Surface patterning and the effects on dynamic characteristics of annular hole-pattern seals

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Introduction

Non-Contacting Annular Gas Seals
- reduce leakage rate between different pressure regions
  - acceleration and deceleration of the process fluid as it passes through a small restriction area followed by a subsequent expansion region arranged in an surface pattern
  - convoluted flow path is therefore very important to the performance of the annular gas seal
- strong influence on the dynamic characteristics of the entire machine

Goals
- To investigate the effect of surface patterning
  - on leakage rate in hole-pattern seals
  - on rotor dynamic properties
  - alternately arranged surface pattern

Computational Model

Regular vs Alternately Arranged Pattern

Parameterization

Baseline Model
Alternately arranged surface patternning obtained through parameterization

Design of Experiments

Direct Damping

Alternately arranged pattern seals

Effective Damping

Regression model and Response Surface

Regression analysis is a statistical process for estimating the relationships among variables.

Response surface methodology explores the relationships between several explanatory variables and one or more response variables.

Regression models are obtained by performing backwards elimination on full quadratic least squares regression models.

Results

Leakage Rate

Examples of a higher C_eff model

Conclusions

- Alternately arranged hole-patterning has significant effect on dynamic response
- Leakage rate is reduced when the total area of the holes on the stator surface increases
- The radius of larger holes and the number of holes in both axial and circumferential directions are identified as relatively important factors
- The depth of the holes is very important for effective damping
- Using different depths on an alternately arranged hole-pattern design can significantly affect the dynamic characteristics of the seal
- Results are helpful in designing a seal that can concurrently satisfy constraints on both the leakage rate and the rotor dynamic response while maintaining same design envelope