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/m² (40 psia).

How it's done:
The windage loss for a solid rotor was found to be

\[ W = R^4L \cdot C_d \pi \rho \omega^3 \]

where
- \( \rho \) = gas density
- \( R \) = rotor radius
- \( \omega \) = 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 \( K = \frac{3}{4} \).

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.

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