Association for Machines and Mechanisms News Bulletin

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Our Objectives and Activities

The main objective of AMM is to contribute to mechanical design at all levels starting from academic research to industrial initiatives, thereby enhancing the quality and reliability of indigenous machines. With this in view, AMM organises the National Conference on Machines and Mechanisms, NaCoMM, and the workshops on Industrial Problems on Machines and Mechanisms, IPRoMM.

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Message from the Editor-in-Chief

Dynamics and Balancing of Multibody Mechanical Systems

A multibody system can be defined as a number of bodies interconnected with constraint elements such as joints, bearings, springs, dampers, actuators, and acted upon by external and internal forces. Mechanisms and machines are multibody systems. Computer-aided analysis of multibody dynamics emerges as a major tool for the analysis and design of multibody systems. This is possible due to improvements of the computer technology at the level of both hardware and software. Before the advent of computer-aided tools, the design of machines and their components was based on trial and error and graphical methods. In the last four decades, a great number of methods and techniques have been proposed to analyse the dynamic behaviour of systems consisting of multiple bodies. There is a great need to utilise those methods to produce cost effective components and machines with high reliability and durability. To achieve this goal, the analysis of complex mechanical systems which include kinematic and dynamic analyses, synthesis, and optimisation of forces must be viewed in an integrated manner. On the other hand, balancing is one of the crucial steps in the design of high speed machineries. It is a difficult problem due to the interaction amongst various dynamic quantities, e.g., shaking force, shaking moment, bearing reactions, and driving torques/forces. These interactions can, however, be considered in an optimisation problem where various dynamic quantities are computed repeatedly.

Advanced techniques can not only used for analysis of complex systems like robots, heavy machinery, automobile suspensions and steering systems, machine tools, animal bodies, satellites, etc. but also for improving tools and equipment used in handicrafts sectors. The next national conference on Industrial Problems on Machines and Mechanisms (IPRoMM-2010) focuses on such advanced techniques which can be used for handicrafts sectors. An international conference on multibody dynamics (ICMBD-2011) is also scheduled in the beginning of next year.

Himanshu Chaudhary

Editor-in-Chief

Fabric Thickness and Compression Tester Using Inductance Principle

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Background

Fabric thickness is generally evaluated by measuring the distance between two parallel plates separated by a test sample. Various gadgets are commercially available to measure the fabric thickness. The underlying principle of all of these equipments is based on the monitoring of distance between the two parallel plates. Here, a fabric thickness and compression tester has been presented which works on the principle of composite magnetic circuit.

Instrument Fabrication and Testing

The instrument has been developed using UI 100 core of Ferrite, which is a composite of Fe_2O_3 with oxides of one or more bivalent metals such as Manganese (Mn), Zinc (Zn), Nickel (Ni), Magnesium (Mg) etc. This type of core has relative permeability of 2000 or higher. Two coils each having 1500 turns was wound over the two limbs of the U-section. Copper wire of 33 SWG was chosen for the coil, which can carry up to 150 mA current without overheating and this amount of current handling capability is sufficient for the instrument even in case of online measurement. The fabric samples are placed between the U and I section (Figure 1). As the magnetic permeability of fabric is much less than that of Ferrite, the gap created by the fabric between U & I section can be considered to be an air gap having a length equal to twice the fabric thickness. The inductance is measured by a standard LCRQ bridge having a resolution of 10 μH.

Relationship between Inductance and Fabric Thickness

Figure 2 depicts the scatter plot of the measured inductance and fabric thickness values. It is observed that a nonlinear inverse relationship prevails between the two parameters. The best fit power equation, which relates the fabric thickness (Y) and inductance (X) is given in the following equation. The developed instrument can measure the fabric thickness with very good accuracy.

$$Y = 8.511\, X^{-1.435} \qquad (R^2 = 0.971)$$

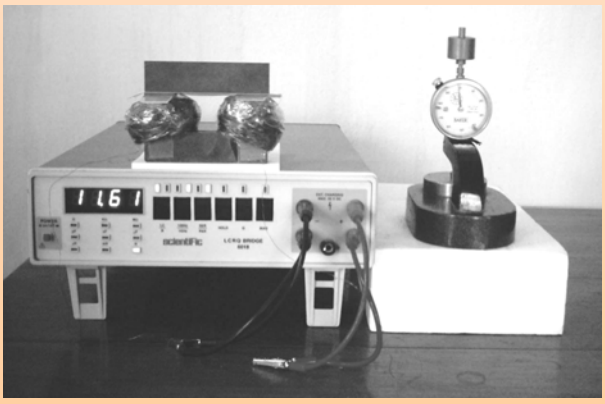

Figure 1: The developed fabric thickness tester

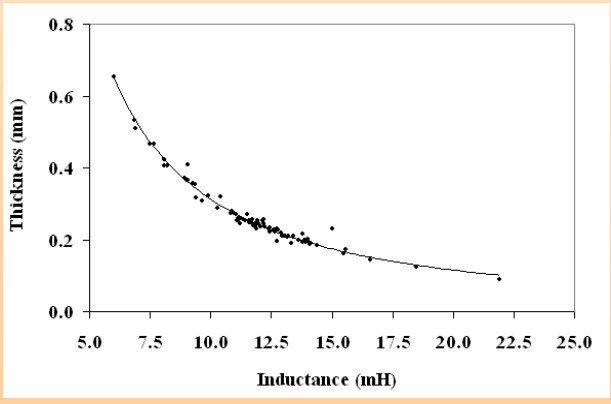

Figure 2: Inductance and fabric thickness

Reference

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Industry Watch

Co-simulation approach for complete product simulation

Many components constitute a system and similarly many systems come together to complete an industrial product. These systems can be of varying nature, but they coexist and collaborate to contribute to the product functioning. Traditionally their interactions have only been investigated through physical prototype testing. But with currently available simulation tools, modeling and coupling these systems together has became possible. This helps to generate the complete virtual prototype and understand the effects of interactions at design stage.

The simulation where these varying type of systems are modeled and simulated in their respective simulation tools which collaborate with each other is called as 'Co-Simulation'. The different simulation tools run simultaneously and exchange information in a collaborative manner. The type of information exchanged during co-simulation may be boundary conditions such as pressure, flow rate and temperature, or simulation parameters such as time steps or control signals

Some common examples of co-simulation are hydraulic system driving dynamic model in interactive mode, gas turbine operation and turbine blade stress analysis, control system and the engine simulations, etc.

Adopting co-simulation allows the analyst to choose the best in class simulation tools for each discipline and provides engineers with the ability to create virtual prototypes of entire systems. Co-simulation offers a range of advantages by uniting the speed and robustness of all the simulation tools used. Most of the simulation tools have developed the capability to collaborate with others, which help to spread the use of co-simulation.

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Student Column

Solid Mechanics: A looking back

Mechanics of solids has had a long, rich and wonderful history. Although its earliest roots can be traced back to antiquity, the modern theory of solid mechanics may be considered to have begun with the studies of Newton's laws of motion. Applied solid mechanics was most probably motivated by the desire to control and repair cracks and fractures in constructional structures. A possible tensile test of wires has been found in the notebooks of the Italian genius, Leonardo da Vinci (1452-1519) [1]. Galileo Galilie (1564-1642) had investigated loading of rods and concluded that tension was independent of length and varied as area; the first step towards the concept of stress [1].

Hooke (1653-1703) discovered in 1660 (pub.1678) law of elasticity named after him, but not yet in terms of stress and strain [2]. Mariotte (Fra,1620-84) wrote a paper on how beams reacted to torque caused by transverse loading [3]. Bernoulli (1655-1705), in the final paper of his life in 1705, showed how deflections could be expressed in terms of *force per unit area* and as a function of length (strain) [4]. Euler (1707-83) in 1727 [5] first proposed the stress strain relationship. Leibnitz (1646-1716) in 1684 [6] introduced the idea of internal forces. Coulumb (1789-1857) [7] came up with the flexure equation. French mathematician Parent (1713) introduced the concept of shear stress.

Euler, Cauchy and formalisation: *Cauchy* (1789-1857), originally educated as an engineer, first formalised the concept of stress and expressed it as a generalised 3x3 tensor. He also developed the equations that express the *6 components of strain* in terms of derivatives of displacements. Similar expressions for the *rates of strain* in terms of the derivatives of fluid field velocity were given earlier by Euler [8]. He gave his famous formula for buckling of a column in 1744. He also introduced the concept of strain energy per unit volume and showed it to be varying as the *square* of the beam's curvature. Following the *principle of virtual work* introduced by Bernoulli (1667-1784) in 1717, Euler rendered the energy stationary and developed the Calculus of Variations [9]. Prof. Lanza of MIT in 1885 in 'Applied Mechanics' used the method of section in *trusses*. Free-body diagram (FBD) as we know was championed by Prof. Church of Cornell in 'Mechanics of engineering' in 1887. *"Draw the FBD"* is an admonition that is a key to becoming a mechanical engineer [10].

Elasticity theory: Theory of finite elasticity, while had its roots embedded in the classical theory, esp. in the works of Piola in the mid-1800s, the development of a viable theory with understanding of physical effects of *non-linearity* in problems like torsion and bending, was mainly the achievement of British-born engineer and mathematician Rivlin in the 1940s,'50s [11].

Theory of plasticity had its origins in Poncelet (Fra,1788-1867) and Rankine (Scot,1820-72)'s mechanics of soils (1853). Terzaghi (Austrian-American, 1883-1963) developed the concepts of effective stress and consolidation in light of *Darcy's law*. Metal plasticity theory began with Tresca in 1864. Prandtl (Ger,1875-1953) developed the elements of *plane plastic flow* in 1920-21 with an analysis of indentation of a ductile solid by a flat-edged rigid indenter, and the resulting *theory of plastic slip lines* was completed by Henckey in 1923 and Geiringer in 1930 [12]. Boltzmann (Austria,1844-1906) in 1874 developed visco-elasticity.

Computational Mechanics: With the advent of powerful mainframe computers from the latter part of the 20th century (1970s), Courant (1943), Turner (mid-1950s), Clough, Martin and Topp (all from US), Argyris and Kelsey(UK) et.al., gradually pioneered *Finite Element Methods* for analyzing several problems of solid mechanics.

Thus, it can easily be appreciated that the history of mechanics of solids is indeed extremely interesting, vast and ever-vibrant.

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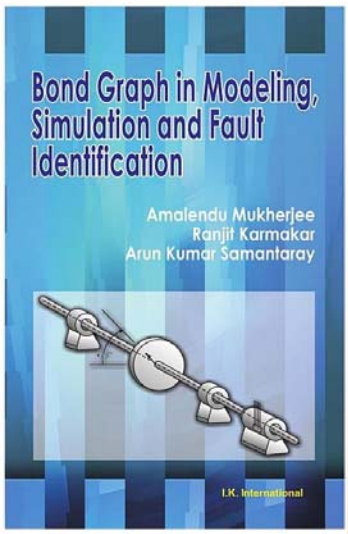
Book Review

Bond Graph in Modeling, Simulation and Fault Identification

By Amalendu Mukherjee, Ranjit Karmakar, Arun Kumar Samantaray

The book on Bond Graph in modeling, simulation and fault identification is an excellent book for modeling and simulation courses. It is one of the good books available in subject. Bond graphs are used for modeling of the dynamic system. It models with ease the systems in multi-energy domain in a unified manner. They represent the power exchange portrait of the system. Power is expressed as multiplication of two factors, generalized effort and generalized flow. In bond graph modeling a modeler divides a system into dynamic units comprised of inertances (*I*), compliances (*C*), and dissipations (*R*). The external sources of input to system are expressed as source of effort (*SE*) or source of flow (*SF*) elements. Two multi-port elements transformer (*TF*) and Gyrator (*GY*), are also used. *TF* elements perform flow-to-flow or effort-to-effort conversion, whereas *GY* element converts flow-to-effort or effort-to-flow. Constraints are represented using junction 1 (representing constant flow) and junction 0 (representing constant effort). The elements are connected by line segments called bonds, which portray the path of exchange of power within the constraint structure and elements. The notion of causality provides a tool for formulation of system equations, and knowing of the controllability of the system or observability of system parameters.



Salient Feature of the Book

- Simple and easy to understand.
- Modeling of thermal, hydraulic, multi body systems, structural members and electronic circuit are dealt with nicely and lucid manner.
- Project type of exercise problems available at the end of chapter.
- Concise set of lectures covering book topics available separately in video CD format.

The book is accompanied with a CD of SYMBOLS Shakti bond graph modeling software. There are examples on modeling of simple system such as an automobile with road excitation, four bar mechanism, and complicated system such as three phase induction motor, modeling of rotor dynamics and many more for interested readers.

Review Report

The book on Bond Graph in modeling, simulation and fault identification assumes that the reader does not have any back ground of bond graph modeling. It comprises of 15 chapters. The first three chapters are on introduction, notion of causality, creation of system equations. These chapters are sufficient to learn the basics of bond graph modeling. The examples given in book are valuable for beginners. Next chapter deals with various methods which can be used for creation of bond graphs of complex mechanical and electrical systems. One of the interesting chapters in the book is on use of non-inertial coordinates. Modeling of structural members gives the idea of modeling of continuous systems. Modeling of multi body systems chapter begins with very simple system such as slider cranks modeling and culminates with modeling of five degrees of freedom robot.

For the thermal systems the irreversible thermodynamics is presented in such a way that true bond graphs for much generalized thermodynamic systems may be created. The connection between true and pseudo bond graphs for transfer of heat is discussed. The chapter also presents incorporation of pseudo graphs for a part of system in an over all true bond graph model for convenience in formulation and modeling.

The book also deals with the modeling of hydraulic systems where bond graph elements corresponding to hydraulic system have been derived. The authors gradually introduced the control strategies in physical domain by introducing deduction of signal flow graphs from bond graphs. The implementation of proportional control, proportional integral control, and proportional integral derivative control are very much appreciated by students. In fact using control strategies in physical domain several different control strategies for complicated systems in multi energy domain may be derived.

The authors have nicely presented modeling of electronic devices such as semi conductor diodes, transistors. The signal conditioning devices using operational amplifiers are also covered. The addition of chapter on fault detection and isolation is new in this edition of book. In this chapter authors have presented qualitative and quantitative methods in fault detection and isolation. The methodology for derivation of analytical redundancy relations from bond graph model are presented. A discussion on fault tolerant control is presented. At the end of book examples of modeling and simulation of various systems such as thermopneumatic systems, power hydraulics, and market economics have been incorporated. There are many solved and exercise problems. They begin from very simple problem to complex problems. As the reader gathers confidence he/she can attempt project type problems.

I found the book to be useful for undergraduate and post graduate students, research scholars and professionals.

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Forthcoming Events

IPRoMM 2010

Industrial Problems on Machines and Mechanisms

Jaipur

www.ipromm2010.org

National Conference on Industrial Problems on Machines and Mechanisms

(IPRoMM-2010)

December 17-18, 2010

organized by

Department of Mechanical Engineering
Malaviya National Institute of Technology
Jaipur, India

in association with

Association for Machines and Mechanisms

Call for Abstracts

Authors are invited to submit one page abstract, clearly stating the objectives, methods, results and conclusions of the work along with title, author's affiliations, and Email address. Authors of accepted abstracts will be invited to submit full papers, which will be included in the conference proceedings.

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Important Dates

One page abstract Submission deadline: **31st July 2010**
Notification of Acceptance/rejection of Abstracts:**16th August 2010**
Full length paper submission dead line:**15th September 2010**
Intimation about acceptance of full paper:**1st November 2010**
Submission of revised manuscript:**15th November 2010**
Last Date of Registration:**1st December 2010**

For more details and updates see conference website: www.ipromm2010.org

About Conference

The National Conference on Industrial Problems on Machines and Mechanisms (IPRoMM) is a series of national conferences organized biannually under the aegis of Association for Machines and Mechanisms (AMM), an affiliate of the International Federation for Promotion of Mechanism and Machine Science (IFToMM), on different themes of interest of Industrial Problems on Machines and Mechanisms. The 10th IPRoMM is being organized by the Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur (Rajasthan), India.

IPRoMM-2010 aims at bringing together the experts in the country on a common platform to speak and outline their vision on the frontier research activities in the area of problems on Machines and Mechanisms. Another major goal is to promote academic-industry interaction and foster collaboration. This conference will consist of several key-note lectures and contributory paper presentations by the eminent researchers and experts from academia and industry.

Handicrafts sector is highly unorganised and the most neglected by researchers. To draw attention of researchers towards this unorganised sector, theme of this conference is chosen as Design and Development of Tools and Equipment for Handicrafts Sector.

International Conference On Multi Body Dynamics

(ICMBD – 2011)

February 24-26, 2011

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First Announcement and Call for Papers

Authors are invited to submit one page abstract, clearly stating the objectives, methods, results and conclusions of the work to be discussed in the presentation. All abstracts will be reviewed by technical committee and, if accepted, authors will be invited to submit full papers, which will be included in conference proceedings.

Important Dates:

One page abstract Submission deadline
15th August 2010
Notification of Acceptance/rejection of Abstracts
15th September 2010
Full length paper submission dead line
15th October 2010
Intimation about acceptance of full paper
1st December 2010
Last Date of Registration
31st December 2010

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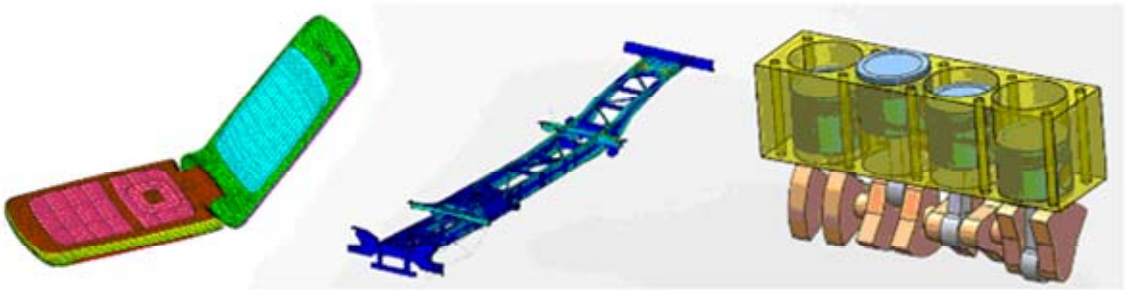

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