

# mechanics

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**American Academy of Mechanics**  
**Academia Americana de Mecánica**

## MESSAGE FROM THE PRESIDENT

Dear Members of the American Academy of Mechanics,

First, I want to congratulate Professor Horacio Espinosa of Northwestern University for receiving the Academy's Junior Award. His research activities as well as editorship of *MECHANICS* are outstanding.

Secondly, I want to congratulate our four newest Fellows of the Academy: Robert Brodkey of Ohio State, Ken Chong of the National Science Foundation, Giulio Maier of Milan Polytechnic, and Robert McMeeking of the University of California, Santa Barbara.

Third, I want to extend my best wishes to Professor Subhendu Datta of the University of Colorado, Boulder, who has succeeded me as the Secretary to the Fellows.

Looking ahead, I want to mention these upcoming meetings involving the Academy:

- AAM spring meeting in Scottsdale, AZ, in connection with the ASME Mechanics and Materials Conference, June 17-20, 2003
- AAM fall meeting in Washington, DC, in connection with the ASME International Mechanical Engineering Congress and Exhibition, November 16-21, 2003
- The 8<sup>th</sup> Pan American Congress of Applied Mechanics (PACAM VIII) in Havana, Cuba, January 5-9, 2004

Sincerely,

Charles W. Bert  
President



**VISIT the AAM Website  
at <http://www.AAMech.org>**

**AWARDS****The 2002 American Academy of Mechanics  
Junior Award Recipient:**

**Horacio D. Espinosa**, Associate Professor of Mechanical Engineering, Northwestern University, received the AAM Junior Award, November 20, 2002, during the Applied Mechanics Banquet at the ASME International Mechanical Engineering Congress and Exposition in New Orleans, Louisiana. The award is given to recognize excellence in research during the first decade of the professional career.

Professor Espinosa has made important contributions in the area of wave propagation plate impact soft-recovery experiments and numerical simulations of damage and failure of brittle materials and fiber composites. He has developed a novel microcracking multiple-plane model that he recently integrated to a granular model to simulate dynamic failure of multi-layered ceramics. This has always been a very difficult problem because it involves modeling the transition from intact to pulverized ceramics, large deformation rate dependent plasticity, mesh adaptivity, multi-body contact including frictional effects and thermo-mechanical coupling. Other contributions from Professor Espinosa are in the area of composite materials. He developed a three-dimensional anisotropic elasto-visco-plastic model together with cohesive laws to capture intersonic crack propagation in unidirectional fiber composites. Professor Espinosa has also developed a variety of experimental techniques. Among them can be mentioned: novel wave propagation soft-recovery experiments, as well as dynamic friction, high temperature and dynamic fracture experiments. Recently, he designed and implemented a novel test for mechanical testing of freestanding thin films and microelectromechanical system (MEMS). Using this technique, he identified strong plasticity size effects, *in the absence of strain gradients*, in submicron gold, aluminum and copper films. These findings will have an important impact in the design of microelectronic and MEMS devices.

Two projects he is working on in emerging areas are: i) reliability of MEMS and NEMS-Radio Frequency switches for condition monitoring of airplane structures, and ii) design of a massively parallel multi-probe system for the fabrication of genomic chips. The MEMS/NEMS effort is an activity of the Center for Quality Engineering and Failure Prevention directed by Jan Achenbach. The genome chip project is an activity within the NSF-Nanoscience and Engineering Center at Northwestern University directed by Chad Mirkin.

Professor Espinosa received his degree in Civil Engineering from Universidad Nacional del Nordeste, Argentina, in 1981, his M.Sc. in Structural Engineering from Politecnico di Milano, Italy, in 1987, and his M.Sc. in Applied Mathematics and Ph.D. in Applied Mechanics from Brown University, in 1991 and 1992, respectively. Professor Espinosa was the recipient of two young investigator awards, NSF-Career and ONR-YIP, and co-PI of a multi-disciplinary research award (MURI) on Lightweight Armor Materials from ARO. He is also an Associate Editor of *Experimental Mechanics*, Guest Editor of three special journal volumes in Micro and Nanomechanics, Editor of *Mechanics*, and a Fellow of the American Academy of Mechanics.

## BIOGRAPHICAL SKETCHES OF THE AMERICAN ACADEMY OF MECHANICS FELLOWS ELECTED IN NOVEMBER 2002

**Professor Robert S. Brodkey** is a Professor Emeritus in the Department of Chemical Engineering at The Ohio State University, where he has been on the faculty since 1957. Previously, he spent five years with Standard Oil of New Jersey at their Esso Research and Engineering facility.

He received his B.S. degree in chemistry and M.S. degree in chemical engineering from the University of California, Berkeley, and his Ph.D. degree in chemical engineering from the University of Wisconsin.

His research has been in the field of fluid mechanics with specialization in the areas of fundamental turbulent fluid flow, mixing, rheology, two-phase flow, and imaging for flow measurements. He is well known for his graduate and undergraduate texts, The Phenomena of Fluid Motions, and Transport Phenomena: A Unified Approach (with H.C. Hershey), respectively. Professor Brodkey has received awards in the U.S., Canada, Germany, and Japan. He is a fellow of AAAS, AIChE, American Institute of Chemists, and American Physical Society. The citation for his American Academy of Mechanics Fellow Award is “for pioneering research on the existence of coherent structures in turbulence using imaginative visualization techniques”.

**Professor Ken P. Chong** is the Director of Mechanics and Materials at the National Science Foundation, a position he has held since 1999. For the ten preceding years he was Director of Structural Systems at NSF. Prior to joining NSF, he was a Professor and chairman of the Structures / Solid Mechanics Group at the University of Wyoming, and Sr. Project Engineer of R&D at National Steel Corp.

He received his BS degree from National Cheng Kung University in Taiwan, an MS degree in structures from University of Massachusetts, and MSE and PhD degrees in Engineering Mechanics from Princeton University.

Dr. Chong’s research includes pioneering analysis and development of sandwich panels with cold-formed steel facings and foam cores. He has also developed new semi-circular fracture specimens for core-based brittle materials and conducted research on hybrid girders. Dr. Chong has been active in numerous technical society committees, such as chairing the ASCE Stability Committee and serving as Associate Editor of the ASCE Journal of Engineering Mechanics. Since 1987, he has edited the Journal of Thin-Walled Structures. He has edited or authored ten monographs, including the widely used elasticity text co-authored with Professor Art Boresi, Elasticity in Engineering Mechanics, which is now in its second edition. He has received numerous awards for his teaching such as the Dow and Halliburton awards and for his research leadership such as the Friedman Professional Recognition Award and the NSF Special Achievement Award. The citation for his American Academy of Mechanics Fellow Award is “for contributions to brittle fracture mechanics, tennis-racket sweet spots, composite panels, and leadership in supporting mechanics research”.

**Professor Giulio Maier** is a Professor of Structural Engineering at the Technical University (Politecnico) of Milan, Italy, where he has been on the faculty since 1965. Prior to then, he was on the faculty at the University of Trieste, Italy.

He received his “Laurea” (M.S.) degree in mechanical engineering from the University of Trieste and his “Specializzazione” (Ph.D.) degree in aeronautical engineering from the University of Rome.

His research has been very broad, including solid mechanics aspects of both mechanical as well as structural engineering. For example, in the 1960s, he was the first to analyze structural instabilities and path bifurcations due to softening damage or nonassociated plastic flow, and at the same time, he was well known for his pioneering research in tension structures. He has been one of the most influential academics in Europe. He was the co-founder of the European Journal of Mechanics: Solids. He has served as consultant to industry for such major projects as the tension structure of the Genoa Sports Palace, the Transmediterranean Pipeline, the Messina Straits Submarine Tunnel, simulations of explosions, ductile fracture, and soil-structure interactions. He has received many awards from Belgium, China, Hungary, Italy, Poland, Russia, South Africa, and the U.S.

It should be noted that although Professor Maier does not reside in the Americas, has spent considerable time in the U.S. collaborating with U.S. researchers, attending conferences, and giving lectures. He has been a Corresponding Member of the American Academy of Mechanics and thus eligible for nomination and election to Fellow. The citation for his AAM Fellow Award is “for contributions to plastic shakedown, softening damage, fracture, structural optimization and identification, and boundary elements”.

**Professor Robert M. McMeeking** is Professor, Department of Mechanical and Environmental Engineering and Department of Materials at the University of California, Santa Barbara, where he has been on the faculty since 1985. Previously he was on the faculty in the Department of Theoretical and Applied Mechanics of the University of Illinois at Urbana-Champaign. He received his B.Sc. degree (with 1<sup>st</sup> class Honors) in mechanical engineering from the University of Glasgow, Scotland. His M.S. and Ph.D. degrees, both in Solid Mechanics, are from Brown University.

Professor McMeeking’s research has been very wide reaching, including plasticity, fracture mechanics, computational mechanics, glaciology, tough ceramics, composite materials, powder consolidation and sintering, ferroelectrics, structural evolution, and nanotribology.

Professor McMeeking has been honored as a visiting scholar at Cambridge University twice. He has been a lecturer in both the Midwest Mechanics Series and the Southwest Mechanics Series. He is a Fellow of the American Society of Mechanical Engineers. He serves on the editorial boards of several journals in the fields of solid mechanics and materials, and is the incoming Technical Editor to lead the ASME Journal of Applied Mechanics. He was recently recognized by the Institute for Scientific Information as a Highly Cited Researcher in the fields of Materials Science and Engineering. The citation for his American Academy of Mechanics Fellow Award is “for mechanics contributions to elastic-plastic fracture, tough ceramics, powder consolidation, composites, and ferroelectrics”.

## **American Academy of Mechanics**

### **Founders Prize and Grant**

Up to \$10,000 For the Academic Year 2003-2004

(Deadline: July 1, 2003)

The American Academy of Mechanics is pleased to announce the availability of a Founder's Prize and Grant to be awarded in September 2003 to a doctoral candidate in the field of Mechanics. Funding has been arranged by the Robert M. and Mary Haythornthwaite Foundation through the good offices of Professor Haythornthwaite, founder and first President of the Academy. The award will be made on the recommendation of an AAM committee. The prize consists of a Certificate and \$1,000 that will be presented at the annual meeting of the Academy, usually held in November. The Grant will be made to that same person in two installments, \$6,000 in September 2003 and up to \$3,000 in January 2004, the latter dependent on the size of the approved budget and receipt by the AAM committee of an acceptable progress report. In order to encourage contestants to think constructively about the impact of new and pending developments, they will be asked to compose an original essay of no more than a thousand words under the title "Progress through Mechanics". The winning essay will be published in *mechanics*. The award is open to those who, as of July 1, 2003, are registered as graduate students at a degree granting institution within the Americas, have completed at least one year of full-time graduate study at that institution, have been assigned a thesis advisor at the institution and have had a doctoral thesis topic emphasizing mechanics approved by the institution following candidacy or equivalent procedures. There are no restrictions with regard to citizenship, residency, race, religion, or sex. Letters of support will be required of the thesis advisor and in addition one from either a Member or a Fellow of AAM. Contestants will be judged on the basis of the essay, plans, references and academic history. The intent of the Grant is to support the research of the student through an approved combination of equipment purchases, information access, travel, etc., but not routine living expenses or fees. Detailed rules for the competition will be issued soon: to receive them, express your interest to the committee by FAX to (215) 204-6936, or by writing to:

AAM Founders Prize and Grant Committee  
c/o Civil and Environmental Engineering Department  
Temple University (084-53)  
Philadelphia, PA 19122

## SELECTIONS OF THE EDITOR

### EDUCATION FOR THE PROFESSION FORMERLY KNOWN AS ENGINEERING

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By Rosalind Williams

*Rosalind Williams is director of the Massachusetts Institute of Technology's program in science, technology, and society. This article is adapted from RETOOLING: A HISTORIAN CONFRONTS TECHNOLOGICAL CHANGE (MIT Press, 2002, <http://mitpress.mit.edu/0262232235>) and originally appeared in The Chronicle Review, Volume 49, Issue 20, Page B12.*

Engineering is undergoing an identity crisis. The mission of engineering changes when its dominant problems no longer involve the conquest of nature but the creation and management of a self-made habitat. To adapt to this new habitat, engineers have to retool, starting with their understanding of engineering education. Today, technological change is something that happens to engineers as much as to anyone else.

For most of the 20th century, engineering faculty members assumed that industrial practice depended on students' understanding of science's "fundamentals": the laws of motion, the conservation of energy, the atomic structure of matter, electromagnetics, the rules of chemical action, fluid dynamics, and the like.

In the 1950s, for example, the department of aeronautics and astronautics at the Massachusetts Institute of Technology portrayed its curriculum as a tree with the basic sciences (math, physics, chemistry) as the deep roots, the applied sciences (fluid mechanics, thermodynamics) as the shallow root system, the engineering sciences (vehicle dynamics, flight control) as branches, and vehicle system engineering at the top.

Today that model is rapidly being displaced by the much more complex interactions of "technoscience" -- a constant process of interaction in interdisciplinary projects where the projects, not the disciplines, define the terms of engagement. In part that is because the science that is now most dynamic -- biology -- does not rest on first principles in the way that physics and chemistry do. More generally, the relationship between science and engineering is no longer summarized in a set of reliable equations; it now includes all the complexities of evolving life forms.

Participants in technoscience enter what the historian of science Peter L. Galison has called a "trading zone, an intermediate domain where procedures could be coordinated locally even where broader meanings clashed." In science, the fundamental unit of accomplishment remains the discovery; in engineering, the fundamental unit of accomplishment is problem solving. Yet in the trading zone of technoscience, engineers and scientists invent ways of communicating through instruments, habits, and words to coordinate a project even though they come from different professional cultures. The vitality of trading zones, technoscientific or otherwise, lies in breaking down boundaries, keeping things mixed up, developing a lot of interfaces, going with the flow.

The flow goes both ways. In the trading zone of biology and engineering, for example, biological research generates a constant stream of projects that engage engineers, especially mechanical and

chemical engineers. At the same time, biologists think more and more like engineers as they probe systems and mechanisms, worry about quality control, and construct large technical systems. The best of them often bring specialized technical knowledge to their biological research.

A major factor in the success of this trading zone -- and more generally a major factor in the rise of technoscientific mixes -- is the role of information technology in providing a common, readily transferable language. Most engineering departments are becoming, to a greater or lesser extent, departments of applied-information technology. In the form of a common digital language, technology dissolves the familiar boundaries of engineering. It also lifts engineering, once the most down-to-earth of professions, from its familiar ground of materiality, endowing it with a ghostly lightness of being.

Fewer faculty members in engineering actually make things or build things; more work with symbols and models. In a sense they are still working with machines, of course, but the meanings of both engineering and machinery are redefined when the machines process information rather than matter. To see the evidence one need only survey the internal redefinitions of MIT's engineering departments. Today many members of the civil engineering faculty design not structures but software systems to manage construction. Similarly, in mechanical engineering, many faculty members are using electronics and computers to assume functions previously performed by conventional mechanical systems.

One side of engineering diffuses into the microscopic world of biology, another into the ethereal realm of cyberspace. Engineers always thought of themselves as doers; now some are logicians, sitting in an office all day, writing. Engineering is no longer necessarily applied science. It has developed its own theoretical wing, with practitioners who never actually build things and whose research takes them well beyond the range of common-sense experience.

An equally strong and apparently contradictory trend in engineering is to move engineering education, and to some extent engineering research, back toward the realities of industrial practice. In mature areas of engineering, there is little fundamental science of interest left to explore. In civil engineering, materials like concrete and steel are still essential for construction, but they offer dwindling interest for research.

In this situation, academically based engineers have two choices. Either they can migrate toward areas where the science is more exciting, or they can put new emphasis on non-science-based facets of engineering: how things are designed, how they are manufactured, how organizations work, how innovation is brought to market -- all of which are often lumped together under the label "practice."

The back-to-practice movement could also be called a back-to-the-market movement, in the sense of renewed and direct attention to profitability. In the postwar period, governmental policies shielded huge sectors of engineering practice -- defense contracting, highway construction, communications -- from direct market pressures. Government patronage made academics less tightly linked to industrial concerns and perspectives. Beginning around 1990, government support for research in science and engineering, both in corporations and in universities, began to level off in most areas (biology being the big exception). Since then, university-based engineers have sought to revitalize their links with industry as sources of research support and as employers of their graduates.

Industrial support for engineering research has been strongly market oriented. As government support has flattened, industry has begun to take a more "value-received perspective" in regard to research investments: They have to be justified in terms of the bottom line, and the short-term bottom line at

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that. Some corporate labs have become mission oriented; some have disappeared. As investment in research has diminished or scattered, consulting has become less important as a bridge between universities and industries. Instead, businesses have found that they can get the benefit of good research ideas by investing in and eventually buying up small companies, which pay more attention to marketability, timeliness, and productivity than university labs. Universities with strong engineering departments, like MIT, have found themselves competing not only with other higher-education institutions but also with start-up companies -- a fair number of which are connected with universities through their founders.

There are two major ways that engineers define getting back to practice. One group of engineers looks to a renewed emphasis on design; the other group advocates a new emphasis on large technological systems. The interesting psychological and sociological differences between these two groups could be summarized as follows: The design advocates identify with entrepreneurs, the systems advocates with managers. Many design advocates, whatever their age, have a sort of Young Turk quality. They challenge what they see as the engineering-science establishment, asserting that they do real engineering by designing and building useful things that actually work. In contrast, advocates of the technological-systems approach tend to be experienced individuals accustomed to working outside their departments or even outside their school. (At MIT, they often collaborate with the Sloan School of Management.)

Both the design movement and the systems engineering movement seek to reclaim a distinctive identity for engineering: to proclaim that here is something engineers do that scientists and businessmen do not do. In the end, however, the reclamation efforts only underscore engineering's loss of identity. In both design and systems work, many people other than engineers are in on the act. In design today, engineering, programming, science, language, and art converge. In dealing with technological systems, it is even more obvious that engineers have to collaborate with political scientists, economists, lawyers, and managers, just for starters. In fact, the constant dilemma for engineers at MIT and other universities is whether to hire these collaborators as faculty members or to try to get other departments and schools to hire them.

The good news is that engineering education is becoming more and more socialized. The bad news is that this is happening almost entirely under the aegis of business. Whatever the official curricular requirements, many engineering students regard economics or management as a de facto requirement. Students are looking for an education that is socially aware in a very pragmatic sense. They are increasingly aware that they need to know how society works, which is not necessarily the same thing as an education that highlights social responsibilities.

As a result, engineering education today is, as we say in the humanities, contested terrain -- a site where different strategic goals collide. Most students want a socially aware (in the practical sense) and technically oriented education. Design advocates and systems advocates want to reorient engineering education away from engineering science, but no one wants to give up the strengths of an engineering-science education. Yet the boundaries between engineering and science keep getting fuzzier as the biological sciences challenge the whole idea of "fundamentals."

The result is a curricular logjam. Everyone concerned with engineering education yearns for dynamite, if only they could agree on where to set the charge. From the faculty's point of view, designing an engineering curriculum is one of the most difficult design problems in engineering today. One faculty member joked that he truly wondered if degree requirements at MIT were a computable function.

Faculty members may laugh, but it is the student who has to cope with the multiplicity of uncoordinated demands.

What engineers are being asked to learn keeps expanding along with the scope and complexity of the hybrid world. Engineering has evolved into an open-ended Profession of Everything in a world where technology shades into science, art, and management, with no strong institutions to define an overarching mission. All the forces that pull engineering in different directions -- toward science, toward the market, toward design, toward systems, toward socialization -- add logs to the curricular jam.

Inevitably the profession formerly known as engineering will multiply into a much wider variety of grades, types, and levels because engagement with technology has far outgrown any one occupation. The future of engineering lies in accepting rather than resisting this multiplicity.

In terms of education, that means that the trend toward cramming more and more into the engineering curriculum runs in exactly the wrong direction. Few students will want to commit themselves to an educational track that is nearly all-consuming. What we now call engineering education should be lowering the threshold for entry, mixing itself with the larger world rather than trying to keep expanding its own world. Students are trying to do this mixing on their own, but in too many cases they are trying to pour new educational wine into old institutional containers.

The most obsolete institutional container is that of the "engineering school." Its *raison d'être* is to educate students for engineering, defined as a distinctive profession with its own well-defined identity. As this professional identity dissipates in a process of expansive disintegration, engineering schools will have to evolve or else find another mission. The segregation of engineering education served its purpose in the 19th century, by allowing an alternative form of education to develop. Now this segregation defeats the purposes both of engineering education and of higher education, at once marginalizing engineering and depriving the rest of higher education of its benefits. MIT still takes pride in not being Harvard -- but students at the two institutions today are virtually indistinguishable in aptitudes (including verbal and math SAT scores), social background, interests, and ambitions. Harvard, along with a host of other colleges and universities, is vigorously building up its technically oriented education, for which there is huge student demand.

The convergence of technological and liberal-arts education is a deep, long-term, and irreversible trend. Students need to be prepared for life in a world where technological, scientific, humanistic, and social issues are all mixed together. Such mixing will not take place if students have to decide from the outset that they are attending an "engineering school" as opposed to a "nonengineering school." No matter how excellent the engineering school, and no matter how racially and ethnically diverse, if it attracts mainly faculty members and students who gravitate toward the technical problem-solving approach, then those students have an education that does not prepare them well for life experience. Students need to be educated in an environment where they get used to justifying and explaining their approach to solving problems and also to dealing with people who have other ways of defining and solving problems. Only a hybrid educational environment will prepare engineering students for handling technoscientific life in a hybrid world.

# **MONITORING THE STRUCTURAL CONDITION OF CABLES: EXPERIMENTAL METHODS**

by Patricio A. Laura

## **ABSTRACT**

Cables and ropes are among the earliest structural elements used by man in the history of technology. They play a fundamental role in many life-sustaining situations: suspended and cable-stayed bridges, salvage operations, mining engineering, aerial transways, elevators, etc. Other important applications are: towing, remote control, and for the supply of communication or other service links between two vehicles. This paper surveys the techniques which attempt to provide detailed knowledge of the alterations of the structural health of the cable which may be produced by breakage of individual wires, fatigue and/or corrosion.

**KEY WORDS.** Cables, ropes, bridges, salvage operations, mining engineering, aerial transways, elevators, remote control, towing, wires.

## **INTRODUCTION**

It has become of deep interest for civil engineers to perform non-destructive detection on possible damage in large-scale structures such as cable-suspended and cable stayed bridges, taut leg mooring systems, etc. [1-2].

Obviously, this is due to the fact that visual inspection is practically out of the question on one hand and on the other is not sufficiently reliable and accurate.

Significant effort is placed nowadays on system identification techniques and, certainly, the inherent structural dynamic properties are very important parameters to be used for monitoring structural alterations.

In the case of suspended and cable-stayed bridges one must distinguish between “global” structural properties and “localized” alterations. The breakage of individual wires in a cable will change the dynamic characteristics of the cable itself from a microdynamics viewpoint, but only the failure of a strand or strands will produce considerable changes in the static and dynamic response of the cable and of the global behavior of the bridge.

Certainly one possible way of detection of wire failure is by means of rather sophisticated technologies such as the electromagnetic (EM) method, acoustic emission, and fiber optics. But this is the case, in general, under controlled conditions.

When dealing with ocean engineering applications (towing operations, off - shore platforms, etc.) where mechanical cables are of fundamental importance, the previous considerations possess similar weight. In the case of a towed sonar the mechanical - electrical requirements are coupled during the towing operation.

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An idea of the universality of cables is given by the fact that they are used in the Hidro-Cushion Camel developed at Treasure Island Naval Station in San Francisco, California in 1967. The Hidro-Cushion Camel consists of eight four, three foot water filled cells, grouped into four clusters, sandwiched between two timber rubbing faces and held in place by cables [3]. The water filled cylinders maintain constant pressure during compression upon impacting forces by forcing water out through small orifices in the tops of the cylinders. High energy absorption results from the compression of the cylinders and the resulting fluid dynamics action, bending of the timber faces, and crushing of the timber elements. Synthetic (e.g. kevlar) cables may be used to advantage.

As pointed out by Costello [4] "... a list of the uses of wire rope is almost endless... possible use of wire strands as braces for teeth... wire rope is also being considered in super conductivity applications, etc."

### **ABOUT ROPES AND CABLES**

Rope, probably made of plaited thongs, is already represented in use in Elam (southwest Asia) in the 4<sup>th</sup> millenium B.C. Probably more modern is rope made of back fiber used in southeast Asia. On the other hand, cord has probably been used in the Upper Paleolithic period to attach tools to handles conforming knives, axes, etc. Late in the 2<sup>nd</sup> millennium B.C., cables of considerable diameter are reproduced in bronze as handles of vessels in China [5]. For example, a cable made of copper wires was found in the ruins of Ninive, near Babylon, which was probably manufactured about 700 BC [4].

The first wire rope, made of steel, was fabricated by tying together single strands of straight wire, then grouping and tying several of these units together to form a rope. The performance of this structural element was unsatisfactory [6]. A more successful approach was developed by A. Albert in 1834 and the rope was utilized in a German mine. R. S. Newall obtained a patent in England in 1840 for the first wire-ropemaking machine [6].

However suitable, steel produced in long lengths and with uniform mechanical and chemical properties required for rope wire was possible about 1880 due to the invention of the Bessemer and Siemens-Martin processes for steel-making. It may be useful to recall at this point that a wire rope possesses, in general, three components:

- a) wires that form the strand
- b) a core and
- c) multiwire strands that are helically wrapped around the core.

As stated by Costello [4]

"... the core may be either wire rope, natural fibers or polypropylene and its main purpose consists of providing adequate support for the strands under normal bending and loading conditions... On the other hand, the strands have a center wire around which the individual metallic wires are wrapped helically. Modern methods require that the strands be permanently shaped into the helical configuration they will assume in the rope. The main property of ropes, yarns, cords, cables and strands is their capability of resist large axial loads as compared with bending or torsional influences".

It is generally agreed that nearly all operating structures require some type of monitoring of their integrity and health conditions to extend their life span or to prevent catastrophic failure. In the case where mechanical cables are used, e.g. suspended or stayed bridges, towing systems, etc., no globally ideal solutions for monitoring their structural condition have been found as of this date in view of the complexity of the dynamic environment and the tremendous length of cables employed. A similar situation takes place in off-shore structures, such as in mining operations.

In view of the fact that the weight of long wire rope catenaries becomes an excessive factor in the design and performance of the system, one modern and optimized solution is to use taut leg mooring systems employing polyester fiber ropes which possess nearly neutral buoyancy and are resistant to corrosion [2]. This solution has been successfully implemented by PETROBRAS, S.A. (Brazil). An important question about this solution is the long-term integrity of these synthetic fiber cables [7]. Consequently, a fundamental problem regarding these fiber ropes is to determine the ways in which they degrade under operating conditions. An outstanding overall research program is already in progress at the University of Reading, U.K. [2]

A short survey of the experimental techniques, which have been developed for non-destructive testing of cables and/or monitoring their condition, is presented in this paper.

## **EXPERIMENTAL TECHNIQUES FOR NONDESTRUCTIVE TESTING AND STRUCTURAL CONDITION MONITORING OF MECHANICAL CABLES.**

The methodologies available are:

### **Visual Inspection and Measurement of the Cable Diameter**

This approach provides a rough but important answer to the problem. Considerable experience is required. Surface flaws can be detected. The methodology must be used in combination with other test procedures, for instance, in connection with the X-rays inspection method.

### **X - rays**

Once a damaged zone has been found, the X-rays approach will allow the determination of broken inner wires, degree of damage suffered by the core, etc.

### **Induced wave propagation**

This technique has been developed by Kwun and Burkhardt [8]. The method uses the propagation properties of a wave induced by applying a transverse impulsive force to a rope. The technique can detect localized flaws and also determine the load magnitude acting in the rope. The methodology allows for the inspection of a rope of several hundred feet in length, within several seconds and from a single location. It is applicable whether the rope material is metallic or non-metallic.

### **Magnetostrictive sensors**

Kwun and Teller [9] have shown that fractured wires in a steel wire cable can be detected using magnetostrictively transmitted and detected mechanical waves without direct physical contact to the cable. The authors report good inspection depth (more than 15 mm), long inspection range

(more than 100 m) and good detectability of small-size flaws (corresponding to approximately 2% of the total metallic cross-section of the cable). The sensors operated in a low 10 kHz frequency range.

### **Electromagnetic field (EM)**

This technique is not applicable in the case of synthetic materials.

One must distinguish two basic modes of deterioration of wire rope: 1) loss of metallic cross-sectional area (LMA) produced by external and internal abrasion, and 2) corrosion and localized faults (LF), such as broken wires, kinks, etc. The first practical LF instruments used D.C magnetization of the rope. They measure the magnetic flux leakage surrounding the rope, and magnetically saturate a section of the steel rope in the longitudinal direction by strong permanent or electric magnets. In the case of broken wires or core, corrosion, or abrasion, the magnetic flux is distorted and leaks from the rope. The LMA AC instruments are based on AC magnetization of the rope which serves as a ferrous core of a transformer. A variation of the cross sectional area of the rope modifies the impedance area of the rope and, in turn, this change is a measure of the modification of the cross sectional area.

Some European and Canadian equipment presently used are of the LF type, while the operational systems developed in the USA can simultaneously detect broken wires and evaluate the loss of metallic cross sectional area (LMA) [10].

In the case of mooring ropes used in offshore applications, a waterproof sensor has been developed by Bavins [11].

Based on similar physical principles, the Magnetic Perturbation Cable System (MPC) of Nondestructive Evaluation (NDE) has been developed, and attempts to provide assessment of the structural integrity of the main structural cables of long-span suspension bridges. Barton et al. [10] describe the development of a magnetic perturbation NDE system for inspecting and monitoring wire ropes used in suspension bridges. The method has been applied with a certain degree of success to small diameter cables.

### **Acoustic emission method**

If a crack propagates in a solid subjected to mechanical and/or thermal loading, the acoustic emission phenomenon takes place. A portion of the strain energy stored in the body is released and a compression wave propagates. In the case of a wire rope, the main sources of detectable acoustic emission include wire break, interwire fretting and corrosion. Emissions are also generated by the material used to terminate the rope in steel sockets. The displacements produced by the stress waves are detected by adequate instrumentation placed on the surface of the body under study and which convert mechanical into electrical signals. These signals are then amplified, conditioned, recorded, and located using difference in time of arrival techniques.

Apparently the first known study of acoustic emission phenomena in wire ropes was performed by Laura et al. [13] who used accelerometers clamped to 10 mm diameter rope to detect wire breaks at about 95% of the maximum load during rising load-tests to failure. The acoustic emission signals corresponding to wire breaks were 15 -20 dB above background noise.

Subsequent work was reported by Harris [14], Harris and Dunegan [15], Bamberger and Robert [16], Fritz [17], Matthews and Black [18], Matthews et al. [19], and Hanzawa et al. [20].

Extremely important research in the area was performed at University College, Cardiff by Casey and coworkers during the period 1980-1987. Based on the results obtained, elaborate instrumentation was developed by the research team to detect the failure of wires.

They reached to the following conclusions [21]:

- I. The most realistic application of acoustic-emission technology to wire-rope applications is in the detection and location of wire breaks.
- II. Successful detection and location of wire breaks is dependent upon rope construction, diameter, length and number of wire breaks.
- III. The occurrence of large numbers of wire breaks works against the technique. Although such large numbers of wire breaks are only likely to be generated in the laboratory during the fatigue testing of rope specimens.
- IV. Acoustic emission can be a useful laboratory tool, but application of the technique to ropes in service will probably be limited.
- V. Future work needs to concentrate on the rope constructions which are most commonly used in industry, and on developing wire-break signatures that could be designed into future equipment. This can be achieved through narrow-band filters, matching the resonant frequency of the transducers to the main frequency components of a wire break and pattern-recognition software.

Possible applications of the acoustic emission method would be monitoring the section of rope at the fairlead pulley of a floating production platform and detecting wire breaks at the termination of bridge hanger cables where corrosion fatigue could take place.[21] In the case of a towing system, a very successful program was run by Matthews and Black [18]. Vanderveldt and Tran [21] were the first researchers to apply the acoustic emission technique to the study of synthetic rope failure. They have shown that the approach possesses a good potential. Later, Williams and Lee [23] found that acoustic emission is generated in a random fashion throughout the testing sample for up to 60% - 70 % of the ultimate load. After this load level a majority of the acoustic emission signals are generated in a more concentrated subdomain where the failure location may be probably located.

## **RECENTLY SUGGESTED TECHNIQUES**

### **Fiber-Optics and Condition of Cables.**

Ludden et al. [24] and Robertson and Ludden [25] tackled the problem of monitoring Kevlar Parafil fiber mooring ropes in service taking into account the following considerations [2]:

- monitoring yarn breakage by detection of acoustic emissions
- strain measurements along the rope length
- access limited to one end of the rope for interrogation purposes
- opto - electronics of relatively simple and robust nature
- rope temperature measurement and compensation in the range 0<sup>0</sup>-50<sup>0</sup>C
- strain: 0-2.5% range. As pointed out by Rebel et al. [2] this range is not adequate for polyester ropes
- total maximum operational length: 5 Km

An array of fiber Bragg grating pairs along the optical fiber was used to measure changes in reflection wavelength in order to determine strain and temperature. The principles of the monitoring system were shown to be effective by Robertson and Ludden [25]. Arrays of distributed fiber optic sensors have been used for monitoring the state of health of two Carbon Fiber Reinforced Polymer strands of a cable stayed bridge in Switzerland [26].

As reported by Rebel et al. [2], the European community is presently sponsoring Research and Development Projects on the subject matter (development of an optical scanning apparatus for ropes, OSCAR). Two projects have been finished already. It is estimated that the total installed cost of the OSCAR system will be much less than 10% of the cost of the mooring system. An attempt to detect the breakage of individual wires in a rope has also been proposed and successful tests have been run in air and in water [27, 28].

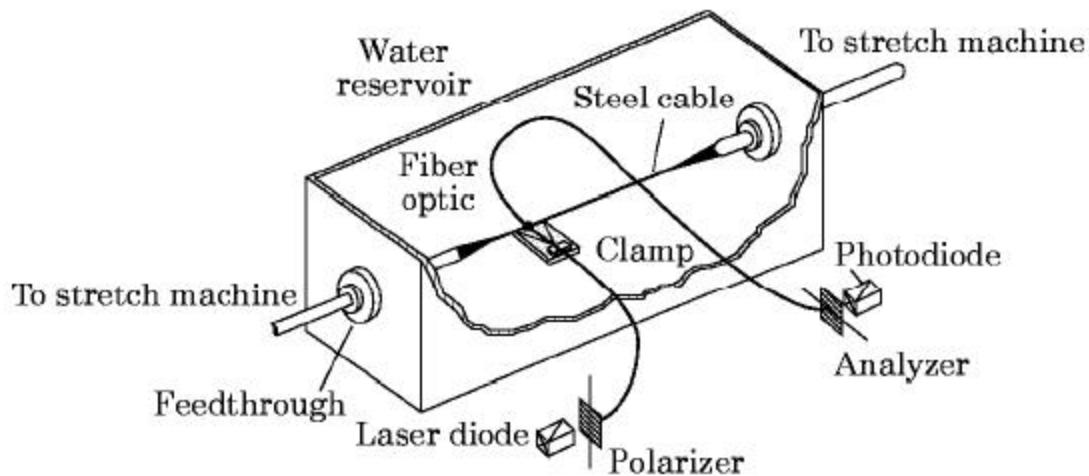


Figure 1. Experimental set-up developed for tests performed in water medium. [28]

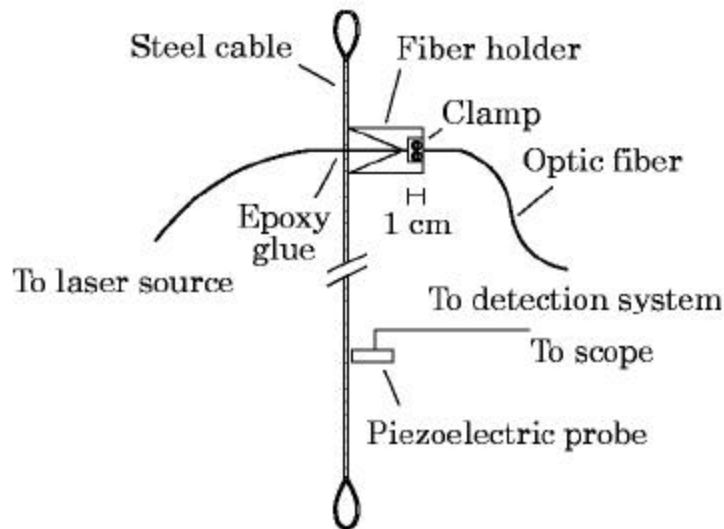


Figure 2. Details of the optic fiber-mechanical cable attachment. [28]

Experiments have also been performed in the case of kevlar cables [29]. The approach is based on the photoelastic property of the glass fiber. Figure 1 depicts the experimental arrangement

used to obtain data about individual wires breaking on a cable submerged in water. A 40 cm long, 1.36 mm diameter steel cable composed of seven wires, 0.45 mm. diameter each, is stretched by means of a hydraulic system. An acrylic box with a couple of feedthroughs placed at opposite faces of a container was designed and built for keeping the cable and fiber sensor under water. The lightsource utilized in this test was a 5 m W GaAs diode laser and the photodetector at the end of the fiber consists of a photodiode: see Figure 2. A couple of polaroid sheets were used as polarizer and analyzer in order to detect variations of the light intensity due to the stress applied on the optic fiber as individual wires break. A monomode fiber 125  $\mu\text{m}$  in diameter (jacket included) was attached to the steel multiwire cable using a holder designed to detect the transverse perturbation generated when individual wires break during the stretching procedure.

Typical results obtained are those shown in Figure 3, where successive breakage of four wires is observed. It is concluded that the methodology allows for the detection of breaking of wires with very clear signals, at least when performed under controlled laboratory conditions. Undoubtedly, serious practical difficulties must be overcome before the implementation in a real engineering system.

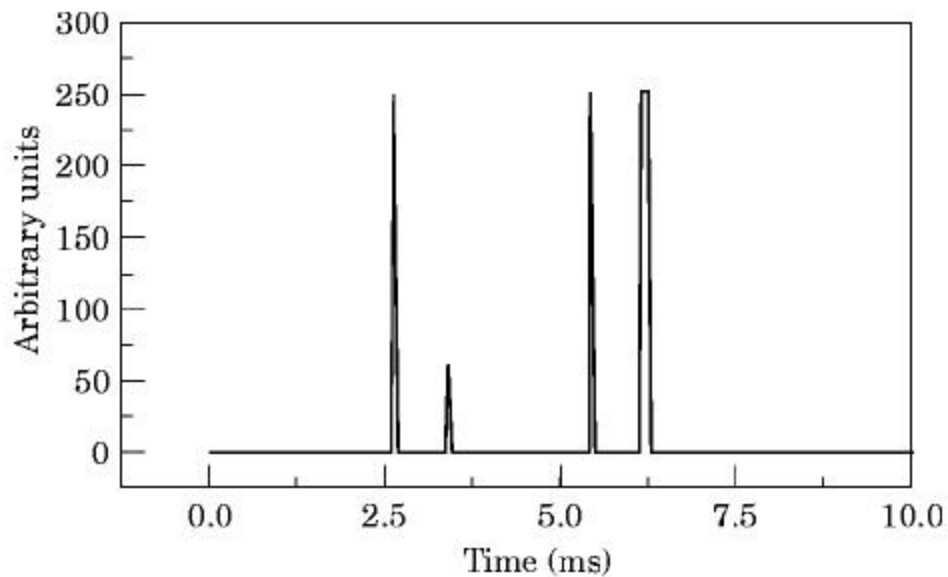


Figure 3. Signals corresponding to consecutive fracture of four wires (cable immersed in water). [28]

Optical fiber sensors for the distributed sensing of strain in cable systems have also been proposed by Uttamchandani et al. [30]. Fiber grating sensors have been used to detect the breakage of single wires in steel ropes [31]. Fiber optic Bragg gratings are also used in [32] to study the vibrational behavior of a cracked cantilever beam as the epoxy resin used to repair it is in the curing process. The authors indicate that the basic procedure may be of use in the case of a fractured healing bone.

### Use of an Infrared Detector.

The basic system is made of:

- an infrared emitter diode
- a receiver diode.

The basic operation is the following: the infrared incident ray is reflected by the vibrating element according to its relative motion with respect to the transducer. The intensity of the reflected ray is modified as a function of the displacement of the vibrating object. This in turn allows for the determination of the frequency of the vibrating object from extremely low frequencies of excitation (approaching the static case) to any frequency value [33]. In the case of a mechanical cable the transducer senses the vibratory phenomenon generated by breakage of wires [34].

The thorough survey published by Rebel et al. [2] analyzes briefly other methodologies, which have also been proposed for the condition monitoring of cables:

### **Magnetic Resonance.**

The study of damage in nylon ropes has been carried out by Bryden and Poehler [35-36]. They investigated the magnetic properties of unstressed and stressed nylon rope fibers and analyzed broken bonds in the polymer chain as the polymer is subjected to ultraviolet and X rays and mechanical fracture by different modes (stressing to failure, cutting and machining).

### **Conductive Internal Elements.**

Javidinejad and Joshi [37] have investigated the insertion of conductive elements, e.g. copper wires or conductive thermoplastics, in a rope which fails when the individual strain limits are reached. Time domain reflectometry methods, applied from both ends of the cable, may be utilized to determine the location of failure. References [38] and [39] considered the use of monitoring fatigue damage in carbon fibre composites by determining electrical resistance variations. Rebel et al. [2] discuss some of the problems which arise when the cable system operates in salt water.

## **CONCLUSION**

The depth and thoroughness of Reference [2] makes it an extremely valuable contribution. Fiber optic strain sensors are discussed in detail as well as the problem of adequate strain ratio and monitoring fiber length. The authors discuss technological procedures for rope manufacturing in order to avoid damage to sensor arrays, the mechanical coupling between the monitoring system and the cable configuration, to fiber mooring ropes, as the title indicates. In view of the universality of the use of mechanical cables in a quasi-infinite number of applications, such as suspension and stayed-bridges, elevators, mine-hoists, aerial transways, ski chair lifts, and gondolas, as well as an almost endless list of ocean engineering applications (including the recovery of the H-bomb lost off Palomares, Spain), reliable monitoring systems are needed. Like many real life situations there is not a unique solution. Many of the existing proposed solutions will continue to possess validity depending upon the circumstances and researchers must be encouraged to improve them and to look for new ones which serve better to new, future requirements [40-41].

## **ACKNOWLEDGMENT**

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**POSITION OPENINGS****Faculty Position*****The John and Bea Slattery Chair in Aerospace Engineering*****Department of Aerospace Engineering  
Texas A&M University**

The Department of Aerospace Engineering at Texas A&M University invites nominations and applications for the John and Bea Slattery Chair in Aerospace Engineering.

To fill this prestigious position we are seeking candidates who have made outstanding contributions to one or more areas of research in aerospace engineering and have gained international recognition. We expect the selected candidate to actively participate in our undergraduate and graduate programs of education, conduct interdisciplinary and multi-disciplinary research within the Department, across the University and beyond, and provide academic leadership.

The Department of Aerospace Engineering has an undergraduate enrollment of over 500 and the current graduate enrollment exceeds 90. Affiliated with the department are the Aerospace Vehicle Systems Institute (AVSI) and the Commercial Space Center for Engineering (CSCE). The department is the leading participant in the newly established NASA URETI for Intelligent Bio-Nano Materials and Structures for Aerospace Vehicles. The research funding in aerospace engineering at Texas A&M University stands at more than \$4 million in the year 2002. Please visit <http://aeromaster.tamu.edu> for further details on the department's activities.

Please send nominations or applications to:

Dr. Ramesh Talreja  
Tenneco Professor and Head  
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## ***Faculty Position***

### **Department of Aerospace Engineering Texas A&M University**

The Department of Aerospace Engineering at Texas A&M University invites applications for a faculty position in aerospace engineering. The appointment will be at a rank commensurate with the applicant's qualifications. An endowed position is also possible.

The position is related to activities within the scope of a newly established NASA URETI for Intelligent Bio-Nano Materials and Structures for Aerospace Vehicles. Particular areas of interest are nanomaterials, biomaterials, multifunctional material systems, active materials and smart structures, molecular simulation, multi-scale material modeling, and composites. The selected candidate will be expected to teach courses in one or more of the aerospace engineering disciplines such as mechanics and materials, and to conduct multidisciplinary research.

The Department has active research programs in solid mechanics and structures, aerodynamics and fluids, and dynamics and control, and is engaged in collaborative multidisciplinary research across campus and with other universities. Available within the Department and elsewhere on campus are research centers, laboratories and facilities such as Center for Mechanics of Composites, Center for Mechanics and Control, Materials Testing Laboratory, Intelligent Systems Laboratory, Polymer Technology Center, Center for Integrated Microchemical Systems, Laboratory for Molecular Simulations and Microscopy & Imaging Center.

Applicants should send a curriculum vita, a brief statement of their interests that includes their vision for research and teaching, and five references to

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# Stanford University

## Department of Mechanical Engineering

### Faculty Position

The Department of Mechanical Engineering at Stanford University invites applicants for a tenure-track faculty position at the junior level (Assistant or untenured Associate Professor) in the broadly defined area of mechanics. We are searching for an energetic and visionary individual in any area of mechanics, but we are especially interested in the following: multiscale modeling and simulation with application to materials, devices or biological systems; nano- and micro-scale mechanics; computational and solid mechanics.

Applicants must hold a doctorate in an appropriate field and must have demonstrated an ability to carry out outstanding research and have a strong record of, or promise for, exceptional teaching. Appointment will be at a rank commensurate with the applicant's experience.

Applicants should send a curriculum vita, a brief statement of their interests that includes their vision for their research area and teaching, copies of one or two publications, and complete contact information for at least five references, to the following address:

Professor Peter M. Pinsky  
Department of Mechanical Engineering  
275 Durand Building-496 Lomita Mall  
Stanford University  
Stanford, CA 94305-4040

Applications are requested by November 30, 2002, but will continue to be accepted until the position is filled. Stanford University is an equal opportunity employer and welcomes nominations of women and minority group members and applications from them.

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The Department of Aerospace Engineering and Mechanics at the University of Minnesota anticipates filling a faculty position in the area of solid mechanics. The position is at the rank of assistant professor; exceptionally qualified candidates may be considered for appointment at the rank of associate professor without tenure.

We are searching for candidates whose research program will set promising new directions in solid mechanics. We are especially interested in candidates who use computational or experimental tools to bring fundamental atomic scale information to the study of the mechanical behavior of materials or structures. Candidates from any branch of mechanical science and engineering are encouraged to apply, as are candidates from physics, materials science, applied mathematics, biophysics, electrical engineering or solid state chemistry. The successful candidate must also be able to develop and teach undergraduate and graduate courses in aerospace engineering and mechanics.

Current research activities in the department include the study of active materials (such as shape memory and magnetostrictive materials), phase transformations, continuum mechanics, fracture mechanics and biomechanics.

Applicants must have earned a doctorate in a related field by the date of appointment; experience beyond the doctorate degree is desirable. The successful candidate will be expected to develop an independent, externally funded research program, and to participate in all aspects of the department's mission. Strong written and verbal communication skills are required.

It is anticipated that the appointment will begin fall, 2003.

Applicants should send a letter of application, detailed resume, and the names and addresses of three references to:

**Solids Search Committee (IT1017)**  
**Department of Aerospace Engineering and Mechanics**  
**University of Minnesota**  
**107 Akerman Hall**  
**110 Union Street S. E.**  
**Minneapolis, MN 55455**

**Application Deadline:** The initial screening of applications will begin on January 1, 2003; applications will be accepted until the position is filled.

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### First Announcement and Call For Papers

**<http://ictam04.ippt.gov.pl>**

#### SCIENTIFIC PROGRAM

Congress participants are encouraged to submit a paper. Papers are sought for all topics corresponding to Pre-Nominated Session or Mini-Symposium subject matters. The paper must be in English and should present material that is novel and preferably unpublished at the time of the Congress. All papers presented at the Congress are by invitation based on the recommendation of the International Papers Committee. No author will be invited to present more than one paper. Prospective authors are asked to submit only one paper for consideration.

#### MINI-SYMPOSIA

Smart materials and structures ? Tissue, cellular and molecular biomechanics ? Mechanics of thin films and nanostructures ? Microfluidics ? Microgravity flow phenomena ? Atmosphere and ocean dynamics

#### Pre-Nominated Sessions:

##### IN FLUID MECHANICS

Biological fluid dynamics ? Boundary layers ? Combustion and flames ? Complex and smart fluids ? Compressible flow ? Computational fluid dynamics (jointly with IACM) ? Convective phenomena ? Drops and bubbles ? Environmental fluid mechanics ? Experimental methods in fluid mechanics ? Flow control ? Flow in porous media ? Flow instability and transition ? Flow in thin films ? Fluid mechanics of materials processing ? Granular flows ? Low-Reynolds-number flow ? Magnetohydrodynamics ? Multiphase flows ? Solidification and crystal growth ? Stirring and mixing ? Fluid mechanics of suspensions ? Topological fluid mechanics ? Turbulence ? Vortex dynamics ? Waves

##### IN SOLID MECHANICS

Computational solid mechanics (jointly with IACM) ? Contact and friction problems (jointly with IAVSD) ? Control of multibody systems ? Control of structures ? Damage mechanics ? Dynamic plasticity of structures ? Elasticity ? Experimental methods in solid mechanics ? Fatigue ? Fracture and crack mechanics (jointly with ICF) ? Functionally graded materials ? Impact and wave propagation ? Material instabilities ? Mechanics of composites ? Mechanics of phase transformations (jointly with IACM) ? Mechanics of porous materials ? Multibody dynamics ? Plasticity and viscoplasticity ? Plates and shells (jointly with IACM) ? Rock mechanics and geomechanics ? Solid mechanics in manufacturing ? Stability of structures ? Stochastic micromechanics ? Structural optimization (jointly with ISSMO) ? Structural vibrations ? Viscoelasticity and creep

##### TOPICS INVOLVING BOTH FLUID MECHANICS AND SOLID MECHANICS

Acoustics ? Chaos in fluid and solid mechanics ? Continuum mechanics ? Fluid-structure interaction ? Mechanics of foams and cellular materials ? Multiscale phenomena in mechanics

Correspondence related to the Congress should be sent to:

Prof. Tomasz Kowalewski, ICTAM04 Secretary-General  
Institute of Fundamental Technological Research  
Świętokrzyska 21, 00-049 Warszawa, Poland  
e-mail: ictam04@ippt.gov.pl

## **Nonlinear Dynamics, Chaos, Control and Their Applications to Engineering Sciences**

*Editors:* José M. Balthazar, Paulo B. Gonçalves, Reyolando M. F. L. R. F. Brasil,  
Ibere L. Caldas, and Felipe B. Rizzato

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Brazilian Society of Applied and Computational Mathematics (SBMAC) and Società Italiana di Matematica  
Applicata e Industriale (SIMAI). Printed in Brazil.*

- Vol. 3: New Trends in Dynamics and Control (ISBN: 85-900351-3-1), 15 Chapters, 204 pages, 2002
- Vol. 4: Recent Developments in Nonlinear Dynamics (ISBN: 85- 900351-4-X), 11 Chapters, 401 pages, 2002
- Vol. 5: Chaos, Control and Time Series (ISBN: 85- 900351-5-3), 5 Chapters, 447 pages, 2002
- Vol. 6: Applications of Nonlinear Phenomena (ISBN: 85- 900351-6-6), 5 Chapters, 427 pages, 2002

These volumes contain the papers presented in the scientific event: I, II and III; Conference In Nonlinear Dynamics, Chaos, Control and Their Applications to Engineering Sciences held in Campos do Jordão, São Paulo, Brazil, July 31 - August 4, 2000 (ICONNE 2000).

Other volumes of the series are also available :

- Vol. 1: (ISBN: 85-900351-1-5), 3 Chapters, 377 pages. J M Balthazar, D T Mook, J M Rosário (Editors). *Copyright© 1997 Brazilian Society of Mechanical Sciences (ABCM), American Academy of Mechanics (AAM)*
- Vol. 2: Vibrations with Measurements and Control (ISBN: 85- 900351-2-3), 15 Chapter, 250 pages. J M Balthazar *Copyright©1999 Brazilian Society of Applied and Computational Mathematics (SBMAC), Brazilian Society of Mechanical Sciences (ABCM), Society for Industrial and Applied Mathematics(SIAJM)*

These volumes are also available in the Portuguese language:

- Applications on Dynamics and Control (ISBN: 85-85769-09-2), 501 pages, 16 Chapters, 2001. *Copyright© 2001 Brazilian Society of Applied and Computational Mathematics (SBMAC), Brazilian Society of Mechanical Sciences (ABCM).*
- Proceedings of The First Brazilian School on Dynamics and Control (ISBN: 85-85769-08-4), 233 pages, 2001. *Copyright© 2001 Brazilian Society of Applied and Computational Mathematics (SBMAC), Brazilian Society of Mechanical Sciences (ABCM).*
- Proceedings of The Second Brazilian School on Dynamics and Control (ISBN: 85-6883-05-0), CD-ROM, 2002. *Copyright© 2001 Brazilian Society of Applied and Computational Mathematics (SBMAC), Brazilian Society of Mechanical Sciences (ABCM).*

For further information, please contact:

Prof. Dr. J M Balthazar, *Editor-in-Chief*  
State University of São Paulo at Rio Claro  
São Paulo, PO Box 178, 13500-230 Rio Claro, SP, Brazil  
E-mail: jmbaltha@rc.unesp.br

**CALL FOR PROPOSALS TO HOST AN  
IUTAM SYMPOSIUM  
or  
INSTRUCTIONAL SUMMER SCHOOL  
IN 2006 OR 2007**

The United States National Committee on Theoretical and Applied Mechanics (USNC/TAM) seeks proposals from U. S. authors and institutions to host IUTAM Symposia or Instructional Summer Schools in 2006 or 2007. Information for US proposers can be found on the USNC/TAM website at: <http://www7.nationalacademies.org/usnctam>. IUTAM provides a small amount of financial support for symposia and summer schools. US organizers are strongly encouraged to seek additional financial support from other sources. The primary use of financial support is to help with travel expenses for younger scientists and for scientists from developing countries.

**IUTAM Symposia**

The goal of an IUTAM Symposium is to assemble a group of active scientists, within a well-defined field, for the development of science in that field. Participation is by invitation only. In order to achieve effective communication within the group it should, typically, be limited to 60-80 scientists with expertise in the subject area of the symposium. Symposia typically consist of a few invited lectures, and a larger number of contributed papers, presented as lectures and/or posters, all pre-screened by the Symposium Scientific Committee.

**IUTAM Instructional Summer Schools**

The purpose of an IUTAM Instructional Summer School is to provide lectures by leading experts in a new or emerging field of science and engineering in order to foster developments in that field. Schools are typically 3-5 days in length and intended primarily for younger scientists and those with only limited knowledge in the specific field of the school. Participation of is by invitation only.

**Proposal Submission**

Proposals from the United States to host a symposium or summer school should be submitted on the appropriate two-page Proposal Submission Form available on the USNC/TAM website. The completed proposal should be sent electronically to the USNC/TAM Secretary ([herak@virginia.edu](mailto:herak@virginia.edu)) no later than January 15, 2004. Proposers may submit their proposals directly to IUTAM. However, experience has shown that proposals benefit from the feedback provided by USNC/TAM, and that the recommendation of USNC/TAM when the proposal is finally submitted to IUTAM carries considerable weight.

**Final Approvals**

Proposals will be assessed by the USNC/TAM and then forwarded to IUTAM where they are reviewed by IUTAM panels. The IUTAM General Assembly will vote on the panel recommendations in August 2004 at the International Congress on Theoretical and Applied Mechanics in Warsaw, Poland (<http://ictam04.ippt.gov.pl/>).

**FIRST CALL FOR PAPERS:  
2003 MECHANICS AND MATERIALS CONFERENCE**

[www.eas.asu.edu/~cpd/conference.html](http://www.eas.asu.edu/~cpd/conference.html)

The **2003 Mechanics and Materials Conference**, also known as the Summer meeting of the Applied Mechanics and Materials Division of the ASME, will take place in Scottsdale, Arizona from June 17 to 20th, 2003. The venue is the renown Camelback Inn Resort. Abstracts are now being sought for the many sessions and special symposia being organized and covering most areas of mechanics and materials. The conference web site [www.eas.asu.edu/~cpd/conference.html](http://www.eas.asu.edu/~cpd/conference.html) provides all information currently available and will be periodically updated.

For additional information or questions, please send an email to: [mechmat2003@asu.edu](mailto:mechmat2003@asu.edu)

Submission of abstracts should be accomplished before **February 15<sup>th</sup>** and preferably by uploading to the web site. Note that the abstracts of the papers to be presented at the conference will be collected in a book distributed to all attendees.

We look forward to seeing you in Scottsdale!

Prof. Dusan Krajcinovic and Marc Mignolet  
*Conference Co-Chairs*

**MINI-SYMPOSIUM: TRIBUTE TO KIRK C. VALANIS  
Call for Abstracts**

Sixteenth ASCE Engineering Mechanics Conference (EM2003)  
University of Washington, Seattle, Washington, July 16-18, 2003

As a tribute to Dr. Kirk Valanis' visionary and lasting contributions in mechanics a Mini-Symposium comprising of three sessions will be held at the 16th ASCE Engineering Mechanics Conference. The Symposium will provide a forum for discussion of new as well as non-traditional developments in solid mechanics, specifically in the areas of fundamental constitutive theory, thermodynamics of materials and its applications to constitutive theory, plasticity theories - including finite strain theories - and plasticity models, internal variable theory, nano and micromechanics, material science and engineering.

The Mini-Symposium is organized by: Vassilis Panoskaltzis (Case Western Reserve University), Stein Sture (University of Colorado, Boulder), George Z. Voyiadjis (Louisiana State University), and Victor Kaliakin (University of Delaware)

One-page abstract submission deadline: **January 15, 2003**

Submit via e-mail to: Prof. V. Panoskaltzis ([vpp@nestor.eciv.cwru.edu](mailto:vpp@nestor.eciv.cwru.edu)) or to Prof. S. Sture ([sture@grieg.colorado.edu](mailto:sture@grieg.colorado.edu))

Paper submission deadline: **April 15, 2003**

Early registration (EM2003) deadline: **June 16, 2003**

EM2003 Conference: **July 16-18, 2003**

## **7th Meeting on Current Ideas in Mechanics and Related Fields** **CIMRF-2003**

**The 7th Meeting on Current Ideas in Mechanics and Related Fields (CIMRF-2003)** will take place at Portland State University in Portland, Oregon, August 18-21, 2003. Like previous CIMRF meetings, this symposium will be concerned with broadly understood applications of mathematics and mathematical techniques to mechanics. However, the leading theme of this conference will be the mathematical methods (geometric, group theoretical, variational, PDEs) in mechanics of materials with special emphasis on representation and understanding the role of inhomogeneities, phase transitions, their creation and evolution.

Plenary lectures will be given by Richard James (University of Minnesota), David Owen (Carnegie-Mellon), and Gareth Parry (University of Nottingham).

### **Call For Papers**

These participants who would like to speak at the meeting are requested to send a one-page abstract (in TeX/LaTeX, both the source file and the dvi file) by e-mail to Serge Preston at [serge@math.pdx.edu](mailto:serge@math.pdx.edu), with a copy to Marek Elzanowski at [marek@math.pdx.edu](mailto:marek@math.pdx.edu), no later than **June 30, 2003**. Abstract macro will be available on the conference website at <http://www.math.pdx.edu/~marek/cimrf/2003/cimrf2003.html>

### **Registration**

Those interested in attending this meeting, are kindly requested to submit as soon as possible a *pre-registration form*, which can be found at <http://www.math.pdx.edu/~marek/cimrf/2003/cimrf2003.html>

### **Conference Fees**

The Conference fee for CIMRF-2003 is \$240.00, if paid by money order sent directly to the organizers, and \$260.00, if paid by wire transfer. The conference fee includes the welcome reception planned for the evening of August 17th, coffee breaks, conference banquet on Wednesday, August 20th, and the book of abstracts.

Prospective participants are requested to send, preferably before **May 30, 2003**, an international money order, payable to CIMRF2003, to Marek Elzanowski, Department of Mathematics and Statistics, Portland State University, P.O.Box 751, Portland, Oregon 97207, U.S.A. The conference fee (\$260.00) can also be paid directly to CIMRF2003 at US Bank, routing number: 123000220, account number: 153691205261.

### **Housing and Travel Information**

Information about local hotels, travel directions, weather, local attractions etc., can be found on the conference website at <http://www.math.pdx.edu/~marek/cimrf/2003/cimrf2003.html>

Marek Elzanowski (Portland, [marek@math.pdx.edu](mailto:marek@math.pdx.edu))

Marcelo Epstein (Calgary, [epstein@enme.ucalgary.ca](mailto:epstein@enme.ucalgary.ca))

Serge Preston (Portland, [serge@math.pdx.edu](mailto:serge@math.pdx.edu))

# ***PACAM VIII***

**Eighth Pan American Congress of Applied Mechanics  
January 5-9, 2004  
Havana, Cuba**

<http://www.pacam8.mcgill.ca/>

The Eighth Pan American Congress of Applied Mechanics (PACAM VIII), jointly sponsored by the University of Havana, the Institute of Cybernetics, Mathematics, and Physics of Cuba, and the American Academy of Mechanics, will be held January 5-9, 2004 at the Convention Center, Havana, Cuba. The Honorary Chairman of the Organizing Committee is Prof. Alina Ruiz Jhones of the University of Havana. The Co-Chairmen are Prof. Martin Ostoja-Starzewski of McGill University and Prof. Reinaldo Rodríguez-Ramos of the University of Havana. The Chairman of the Editorial Committee is Prof. Julián Bravo-Castillero of the University of Havana, and the Chairman of the Local Arrangements Committee is Prof. Raúl Guinovart-Díaz of the University of Havana, Cuba.

The aim of sponsors is to promote progress in the broad field of mechanics by (1) exposing engineers and scientists, including graduate students, to new research findings, techniques, and problems, and (2) providing opportunities for personal interactions between mechanics of North and South America, as well as other continents. It is the only conference sponsored by the American Academy of Mechanics (AAM).

The Pan American Congresses of Applied Mechanics are held every two years early in January, always in a Latin American venue, at a time when few other conferences are scheduled. The previous Congresses were held in Rio de Janeiro, Brazil in 1989; Valparaiso, Chile in 1991; São Paulo, Brazil in 1993; Buenos Aires, Argentina in 1995; San Juan, Puerto Rico in 1997, Rio de Janeiro, Brazil in 1999 and Temuco, Chile in 2002. Participants come from the Americas as well as Africa, Asia, Australia, and Europe.

Persons willing to organize special sessions in any area of mechanics are welcome to contact the organizers listed below. All the future announcements will be made at the website listed above, and through the AAM (<http://www.AAMech.org/>). Four-page papers for the conference proceedings will be due June 30, 2003, at either address:

**Latin American Co-Chairman**

Professor Reinaldo Rodríguez-Ramos  
Facultad de Matematica y Computacion  
Universidad de la Habana  
San Lazaro y L, Vedado, CP 10400  
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Department of Mechanical Engineering  
McGill University  
817 Sherbrooke Street West  
Montreal, PQ, Canada H3A 2K6  
martin.ostoja@mcgill.ca  
<http://www.mcgill.ca>

*Note on travel to Cuba from the United States*-a link has been provided on the PACAM website that shows travel is possible to Cuba from the United States.

## **FOURTH INTERNATIONAL SYMPOSIUM ON VIBRATIONS OF CONTINUOUS SYSTEMS**

The Fourth International Symposium on Vibrations of Continuous Systems will take place in Keswick, England, July 7-11, 2003. The primary goal of this Symposium is to bring together outstanding experts in the field of vibrations of continuous systems from all over the world, to discuss technical topics in a very informal atmosphere. As before, participation will be by invitation only, and will be limited to maximum numbers of 50 participants and 40 presentations.

The Symposium is devoted to the vibrations of continuous systems (e.g. strings, rods, straight and curved beams, membranes, plates, shells, and three-dimensional bodies). Examples of topics to be considered include: free and forced vibration, linear and nonlinear vibration, undamped and damped vibration, fluid-structure interaction, and structural elements of composite material.

The Symposium location, Keswick, is in the heart of the Lake District of northwestern England, famous for its beautiful lakes and hills. Typical days at the Symposium will consist of morning hikes or bus excursions, presentation sessions in the afternoons, and social gathering times in the evenings. The outings and social gatherings have proved to be excellent ways of generating relaxed and informal technical discussions and friendships which have been of great value to ongoing research.

Individuals who are interested in taking part in this Symposium should write to:

Professor Arthur W. Leissa  
General Chairman, ISVCS IV  
Dept. of Mechanical Engineering  
206 West 18<sup>th</sup> Ave.  
Ohio State University  
Columbus, Ohio 43210  
USA

Letters should be accompanied by a one-page summary of the writer's research accomplishments (include a list of published books, papers, reports, etc.) in the theme of this Symposium.

**ADVERTISEMENT POLICY**

Upon the decision of the Board of Directors, an advertisement for a position opening is charged a flat rate of \$200. Payment must be done only by check and sent to:

**American Academy of Mechanics****Horacio D. Espinosa, Editor**

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2145 Sheridan Road

Evanston, IL 60208

e-mail: [mech1@clifton.mech.northwestern.edu](mailto:mech1@clifton.mech.northwestern.edu)

The FID number for AAM is 23-7045163. Make check payable to American Academy of Mechanics. Announcements for forthcoming events, conferences, and workshops are free of charge. Advertisements may be sent by FAX or e-mail (LaTeX, MSWord, PDF or plain text). Logo of the institution may be included if the postscript (graphic file) is provided.

Mechanics is a bi-monthly magazine. To be considered for publication in forthcoming issues, an advertisement must be received one month in advance of the publication date. For example, an advertisement must be received before the end of November to appear in the January-February issue. Please note that the magazine is distributed at the beginning of the two-month period. The advertisement will continue to appear in future issues until the deadline of the position opening.

Visit the AAM website to read recent advertisements of position openings and past issues of Mechanics at <http://www.AAMech.org>.

***MECHANICS* On-line**

To access *Mechanics* on-line, please visit

[www.AAMech.org](http://www.AAMech.org)

Access to the on-line issues is restricted to AAM members. A username and password is required to access the on-line issues. This information was sent by e-mail to all AAM members. If you did not receive the username and password information by e-mail, please contact the Editor's Assistant, Thomas Milic, at the following e-mail address:

[mech1@clifton.mech.northwestern.edu](mailto:mech1@clifton.mech.northwestern.edu)

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- 4925 Fabrication of cu-induced networks of linear nanostructures on different length scales Adelung R. Hartung W. Ernst F.

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| 1113 | Dynamic modelling of flexible robotic mechanisms and adaptive robust control of trajectory computer simulation - part i | Knani J.                      |
| 1125 | Thermoelasticity without energy dissipation of materials with microstructure  | Quintanilla R.                |
| 1139 | A sigma coordinate 3d kappa-epsilon model for turbulent free surface flow over a submerged structure                    | Li CW. Zhu B.                 |
| 1151 | Maximum entropy analysis to the n policy m/g/1 queueing system with a removable server                                  | Wang KH. Chuang SL. Pearn WL. |

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| 867 | Restudy of theories for elastic solids with microstructure   | Dai TM.   |
| 875 | The transient elliptic flow of power-law fluid in fractal porous media   | Song FQ. Liu CQ.                                |
| 881 | Cavitated bifurcation for incompressible hyperelastic material   | Ren JS. Cheng CJ.                               |
| 889 | General solution of the overall bending of flexible circular ring shells with moderately slender ratio and applications to the bellows (i) - governing equation and general solution | Zhu WP. Huang Q.                                |
| 898 | General solution of the overall bending of flexible circular ring shells with moderately slender ratio and applications to the bellows (ii) - calculation for omega-shaped bellows   | Zhu WP. Huang Q.                                |
| 906 | Numerical simulation of orientation distribution function of cylindrical particle suspensions  | Lin JZ. Zhang LX.                               |
| 913 | Unilateral contact problems using quasi-active set strategy  | Xuan ZC. Li XS.                                 |
| 922 | On influence of kinematics to equivalent linear damping of helicopter blade hydraulic damper   | Hu GC. Xiang JW. Zhang XG.                      |
| 931 | Numerical simulation of oil migration-accumulation of multilayer and its application   | Yuan YR. Zhao WD. Cheng AJ. Wang WQ.<br>Han YJ. |
| 942 | Some problems in the z-c-x space   | Zhu CX.   |
| 948 | Topology and vortex structures of a curving turbine cascade with tip clearance (i) - experimental model and topological flow patterns on both endwalls and blade surfaces            | Yang QH. Huang HY. Han WJ.                      |
| 958 | Topology and vortex structures of a curving turbine cascade with tip clearance (ii) - topological flow pattern and vortex structure in the transverse section of a blade cascade     | Yang QH. Huang HY. Han WJ.                      |
| 963 | Series perturbations approximate solutions to n-s equations and modification to asymptotic expansion matched method  | Li DM. Zhang HP. Gao YX.                        |
| 973 | Chaos-regularization hybrid algorithm for nonlinear two-dimensional inverse heat conduction problem  | Wang DG. Liu YX. Li SJ.                         |
| 981 | Bifurcations of subharmonic solutions in periodic perturbation of a hyperbolic limit cycle   | Han MA. Gu SS.                                  |
| 987 | Perturbation theory for nonlinear klein-gordon equation  | Liu TG. Yan JR.                                 |

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| 287 | Spectral stability of small shock waves      | Freistuhler H. Szmolyan P.    |
| 311 | Infinitely many syzygies                     | Montgomery R.                 |
| 341 | From molecular models to continuum mechanics | Blanc X. Le Bris C. Lions PL. |

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| 363 | Spectral structures and radiation patterns of scattering waves in a layered acoustic half-space  | Touhei T.                                    |
| 379 | Robust-controller design with hard constraint on the control signal - application for active vibration suppression of flexible structure | Forrai A. Hashimoto S. Funato H. Kamiyama K. |
| 395 | Imperfection sensitivity and stability of an elastic-plastic conical shell under axisymmetrical load                                     | Zielnica J.                                  |
| 418 | Analysis of various effects in dynamic cyclic fatigue damage   | Dornowski W. Perzyna P.                      |
| 439 | Characterization of electroelastic beams under biasing fields with applications in buckling analysis                                     | Hu YT. Yang JS. Jiang Q.                     |
| 451 | Continuum modelling and the internal instability of certain periodic structures  | Wierzbicki E. Wozniak C.                     |
| 458 | On a moving griffith crack in anisotropic piezoelectric solids   | Soh AK. Liu JX. Lee KL. Fang DN.             |
| 470 | Wave propagation in transversely isotropic plates in generalized thermoelasticity  | Verma KL. Hasebe N.                          |

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| 483 | Static and dynamic analysis of a gradient-elastic bar in tension                                     | Tsepoura KG. Papargyri-Beskou S. Polyzos D. Beskos DE. |
| 498 | A modular damage model for quasi-brittle solids - interaction between initial and induced anisotropy | Halm D. Dragon A. Charles Y.                           |
| 511 | Weak shock waves in constrained thermoelastic solids   | Gultop T.  |
| 522 | Buckling of an elastically restrained multi-step non-uniform beam with multiple cracks               | Li QS.   |
| 536 | Evolutionary random response problem of a coupled vehicle-bridge system                              | Li JQ. Leng XL. Fang T.                                |

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| 1507 | Boundary concentration phenomena for a singularly perturbed elliptic problem                | Malchiodi A. Montenegro M. |
| 1569 | The generation, propagation, and extinction of multiphases in the kdv zero-dispersion limit | Grava T. Tian FR.          |

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| 1159 | Interfacial bond strength and fracture energy at room and elevated temperature in titanium matrix composites (scs-6/timetal 834)                              | Zeng WD. Peters PWM. Tanaka Y.                                |
| 1171 | Carbon composites based on multiaxial multiply stitched preforms. part 1. geometry of the preform   | Lomov SV. Belov EB. Bischoff T. Ghosh SB. Chi TT. Verpoest I. |
| 1185 | Engineering and characterisation of the interface in flax fibre/polypropylene composite materials. part ii. the effect of surface treatments on the interface | Zafeiropoulos NE. Baillie CA. Hodgkinson JM.                  |
| 1191 | Elastic behaviour of circular composite plates transversely loaded at the centre  | Caprino G. Langella A. Lopresto V.                            |
| 1199 | Robotic tow placement for local reinforcement of glass mat thermoplastics (gmts)  | Wakeman MD. Hagstrand PO. Bonjour F. Bourban PE. Manson JAE.  |
| 1209 | Fracture behaviour of cross-ply nicalon/cas-ii glass-ceramic matrix composite laminate at room and elevated temperatures                                      | Yasmin A. Bowen P.  |
| 1219 | Electrical and impact properties of the hybrid knitted inlaid fabric reinforced polypropylene composites  | Cheng KB. Lee KC. Ueng TH. Mou KJ.                            |
| 1227 | Characteristics of cf/pei tape winding process with on-line consolidation   | Dai SC. Ye L.   |
| 1239 | Synthesis of unsaturated polyesters for improved interfacial strength in carbon fibre composites  | Gamstedt EK. Skrifvars M. Jacobsen TK. Pyrz R.                |
| 1253 | Improving joints between composites and steel using perforations  | Melograna JD. Grenestedt JL.                                  |
| 1263 | Branch and bound search to optimize injection gate locations in liquid composite molding processes  | Gokce A. Hsiao KT. Advani SG.                                 |

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**29(4-5) 2002**

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| 277 | A general algorithm for the numerical evaluation of nearly singular boundary integrals of various orders for two- and three-dimensional elasticity   | Ma H. Kamiya N.                                    |
| 289 | Simulation of airbag inflation processes using a coupled fluid structure approach  | Marklund PO. Nilsson L.                            |
| 298 | Time-dependent creep fracture using singular boundary elements   | Providakis CP. Kourtakis SG.                       |
| 307 | Combined shape and sizing optimization of truss structures   | Wang D. Zhang WH. Jiang JS.                        |
| 313 | An integral equation approach to the inclusion-crack interactions in three-dimensional infinite elastic domain   | Dong CY. Cheung YK. Lo SH.                         |
| 322 | Swept and curved wings: a numerical approach based on generalized lifting-line theory  | Devinant P. Gallois T.                             |
| 332 | A mixed least squares method for solving problems in linear elasticity: theoretical study  | Tchonkova M. Sture S.                              |
| 340 | A rate-independent elastoplastic constitutive model for biological fiber-reinforced composites at finite strains: continuum basis, algorithmic formulation and finite element implementation | Gasser TC. Holzapfel GA.                           |
| 361 | A boundary element method for solving 3d static gradient elastic problems with surface energy  | Tsepoura KG. Papargyri-Beskou S. Polyzos D.        |
| 382 | A localized differential quadrature (ldq) method and its application to the 2d wave equation   | Zong Z. Lam KY.                                    |
| 392 | Boundary collocation method for acoustic eigenanalysis of three-dimensional cavities using radial basis function   | Chen JT. Chang MH. Chen KH. Chen IL.               |
| 409 | Crashworthiness design optimization using successive response surface approximations   | Kurtaran H. Eskandarian A. Marzougui D. Bedewi NE. |
| 422 | The influence of inlet velocity profile on three-dimensional three-generation bifurcating flows  | Zhang CH. Liu Y. So RMC. Phan-Thien N.             |
| 430 | Stability analysis of an explicit finite element scheme for plane wave motions in elastic solids   | Ling X. Cherukuri HP.                              |

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| 5119 | A mortar spectral/finite element method for complex 2d and 3d elastodynamic problems  | Casadei F, Gabellini E, Fotia G, Maggio F, Quarteroni A. |
| 5149 | On the regularity and uniformness conditions on quadrilateral grids   | Chou SH, He SN.  |
| 5159 | On the role of frame-invariance in structural mechanics models at finite rotations  | Ibrahimbegovic A, Taylor RL.                             |
| 5177 | Development of a one point quadrature shell element for nonlinear applications with contact and anisotropy  | Cardoso RPR, Yoon JW, Gracio JJ, Barlat F, de Sa JMAC.   |
| 5207 | Finite element analysis of the vibratory characteristics of cylindrical shells conveying fluid  | Zhang YL, Reese JM, Gorman DG.                           |
| 5233 | Numerical comparison of iterative eigensolvers for large sparse symmetric positive definite matrices  | Bergamaschi L, Putti M.                                  |
| 5249 | Discussions of "a galerkin method for a nonlinear integro-differential wave system" by i. christie and j.m. sanz-serna, comput. meth. appl. mech. engrg. 44 (1984) 229-237" | Peradze J.   |

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| 5265 | Convergence of finite volume schemes for a degenerate convection-diffusion equation arising in flow in porous media | Afif M, Amaziane B.                                  |
| 5287 | Bifurcation of elastoplastic solids to shear band mode at finite strain   | Borja RI.  |
| 5315 | On the use of space-time finite elements in the solution of elastodynamic problems with strain discontinuities      | Huang H, Costanzo F.                                 |
| 5345 | An efficient characteristic galerkin scheme for the advection equation in 3-d                                       | Kaazempur-Mofrad MR, Ethier CR.                      |
| 5365 | Free vibration analysis of circular plates using generalized differential quadrature rule                           | Wu TY, Wang YY, Liu GR.                              |

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| 149 | Optimal control of cylinder wakes via suction and blowing   | Li ZJ, Navon IM, Hussaini MY, Le Dimet FA. |
| 173 | The extension of incompressible flow solvers to the weakly compressible regime  | Munz CD, Roller S, Klein R, Geratz KJ.     |
| 197 | A fourier analysis of the ipsa/pea algorithms applied to multiphase flows with mass transfer  | Miller TF, Miller DJ.                      |
| 223 | Element residual error estimate for the finite volume method  | Jasak H, Gosman AD.                        |
| 249 | Numerical investigation of fully developed channel flow using shock-capturing schemes   | Mossi M, Sagaut P.                         |
| 275 | Study on the rapid pressure-strain rate in the second-moment closure for turbulent flows undergoing strong compression and large distortion | Xie MZ, Sun W, Li F.                       |

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| 287 | Low reynolds number turbulent flows around a dynamically shaped airfoil  | Lian YS, Steen J, Trygg-Wilander M, Shyy W.        |
| 305 | Computer simulation of high explosive explosion using smoothed particle hydrodynamics methodology                      | Liu MB, Liu GR, Zong Z, Lam KY.                    |
| 323 | A two-step grid redistribution method  | Tang L, Baeder JD.                                 |
| 337 | Transition in a 2-d lid-driven cavity flow   | Peng YF, Shiau YH, Hwang RR.                       |
| 353 | Instability of the flow in the vicinity of trailing edge of a class of thin aerofoils                                  | Turkyilmazoglu M.                                  |
| 373 | Computationally efficient, numerically exact design space derivatives via the complex taylor's series expansion method | Burg COE, Newman JC.                               |
| 385 | On the computation of steady axi-symmetric withdrawal from a two-layer fluid   | Forbes LK, Hocking GC.                             |
| 403 | One- and two-equation turbulence models for the prediction of complex cascade flows using unstructured grids           | Koubogiannis DG, Athanasiadis AN, Giannakoglou KC. |
| 431 | A direct spectral domain decomposition method for the computation of rotating flows in a t-shape geometry              | Raspo I.   |

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| 1749 | Free vibration of composite spherical shell cap with and without a cutout   | Ram KSS. Babu TS.                       |
| 1757 | Load carrying capacity of circular and annular plates using an arbitrary yield criterion                              | Aryanpour M. Ghorashi M.                |
| 1763 | Residual thermal stress analysis in cylindrical steel bars using finite element method and artificial neural networks | Toparli M. Sahin S. Ozkaya E. Sasaki S. |
| 1771 | Finite element simulation of metal forming and in-plane crack propagation using ductile continuum damage model        | Chung SW. Kim SJ. Kim JH.               |
| 1789 | Semi-discrete finite element analysis of slab-girder bridges  | Guo MW. Harik IE. Ren WX.               |
| 1797 | Static behavior of piezoelectric actuated beams   | Yocum M. Abramovich H.                  |

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| 1817 | Radius ratio estimation and fold situation prediction of the deformation profile in forging-extrusion process | Lin FC. Lin SY.                                 |
| 1827 | Fem analysis of a travelling web  | Laukkanen J.                                    |
| 1843 | A displacement method for the analysis of flexural shear stresses in thin-walled isotropic composite beams    | Wagner W. Gruttmann F.                          |
| 1853 | Turbine blade fir-tree root design optimisation using intelligent cad and finite element analysis             | Song WB. Keane A. Rees J. Bhaskar A. Bagnall S. |

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| 1907 | Elastic-plastic fe analysis of a notched cylinder under multiaxial nonproportional fatigue loading with variable amplitudes   | Savaidis A. Savaidis G. Zhang C. |
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| 1945 | Dynamic response of a flexural non-classically damped continuous beam under moving loadings                  | Greco A. Santini A.      |
| 1955 | Design optimisation of structures vibration behaviour using first order approximation and local modification | Bahai H. Aryana F.       |
| 1965 | Elastic-plastic beam-on-foundation subjected to mass impact or impulsive loading                             | Yu TX. Chen XW. Chen YZ. |
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| 2073 | An analysis of crack growth in thin-sheet metal via a cohesive zone model  | Li WZ. Siegmund T.                           |
| 2095 | Strain-driven corrosion crack growth - a pilot study of intergranular stress corrosion cracking  | Jivkov AP. Stahle P.                         |
| 2113 | Environmental degradation of the interfacial fracture energy in an adhesively bonded joint   | Loh WK. Crocombe AD. Wahab MMA. Ashcroft IA. |
| 2129 | Boundary element analysis of flat cracked panels with adhesively bonded patches  | Wen PH. Aliabadi MH. Young A.                |
| 2147 | Analysis of crack propagation during tooth interior fatigue fracture   | MackAldener M. Olsson M.                     |
| 2163 | Micromechanical modeling of fracture initiation in 7050 aluminum   | Hill MR. Panontin TL.                        |
| 2187 | Crack growth under biaxial compression   | Sahouryeh E. Dyskin AV. Germanovich LN.      |
| 2199 | Investigation of near-tip displacement fields of a crack normal to and terminating at a bimaterial interface under mixed-mode loading        | Kang YL. Lu H.                               |

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| 1   | Mesh-free analysis of cracks in isotropic functionally graded materials   | Rao BN, Rahman S.                           |
| 29  | Extended finite element method and fast marching method for three-dimensional fatigue crack propagation                     | Sukumar N, Chopp DL, Moran B.               |
| 49  | Micro structure-based fatigue modeling of cast a356-t6 alloy  | McDowell DL, Gall K, Horstemeyer MF, Fan J. |
| 81  | The efficiency of mechanical concrete comminution   | Momber AW.                                  |
| 93  | Fracture mechanics approach to facesheet delamination in honeycomb: measurement of energy release rate of the adhesive bond | Ural A, Zehnder AT, Ingraffea AR.           |
| 105 | Dynamics of anisotropic composite cantilevers weakened by multiple transverse open cracks                                   | Song O, Ha TW, Librescu L.                  |
| 125 | Fractal dimension - a measure of fracture roughness and toughness of concrete   | Issa MA, Islam MS, Chudnovsky A.            |

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| 1   | A simple shear wall model taking into account stiffness degradation  | Brun M, Reynouard JM, Jezequel L.             |
| 11  | Earthquake response of tall reinforced concrete chimneys   | Wilson JL.                                    |
| 25  | Direct displacement-based design for building with passive energy dissipation systems  | Lin YY, Tsai MH, Hwang JS, Chang KC.          |
| 39  | Seismic effectiveness of tuned mass dampers for damage reduction of structures   | Pinkaew T, Lukkunaprasit P, Chatupote P.      |
| 47  | Response of drilled shafts with minor flaws to axial and lateral loads   | O'Neill M, Tabsh SW, Sarhan H.                |
| 57  | Damage identification in beam-type structures: frequency-based method vs mode-shape-based method   | Kim JT, Ryu YS, Cho HM, Stubbs N.             |
| 69  | Full-scale testing of space steel frame subjected to proportional loads  | Kim SE, Kang KW, Lee DH.                      |
| 81  | 3-d second-order plastic-hinge analysis accounting for local buckling  | Kim SE, Lee J, Park JS.                       |
| 91  | An analytical model to evaluate the static soil pressure on a buried structure   | Karinski YS, Dancygier AN, Leviathan I.       |
| 103 | Performance of reinforced concrete buildings during the august 17, 1999 kocaeli, turkey earthquake, and seismic design and construction practise in turkey | Sezen H, Whittaker AS, Elwood KJ, Mosalam KM. |
| 115 | Pumice concrete for structural wall panels   | Cavaleri L, Miraglia N, Papia M.              |

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| 495 | Investigations of time-growing instabilities in laminar separation bubbles                                      | Rist U, Maucher U.                       |
| 511 | The effect of viscosity, surface tension and non-linearity on richtmyer-meshkov instability                     | Carles P, Popinet S.                     |
| 527 | Vortex dynamics in a model left ventricle during filling  | Baccani B, Domenichini F, Pedrizzetti G. |
| 545 | A note on bodewadt-hartmann layers  | Davidson PA, Potherat A.                 |
| 561 | Focusing of edge waves above a sloping beach  | Kurkin A, Pelinovsky E.                  |
| 579 | Poiseuille, thermal creep and couette flow: results based on the ces model of the linearized boltzmann equation | Siewert CE.                              |
| 599 | Study of a shock wave structure in gas mixtures on the basis of the boltzmann equation                          | Raines A.                                |

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| 232 | A simple technique for determining yield strength of thin films  | Gordon MH, Schmidt WF, Qiao Q, Huang B, Ang SS. |
| 237 | Optoelectronic strain measurement for flywheels  | Emerson RP, Bakis CE.                           |
| 247 | On testing of charpy specimens using the one-point bend impact technique   | Rittel D, Pineau A, Clisson J, Rota L.          |
| 253 | The use of automated projection interferometry in monitoring aerofoil buckling   | Featherston CA, Lester WD.                      |
| 261 | Experimental investigation of structural response to generalized ground shock excitations  | Lu Y, Hao H, Ma GW.                             |
| 272 | Digital volume correlation including rotational degrees of freedom during minimization   | Smith TS, Bay BK, Rashid MM.                    |
| 279 | Characterization of short duration stress pulses generated by impacting laminated carbon-fiber/epoxy composites with magnetic flyer plates | Bruck HA, Casem D, Williamson RL, Epstein JS.   |
| 288 | Distributed strain sensing using frequency-modulated continuous-wave reflectometric optical technique                                      | Seah LK, Won PC.                                |
| 295 | Computational method for the spsd of dynamic systems and its application   | Zhao WL, Liu DG.                                |
| 298 | Determination of impact parameters by optical measurement of the impactor displacement   | Degrieck J, Verleysen P.                        |
| 303 | Systematic errors in digital image correlation due to undermatched subset shape functions  | Schreier HW, Sutton MA.                         |

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| 311 | Moire-numerical hybrid analysis of cracks in orthotropic media   | Rhee J. Rowlands RE.                              |
| 318 | Analysis of a multiaxial test on a c/c composite by using digital image correlation and a damage model | Perie JN. Calloch S. Cluzel C. Hild F.            |
| 329 | Dynamic stress chain formation in a two-dimensional particle bed                                       | Roessig KM. Foster JC. Bardenhagen SG.            |
| 338 | Elasto-optic technique for measurement of elastic wave propagation in solids                           | Henderson BK. Maslov KI. Eggenpieler G. Kinra VK. |
| 344 | Full-field speckle pattern image correlation with b-spline deformation function                        | Cheng P. Sutton MA. Schreier HW. McNeill SR.      |
| 353 | Effects of boundary conditions and anisotropy on elastically bent silicon                              | Kaldor SK. Noyan IC.                              |

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| 503 | Resonance behavior of liquid bridges under axial and lateral oscillating total body forces   | Mahajan MP. Tsige M. Zhang S. Alexander JID. Taylor PL. Rosenblatt C.   |
| 508 | Experimental investigation of critical pressure ratio in orifices  | Shannak BA.   |
| 512 | Experimental studies on caisson-type porous seawalls   | Zhu ST. Chwang AT.  |
| 516 | Analysis of self-sustained oscillation sources in segmented flows  | Vetel J. Plourde F. Doan-Kim S.   |
| 531 | Use of pressure-sensitive paint for diagnostics in turbomachinery flows with shocks  | Lepicovsky J. Bencic TJ.  |
| 539 | Experimental investigation of an axisymmetric, impinging turbulent jet. 2. scalar field  | Fairweather M. Hargrave GK.   |
| 545 | Photobleached-fluorescence imaging of microflows   | Mosier BP. Molho JI. Santiago JG.                                       |
| 555 | Dpiv, hptv and visualization study of a vortex ring-moving wall interaction  | Dupont P. Croisier G. Werquin O. Stanislas M.                           |
| 565 | Properties of vortices in the self-similar turbulent jet   | Agrawal A. Prasad AK.   |
| 578 | Numerical and experimental investigations on the cavitating flow in a cascade of hydrofoils  | Lohrberg H. Stoffel B. Fortes-Patella R. Coutier-Delgosha O. Reboud JL. |
| 587 | Characterization of a water mist based on digital particle images  | Wang XS. Wu XP. Liao GX. Wei YX. Qin J.                                 |
| 594 | Details on the start-up development of the Taylor-Görtler-like vortices inside a square-section lid-driven cavity for $1,000 \leq Re \leq 3,200$ | Migeon C.   |
| 603 | The application of a 3d ptv algorithm to a mixed convection flow   | Kieft RN. Schreel KRAM. van der Plas GAJ. Rindt CCM.                    |

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**25(11) 2002**

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| 993  | On the development of crack closure at high r levels  | McEvily AJ. Ishihara S.                                       |
| 999  | Experimental techniques for fracture instability toughness determination of uni-directional fibre metal laminates             | Castrodeza EM. Ipina JEP. Bastian FL.                         |
| 1009 | Stress distribution ahead of an interface crack tip in a ductile adhesive layer   | Kang KJ. Kim DH.  |
| 1015 | Fatigue voids and their significance  | Sunder R. Porter WJ. Ashbaugh NE.                             |
| 1025 | Fatigue life prediction of offshore tubular joints using fracture mechanics   | Lee MMK. Bowness D.   |
| 1033 | A fracture mechanics interpretation of the dnv brittle fracture criteria for ships and mobile offshore units                  | Wallin K. Nevasmaa P. Laukkanen A.                            |
| 1045 | High cycle fatigue mechanics in a cast am60b magnesium alloy  | Horstemeyer MF. Yang N. Gall K. McDowell D. Fan J. Gullett P. |
| 1059 | Fluids and cracks   | Beck S. Yates J.  |
| 1061 | A rolling contact fatigue crack driven by squeeze fluid film  | Bogdanski S.  |
| 1073 | A quantitative model for predicting the morphology of surface initiated rolling contact fatigue cracks in back-up roll steels | Frolich MF. Fletcher DI. Beynon JH.                           |
| 1087 | A probabilistic simulation of fluid leakage in multiple cracks situation  | Xie L. Yu Z.  |
| 1095 | The influence of surface roughness on fluid flow through cracks   | Chivers TC.   |

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| 1  | Assessment of crack growth in a space shuttle main engine first-stage high-pressure fuel turbopump blade | Abdul-Aziz A.  |
| 17 | Design and finite element analysis of a wet cycle cement rotary kiln                                     | del Coz Diaz JJ. Mazon FR. Nieto PJG. Dominguez FJS. |
| 43 | Finite element analysis of steel members under cyclic loading  | Mingzhou S. Qiang G. Bing G.                         |
| 55 | Object-oriented finite element-based design and progressive steel weight minimization                    | Tabatabai SMR.                                       |

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| 79  | Finite element modeling of spur gearing fractures  | Sfakiotakis VG. Anifantis NK. |
| 93  | Application of the impedance coupling method and the equivalent rotor model in rotordynamics | Choi BL. Park JM.             |
| 107 | Improving dimensional accuracy of a u-shaped part through an orthogonal design experiment    | Liu G. Lin ZQ. Bao YX.        |
| 119 | Shape design sensitivity analysis and optimization of general plane arch structures          | Choi JH.                      |
| 137 | Analysis of die behaviour during bulge forming operations using the finite element method    | Mac Donald BJ. Hashmi MSJ.    |

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| 419 | Modelling thermal front dynamics in microwave heating   | Mercado GA. Luce BP. Xin J. |
| 441 | A new methodology for the stability analysis of pairwise triangularizable and related switching systems                   | Shorten R. Cairbre FO.      |
| 459 | The global structure of periodic solutions to a suspension bridge mechanical model  | McKenna PJ. Moore KS.       |
| 479 | Robust and high-order effective boundary conditions for perfectly conducting scatterers coated by a thin dielectric layer | Bartoli N. Bendali A.       |

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| 1253 | Numerical simulation of the fracture process in cutting heterogeneous brittle material         | Liu HY. Kou SQ. Lindqvist PA. |
| 1279 | Transient deformation of a poroelastic channel bed   | Hsieh PC. Shih WP. Huang LH.  |
| 1299 | Mode I crack propagation in concrete under fatigue: microscopic observations and modelling     | Toumi A. Bascoul A.           |
| 1313 | A theoretical framework for constructing elastic/plastic constitutive models of triaxial tests | Collins IF. Hilder T.         |
| 1349 | A simplified analysis method for piled raft and pile group foundations with batter piles       | Kitiyodom P. Matsumoto T.     |

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| 1371 | Direct, partitioned and projected solution to finite element consolidation models   | Gambolati G. Pini G. Ferronato M.             |
| 1385 | Numerical analysis of pile behaviour under lateral loads in layered elastic-plastic soils   | Yang ZH. Jeremic B.                           |
| 1407 | Template elastic-plastic computations in geomechanics   | Jeremic B. Yang ZH.                           |
| 1429 | Analytical and numerical investigation of uniqueness and localization in saturated porous media   | Zhang HW. Schrefler BA.                       |
| 1449 | Elastic solutions for stresses in a transversely isotropic half-space subjected to three-dimensional buried parabolic rectangular loads | Wang CD. Liao JJ.                             |
| 1477 | Analysis of steady-state heat transfer through mid-crustal vertical cracks with upward throughflow in hydrothermal systems              | Zhao CB. Hobbs BE. Muhlhaus HB. Ord A. Lin G. |

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| 1255 | Improvements and algorithmical considerations on a recent three-dimensional model describing stress-induced solid phase transformations | Auricchio F. Petrini L.                      |
| 1285 | Strain-driven homogenization of inelastic microstructures and composites based on an incremental variational formulation                | Miehe C.                                     |
| 1323 | Buckling analysis for delaminated composites using plate bending elements based on higher-order zig-zag theory                          | Kim JS. Cho MH.                              |
| 1345 | Fast and robust delaunay tessellation in periodic domains   | Thompson KE.                                 |
| 1367 | Fidelity of the integrated force method solution  | Hopkins D. Halford G. Coroneos R. Patnaik S. |

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| 1373 | The maximum principle violations of the mixed-hybrid finite-element method applied to diffusion equations                      | Hoteit H. Mose R. Philippe B. Ackerer P. Erhel J. |
| 1391 | A continuum sensitivity method for finite thermo-elastic deformations with applications to the design of hot forming processes | Ganapathysubramanian S. Zabaras N.                |
| 1439 | All-hexahedral element meshing: automatic elimination of self-intersecting dual lines  | Calvo NA. Idelsohn SR.                            |
| 1451 | Life-cycle cost optimization of steel structures   | Sarma KC. Adeli H.                                |
| 1463 | Direct modification for non-conforming elements with drilling dof  | Choi CK. Lee TY. Chung KY.                        |
| 1477 | Mesh-independent p-orthotropic enrichment using the generalized finite element method  | Duarte CA. Babuska I.                             |

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| 951  | Editorial comment  | Gresho P.   |
| 953  | Computational predictability of time-dependent natural convection flows in enclosures (including a benchmark solution) | Christon MA. Gresho PM. Sutton SB.                |
| 981  | An extended chebyshev pseudo-spectral benchmark for the 8 : 1 differentially heated cavity                             | Xin S. Le Quere P.                                |
| 999  | A petrov-galerkin method for flows in cavities: enclosure of aspect ratio  | Suslov SA. Paolucci S.                            |
| 1009 | Unsteady natural convection in tall side-heated cavities   | Armfield S. Schultz A.                            |
| 1019 | An operator-splitting finite-element approach to the 8 : 1 thermal-cavity problem                                      | Davis D. Bansch E.                                |
| 1031 | Fourth-order finite difference simulation of a differentially heated cavity  | Johnston H. Krasny R.                             |
| 1039 | Numerical prediction of natural convection in a tall enclosure   | Christopher DM.                                   |
| 1045 | A numerical study of a natural convection flow in a cavity   | Guo YH. Bathe KJ.                                 |
| 1059 | Computational bifurcation and stability studies of the 8 : 1 thermal cavity problem                                    | Salinger AG. Lehoucq RB. Pawlowski RP. Shadid JN. |
| 1075 | Parallel computations of natural convection flow in a tall cavity using an explicit finite element method              | Dunn TA. McCallen RC.                             |
| 1083 | Application of the fidap code to the 8 : 1 thermal cavity problem  | Gresho PM. Sutton SB.                             |
| 1093 | From steady to chaotic solutions in a differentially heated cavity of aspect ratio 8                                   | Bruneau CH. Saad M.                               |
| 1109 | Fully coupled and operator-splitting approaches for natural convection flows in enclosures                             | Turek S. Schmachtel R.                            |
| 1121 | Numerical investigation of the first instabilities in the differentially heated 8 : 1 cavity                           | Auteri F. Parolini N.                             |
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| 309 | Failure modes of composite sandwich beams   | Daniel IM. Gdoutos EE. Wang KA. Abot JL. |
| 335 | An experimental study of shear damage using in-situ single shear test   | Tang CY. Lee TC. Rao B.                  |
| 355 | Damage characterization and its incorporation into the constitutive model for several solders in electronic packaging | Wen SM. Keer LM.                         |
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| 2041 | Evaluation of the hall parameter of electrolyte solutions in thermosyphonic mhd flow                | Sawaya E. Ghaddar N. Chaaban F.                             |
| 2057 | 2d electro-elastic fields in a piezoelectric layer-substrate structure                              | Nowacki JP. Alshits VI. Radowicz A.                         |
| 2077 | On the propagation of waves in layered anisotropic media in generalized thermoelasticity            | Verma KL.   |

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| 2097 | Uniqueness and reciprocity theorems in generalized linear micropolar thermoviscoelasticity  | El-Karamany AS.              |
| 2119 | Boundary optimal control of the navier-stokes equations - a numerical approach  | Park HM. Lee WJ. Chung JS.   |
| 2137 | An edge dislocation interacting with a slightly wavy interface  | Xiao ZM. Chen BJ. Steele CR. |
| 2163 | A mixed non-linear boundary value problem appearing in gas dynamics: generalized solutions and numerical results                              | Le Brizaut JS. Pogu M.       |
| 2183 | Nonlinearly elastic membrane model for heterogeneous plates: a formal asymptotic approach by using a new double scale variational formulation | Pruchnicki E.                |

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| 1  | Fatigue life prediction of gas tungsten arc welded aisi 304l cruciform joints with different lop sizes  | Singh PJ. Achar DRG. Guha B. Nordberg H.           |
| 9  | On generating fatigue crack growth thresholds   | Forth SC. Newman JC. Forman RG.                    |
| 17 | Notch size effects in the fatigue limit of steel  | Makkonen M.  |
| 27 | Polycrystal orientation distribution effects on microslip in high cycle fatigue   | Bennett VP. McDowell DL.                           |
| 41 | In situ ultrasonic monitoring of surface fatigue crack initiation and growth from surface cavity  | Rokhlin SI. Kim JY.                                |
| 51 | In situ ultrasonic measurement of crack closure   | Rokhlin SI. Kim JY.                                |
| 59 | Analysis of the effects of controlled shot peening on fatigue damage of high strength aluminium alloys  | Curtis S. de los Rios ER. Rodopoulos CA. Levers A. |
| 67 | Theoretical and numerical aspects of the volumetric approach for fatigue life prediction in notched components                                | Adib H. Pluvinage G.                               |
| 77 | The role of residual stress and heat affected zone properties on fatigue crack propagation in friction stir welded 2024-t351 aluminium joints | Bussu G. Irving PE.                                |
| 89 | On the calculation of stress intensity factors for surface cracks in welded pipe-plate and tubular joints                                     | Wang X. Lambert SB.                                |

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| 313 | Fracture propagation in 3d by the symmetric galerkin boundary element method         | Frangi A.               |
| 331 | Crack configurations related by fractional linear mapping                            | An D.                   |
| 347 | Non-linear fracture mechanics analyses of part circumferential surface cracked pipes | Kim YJ. Kim JS. Lee YZ. |

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| 744 | Vortex generating jets; effects of jet-hole inlet geometry  | Johnston JP. Mosier BP. Khan ZU.                                 |
| 750 | Reynolds averaged simulation of flow and heat transfer in ribbed ducts  | Ooi A. Iaccarino G. Durbin PA. Behnia M.                         |
| 758 | Turbulent mixed convection flow over a backward-facing step - the effect of the step heights                        | Abu-Mulaweh HI. Chen TS. Armaly BF.                              |
| 766 | A new proposal for lagrangian correlation coefficient   | Altinsoy N. Tugrul AB.   |
| 769 | A proposed mechanism for hydrodynamically-controlled onset of significant void in microtubes                        | Chedester RC. Ghiaasiaan SM.                                     |
| 776 | The effect of internal surface modification on flow instabilities in forced convection boiling in a horizontal tube | Karsli S. Yilmaz M. Comakli O.                                   |
| 792 | Thermo-mechanical modeling of turbulent heat transfer in gas-solid flows including particle collisions              | Mansoori Z. Saffar-Avval M. Basirat-Tabrizi H. Ahmadi G. Lain S. |
| 807 | A model for droplet entrainment in heated annular flow  | Holowach MJ. Hochreiter LE. Cheung FB.                           |
| 823 | Buoyancy-induced flow and convective heat transfer in an inclined arc-shape enclosure                               | Chen CL. Cheng CH.   |
| 831 | Mixed convection boundary layer flow of non-newtonian fluids along vertical wavy plates                             | Wang CC. Chen CK.  |
| 840 | Similarity solution of thermal boundary layers for laminar narrow axisymmetric jets                                 | Fang TG.   |
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| 13 | Finite-element modeling of the ballistic impact of fabric armor   | Lim CT. Shim VPW. Ng YH.       |
| 33 | Deformation mechanism and defect sensitivity of notched free-free beam and cantilever beam under impact | Ruan HH. Yu T.                 |
| 65 | Anomalous elastic-plastic responses to short pulse loading of circular plates                           | Bassi A. Genna F. Symonds PS.  |
| 93 | Dimensionless formulae for penetration depth of concrete target impacted by a non-deformable projectile | Li QM. Chen XW.                |

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| 183 | Instability and ductile failure of thin cylindrical tubes under internal pressure impact                  | Tugcu P.  |
| 207 | Perforation of high-strength fabric by projectiles of different geometry                                  | Tan VBC. Lim CT. Cheong CH.                       |
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| 287 | On the flow of a bingham fluid passing through an electric field   | Busuioc V. Cioranescu D.          |
| 305 | Hydromagnetic flow at an oscillating plate   | Vajravelu K. Rivera J.            |
| 313 | Constitutive relations for the interaction force in multicomponent particulate flows [review]                            | Massoudi M.                       |
| 337 | Dynamic geometrically nonlinear analysis of transversely compressible sandwich plates                                    | Perel VY. Palazotto AN.           |
| 357 | Projectile motion in a resistant medium part 1: exact solution and properties  | Hayen JC.                         |
| 371 | Projectile motion in a resistant medium part ii: approximate solution and estimates                                      | Hayen JC.                         |
| 381 | A note on the critical points of equilibrium paths in imperfect structures   | Wu BS. Piao YX.                   |
| 389 | Analytical approximations for stick-slip vibration amplitudes  | Thomsen JJ. Fidlin A.             |
| 405 | Some properties of multi-degree-of-freedom potential systems and application to statistical equivalent non-linearization | Cavaleri L. Di Paola A. Failla G. |
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- 441 Sufficient conditions for strong ellipticity for a class of anisotropic materials Walton JR. Wilber JP.
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- 501 Mhd flow of a third-grade fluid due to eccentric rotations of a porous disk and a fluid at infinity Hayat T. Haroon T. Asghar S. Siddiqui AM.
- 513 Similarity analysis in magnetohydrodynamics: hall effects on free convection flow and mass transfer past a semi-infinite vertical flat plate Megahed AA. Komy SR. Afify AA.
- 521 Non-elliptic deformation field near the tip of a mixed-mode crack in a compressible hyperelastic material Ru CQ.
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- 585 Simultaneous combination and 1 : 3 : 5 internal resonances in a parametrically excited beam-mass system Dwivedy SK. Kar RC.
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- 691 Friction, self-inhibition and self-excitation: thoughts on the painleve paradox [german] Brommundt E.
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- 723 Linear and nonlinear dynamics of reciprocating engines Metallidis P. Natsiavas S.
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| 1683 | On the r-value of textured sheet metals  | Man CS.                              |
| 1707 | Experimental study of the phase transformation plasticity of 16mnd5 low carbon steel under multiaxial loading              | Coret M. Calloch S. Combescure A.    |
| 1729 | Creep-rupture lifetime simulation of unidirectional metal matrix composites with and without time-dependent fiber breakage | Goda K.                              |
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| 1775 | Anisotropic hardening equations derived from reverse-bend testing (vol 18, pg 743, 2002)                                   | Geng LM. Shen Y. Wagoner RH.         |

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| 91  | On finite plastic deformation of anisotropic metallic materials  | Wu HC.  |
| 121 | Evaluation of anisotropic yield functions for aluminum sheets  | Wu PD. Jain M. Savoie J. MacEwen SR. Tugcu P. Neale KW. |

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| 5379 | Reflection and transmission of a transient, elastic, line-source excited sh wave by a planar, elastic bonding surface in a solid | de Hoop AT.                           |
| 5393 | An exact transient analysis of plane wave diffraction by a crack in an orthotropic or transversely isotropic solid               | Brock LM. Hanson MT.                  |
| 5409 | Perturbation of a dynamic planar crack moving in a model viscoelastic solid  | Woolfries S. Movchan AB. Willis JR.   |
| 5427 | A unified formalism for elastostatics or steady state motion of compressible or incompressible anisotropic elastic materials     | Ting TCT.                             |
| 5447 | Application of the reverberation-ray matrix to the propagation of elastic waves in a layered solid                               | Su XY. Tian JY. Pao YH.               |
| 5465 | Acoustic emission from strain-determined sources   | Ziegler F.                            |
| 5481 | Elastic waves from localized sources in composite laminates  | Mal A.                                |
| 5495 | Scattering coefficient reconstruction in plates using focused acoustic beams   | Chimenti DE. Fei D.                   |
| 5515 | On transient ultrasonic waves in a homogeneous plate with thin superconducting coating layers                                    | Niklasson AJ. Datta SK.               |
| 5529 | Ultrasonic waves in layered anisotropic media: characterization of multidirectional composites                                   | Rokhlin SI. Wang L.                   |
| 5547 | Random walk methods and wave diffraction   | Budaev BV. Bogy DB.                   |
| 5571 | Multiwave non-linear couplings in elastic structures part 1. one-dimensional examples  | Kovriguine DA. Maugin GA. Potapov AI. |
| 5585 | Wave propagation in nonlinear and hysteretic media - a numerical study   | Meurer T. Qu J. Jacobs LJ.            |
| 5615 | The dynamics of multiple neck formation and fragmentation in high rate extension of ductile materials                            | Guduru PR. Freund LB.                 |
| 5633 | Size effect and asymptotic matching approximations in strain-gradient theories of micro-scale plasticity                         | Bazant ZP. Guo ZY.                    |
| 5659 | Rate form of the eshelby and hill tensors  | Suvorov AP. Dvorak GJ.                |

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| 5699 | The nonlinear viscoelastic response of carbon black-filled natural rubbers  | Drozdov AD. Dorfmann A.   |
| 5719 | An efficient numerical model for contact-induced crack propagation analysis                                       | de Lacerda LA. Wrobel LC. |
| 5737 | Transient piezothermoelasticity for a cylindrical composite panel composed of angle-ply and piezoelectric laminae | Ootao Y. Tanigawa Y.      |
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- 5787 Solution of flat crack problem by using variational principle and differential-integral equation Chen YZ. Lee KY.
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- 755 Modeling of plastic strain-induced martensitic transformation for cryogenic applications Garion C. Skoczen B.
- 763 Analysis of belt-drive mechanics using a creep-rate-dependent friction law Leamy MJ. Wasfy TM.
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- 775 Scattering from an elliptic crack by an integral equation method: normal loading Saha TK. Roy A.
- 785 Large deflection of thin plates in pressure sensor applications Tong P. Huang W.
- 790 Thermomechanical buckling of laminated composite plates using mixed, higher-order analytical formulation Dafedar JB. Desai YM.
- 800 On the singularity induced by boundary conditions in a third-order thick plate theory Huang CS.
- 811 Transient ultrasonic waves in multilayered superconducting plates Niklasson AJ. Datta SK.
- 819 Wave propagation in a piezoelectric coupled solid medium Wang Q.
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- 867 Discussion: "computationally efficient micromechanical models for woven fabric composite elastic moduli" - (tanov, r., and tabiei, a., 2001, asme j. appl. mech., 68, pp.533-560) Huang ZM.
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- 2421 Dynamic characteristics of laminated woven e-glass-epoxy composite plates subjected to low velocity heavy mass impact Aslan Z. Karakuzu R. Sayman O.
- 2443 Design, analysis, manufacture, and test of shallow water pressure vessels using e-glass/epoxy woven composite material for a semi-autonomous underwater vehicle Ng RKH. Yousefpour A. Uyema M. Nejjad MNG.
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- 27 Computational aspects of the ultra-weak variational formulation Huttunen T. Monk P. Kaipio JP.

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| 91  | Finesse: axisymmetric mhd equilibria with flow  | Belien AJC. Botchev MA. Goedbloed JP. van der Holst B. Keppens R.<br>Men'shov I. Nakamura Y. |
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| 191 | A super-grid-scale model for simulating compressible flow on unbounded domains  | Weinan E. Huang ZY.  |
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| 147 | A note on caustics and two-dimensional hot spots in microwave heating   | Reimbert CG. Jorge MC. Minzoni AA. Vargas CA. |
| 155 | Microwave heating in multiphase systems: evaluation of series solutions | Ayappa KG. Sengupta T.                        |
| 173 | Microwave heating of laminate panels                                    | Kriegsmann GA. Tilley BS.                     |
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| 229 | Analysis of radiative heat-loss effects in thermal explosion of a gas using the integral manifold method | Goldfarb I. Gol'dhstein V. Greenberg JB. Kuzmenko G. |
| 245 | Bifurcation of cavitation solutions for incompressible transversely isotropic hyperelastic materials     | Ren JS. Cheng CJ.                                    |
| 259 | Liquid impact, kinetic energy loss and compressibility: lagrangian, eulerian and acoustic viewpoints     | Cooker MJ.   |
| 277 | On diffusion theory in turbulence  | Brouwers JHH.  |
| 297 | Water-wave scattering by two symmetric circular-arc-shaped thin plates                                   | Mandal BN. Gayen R.                                  |

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| 1169 | Flow establishment in elastic pipes   | Lam KWF. Leutheusser HJ.          |
| 1174 | Collapse of composite rings due to delamination buckling under external pressure                                      | Rasheed HA. Tassoulas JL.         |
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| 971 | A simplified linearized model for the fluid-coupled vibrations of spent nuclear fuel racks                           | Moreira M. Antunes J.                           |
| 989 | Flow-induced vibration of free edges of thin films   | Chang YB. Moretti PM.                           |

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| 13  | Improvement in techniques for the determination of extensional rheological data from entrance flows: computational and experimental analysis | Zatloukal M. Vlcek J. Tzoganakis C. Saha P. |
| 39  | Mean field heat transfer scaling for non-newtonian stagnant lid convection   | Reese CC. Solomatov VS.                     |
| 51  | Large amplitude oscillatory shear as a way to classify the complex fluids  | Hyun K. Kim SH. Ahn KH. Lee SJ.             |
| 67  | Numerical studies of fiber suspensions in an axisymmetric radial diverging flow: the effects of modeling and numerical assumptions           | Chung DH. Kwon TH.                          |
| 97  | On the stability of thermally driven shear flow of an oldroyd-b fluid heated from below  | Kaloni PN. Lou J.                           |
| 111 | Drop deformation for non-newtonian fluids in slow flows  | Greco F.                                    |
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| 1423 | Analysis of thin-walled composite beams with arbitrary layup   | Kollar LP. Pluzsik A.  |
| 1467 | Bounds on transverse modulus of a multiphase composite   | Sharma R. Ranjan A. Sharma A.                                  |
| 1477 | Free vibration analysis of two layered cross-ply laminated beams using layer-wise trigonometric shear deformation theory | Shimpi RP. Ainapure AV.  |
| 1493 | A study on biodegradable composite prepared from jute felt and polyesteramide (bak)                                      | Dash BN. Sarkar M. Rana AK. Mishra M. Mohanty AK. Tripathy SS. |
| 1505 | Progressive failure analysis of laminated composite plates by finite element method                                      | Pal P. Ray C.  |

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| 19  | Improvement of the semi-analytical method, for determining the geometrically non-linear response of thin straight structures: part ii - first and second non-linear mode shapes of fully clamped rectangular plates | El Kadiri A. Benamar R.                  |
| 63  | Plane wave solutions and modal analysis in higher order shear and normal deformable plate theories  | Batra RC. Vidoli S. Vestroni F.          |
| 89  | Strategy for finding a near-optimal measurement set for parameter estimation from modal response  | Pothisiri T. Hjelmstad KD.               |
| 107 | Dynamic response of a rotating flexible arm carrying a moving mass  | Yau DTW. Fung EHK.                       |
| 119 | A new method for separating longitudinal waves in a large diameter hopkinson bar  | Zhao PJ. Lok TS.                         |
| 131 | Prediction of non-cavitating underwater propeller noise   | Seol H. Jung B. Suh JC. Lee S.           |
| 157 | Control design of active vibration isolation using mu-synthesis   | Bai MR. Liu W.                           |
| 177 | Effects of viscous friction and non-friction damping mechanisms in a reciprocating engine   | Wang Y. Lim TC.                          |
| 189 | Wave propagation through cylinders and spheres as computed by ordinary exponentials   | Ivansson S.                              |
| 202 | A modified mickens procedure for certain non-linear oscillators   | Lim CW. Wu BS.                           |

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| 247 | Health-monitoring method for bridges under ordinary traffic loadings  | Lee JW. Kim JD. Yun CB. Yi JH. Shim JM. |
| 265 | Vibration power transmission over a rectangular area of an infinite plate subject to uniform conphase velocity excitation | Dai J. Lai JCS.                         |
| 283 | Vibrational power transmission from a machine to its supporting cylindrical shell   | Li WL. Daniels M. Zhou W.               |
| 301 | Dynamic analysis of large-diameter sagged cables taking into account flexural rigidity                                    | Ni YQ. Ko JM. Zheng G.                  |
| 321 | Is a simple support really that simple?   | Aglietti GS. Cunningham PR.             |
| 337 | Non-linear beam oscillations excited by lateral force at combination resonance  | Avramov KV.                             |

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 457 Acoustic insulation of single panel walls provided by analytical expressions versus the mass law  
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 527 The influence of cylinder lubrication on piston slap  
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- 815 Effective vibration analysis of IC engines using cyclostationarity. part i - a methodology for condition monitoring  
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 857 An intelligent tap test as an inspection tool for corrosion in chequer plate floors  
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| 977 | Structural fatigue life prediction with system uncertainties  | Wang X. Sun JQ.                   |
| 985 | Evaluation of the parametric instability of an axially translating media using a variational principle            | Liu ZS. Huang C.                  |
| 996 | Continuous and discrete models for longitudinally vibrating elastic rods viscously damped in-span                 | Yuksel S. Gurgoze M.              |

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| 31  | Complex dynamics of high-speed axially moving systems  | Pellicano F. Vestroni F.          |
| 45  | Effects of mode localization on input-output directional properties of structures                                    | Mugan A.                          |
| 65  | Dynamic stability of trains moving over bridges shaken by earthquakes  | Yang YB. Wu YS.                   |
| 95  | On the false degeneracy of the helmholtz boundary integral equations   | Yeih W. Kuo SR. Liu RF. Chang JR. |
| 123 | Practical aspects in moving load identification  | Zhu XQ. Law SS.                   |
| 147 | Analyses of dynamic response of vehicle and track coupling system with random irregularity of track vertical profile | Lei X. Noda NA.                   |
| 167 | Free non-linear vibration of a rotating thin ring with the in-plane and out-of-plane motions                         | Kim W. Chung J.                   |
| 179 | Energy efficient actuators in vibration control of plated structures   | Mukherjee A. Joshi S.             |
| 191 | Investigation on the whirling motion of full annular rotor rub   | Choi YS.                          |
| 199 | Step-size dependence of the period for a forward-euler scheme of the van der pol equation                            | Mickens RE.                       |

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| 2509 | Thin interphase/imperfect interface in elasticity with application to coated fiber composites  | Hashin Z.   |
| 2539 | The elastic response of a cohesive aggregate - a discrete element model with coupled particle interaction  | Jefferson G. Haritos GK. McMeeking RM.              |
| 2577 | High-rank nonlinear sequentially laminated composites and their possible tendency towards isotropic behavior   | deBotton G. Hariton I.                              |
| 2597 | A phase-field theory of dislocation dynamics, strain hardening and hysteresis in ductile single crystals   | Koslowski M. Cuitino AM. Ortiz M.                   |
| 2637 | Dynamic stability of a propagating crack   | Obrezanova O. Movchan AB. Willis JR.                |
| 2669 | Particle impact on metal substrates with application to foreign object damage to aircraft engines  | Chen X. Hutchinson JW.                              |
| 2691 | Disclinated states in nematic elastomers   | Fried E. Todres RE.                                 |
| 2717 | Experimental and numerical determinations of the initial surface of phase transformation under biaxial loading in some polycrystalline shape-memory alloys | Lexcelent C. Vivet A. Bouvet C. Calloch S. Blanc P. |

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| 13 | Detection of material properties in a layered body by means of thermal effects   | Lukasiewicz SA. Babaei R. Qian RE. |
| 25 | Thermally loaded functionally graded materials with embedded defects   | Wang BL. Noda N.                   |
| 41 | Thermal stresses under the effect of the microscopic heat conduction model   | Naji M. Al-Nimr MA. Mallouh M.     |
| 55 | Dynamic thermoelastic processes in microporous composites  | Baczynski ZF.                      |
| 67 | A bending theory of porous thermoelastic plates  | Birsan M.                          |

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| 0   | Special issue on active constrained layer damping   | Baz AM.                   |
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