ABSTRACTS OF SOME OF THE RESEARCH PROJECTS RECENTLY APPROVED FOR FUNDING

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1. Project No. ME/TURBULENT/246 **Investigators: Dr. H.M. Badr (ME)**
Dr. M.A. Habib (ME)
Dr. S.A.M. Said (ME)
Dr. R. Ben-Mansour (ME)

TITLE: Turbulent Natural Convection Flow in Parallel and Converting-Plate Vertical Channels

Abstract:

This study aims to investigate experimentally and numerically the problem of turbulent natural convection flows in three-dimensional vertical channels. The importance of this problem is mainly due to the many related engineering applications ranging from solar heating systems to cooling of electronic and electric power equipment. The investigation will cover two specific geometries; the first is a vertical channel of uniform cross-section (parallel-plate channel) and the second is a converging-plate vertical channel. The details of the flow and thermal fields are to be obtained from the solution of the conservation equations of mass, momentum and energy in addition to the equations of the low Reynolds number k-ε turbulence model. The study aims to cover the Rayleigh numbers range from 10^5 to 10^7 and focuses on the effect of channel geometry and boundary conditions on the characteristics of the flow and thermal fields as well as the local and average Nusselt number variations. Experimental measurements will be performed for two different geometries with the objective of attaining the details of the velocity fields in the converging-plate channel and validating the calculation procedure. Nusselt number correlations in terms of different flow parameters will be developed.

2. Project No. ME/KALMAN/247 **Investigator: Dr. Ameen El-Sinawi (ME)**

TITLE: Two-Dimensional Vibration Suppression in Machining Using a Kalman-Estimator-Based Feed-Forward Active Controller

Abstract:

Vibration suppression of the tool (cutter) results in improved dimensional accuracy and enhanced productivity in machining operations. Vibration of the tool in machining could be viewed as a tool/workpiece interaction excited by the vibration of the machine tool structure. In light of this, isolating the tool from the machine structure reduces this interaction to a base excitation problem in which sufficient condition to eliminate vibration is to reduce the cutting tool acceleration—ideally to zero. Since most cutting tools are rigidly attached to the machine tool structure, their accelerations are almost identical to those of the structure where they are mounted. To lower the tool vibration, it is necessary to construct an active tool holder capable of isolating the cutting tool (cutter) from the vibration of the machine tool structure. The isolation mechanism is accomplished by means of a novel, Kalman estimator-based feed-forward control strategy, high bandwidth actuators, and acceleration transducers.

The principal investigator has already developed a one-dimensional vibration isolation control strategy for the turning process and carried out several experiments to verify the validity and effectiveness of this strategy. A schematic of the strategy is shown in Figure 1. Experimental surface profiles depicted in Figure 3 shows the remarkable success in improving surface roughness of machined parts achieved using this strategy. The most important and favorable technical aspect of the proposed strategy is that, " the Kalman estimator-based controller is an optimal low order controller". Not to forget that the integrity of the controller is maintained because its design is dependent upon the full order model of the plant. Yet, its implementation is reduced to the realization of a second order estimator regardless of the order of the plant model. This is an important and crucial aspect of control processes that are implemented in real time, which requires fast execution of numerical calculation and fast response to any sudden damage, failure, or parametric changes in the plant. This strategy also has advantages, over other available strategies, in terms of its agility, ease of implementation, low cost, reliability, robustness, and relatively high-bandwidth response to process excitation.

In order for the proposed model to be valid, a proper model for the control has to be formulated and incorporated into the design stage of the control strategy. Therefore, the principal investigator has developed a one-dimensional stochastic model for the cutting process. This model describes the cutting process by a random excitation with Gaussian distribution originating from the nonhomogeneous distribution of the microhardness of the workpiece material [1, 2, 3].

The Kalman filter is a highly effective and widely used estimator. Ideally, its used to estimate (extract) the states of the dynamic systems from primitive measurements that are severely contaminated with noise, which is exactly the situation in this research, since the cutting process is modeled as a random process with Gaussian distribution (i.e., noise). The Kalman filter has gained its popularity because of the fact that its formulation is exact in the discrete domain. Therefore, digital platforms (such as computers) are ideal for its implementation. Verification of the proposed control strategy could by achieved in two ways. First, it could be simulated using commercial software packages such as Matlab and ASPI Banshee System platforms. Second, the process could be implemented experimentally by fabricating an active tool holder that acts as the front end of the control strategy. The active tool holder for one-dimensional cutting is shown in Figure 2. This tool holder incorporates a Terfenol-D actuator. This Actuator, with Terfenol-D smart material element, is capable of generating 500 Newton blocked force, up to 50 microns of displacement, and has a bandwidth of 0-5000Hz. This type of actuators is ideal for this application due to its response speed, relatively high force, and large displacements. The actuator is also low-weight, durable, and requires no cooling even when operated for extended periods of time.

As a sum up, the aforementioned theoretical and experimental work [1, 2, 3] has shown that a) the machine tool structure has significant effect on the cutting process and b) the active control strategy using the proposed Kalman based controller has demonstrated high effectiveness in isolating the tool from the machine tool structural vibration, thus improving the surface texture of the workpiece. This control strategy could also be implemented in many similar vibration isolation problems such as milling, drilling, automobile suspension, and vibration cancellation applications.

The proposed work is intended as a continuation of the previous work and will focus on the

two-dimensional controller design and implementation based on the conclusions drawn from the previous work done, which shows that machine tool dynamics in both feed and radial directions have significant effect on the surface profile, yet little work (theoretical and experimental) has been done on this important subject [1, 2, 3, 41].

3. Project No. CIM/DISCLOSE/248 Investigators: Dr. Haider Madani (CIM)
Dr. Reginald S.O. Wallace

TITLE: Corporate Disclosure and Reporting Practices in the Gulf Cooperative Council Countries: A Cross National Comparative Investigation

Abstract:

The proposed study seeks to determine the extent of corporate compliance with financial reporting and disclosure requirements of the countries in Gulf Cooperative Council (GCC). Further, the relative effects of certain corporate-specific characteristics on the extent of compliance with the requirements will be investigated. The disclosure of mandated information in the annual reports of the public companies that will be sampled in GCC countries will be captured over a period of three years with the help of a disclosure index. A multivariate regression analysis will be conducted to ascertain which corporate-specific characteristics are determinants of the extent by which the GCC companies comply with reporting requirements. The results of the proposed study should aid in any public policy that seeks to improve corporate financial reporting and disclosure practices, and securities regulation in GCC countries.

4. Project No. ME/POROUS-MEDIA/249 Investigator: Dr. Ibrahim Dincer (ME)

TITLE: Porous Media in Modern Technologies, Energy, Electronics, Biomedical and Environmental Engineering (Bookwriting Project)

Abstract:

Engineering is racing toward smaller scales and more complex multi-scale systems. In this book we report several developments that are important to the effort of maximizing the performance of complex flow systems. The main thought is that in the beginning the flow architecture is not known, and that it is malleable. The flow system can morph into better and better configurations. No designer can evaluate the infinity of possible flow configurations. An effective *strategy* is needed for the conceptual design and optimization of macroscopic systems that employ progressively smaller scales.

The need for considering the broad picture—the macroscopic system—is great and universal. No matter how successful we are in discovering and understanding small-scale phenomena and processes, we are forced to face the challenge of assembling these invisible elements into palpable devices. The challenge is to *construct,* i.e., to assemble and to optimize while assembling. This challenge is becoming more difficult, because while the smallest scales are becoming smaller, the number of components and the complexity of the useful device (always macroscopic) become correspondingly greater.

This is a text and reference book on the fundamentals of flows in porous media and the

key roles played by these advances in technologies that are important today and in the foreseeable future. The fundamental topic of flows in porous media is the vehicle for bring together a long list of critically important issues from diverse fields such as energy, civil, bio, chemical, electronics and environmental engineering. This is an interdisciplinary book, because these many technological issues are being brought together with purpose—they are current and important, and are supported by a common scientific structure: the principles and behavior of flows in porous media.

5. Project No. CY/IND.CHEM/250 Investigators: Dr. M. Farhat Ali (Chem)
Dr. Bassam El-Ali (Chem)

TITLE: Handbook of Industrial Chemistry: Organic Chemicals (Bookwriting Project)

Abstract:

The organic chemical industry is an important branch of industry and its structure usually centers around petroleum and hydrocarbon derived chemicals. The volume text of available books is generally lacking in covering other very important non-petroleum based organic industries such as paints, dyes, edible oils, fats and waxes, soap and detergents, sugar and starch, fermentation, chemical explosives, agrochemical industries. Although there are comprehensive chapters on these topics in a number of encyclopedia and handbooks, a single volume text is lacking that describes concisely the current state of such industries.

The proposed book will focus primarily on the chemical processing of raw materials other than petroleum and hydrocarbons into useful and profitable products which are in general use as consumer goods. The book will address the needs of both students and practicing chemists and chemical engineers. It is intended to be a primary source of information for the young practicing professionals who wish to broaden their knowledge of the organic process industry as a whole. The book will also serve as a textbook for advanced undergraduate students. The book will be organized into 14 chapters.

6. Project No. CY/GEN.CHEM/251 Investigator: Dr. Salah Sultan (Chem)

TITLE: General Chemistry (Bookwriting Project)

Abstract:

The book would be useful as a text book for students in all universities in the region studying Sciences, Engineering, Medicine and Pharmacy levels 1 & 2. It is also useful as a general reference material for college students as well as the general public. Messrs. Obeican Publishing House, Riyadh, one of the reputed publishers of educational books and literature has already evaluated the book and revised the Arabic content and will be the main publisher and distributor. The book comprises 21 chapters covering the topics: Matter and Measurements, Atoms, ions and molecules, Chemical reactions and stoichiometry, Electronic structure of atoms, Chemical bonds, Molecular structure, The,

periodic table and the properties of elements, Gases, Solutions and solids, Solvents, Thermochemistry and spontaneity, Chemical equilibrium, Kinetics, Precipitation reactions, Acids and basis, Oxidation-reduction, Electrochemistry, Metals, Coordination compounds, Organic Chemistry, Nuclear Chemistry.

7. Project No. EE/ROBUST/252 Investigators: Dr. A.H. Abdur-Rahim (EE)
Dr. Samir Al-Baiyat (EE)

TITLE: Robust Shunt Connected FACTS Devices for Power Systems Damping Improvements

Abstract:

Parallel FACTS devices like SVC and STATCOM are normally used in power system for voltage support at the bus they are connected to. Besides improvement of voltage profile and reactive power flow, properly controlled SVC and STATCOM devices can also offer extra damping to the system. This research addresses the aspect of design of robust controllers for these two devices to provide damping to the power system over a good range of operating conditions.

The power system models will be developed including SVC and STATCON devices. A nominal system will be obtained by lineraization of the nonlinear dynamics. Methods of multiplicative uncertainty will be employed to model the variations of the operating points in the system for the robust controller design. The design will be carried out applying robustness criteria for stability and performance. It is proposed that a loop-shaping method will be employed to select a suitable open-loop transfer function, from which the robust controller will be constructed. The proposed controller will be tested through a number of disturbances including three-phase faults. The simulation results obtained with the robust controller will also be compared with fuzzy logic design for SVC and STATCOM. An analysis will be carried out considering the applicability of the controllers to real systems.

8. Project No. CHE/MIXING/253 Investigator: Dr. Habib Zughbi (CHE)
Mr. Zahid Khokhar (CHE)

TITLE: Numerical and Experimental Investigations of Mixing in Fluid Jet Agitated Tanks: Effects of Geometry and Flow Asymmetry

Abstract:

Mixing plays an important role in the chemical, processing and allied industries. Mixing is usually used as a means of achieving a desired degree of homogeneity and it may also be used to promote heat and mass transfer. Mixing can be achieved by many means including mechanical agitation and agitation with a fluid jet impingement. Until recently very little has been known about the fluid flow, velocity field and mixing characterization that are generally involved in these systems. As a result, impinging jet mixers have been designed individually

for each specific process, and optimization of such systems has been done largely by trial and error.

Recently, Zughbi and Rakib[47-49] simulated the performance of an impinging jet mixer, and investigated the effects on mixing time of parameters such as location and configuration of the injection tuyere, and the jet Reynolds number using a Computational Fluid Dynamics (CFD) model. A general purpose Computational Fluid Dynamics (CFD) software, FLUENT, was used for the simulations.

Zughbi and Rakib's results are in good agreement with the published experimental data of Lane and Rice[20-23]. The model showed that there is an optimum angle of jet injection for a particular jet location. The optimum angle predicted is not 45º as recommended by Coldrey[3] and adopted by Lane and Rice[20]. In fact the optimum angle was found to be 30º. This optimum is not universal and different optimum angles exist for jet injection at different tank heights. For jet injection at any fixed angle of elevation, there again exists an optimum position along the height of the tank as far as the mixing time is concerned. Zughbi and Rakib[48] also showed that the rollover of the jet after hitting the tank walls is a strong determining factor for the mixing time. They also showed that significant reduction in the mixing time is possible if two side jets are used instead of one.

This proposal details plans for further numerical and experimental investigations of mixing in a fluid jet agitated tank. The investigation concentrates on the effects of geometric factors, such as asymmetric flow caused by the injection of the jet at an angle to a vertical plane passing through the axis of the tank. The effects of baffles inserted in the tank on mixing time will also be investigated. Asymmetric flow is expected to cause further reduction in mixing time. The general numerical model of mixing in a fluid jet agitated tank will be modified so that it simulates the new conditions. Results of the numerical models will be validated against own experimental results.

An experimental investigation of mixing in a fluid jet agitated tank will also be carried out using electric conductance and temperature as the measured variables. This will make the study of parameters, not reported in the literature, possible. Accomplishing the above tasks of investigating mixing in fluid jet agitated tank will be an effective step with many applications in the local petrochemical, oil and other industries. Such an investigation will help deciding the optimum design of a fluid jet mixer.

9. Project No. MS/STOCHASTIC/254 Investigators: Dr. Ibrahim Rahimov (Math)
Dr. Hassen Muttlak (Math)

TITLE: Investigation of a Random Sum of Indicators with Applications in Branching Stochastic Processes

Abstract:

The main object of investigations in the theory of branching stochastic processes is the number of individuals at a given time. However there are other important characteristics describing tree structure of the process. In this project unified method for investigation of such functionals of branching stochastic processes related their genealogy would be developed. The method will be based on construction and study of a special form sum of

independent indicator functions. Using the method limit distributions for generalized reduced processes, for the number of exceedances and for the number of productive ancestors in large populations will be obtained. Possibilities of application in other kind processes will be investigated. This kind of functionals are important for applications of branching stochastic processes in population dynamics, nuclear physics, computer sciences and other areas of the science and technology.