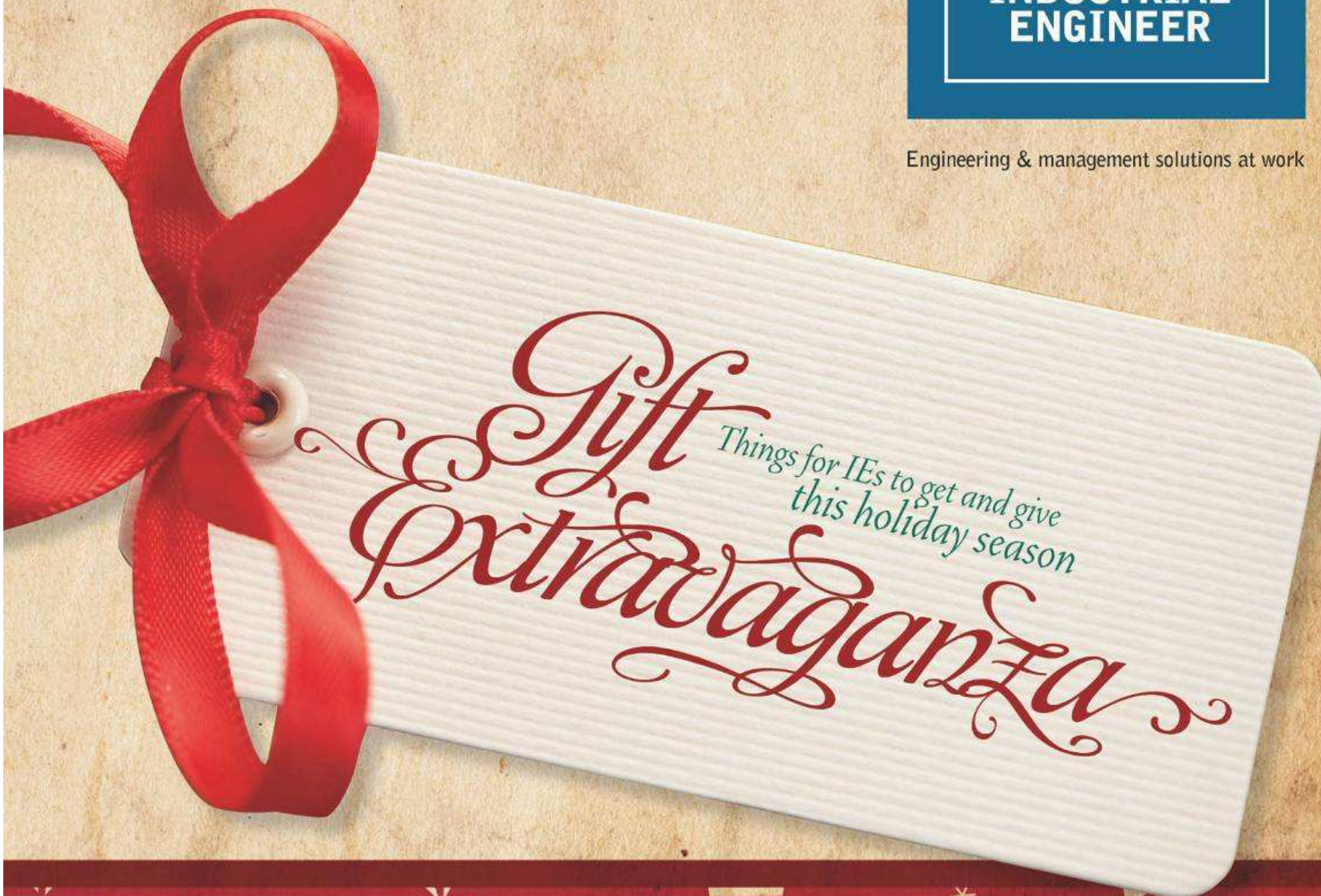
IE INDUSTRIAL ENGINEER

Engineering & management solutions at work



Gift Extravaganza

Things for IEs to get and give this holiday season

December 2010 VOLUME 42 : NUMBER 12 : $11.00

IN THIS ISSUE

Designing stability into a business

Improve audit standards

Marketability through multiple skills

Superperformance for capital projects

Research

EXECUTIVE SUMMARIES : EDITED BY SUSAN ALBIN AND JOSEPH HARTMAN

This month, our research highlights focus on IEs and cutting edge technology. The first addresses nanomanufacturing processes forming a predictive model to describe the process variations at multiple scales. The second describes micro-electro-mechanical systems (MEMS) and how to develop reliability models and preventive maintenance policies for systems that fail due to degradation and shock loads. These articles will appear in the January 2011 issue of IIE Transactions *(Volume 43, No. 1).*

Improve nanomanufacturing process repeatability through modeling

Nanomanufacturing represents the future of U.S. manufacturing. Nanostructured materials and processes have been estimated to increase their market impact to about $340 billion per year in the next 10 years. In the past decade, tremendous efforts have been devoted to basic nanoscience discovery, novel process development and concept proof of nanodevices.

However, there has been relatively little research devoted to improving quality and productivity in nanomanufacturing processing. The process yield of current nanodevices is typically 10 percent or less. The high cost of processing has been a major barrier to transferring the fast-developing nanotechnology from laboratories to industry applications.

In "Physics-Driven Bayesian Hierarchical Modeling of Nanowire Growth Process at Each Scale," professor Qiang Huang of the University of Southern California develops a modeling approach to describe the multiscale process variation in nanowire growth processes. The multiscale process variation is a unique phenomenon in nanomanufacturing, and understanding of multiscale process variation is essential to variation control and reductions in nanomanufacturing processes. The key idea is integrated nanomanufacturing and nanoinformatics, which takes full advantage of available physical knowledge and data.

Professor Qiang Huang has developed a modeling process that improves nanomanufacturing process repeatability.

The work was motivated by the fact that the current physical models are unable to predict nanomanufacturing processes under uncertainties, and there is a lack of observations of most properties at the nanoscale during processing. The proposed modeling approach helps establish a predictive model to describe the process variations at multiple scales.

This research is supported by a National Science Foundation-sponsored project, "In Situ Nanomanufacturing Process Control through Multiscale Nanostructure Growth Modeling," for which Huang is the principal investigator.

CONTACT: Qiang Huang; qiang.huang@usc.edu; (213) 740-2433; Daniel J. Epstein Department of Industrial and Systems Engineering, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA 90089-0193

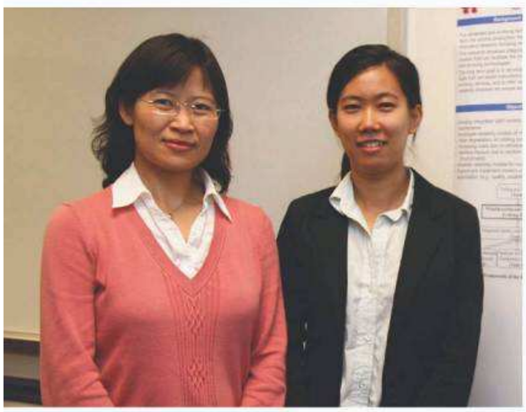
Modeling multiple dependent competing failure processes

For many advanced technology components or systems, failures can result from distinctly different failure mechanisms or processes. When these individual failure processes all occur simultaneously and any of them can cause failure, they can be considered as competing failure processes, and a popular model is a competing risk model. If the individual failure processes are isolated or separate, then the failure processes are often independent, and standard competing risk models are available.

However, for many advanced technology systems, such as micro-electro-mechanical systems (MEMS), failure behavior is more complex, and the failure processes are not independent. MEMS are small machines or systems with components that range from one to 100 micrometers in size. For MEMS and other designs with similar reliability behavior, such as biomedical implant devices, reliability analysis is a complex challenge.

In "Reliability and Maintenance Modeling for Systems Subject to Multiple Dependent Competing Failure Processes," doctoral student Hao Peng and professor Qianmei May Feng from the University of Houston, together with professor David W. Coit from Rutgers University, developed reliability models and preventive maintenance policies for systems subject to multiple, dependent, competing failure processes, specifically considering those failure processes caused by degradation and shock loads.

In practice, common failure mechanisms and causes can be wear degradation, corrosion, fracture, shock loads, fatigue, etc., which may be either independent or dependent. A preventive maintenance policy was developed by minimizing the average long-run maintenance cost rate. This is one of the first research papers to consider this particular problem.



Professor Qianmei May Feng (left) and doctoral student Hao Peng from the University of Houston

Professor David W. Coit from Rutgers University

Peng, Feng and Coit demonstrated the reliability model and maintenance optimization on an example MEMS device. MEMS reliability studies become increasingly important to achieve widespread acceptance of MEMS technology for large-volume commercialization and for critical applications. The issue of multiple failure processes is of particular interest to MEMS researchers because reliability tests have indicated that micro-engines experience two dependent competing failure processes: soft failures due to aging and debris from shock loads and catastrophic failures due to spring fracture. The new reliability and maintenance models were applied to study the micro-engines' reliability and to improve their reliability performance.

CONTACT: Qianmei May Feng; qmfeng@uh.edu; (713) 743-2870; Department of Industrial Engineering, University of Houston, Houston, TX 77204-4008.

The most recent issue of The Engineering Economist *(Volume 55, Number 3) features four articles. Two of the articles deal with advanced cost estimation techniques and compare them with other available methods in two case studies. The second two articles, highlighted here, deal with analysis in the energy industry.*

Valuing tolling agreements in electricity networks

The market for electricity has changed dramatically over the past decade. Many consumers no longer are limited to purchasing power from a monopoly. This, in turn, has led to a number of developments for energy managers as they must compete in markets that sell electricity as well as in markets for acquiring necessary fuel. Tolling contracts have become a common mechanism for securing long-term power contracts.

In a tolling contract, a toller (a power marketer) supplies the tollee (an electricity generator) with the amount of fuel (such as natural gas) needed for power generation. The tollee then makes the production capacity available to the toller in exchange for the payment of a tolling fee. Essentially, the tollee must convert the purchased fuel into electricity so as to allow the toller to retain the pre-agreed output of power.

Tolling contracts were designed to reduce the risk of operating power plants in these new markets. For the power generator, the risk comes from profit uncertainty (market electricity price minus fuel cost). The uncertainty in the fuel cost is eliminated in this tolling contract (for which a fee is paid).

Given the complication of markets and operational constraints on the system (ability to turn on/off power plants, planned maintenance and supply obligations), pricing these tolling contracts is complicated. In "Switch, Switch, Switch! A Regime-Switching Option-Based Model for Valuing a Tolling Agreement," the author proposes a real option valuation model to price a tolling contract. In this model, the toller becomes an energy manager but not the owner of the power plant, in that he or she can operate the plants and switch the power on or off depending on market prices. The value of the contract comes from moving the risk in the spread of the