. The magnetic fields of magnetized parts on an aircraft cause substantial errors in the readings of magnetic compasses. Magnetized articles at sophisticated engineering complexes may disturb the normal operation of automated and computing devices.

Magnetic fields in magnetized pipes and other articles do not allow high-quality electric welding. During repeated inspections of major pipelines with internal flaw detectors, residual magnetization causes false signals and hinders the detection of flaws. All this necessitates the demagnetization of such articles.

The physics of demagnetization and different demagnetization circuits are well-known. It is not difficult to demagnetize small parts. However, the solution of the problems of demagnetizing large objects causes several difficulties, namely:

(i) the demagnetization of an aircraft that was magnetized by the magnetic field of lightning. Magnetization of an aircraft yields a magnetic compass error that exceeds 50° for some courses;

(ii) the demagnetization of rings with diameters of up to 2400 mm, and cross sections of up to 250 × 300 mm, and masses of up to 800 kg, which are magnetized over the entire cross section. The field strength on the ring surface is up to 250 A/cm; and

(iii) the demagnetization of a 100–150-km major pipeline section.

Our experience on the solution of these problems is given below.

DEMAGNETIZATION OF AIRCRAFTS

An aircraft is magnetized by the magnetic field of lightning when it is in the vicinity of a lightning discharge. One case where a high-speed single-seat plane was struck by lightning during its approach is known. As a result the lightning (as if it were an electric welder) cut away the upper part of the tailfin at a 14–20 cm height. The aircraft successfully landed. Measurements of the magnetic field showed that all steel elements of this aircraft were substantially magnetized. The magnetization of the cockpit frame affects the reading of a compass substantially and the error that occurs under the effect of a magnetic field can reach 40°–50°. The error in compass reading after demagnetization should not exceed 5° and then it is reduced to zero by a compass deviation device.
The difficulty of demagnetizing aircraft parts and units occurs due to the fact that the magnetized elements:

(i) are embedded in the structure and cannot be removed from an aircraft;
(ii) have one-way access;
(iii) are made of magnetically hard steel (30ХГСА, 30ХГСНА, etc.);
(iv) have a complex length-varied shape;
(v) are interconnected to form a common magnetic system; and
(vi) have large overall dimensions, which substantially exceed those of demagnetizing devices.

The determination of the demagnetization level leads to a compass peak error of 5°. This corresponds to the strength of the magnetic field that is generated by magnetized elements at the site of the compass mounting, which are not higher than 2 A/m.

Aircraft parts and units are demagnetized using different techniques. Electromagnets that are fed by a commercial-frequency AC current are used. An electromagnet is moved over the surface of the parts to be demagnetized so that the entire surface is scanned by the electromagnet. If the electromagnet is equipped with a current controller, the surface of the magnetized parts is divided into sections. The electromagnet is positioned in turn on these sections, and its current is varied from the maximum value to zero. Demagnetization may be also performed with DC electromagnets; in this case the current is varied at a frequency of 0.5—2 Hz when the electromagnet is moved over the surface of the magnetized parts.

The demagnetization of parts via application of a counter field makes it possible to reach the apparent complete demagnetization of parts and a zero compass error. However, the magnetic state of these parts turns out to be unstable since, in 8—10 h, the compass error returns to its previous value. Thus, based on our experience, demagnetization by applying a counter field of a corresponding strength turned out to be inefficient for the demagnetization of aircraft parts. Other devices and techniques intended for demagnetization are also utilized; however, the desired level of demagnetization is not reached as a rule.

Demagnetization of parts that are embedded in an aircraft to a level that is admissible in magnetic flaw detection is not difficult. In addition, magnetization of parts in the process of the magnetic flaw inspection is local and does not affect the readings on a magnetic compass. Reduction of the magnetization of parts to a level at which the compass error does not exceed the tolerable one causes substantial problems.

When developing techniques and devices for the demagnetization of the cockpit of a passenger aircraft, it was found that when the AC current in a solenoid or an electromagnet decreases from its peak value to zero a substantial increase in the magnetization of the part (or part component) that is to be demagnetized is observed; instead of the expected decrease, it yields a larger magnetic compass error. This effect was studied by investigating the demagnetization of parts and specimens under the simultaneous action of a

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**Fig. 1.** The dependence of the field strength \( H_f \) at the face of specimen number 3 after it was subjected to the action of magnetic fields: (1), a static magnetic field \( H_{st} \); (2), a static field \( H_{st} \) and an alternating field decreasing from 250 A/cm to 0 (during demagnetization) simultaneously; (3), a specimen.