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Modeling of Gas Foil Bearings for S-CO_2 Turbomachinery

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Sandia National Laboratories has been a leader in hardware development of the S-CO_2 Brayton cycle, and is in possession of unique facilities for testing turbomachinery in supercritical fluid flow environments. To achieve conditions necessary for higher efficiency electrical conversion, operation of the Sandia split-flow Brayton loop will soon progress into higher temperature, larger compression ratio operation regimes, requiring greater rotation frequencies and thrust loads. Accurate load capacity estimates will be needed to prevent costly bearing failures, and the existing methods of estimation will no longer be adequate.

Gas foil bearings have proven to be an enabling technology for small to medium-scale advanced high temperature turbomachinery systems such as the Sandia facilities. These machines face high rotation speeds and operating temperatures that conventional ball bearings cannot survive long-term. Their advantages include improved durability, reduced maintenance needs, and the elimination of system contamination (oil-free operation). Despite these benefits, the coupling of gas bearings with turbomachinery is but an emerging practice; only a small amount of performance data is available in literature. Industry has been slow to adopt this technology due to the relatively small number of foil bearing manufacturers and therefore a high perception of risk. Recently (in 2007), NASA and the U.S. Army Research Lab sought to encourage more R&D by conducting a study to design and test open-source gas foil bearings. Sandia's contractor BNI manufactured thrust bearings for use in the present S-CO_2 turbomachinery test loops based on these open-source designs.

In order to better understand the dependency of thrust bearing windage and load capacity to various operational parameters, researchers at a sponsoring laboratory have partnered with Sandia to modify a portion of the split-flow loop into a thrust bearing test rig. The data generated in these tests, and previous tests at Sandia, are ideal for the basis of creating and benchmarking a computational model. For the present study, work has been done to create a simplified, theoretical thrust bearing model by evaluating the Reynolds equation along the thrust disc surface. This has allowed for an analysis of geometric and environmental parameters influencing bearing design for maximum thrust load support. This will serve as a basis for development of a semi-empirical foil thrust bearing model tailored to Sandia supercritical fluid Brayton cycle technologies, providing an extremely useful tool to experimenters during future test runs.