BIOGRAPHICAL SKETCH

Mohsen Safaei was born in Isfahan, Iran. He received his B.S. degree from University of Yazd, Iran, and the M.S. degree from Isfahan University of Technology both in Mechanical Engineering. He is currently working towards his Ph.D. degree with the Dynamic and Smart Systems Laboratory at Tennessee Tech. His research interests include the development of advanced smart material systems for engineering and biomedical applications.

EDUCATION

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M.S., Mechanical Engineering, Applied Mechanics, Isfahan University of Technology, Isfahan, Iran. 2008-2011

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College of Engineering

TENNESSEE TECH

The Department of

Mechanical Engineering

Announces the Dissertation Defense

of

Mohsen Safaei

In Partial Fulfillment of the Requirements

For the degree of

Doctor of Philosophy

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Brown Hall 236

Tennessee Tech University

FIELD OF STUDY

Mechanical Engineering

DISSERTATION TOPIC

A Piezoelectric Instrumented Total Knee Replacement for Sensing and Energy Harvesting

EXAMINING COMMITTEE

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ABSTRACT

Recent developments in the field of orthopedic materials and surgical procedures have made the total knee replacement (TKR) an option for people who suffer from knee diseases and injuries. Due to a lack of in vivo data from the knee joint after surgery, the establishment of a well-quantified alignment method is hindered. In order to obtain information about knee function after the operation, the design of a self-powered instrumented knee implant is proposed in this dissertation. A systematic approach is employed to develop an instrumented TKR with the ability to measure total and compartmental forces as well as to track the location of contact points (CPs) and center of pressure (CoP) in a knee bearing.

Initially, a simplistic polyethylene disc with an embedded piezoelectric transducer is used to investigate the feasibility of sensing and energy harvesting. Next, the results of the preliminary studies are utilized to design various realistic knee bearings with multiple embedded piezoelectric transducers. A bearing equipped with four piezoelectric transducers shows the ability to measure the magnitude of total force and to track the movements in CoP. In addition, the device is able to harvest sufficient energy to power data processing and wireless transmission circuitry in a duty cycle function. Based upon this design, the capabilities of the knee sensory system are improved to sense compartmental forces and CP locations using six and eight embedded piezoelectric transducers. An accuracy of greater than 95% in force sensing and within 1 mm in CP location sensing is achieved from experimentation using a knee bearing with 6 embedded sensors.