April 1971
Brief 71-10074

NASA TECH BRIEF

Lewis Research Center

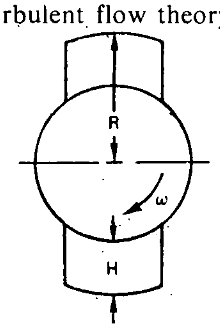
Prediction of Windage Power Loss in Alternators

The problem:

To calculate windage losses in rotating machinery. Past practice has been to estimate the windage loss by comparing a proposed machine to a similar existing machine with known windage loss. For conventional machinery, a considerable body of data exists, and this technique is adequate. However, present day requirements for higher speed rotating electrical machinery have created a need for analytical techniques capable of predicting windage losses.

The solution:

Simplified equations and constants have been developed based on laminar and turbulent flow theory between parallel plates. These equations were checked by comparing calculated results with experimental data for a smooth-cylindrical rotor and a slotted alternator. Agreement was generally good, with a maximum variation of 7% between experimental and calculated losses.



Modifications of these equations were applied to a salient-pole homopolar inductor alternator, with and without shrouds. The results were compared to experimental losses in an equivalent machine run in two different gases over a range of pressures. The curves for both gases show ±10% agreement between the test data and the calculated losses over a pressure range from below standard atmospheric pressure to 275 kN/m^2 (40 psia).

How it's done:

The windage loss for a solid rotor was found to be

$$W = R^4 L C_d \pi \rho \omega^3$$

where

ρ = gas density
R = rotor radius
ω = angular velocity
L = length of the rotor
C_d = a turbulent theory drag coefficient functionally dependent on Reynolds number

For a salient-pole machine, the loss equation must be multiplied by:

$$K = 8.5\left(\frac{H}{R}\right) + 2.2$$

This equation, based on empirical results, is limited to $\frac{H}{R}$ values >0.06.

The addition of a shroud to this design resulted in $K = \frac{3}{2}$.

Using the techniques described in the report, it appears that the basic equation can be modified to accommodate other rotating electrical machinery designs.

Notes:

1. Documentation is available from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference:
   NASA-TN-D-4849 (N68-37162), Prediction of Windage Power Loss in Alternators
2. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B71-10074

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

Source: James E. Vrancik
Lewis Research Center
(LEW-10939)