The eddy-current loss is calculated for nonferromagnetic disks in a rotating magnetic field. The power loss is found as a function of the magnetic field intensity, the field rotation velocity, and the disk dimensions. The eddy-current loss was measured experimentally in rotating fields in copper, aluminum, and zinc disks; a good agreement was found with the calculated values.

In most experimental studies of rotational remagnetization of ferromagnets, a low rotational velocity of the sample or field has been deliberately used to hold the eddy-current loss at a level negligible in comparison with the loss due to rotational hysteresis [1-4], or ferromagnets with a poor conductivity have been studied [5, 6]. Since loss due to rotational hysteresis is always accompanied by eddy-current loss, it seems worthwhile to study the eddy-current loss alone in nonmagnetic conducting samples having the same geometry as ferromagnetic samples. Disk-shaped samples are used most commonly. When there is symmetry in the arrangement of the field and sample, the eddy-current loss can be calculated theoretically without any particular difficulty.

We assume that a nonferromagnetic conducting disk of radius R and thickness h is placed in a rotating magnetic field. We construct the coordinate system shown in Fig. 1. The median plane of the disk is the x0y plane, placed in such a manner that the origin coincides with the center of the disk, and the 0z axis is both the symmetry axis of the disk and the rotation axis for the magnetic field. As the magnetic field H rotates, it remains in the plane of the disk.

In an elementary contour 2z wide and 2r long, a variable electromotive force is induced in the fixed sample as the magnetic field rotates:

\[ e = - \frac{d \Phi}{dt} \]  

so that field rotation is accompanied by a change in the magnitude of the projection of the area of the elementary contour on the field direction,

\[ \Phi = \Phi_0 e^{j \omega t} = B 2 rz e^{j \omega t}, \]  

where \( \omega \) is the angular velocity of the field; and B is the magnetic induction in the disk. Then we have

\[ e = - j4 Brz \omega e^{j \omega t} = 4 Brz \omega e^{j \left( \omega t - \frac{\pi}{2} \right)} \]  

in this case we have \( B = \mu_0 H \). For ferromagnetic disks we have \( \mu = \mu_0 \) \( \mu_0 \) const, and we must also take into account the change in the induction along the depth and the possible appearance of phase shifts.

The maximum and effective electromotive forces are

\[ E_m = 4 Brz \omega, \quad E = \frac{E_m}{\sqrt{2}} = \frac{4 Brz \omega}{\sqrt{2}}. \]  

If the thickness of the elementary eddy contour is \( \Delta z \), and its width is \( \Delta x \), the power loss in the elementary contour, is under the condition \( R \gg h \),
where $\Delta g = \gamma (\Delta x \Delta z / 4r)$ is the conductance of the contour; and $\gamma$ is its conductivity. The total power loss is found by integration over all elementary contours in the entire disk. Taking into account the symmetry of the disk with respect to the coordinate system, we find the following expression for the total loss:

$$P_e = \int dP_e = \frac{\delta^2 D^2}{2} E^3 \gamma.$$  

Substitution of Eqs. (4) and (5) into (6) and integration using $r = \sqrt{R^2 - x^2}$ yield

$$P_e = \frac{\pi}{24} B^3 \omega^2 \gamma \ h^3 \ R^2 = \frac{\pi}{96} B^3 \omega^2 \gamma \ h^3 \ D^3.$$  

The eddy-current power loss in a disk in a rotating magnetic field is proportional to the square of the magnetic induction and to the square of the angular velocity. The conductivity of the disk material appears in the first power in the equation, the disk radius appears in the second power, and the disk thickness appears in the third power.

The current in the elementary contour is

$$i = E \Delta g = E \gamma \frac{\Delta x \Delta z}{4r},$$

so the current density is

$$j = \frac{i}{\Delta x \Delta z} = E \gamma \frac{B \omega \gamma}{V/2},$$

i.e., independent of the position of the point along the disk axis and a linear function of the thickness. In the median plane of the disk, $z = 0$, we have $\delta = 0$, while the current density at the disk surface, $z = h/2$ reaches a maximum:

$$j_m = \frac{B \omega \gamma}{2V/2}.$$  

Comparing Eq. (7) for the eddy-current power loss in a rotating magnetic field with the eddy-current power loss in varying linear magnetic fields [7], we see that the corresponding expressions agree within a constant factor, since any linear variable sinusoidal field can be represented as a superposition of two oppositely directed rotating fields. Pursuing this analogy, we can derive an expression for the specific eddy-current loss in rotating magnetic fields:

$$P_{oe} = \frac{P_e}{V} = \frac{1}{24} B^3 \omega^2 \gamma \ h^3,$$

where $V = \pi R^2 h$ is the disk volume. The specific loss is a quantity averaged over the disk thickness, since the interior and surface layers of the sample do not carry the same eddy currents.

**Method and Results**

The magnetic field is produced by an air-core solenoid in a nonmagnetic conducting holder on a vertical shaft. The magnetizing system is mechanically balanced and rotated rapidly. The rotation velocity is