2017 STLE Annual Meeting & Exhibition
May 21-25, 2017
Hyatt Regency Hotel
Atlanta, Georgia, USA

INVESTIGATION ON HIGH TEMPERATURE STEAM EFFECT OF BRUSH SEALS FOR STEAM TURBINE

TRACK OR CATEGORY

Seals II

AUTHORS AND INSTITUTIONS

Authors: Byun, Jaeseung; Timchenko, Dmytro; Lee, Yongbok
Institutions: Center for Urban Energy Research, Korea Institute of Science and Technology, Seoul, Korea (the Republic of)

INTRODUCTION

Brush seal is widely used in many applications primarily due to its built-in structure which ensures zero clearance between the seal and the rotor. However, care should be taken since physical complexities such as tilted structure, bent bristles, splicing effect of bristles, make the analysis of brush seals more challenging than that of conventional labyrinth seals. Several researchers conducted experiments monitoring sealing performance and wear properties under steam condition experimentally[1-3]. However, detailed comparison to conventional labyrinth or hybrid(labyrinth+brush) seals was not fully considered. In this study, high temperature steam effect of brush seals was investigated. In particular, experiments were conducted to characterize sealing performance of the brush seal, and the wear properties of the brush seal. In the sealing performance experiment, a brush seal unit was incorporated in the labyrinth seal to mimic the commercial steam turbine seal. In the wear experiment, two brush seal units were utilized with a housing, in order to measure pure brush seal effect of the system. Effect of high temperature steam was also discussed.

SEALING PERFORMANCE TEST

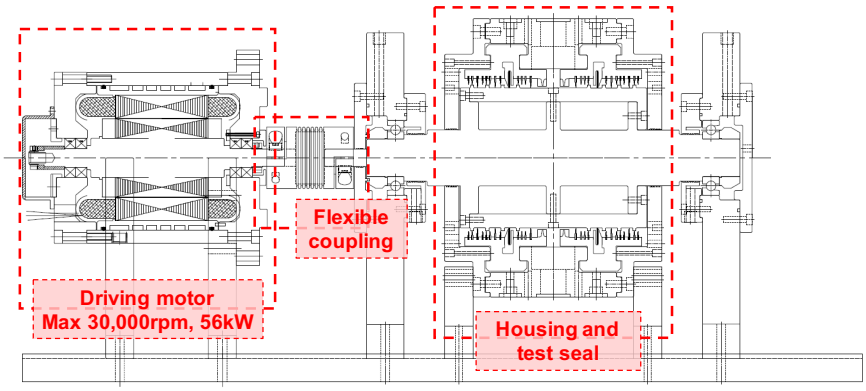

Fig1. Brush seal test schematic(left) and sealing performance test result(right)

Detailed description of the test cycle is showed in Fig1. Injection of steam is controlled by inlet/outlet valves. Considering realistic situations of steam turbine operation, three installation conditions are concerned for the test; Labyrinth seal with brush seal failure(Case A), Labyrinth seal(Case B), Hybrid seal(Case C). Case A is of interest since ensuring allowable sealing is required once brush seal failure due to sudden impact or long term operation. As observed in Fig1., hybrid seal showed 91.7% of enhancement compared to the labyrinth seal. Also, increase of clearance of Case A did

not affect the leakage noticeably. The results show that even concerning the unwanted brush seal failure, hybrid type is favored.

WEAR ANALYSIS

For quantitative approach of wear, two parameters were taken into account to the experiment. Mean clearance was calculated utilizing computer vison algorithm. Once area of clearance is measured(Fig2.), the clearance is obtained,

$$C_m = \frac{D}{2}\left(\sqrt{1+\frac{4A_P}{\pi(\rho D)^2}}-1\right) \qquad (1)$$

Where A_P $[pixcel^2]$ is lit area resulting from the clearance, ρ is pixel density$[mm^2=pixel^2]$ and D is a diameter of the disk.

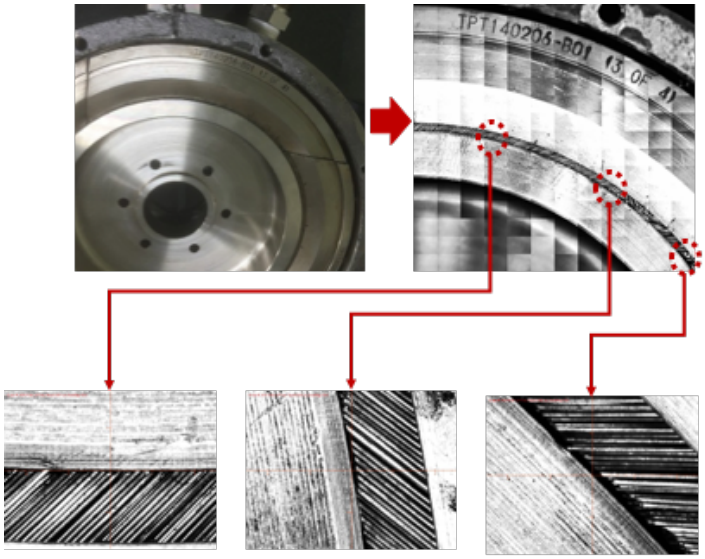

Fig2. Noncontact based clearance measurement procedure

Qualitative research was conducted applying SEM-EDX(Fig3., Table1.). Different from dry sliding conditions[4], substantial oxidation was observed. It is majorly due to high temperature environment and sufficiently humid condition accelerating oxidation process.

CONCLUSION

1. Hybrid seal showed exceptional sealing performance. The performance was more improved under super-heated steam condition, compared to compressed air. Thermal expansion and steam itself both play an important role for the sealing.
2. Mean clearance and weight loss showed abrasive wear and material transfer to bristles. Substantial amount of oxidation film was produced under high-temperature steam condition.

ACKNOWLEDGMENTS

This material is based on a research project (“Study on the ball bearing cage operated under the extreme environmental condition” NRF-2014R1A2A1A10052448) supported by the National Research Foundation of Korea, which is funded by the Ministry of Science, ICT and Future Planning, Korea.

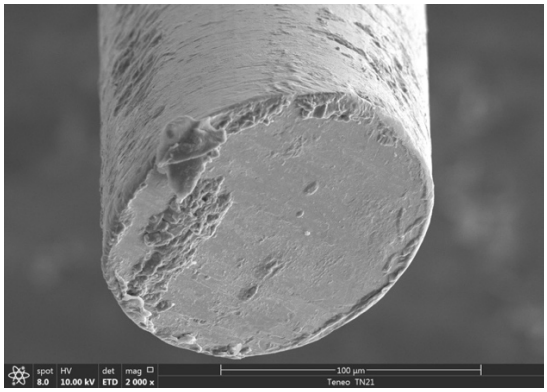

Fig3. SEM analysis of the bristle after steam operation

Element	Wt%
C	03.25
Cr	18.83
Fe	02.37
Co	49.90
Ni	10.83
W	13.32

Element	Wt%
C	06.44
O	07.04
Cr	16.67
Fe	03.89
Co	41.62
Ni	09.35
W	14.99

Table1. EDX data: Before steam operation(left) and after steam operation

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KEYWORDS

Seals, Brush Seals, Wear, Clearance