Advanced Modeling of High Speed Micro Rotordynamics

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Introduction

With the recent developments in microfabrication techniques, production of complex geometries are enabled. Then, development of micro scale systems becomes possible.
A great number of researchers have been working on the development of such devices as micro electric motors, micro turbines, micro pumps, micro reaction wheels, micro gyroscopic sensors and micro spindles. These systems require high speed rotating parts to achieve the same performances in macro level. However classical rotor dynamic modeling approaches can not be sufficient due to the effects becoming crucial in small scale.

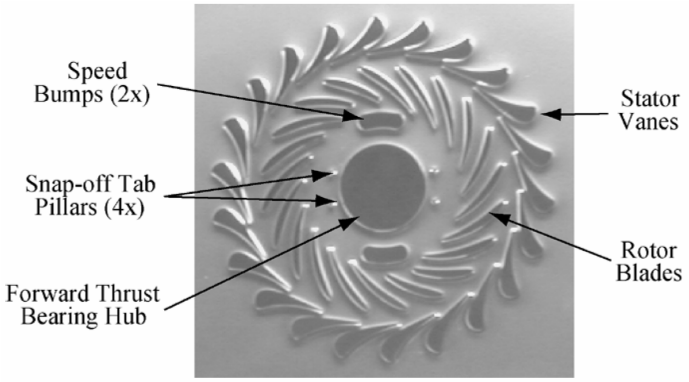

Figure 1: Photograph of the 4.2-mm diameter microturbine [1]

Objective

Some physical effects become more crucial in dynamics of small scale components. The viscous forces are more important at small scale. Heat transfer is another important aspect since micro devices operate in a different design space than large-scale machines.
The high angular speeds (10^5-10^6 rpm) also require untraditional levitation systems for low friction operation.
The aim of this project is to develop dynamic analysis tools for the design of microsystems with high speed rotating parts considering multiphysical effects. Afterwards, the developed models are intended to be used for a specific application to assess their effectiveness. Finally, the sensitivity of the frequently encountered problems of rotordynamics such as imbalance and eccentricity will be analyzed.

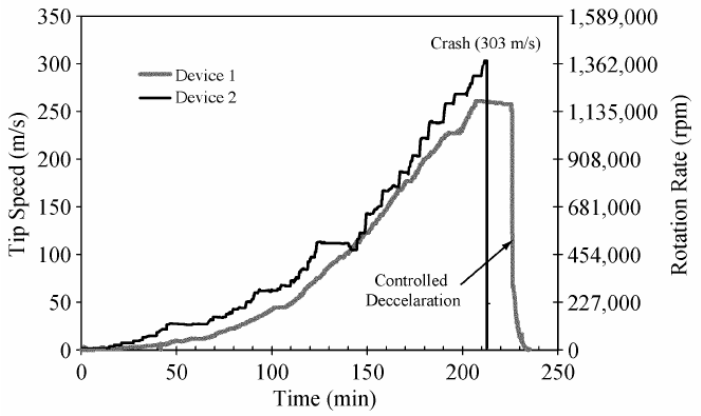

Figure 2: Test results of two microturbine devices- Device 2 was run to a higher speed and crashed due to the unstable hydrodynamic forces [2]

Future Work

The activity plan for the near future is:

- Formulation of multiphysical problems such as fluid structure interaction and temperature effects.
- Coupling these models with the rotor dynamics using a FE code developed in UT.
- Validation of the developed methods with experiments.
- Development of analysis approaches for the support & bearing.

References

[1] Epstein A., "Millimeter-Scale, Micro Electro-Mechanical Systems Gas Turbine Engines", Journal of Engineering for Gas Turbines and Power, Vol. 126, 2004, pp. 205-226.

[2] Fréchette L. G., Jacobson S.A.," High-Speed Microfabricated Silicon Turbomachinery and Fluid Film Bearings", JOURNAL OF MICROELECTROMECHANICAL SYSTEMS, VOL. 14, NO. 1, 2005, pp. 141-152.