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2-D FIELD ANALYSIS OF MAGNETIZING FIXTURE FOR STATOR MAGNET OF AIR-CLEANER DC MOTOR

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Abstrat A capacitor discharge impulse magnetizer is used to produce a high current pulse of short duration in a magnetizing fixture for magnets of the various shapes. The problem of designing custom fixtures for magnetization has often been considered more of conventional experience than a scientific theory. Therefore, the design of magnetizing fixture has until recently been a "cut and try" process. It was common to literally blow up one or more fixtures before achieving the desired results. Finite element CAD package allow the design of such a fixture. Since magnetizing fixtures come in a variety of sizes and shapes, there is usually no simple analysis method that can be used to estimate the field characteristics of the fixtures. Instead, one typically uses finite element analysis. FEA program MAXWELL is the primary tool used here. The purpose of this study was a examine both theoretically and experimentally the field characteristics inside the fixture. Independent of sizes and shapes of magnetizing fixtures, the desired magnetic field can be obtained with resonable predictability. The experimental results have been achieved using a 1000[V], 22.4[KJ] capacitor discharge magnetizer and iron-core fixtures.

I. INTRODUCTION

Multipole magnets are used in a variety of applications such as direct-current motors and for various types of holding magnets. The magnetization of magnet segments is carried out with a special magnetizing coil and with a current impulse[1-2]. The problem of designing custom fixtures for magnetization has often been considered more of conventional experience than a scientific theory. Therefore, the problem of designing custom fixtures for magnetization fixtures has until recently been a "cut and try" process. It was common to literally blow up one or more fixtures before achieving the desired result.

Finite element CAD package allow the design of such a fixture. The permit a rapid variation of many parameters without the necessity of fabricating and testing many prototypes. The use of such programs leads to an important reduction in cost development. However, the package must represent the physical behaviour of the fixture. The magnetic field modeling was performed by using a finite element analysis program[3-9]. The FEA program is MAXWELL 2-D field simulator of Ansoft Co.

The benefits of field analysis of FEA program for fixtures has been demonstrated in the ability to test different configuration without the threat of repetitive destroying the fixture. In addition, the field analysis allows monitoring of all the characteristics in the fixture, if desired, to a much higher level of accuracy than can be typically accomplished with laboratory measurements. Also, the ability to easily run repeated analysis can be used to determine such things as the optimum configuration of the magnetizing fixture. Field analysis of FEA program can provide a way to test complex configurations and their interaction without physically constructing the fixture. Consequently, the purpose of this study was a examine both theoretically and experimentally the 2-D field characteristics inside the fixture.

II. A METHOD FOR 2-D FIELD ANALYSIS

The finite element technique amounts to dividing the fixture geometry into meshes and assigning to each element a polynomial that will approximate the behaviour of the magnetic potential in that element. The coefficients of these polynominals are arranged in a matrix and their values are obtained via the solution of a matrix equation that reflects all of the information of the problem, including the location of each element relative to its neighbors, the underlying field equations, and the boundary conditions.

In the analysis of a fixture (magnetostatic analysis) the underlying field equationa are[3]

$$\nabla \times \mathbf{B} = \mu \mathbf{J} \tag{1}$$

and

$$\nabla \cdot \mathbf{B} = 0$$

where **B** is the magnetic flux density [Tesla], **J** is the current density $[A/m^2]$, and μ is the permeability [H/m].

The boundary condition is usually a simple Dirichlet condition that the fact that the magnetic field should decay to zero at distances that are sufficiently far from the fixture.

The stage of general field analysis using MAXWELL is[10]

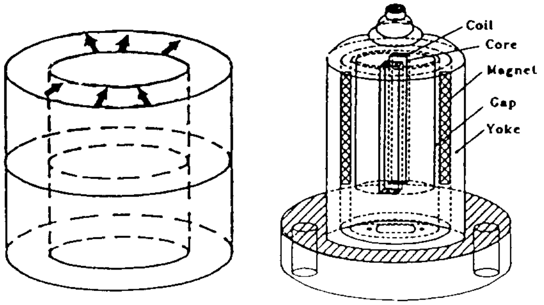
- 1st step : Fixture configuration
- 2nd step : Generation of the mesh
- 3rd step : Definition of a nominal current for the wire regions and the boundary condition
- 4th step : The problem is solved
- 5th step : Plots of the magnetic vector potential, magnetic-flux density, estimation of **B** field

At the point, the various characteristics (inductance and required current, et al) of the fixture are known. The question remains, will the impulse magnetizer deliver this current to the fixture.

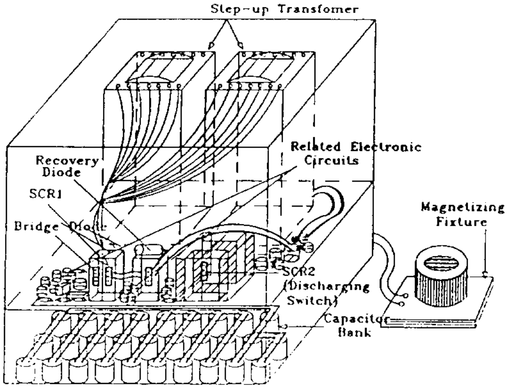
III. FIXTURE FOR STATOR MAGNET OF AIR-CLEANER DC MOTOR

For application example, consider the stator magnet of air-cleaner dc motor shown in Fig. 1(a).

Fig.1(a) shows 2-pole stator magnet of air-cleaner dc motor. Also, the magnetizing fixture shown in Fig.1(b) is designed to magnetize the magnet of Fig.1(a). Also, Fig.1(c) shows the capacitor discharge impulse magnetizer system for energy discharge to the magnetizing fixture. The field analysis starts with the developmentof a wire configuration concept as shown in Fig.2.



(a) 2-pole magnet　(b) 2-pole magnetizing fixture



(c) impulse magnetizer system

Fig. 1 2-pole magnet, 2-pole magnetizing fixture and impulse magnetizer system

Note that the currents are arranged so as to induce the desired 2-pole magnetization across the magnet. Since the length of the fixture is much greater than its width, a 2-D cross-sectional analysis will suffice. Consequently, Fig.3(a) illustrates this 2-D view of the fixture and Fig.3(b) shows an exploded photo. of

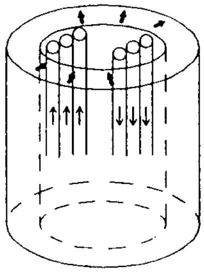
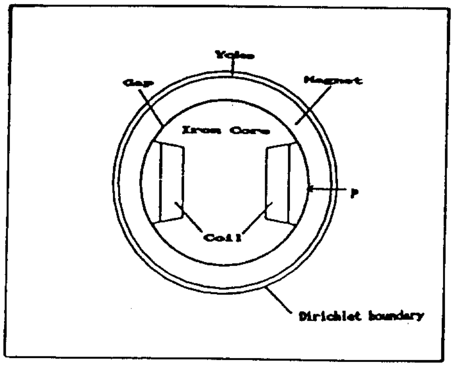
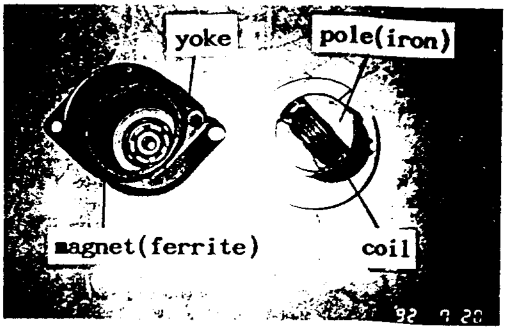


Fig. 2 Wire configuration for magnetization of 2-pole magnet

the actual fixture for constructing a 2-pole wire configuration of Fig.2. The magnetic material is ferrite.



(a) 2-D fixture model

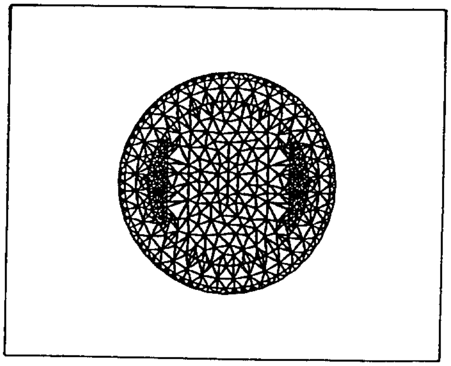


(b) exploded photo. of 2-pole fixture

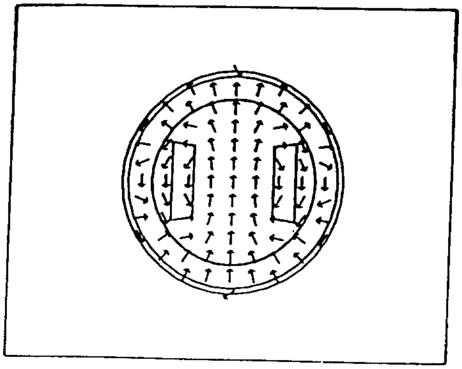
Fig. 3 2-D fixture model and exploded photo. of 2-pole fixture

IV. RESULTS OF 2-D FIELD ANALYSIS

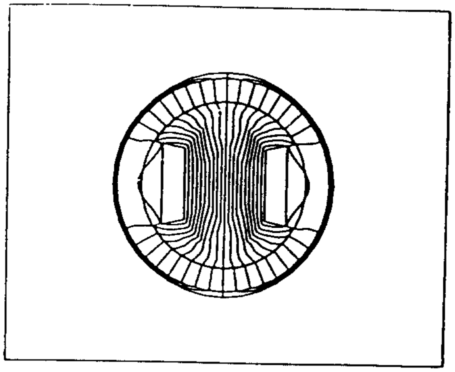
The solving problem is the stage of general field analysis using MAXWELL as above stated section II.



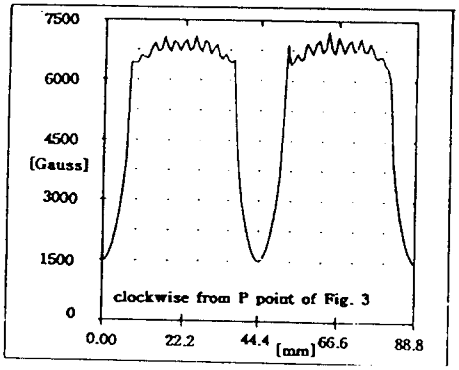
(a) finite element mesh



(b) magnetic vector potential



(c) magnetic flux density



(d) flux density along the inner surface of magnet

Fig. 4 Finite element mesh, magnetic vector potential and magnetic flux density of 2-pole magnetizing fixture

The actual finite element mesh created by the program MESH of MAXWELL is shown in Fig.4(a). The iron is assumed to saturate at 12000[Gauss] and to have a relative permeability of 1000. Fig.4(b) shows the magnetic vector potential and a plot of the flux lines is shown in Fig.4(c).

Also, Fig.4(d) shows the flux density (prescribed flux density : 7200[Gauss]) along the inner surface of 2-pole magnet. On the other hand, the current was measured using an shunt (Rating : 400[A]/50[mV], Type : YS-3, Yamaki Electric) in series with the magnetizing fixture. The flux density (= B) was measured using a hall probe of gauss meter (Rating : 10[V]/1000[Gauss], Type : series 9900, F. W. Bell) at the center of the magnet.

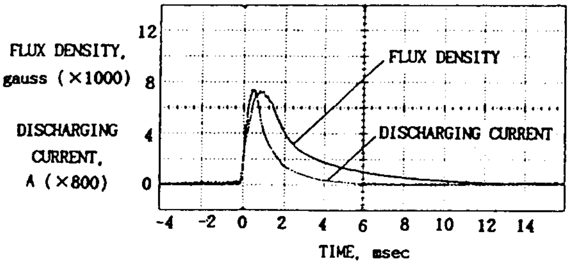


Fig. 5 Measured value from the fixture (replotted from storage-type oscilloscope traces <capacitor bank : 2800[μF].charging voltage : 607[V]>)

The voltage (= V) was measured differentially across the terminals of the impulse magnetizer using high-voltage probe (Rating : 1000:1, Type : P6015 Probe, Tektronix). The experimental graphs from the magnetizing fixture are shown in Fig.5. The maximum flux density achieved is 7400[Gauss]. This measured value of Fig.5 shows very good agreement with the MAXWELL-calculated value (Fig.4), and is well within the expected empirical error bounds.

V. CONCLUSION

The benefits of field analysis of FEA program for fixtures has been demonstrated in the ability to test different configuration without the threat of repetitive destroying the fixture. In addition, the field analysis allows monitoring of all the characteristics in the fixture, if desired, to a much higher level of accuracy than can be typically accomplished with laboratory measurements. Also, the ability to easily run repeated analysis can be used to determine such things as the optimum configuration of the magnetizing fixture.

This paper describes 2-D field analysis of magnetizing fixture for 2-pole magnet. Good agreement between simulated value and measured value has been achieved. Investigation of the field analysis results leads to the following conclusions:

1. This study resulted in field analysis of FEM packages for the magnetizing fixtures that can be used as a tool to evaluate the design effectiveness of the magnetizing fixture.
2. Efforts spent on developing such fixture modelds can be greatly rewarded by the time and expense saved in the design and development of magnetizing fixture.

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