FINGER SEAL: A NOVEL APPROACH TO AIR TO AIR SEALING

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The gas turbine industry uses a variety of sealing mechanisms to contain and direct secondary flows into and around components for cooling, and to limit leakage into and from bearing and disk cavities. The function of these seals is very important to the component efficiencies and attendant engine performance.

Most of these seals are labyrinth seals, which are high-leakage seals that are costly to manufacture. In recent years, brush seals have been introduced which have demonstrated significantly reduced leakage, although they are still expensive and have exhibited wear and hysteresis difficulties.A new innovative concept called finger seal, patented by AlliedSignal, has demonstrated leakage similar to brush seals and is cheaper. The finger seal is comprised of a stack of precision photo-etched sheet metal elements, which allows intricate features to be made at very low cost and with the potential to resist wear and provide the compliance necessary to accommodate rotor excursions. Initial testing in the high-speed/high-temperature seal test facility, at the NASA Lewis Research Center, has corroborated the finger seal performance. The testing also revealed hysteresis problems with the current design.

A NASA funded research project is in progress to correct the functional deficiencies of the finger seal and to refine its features to provide sufficient seal life for commercial transport engines and other long-life applications. This research will benefit the aeronautical gas turbine industry as a whole in terms of fuel consumption, operational characteristics, and cost.

The first phase of this research to reduce finger seal hysteresis has been in progress for the last one year. This paper presents the results of this research to date.

In future the research program will address seal performance, manufacturing, cost and life issues. The research program is expected to be completed by December 1998.

FINGER SEAL IS A REVOLUTIONARY NEW CONCEPT IN SEALING TECHNOLOGY

KEY FEATURES

- o LOW AIR LEAKAGE SIMILAR TO BRUSH SEALS
- o AIR LEAKAGE 20 TO 40 PERCENT THAT OF A LABYRINTH SEAL
- o LOW COST: ABOUT 20 TO 50 PERCENT THAT OF A CONVENTIONAL LABYRINTH OR BRUSH SEAL
- o HIGH SPEED, PRESSURE AND TEMPERATURE CAPABILITY

EXPECTED SYSTEM BENEFITS TO PROPULSION ENGINES

- o 1 TO 2 PERCENT SAVING IN ENGINE AIR FLOW
- o 0.7 TO 1.4 PERCENT REDUCTION IN SPECIFIC FUEL CONSUMPTION
- o 0.35 TO 0.7 PERCENT REDUCTION IN DIRECT OPERATING COST

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ALLIEDSIGNAL IS DEVELOPING FINGER SEALS UNDER TWO CONTRACTS

NASA CONTRACT GOALS:

- o LOW COST: 20 % THAT OF BRUSH SEAL
- o AIR TEMPERATURE: 1000 F
- o DIFFERENTIAL PRESSURE: 100 PSID
- o SURFACE SPEED: 1100 FT/ SEC

NAVY CONTRACT SOALS

- o LOW COST: 20-50 % THAT OF BRUSH SEAL
- o AIR TEMPERATURE: 1500 F
- o DIFFERENTIAL PRESSURE: 160 PSID
- o SURFACE SPEED: 1500 FT/ SEC

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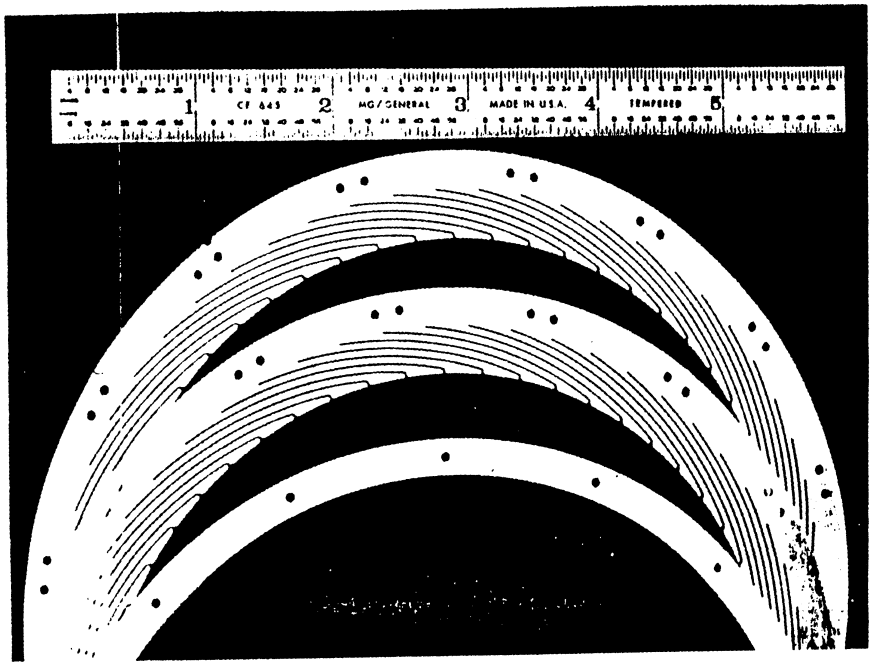
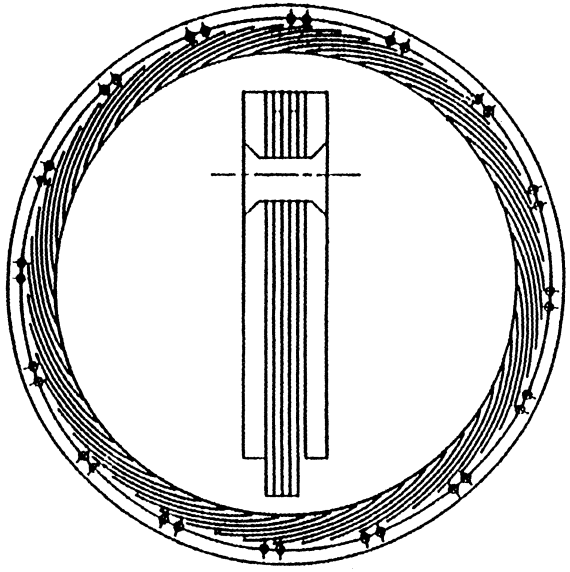
FINGER SEAL CONFIGURATION





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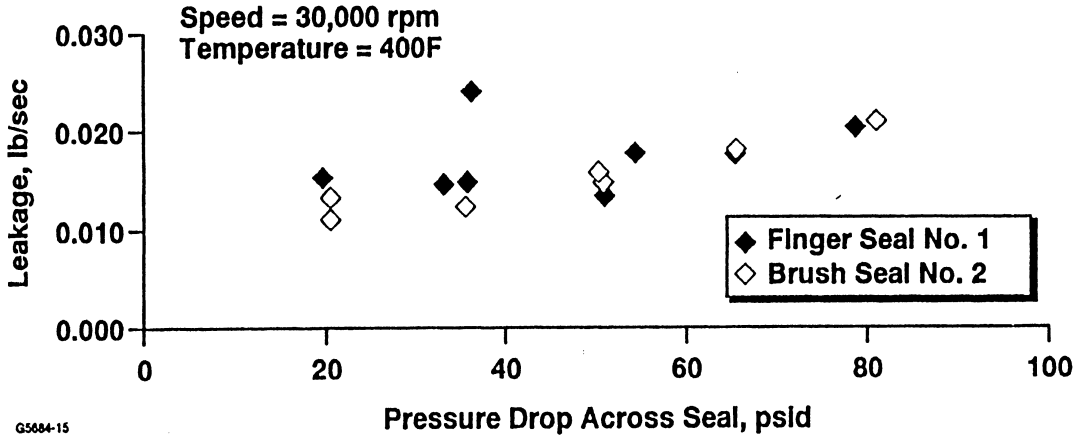
FINGER SEAL HAS DEMONSTRATED AIR LEAKAGE SIMILAR TO A BRUSH SEAL



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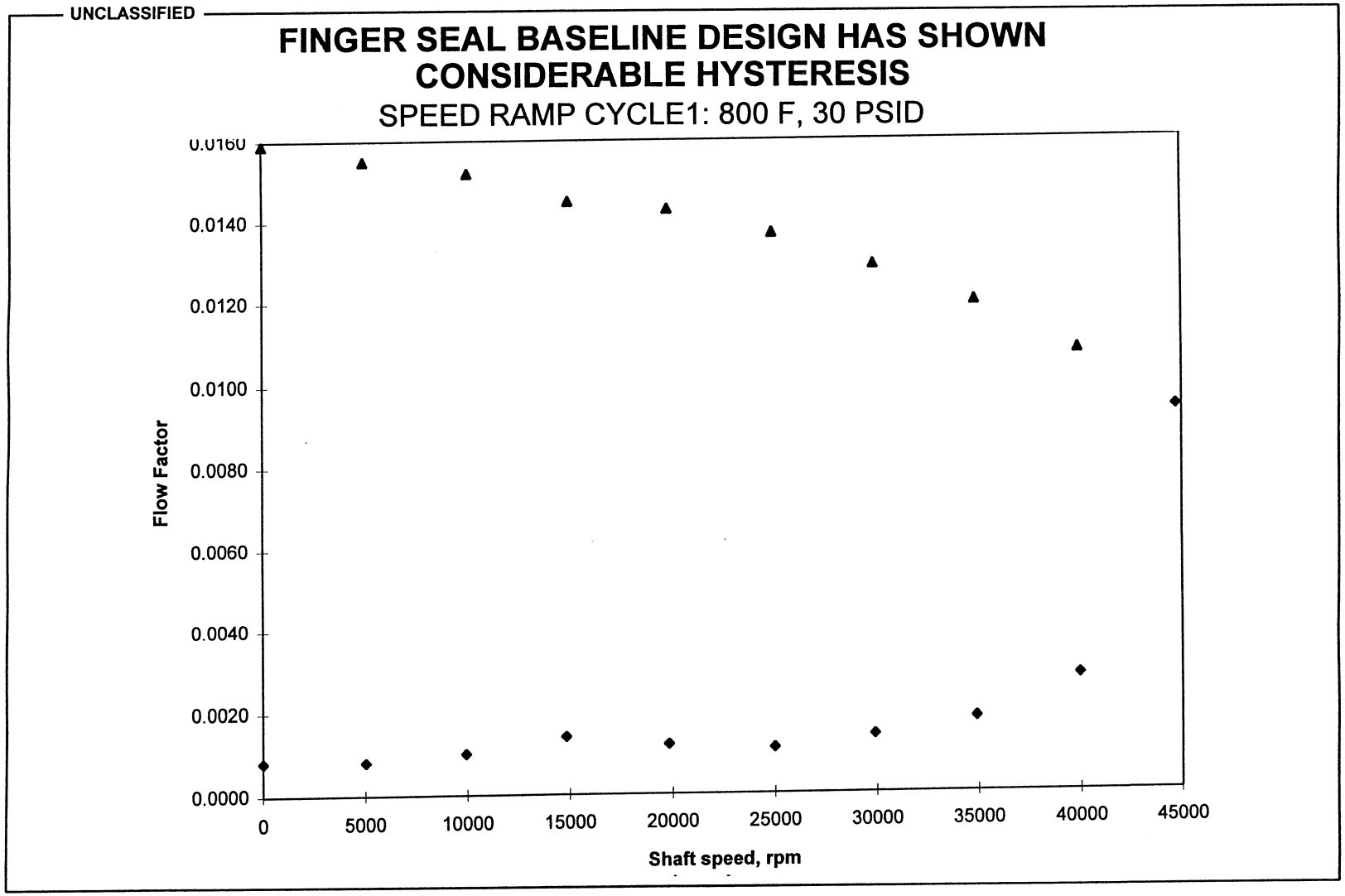
FLOW FACTOR DEFENITION

- FLOW FACTOR PHI IS DEFINED AS
- PHI =(mdot * sqrt (Tavg+459.67)) / (Pu * Di)
-
- where, mdot = Air leakage flow rate, lbm / sec
- Tavg = Average air temperature upstream of the seal, F
- Pu = Air pressure upstream of the seal, psia
- Di = Outside diameter of the seal rotor, inch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FINGER SEAL BASELINE DESIGN HAS SHOWN CONSIDERABLE HYSTERESIS
SPEED RAMP CYCLE1: 800 F, 30 PSID
Flow Factor
0.0160
0.0140
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
0.0000
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
Shaft speed, rpm
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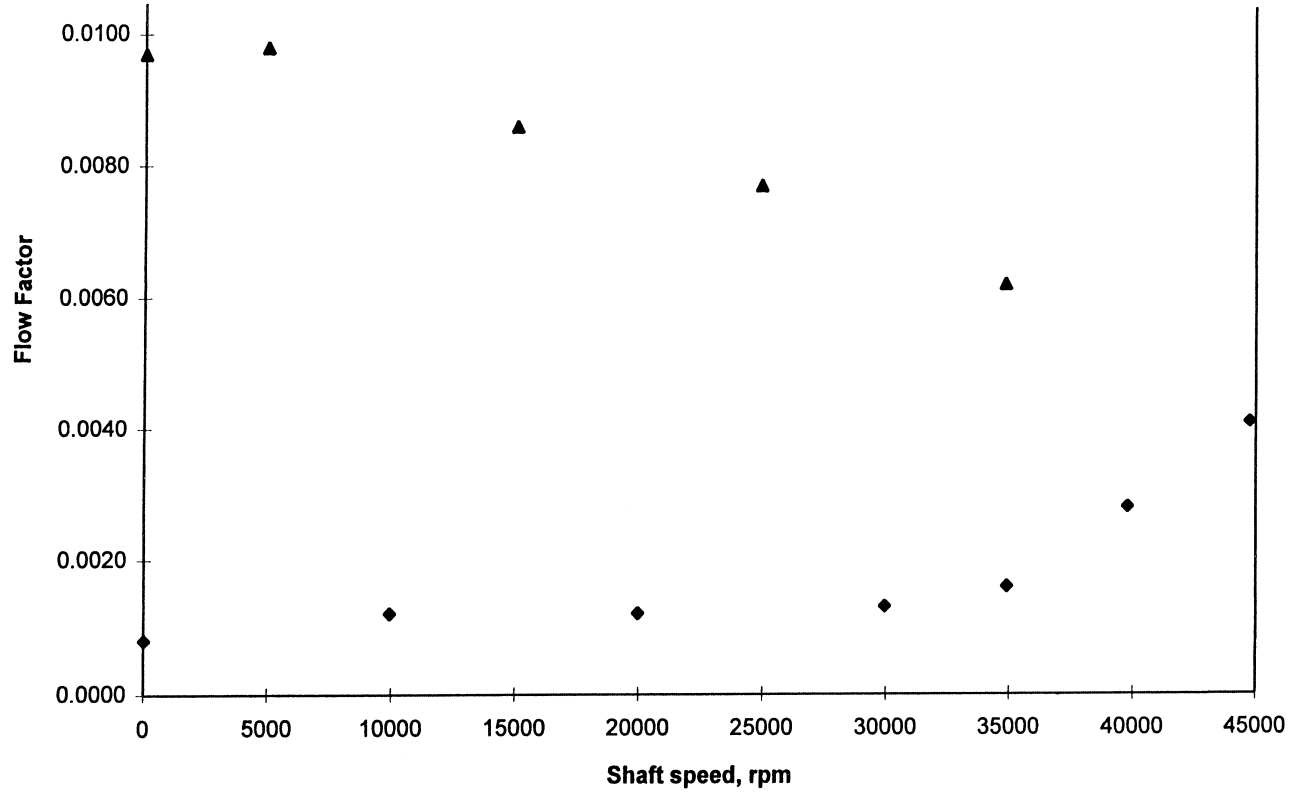
FINGER SEAL BASELINE DESIGN HAS SHOWN CONSIDERABLE HYSTERESIS

SPEED RAMP CYCLE 2: 800 F, 30 PSID



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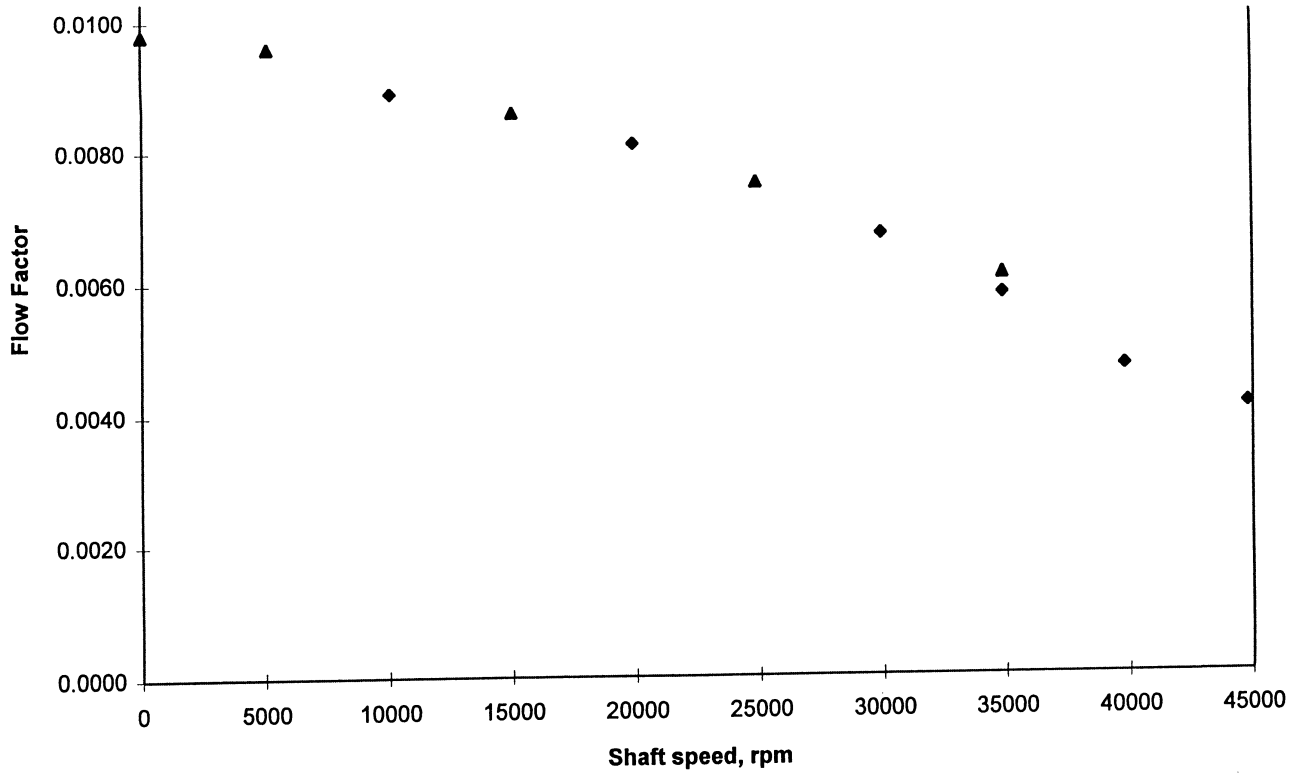
FINGER SEAL BASELINE DESIGN HAS SHOWN CONSIDERABLE HYSTERESIS

SPEED RAMP CYCLE 3: 800 F, 30 PSID



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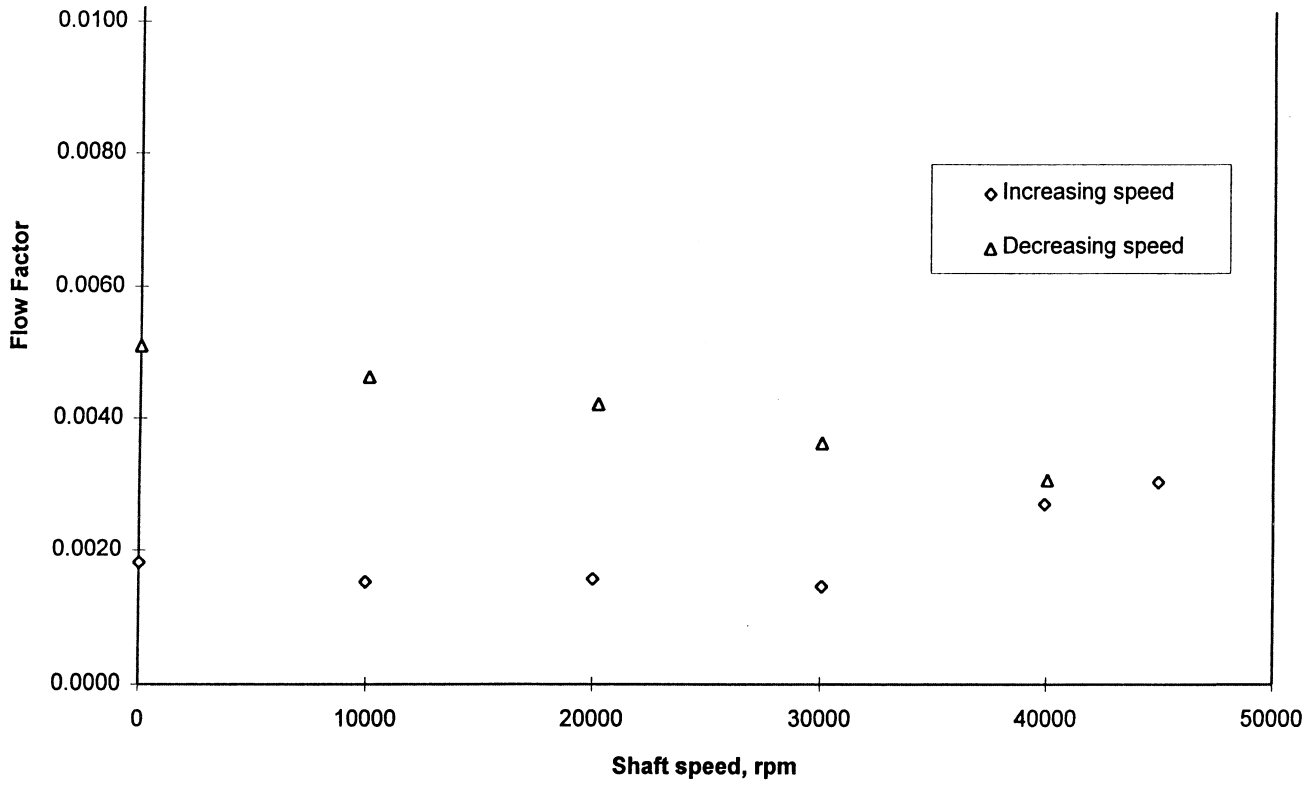
FINGER SEAL PRESSURE BALANCE DESIGN HAS SHOWN REDUCTION IN HYSTERESIS

SPEED RAMP CYCLE 1: 500 F, 30 PSID



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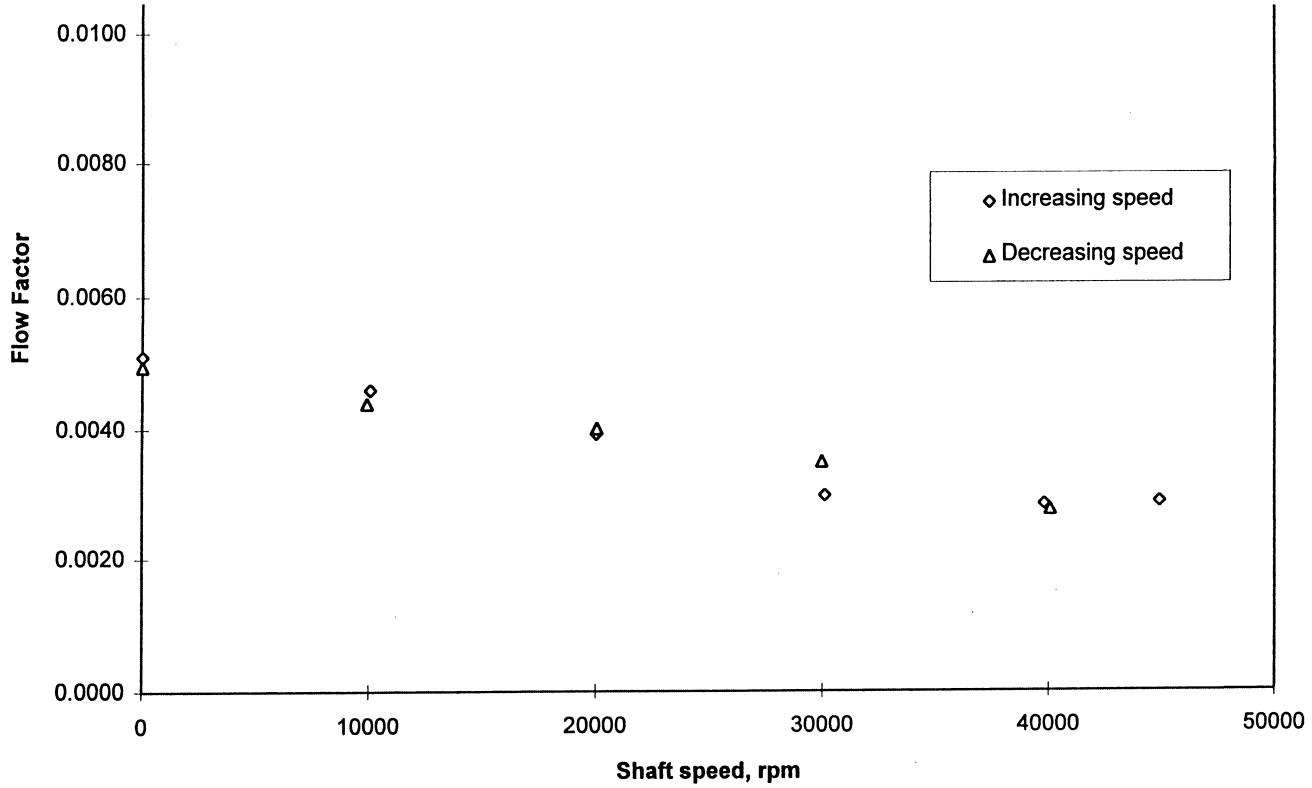
FINGER SEAL PRESSURE BALANCE DESIGN HAS SHOWN REDUCTION IN HYSTERESIS

- SPEED RAMP CYCLE 2: 500 F, 30 PSID



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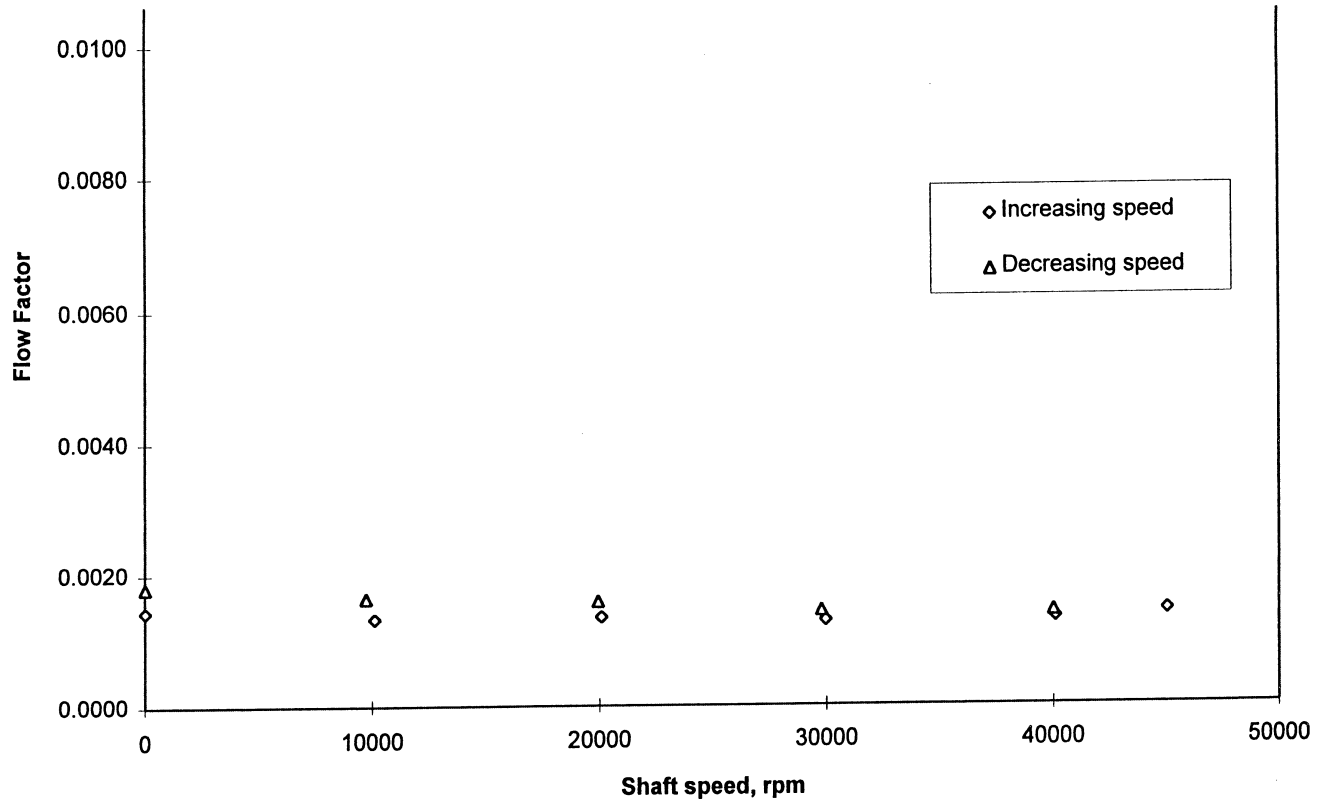
FINGER SEAL PRESSURE BALANCE DESIGN HAS SHOWN REDUCTION IN HYSTERESIS

- SPEED RAMP CYCLE 1: 500 F, 60 PSID



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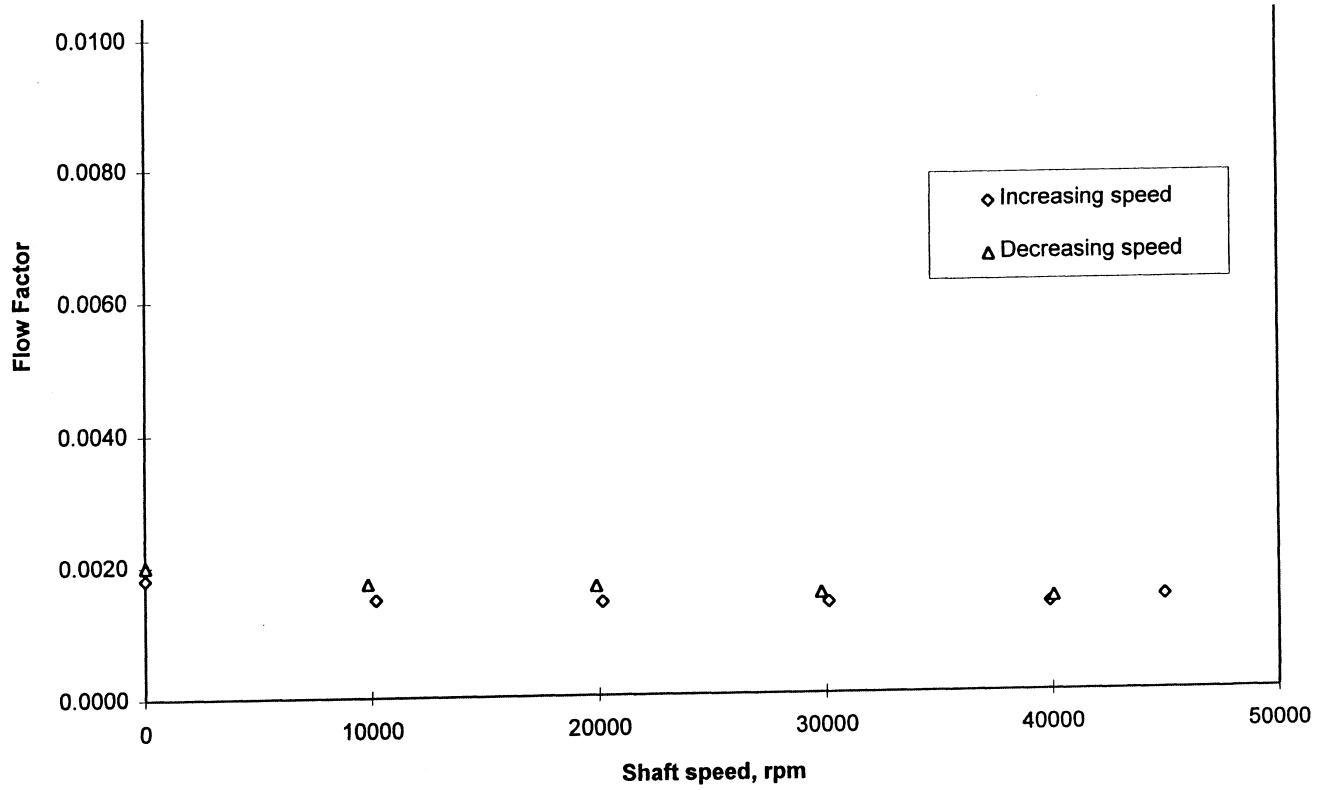
- SPEED RAMP CYCLE 2: 500 F, 60 PSID



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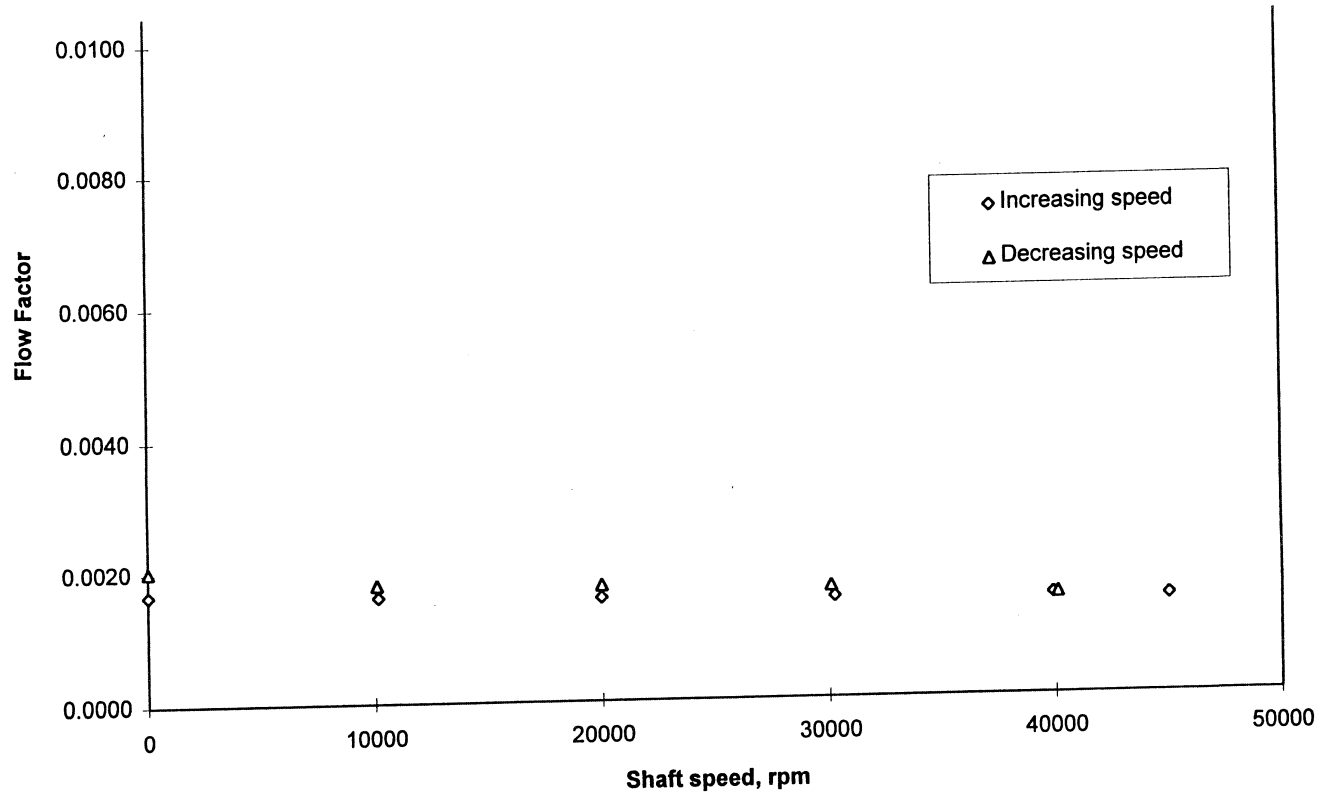
FINGER SEAL PRESSURE BALANCE DESIGN HAS SHOWN REDUCTION IN HYSTERESIS

- SPEED RAMP CYCLE 1: 500 F, 90 PSID



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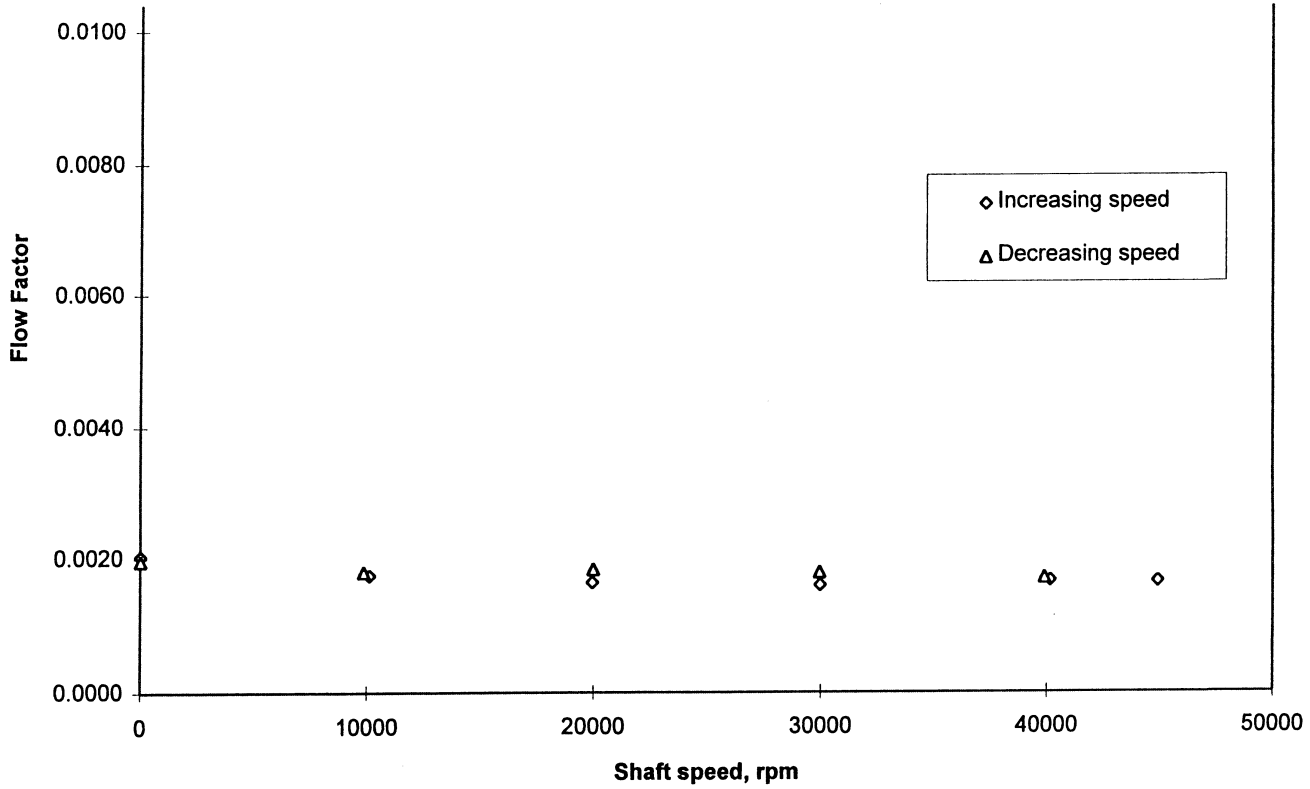
FINGER SEAL PRESSURE BALANCE DESIGN HAS SHOWN REDUCTION IN HYSTERESIS

- SPEED RAMP CYCLE 2: 500 F, 90 PSID



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SUMMARY

- FINGER SEAL LEAKAGE IS SIMILAR TO A BRUSH SEAL
- FINGER SEAL COST GOAL IS 20 TO 50 PERCENT THAT OF BRUSH SEAL
- PRESSURE BALANCE DESIGN HAS SHOWN PROMISE IN REDUCING HYSTERESIS

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