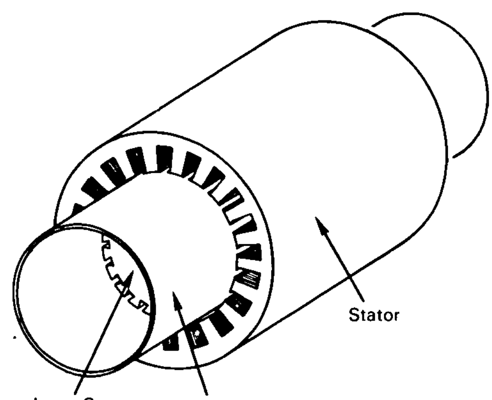
AEC-NASA TECH BRIEF

Concept for Sleeve Induction Motor with 1-msec Mechanical Time Constant



The problem:

To design a low-inertia induction motor that can be used with solid-state devices to control all-electric servo power systems. Previous methods used in various critical, high performance servo applications have required the use of complex electrohydraulic control systems. Other nonhydraulic control systems using power factor correction often produce current-buildup time delays much larger than one-fourth period, or 4.2 msec for a 60-Hz supply frequency.

The solution:

A conductive sleeve induction motor having a 1-msec mechanical time constant. The servomotor rotor inertia is small compared to the maximum force rating of the servo motion, permitting high no-load acceleration. Design optimization procedures allow minimization of the inherently-high reactive power requirement of the sleeve-type motor. Also, a control system which operates the motor under constant flux, varying frequency conditions is proposed as a means of eliminating the time delays associated with the field-energy buildup time of the usual fixed field-variable field control system.

How it's done:

The squirrel cage or solid iron rotor of the typical 2-phase servomotor is replaced with a thin sleeve of light metal revolving in the annular gap between the stationary outer and inner core members. Since low inertia in the sleeve motor can be obtained at the expense of real and reactive power requirements, a "best trade" design consideration between these quantities is made.

The apparent power rating, or rotor loss, is calculated for the rotating conductive sleeve mounted in the magnetic gap between the stator and a stationary internal cylindrical core. Distributed 2-phase windings applied to the stator produce an essentially sinusoidal field of p poles revolving at an angular speed of θ rad/sec. The maximum possible magnetic induction in the gap depends on a simple dimension ratio of the core laminations and the saturation induction of the core material. The ultimate in servo response requires that the motor operate near this maximum gap induction, in fact the mechanical time constant depends only upon the sleeve material, the operating induction, and a dimension ratio. After selecting the

(continued overleaf)

sleeve material, number of poles, operating frequency, sleeve thickness, effective gap spacing, and polar aspect ratio (core stack to pole pitch), a system of equations determines the major motor dimensions for a specified mechanical time constant and apparent power rating.

The reactive power for the gap is high because of the relatively large gap length necessitated by the sleeve thickness plus running clearance on both sides. The resulting lower power factor, or high Q, may lead to severe control amplifier problems. For this reason, the reactive power is also held close to the minimum possible value for the specified apparent power, mechanical time constant, and the selected design parameters.

The inherent low power factor, however, requires large control amplifiers, and, with the usual fixed-field, variable-field control system using power factor correction, current-buildup time delays occur in the controlled field.

To eliminate this time delay, a constant-flux, variable-frequency control technique is proposed. The field windings would be fed by a 2-phase, variable-frequency inverter. In this type control amplifier the frequency of the 2-phase output is made to vary in proportion to the input signal magnitude. Furthermore, the output voltage magnitude is made to vary in a manner which keeps the air gap flux in the motor constant. The result is a revolving field of constant strength and varying speed in the motor. In this way, the time delays usually associated with field-energy buildup are eliminated.

Notes:

1. This sleeve induction motor should be of interest to designers and users of electromechanical control systems.
2. Additional details are contained in *IEEE Transactions on Industry and General Applications*, vol. IGA-2, no. 2, p. 151–157, Mar.–Apr. 1966.
3. This device is in the conceptual stage only, and as of the date of publication of this Tech Brief, neither a model nor prototype has been constructed.
4. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 South Cass Avenue
   Argonne, Illinois 60439
   Reference: B68-10185

Source: D. E. Wiegand
Reactor Engineering Division
(ARG-10124)

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439