Smart Sensing Function Design Using Multifunctional Material for Failure Diagnostics and Prognostics

Abdulaziz T. Almaktoom[1], Zequn Wang[2], Pingfeng Wang[3], and Soobum Lee[4]

[1,2,3]*Department of Industrial and Manufacturing Engineering, Wichita State University Wichita, KS 67260, USA*

[4]*Department of Mechanical Engineering, University of Maryland, Baltimore County Baltimore, MD 21250 USA*

Abstract

Multifunctional structural materials possess attractive attributes that can be designed to realize smart system functionalities such as integrated sensing systems for failure diagnostics and prognostics. With integrated sensing capabilities enabled by multifunctional structural materials, real-time monitoring of potentially damaging structural responses becomes possible. However, due to various uncertainties introduced by structural material properties, manufacturing processes, as well as operating conditions, ensuring the robustness of sensing performance is of vital importance for smart sensing system development. This paper presents a reliability-based robust design approach to develop piezoelectric materials based structural sensing systems for failure diagnostics and prognostics. In the proposed approach, a detectability measure is defined to evaluate the performance of any given sensing system being designed. With the detectability measure, a sensing system design problem can be transformed to a problem of maximizing detectability values for different failure modes through optimally allocating piezoelectric materials into a target structural system. This transformed problem can be conveniently formulated into a reliability-based robust design framework to ensure design robustness while considering the uncertainties. Two engineering design case studies will be employed to demonstrate the efficacy of the proposed methodology in developing multifunctional material sensing systems.

[1] Graduate Student, atalmaktoom@wichita.edu
[2] Graduate Student, zxwang5@wichita.edu
[3] Assistant Professor, pingfeng.wang@wichita.edu, Corresponding Author
[4] Assistant Professor, sblee@umbc.edu