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Report on the Proceedings of the 2001 India–USA Symposium on Emerging Trends in Vibration and Noise Engineering

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Abstract

The joint India–USA symposium was held at The Ohio State University in December 2001 and focused on basic research issues and trends in the general area of vibration and noise engineering. Over 100 delegates and observers participated, including delegates from 19 academic institutions, 18 industrial companies and seven national agencies. Fifteen delegates traveled from India. Overall, 55 articles including state-of-the-art papers were presented on a variety of topics. Papers selected for the 3-day meeting dealt with advanced problem-solving strategies, experimental and computational structural dynamics, intake and exhaust systems, aerospace applications, non-linear dynamics, structure-borne noise and vibration isolation, vibration and acoustic materials, statistical energy analysis, smart structures, turbo-machinery vibration, smart materials and active control, and machinery vibration and acoustics. The impact of new and emerging technologies was illustrated through case studies and personal experiences. In addition, interactive workshops with potential sponsors added an important element to this symposium with key experts from industry and government agencies highlighting their research needs and vision. The Symposium is expected to stimulate further research and collaboration between the two countries. Selected articles (20 including this report) are published in the special edition of the *Journal of Sound and Vibration* for archival purposes and for dissemination to the global noise and vibration control community.

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1. Introduction

The India–USA symposium was held at The Ohio State University in Columbus, Ohio, USA, on December 10–12, 2001 [1]. Chief objectives of the symposium were to exchange information and latest findings, to discuss and identify key research questions or trends in vibration and noise

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engineering which must be addressed in the future, to provide an opportunity for a closer interaction between leading US and Indian experts, and to facilitate collaborations.

The symposium was sponsored by the National Science Foundation, Dept. of Science & Technology (India), Dow Chemical, Owens Corning, OSU (The Ohio State University) College of Engineering, OSU Center for Automotive Research and the OSU Office of International Affairs. It was organized by The Ohio State University, Columbus, USA and the Indian Institute of Technology, Delhi, India. R. Singh, A. Selamet, and B.C. Nakra served as chief organizers with R. Singh as the US delegation coordinator, B.C. Nakra as the Indian delegation coordinator and Ahmet Selamet as the Technical Program Chair. At the 2001 symposium over 100 delegates and observers participated, including delegates from 19 academic institutions, 18 industrial companies and seven national agencies. Refer to Appendix A for a detailed list. Fifteen delegates traveled from India. Overall, 55 articles, including state-of-the-art papers from 27 well-known experts were presented on a variety of topics. These were published in the proceedings that were edited by Selamet, Singh and Nakra [1]. The meeting was organized into eight technical sessions held in the morning and only a single session format was used to ensure maximum possible discussion and interaction. The afternoons consisted of six workshop sessions (two ran simultaneously) where audience participation was encouraged. This format worked very well in that many interesting and useful discussions ensued and often continued beyond the allotted time frame. The focus was on the latest technology and unresolved scientific research issues. Most articles were presented through case studies, state-of-the-art review papers and personal experiences of the specialists. During lunch and dinner meetings, invited guests made presentations on the roles of scientific innovation, industrial research needs, and the mission of governmental funding agencies. Interactive question and answer sessions were very helpful in resolving some key issues and future research directions. As well, industrial tours were taken (December 11 and 12, 2001) of the following facilities: Ford Advanced Engineering Center (Dearborn, MI), General Motors Noise & Vibration Analysis Laboratory (Milford, MI), Delphi Chassis (Dayton, OH) and Copeland Corporation (Sydney, OH). Overall, the organization of the symposium was similar to the 1996 India–USA symposium held in Delhi (India) which was also attended by 12 US delegates and supported by NSF and many institutions in India [2].

Selected papers from the 2001 proceedings were submitted, reviewed, and then revised in accordance with the procedures and policy of the *Journal of Sound and Vibration*. The first author of this article (R. Singh) served as the guest editor. The American Editor, W. Soedel, coordinated and edited the entire issue. This special edition of the Journal should be a valuable publication for the global vibration and noise control community.

2. Importance of the symposium theme

The discipline of vibration and noise engineering is becoming increasingly more important because of higher machinery speeds, demanding operational loads, compact and lightweight designs, and new engineered materials. Experimental work is evolving very rapidly with the advent of high-speed processors, signal processing and control modules, smart sensors and actuators. This area can be viewed as truly interdisciplinary since it includes the elements of many branches of engineering and physical sciences. The need for quieter, reliable and safer products,

machines, and equipment is well recognized. Consequently, the industry must focus on two objectives: (1) to meet environmental/health and safety regulations and standards, and (2) to design high-quality, durable, competitive and customer-friendly products. Such technical issues obviously impact the industrial competitiveness and global trade considerations as well. Much fundamental research is needed to address the technological and societal issues faced by modern vibration and noise engineers and practitioners.

Both India and the US are noted for their education and excellence in engineering, and many outstanding researchers are pursuing important problems in the traditional areas of vibrations. However, research in noise, sound quality, active control, machine dynamics, smart actuators, etc., has not been as prolific in India due to inadequate infrastructure and resources as well as limited opportunities for Indian scientists to travel abroad. The demands of the global economy and competitiveness are forcing the Indian scientists and research organizations to apply modern methods, yet in the area of noise and vibration, such tools are often expensive and they evolve on a very rapid basis. It is hoped that through this meeting fruitful discussions and partnerships have been formed in order to better bridge this gap and make more collaboration between the countries possible.

As with the previous India–USA symposium held in 1996 [2,3], the current workshop addressed the need to expose the Indian community to the cutting edge research and stimulate them to address noise and vibration problems of the Indian industry and society. Issues like noise pollution are drawing more attention as the sound levels in many Indian cities have been increasing on a continual basis. The most fundamental change in this regard can only be accomplished by designing quieter equipment and transport vehicles which will yield global benefits. As well, export and trade considerations require more attention be devoted to dynamic, shock and vibration specifications. New research problems must be defined within the context of the Indian economy and industry. Further, it is desirable to establish a long-term partnership on the international level and to further address common national interests and priorities in the area of noise and vibration control in order to form a focused direction on several important scientific issues pertinent to both countries.

Potential benefits to the USA, its scientists and industry are significant. This activity is expected to provide the USA with the international leadership role and prestige, and to expose its research programs to new customers such as the automotive industry that is growing in India. Major US corporations are increasing their presence in India, and are now inviting Indian Institutes of Technology, Indian Institute of Science and the like to submit research proposals given the technologically advanced work force. Likewise, Asian-Indian émigrés (in USA) are trying to raise money for the Indian institutions that have produced thousands of well-qualified engineers and scientists in the US. We invited representatives from major US companies (especially the automotive, materials, and aerospace industries) to make presentations and to support the collaborative research between Indian and US scientists and it is hoped that the symposium will help establish the US as a major player in an international market that is so vital to its national interests.

3. Symposium results and recommendations

The following three broad areas of basic research emerged. (1) New or improved problem-solving strategies: characterization of vibration and acoustic materials; structural testing, and

analysis, structure-borne issues, torsional vibrations, fault detection or diagnostics for impending failures, identification and quantification of non-linear systems, etc. (2) Smart structures and active vibration and noise control concepts: semi-active and adaptive devices, mechatronics; system integration issues; smart actuators and sensors, control of transient and quasi-steady state signals, etc. (3) New or refined computational and design techniques: improved techniques to solve complex problems involving dynamic interactions, analysis and design of engineered materials, structural dynamic modifications and modal updating, analytical methods for addressing structure–fluid interactions and dissipative effects in silencers, non-linear dynamics and chaos studies, etc. Progress in these areas is already being made by many independent researchers working on focused engineering problems [1].

Based on formal and informal discussions, the following salient points emerged: (1) It was generally felt that the symposium was a unique opportunity for academicians, engineers, researchers and experts in vibration and noise engineering from the two countries, to exchange the latest developments. (2) The quality and standard of presentations was high and all sessions were very well attended. There was a lively discussion at the end of every session. (3) It was generally felt that vibration and noise engineering was a very important area not only from the safety and environment point of view but also from the point of view of reliability of the newer products and utilities. Vibration and noise engineering signals are also very important parameters for condition monitoring and fault diagnosis. (4) The cost of research equipment in the areas of vibration and noise engineering is very high; the same applies to the engineering analyses. Therefore, inter-institutional collaboration between the two countries is worth exploring and encouraging. In particular, it was felt that there was considerable scope and interest for collaboration in research between the academics of both the countries, especially in the areas of machinery dynamics, vibration isolation and damping, duct acoustics, smart materials, non-linear problems, structural dynamic modification, etc. Each side has strength in some of these areas and research efforts may be of the complementary type, in most cases. (5) Some industrial participants from USA expressed their interest to sponsor collaborative projects between US and Indian technical institutions; however, specific proposals on focused projects would be required. (6) Finally, a strong need was expressed to alternate India–USA symposium between India and USA, say, every 3–5 years. Prof. M.L. Munjal proposed that the next symposium could be held at the Indian Institute of Science, Bangalore, say, in 2005.

The chief objectives of the symposium were successfully achieved, and indeed all delegates and observers felt that this was one of the best international meetings they had attended based on technical content, organizational considerations, and hospitality. The formal technical single session format focused lectures at the cutting edge of technology combined with the informal workshop sessions where audience participation was encouraged were cited as primary reasons for the success.

4. Contents of the special issue

Articles in this issue are organized in a sequence that emphasizes the importance of the symposium theme. First, articles on the characterization of vibration and acoustic materials are presented. Deng, Davies and Bajaj lead off with new models of viscoelastic foam, and the article by Singh and Kim compares many isolation measures for multi-dimensional systems. Next, Rao's paper summarizes recent applications of viscoelastic damping, and Chandra, Singh and Gupta

discuss the damping issues in composite materials. The next two papers study dissipative effects in ducts and silencers beginning with Munjal's paper on pod silencers and followed by a paper by Selamat, Lee, and Huff on hybrid silencers. Second, several articles on smart structures and materials are included. Narayanan and Balamurugan describe a model of piezolaminated smart structures, and then Singh, Pruthi, and Agarwal discuss active control strategies. This is followed by an article on magnetostrictive layers by Kumar, Ganesan, Swarnamani and Padmanabhan, Third, articles on non-linear dynamics and signal processing are included. Brown and Adams' article deals with structural health monitoring, and then Namachchivaya and Ramakrishnan's paper analyzes stochastic dynamics of a parametrically excited system. Subsequently, Kochupillai, Ganesan and Padmanabhan examine parametric instability in a pipe. Then Phillips and Allemang review MIMO-FRF excitation and averaging techniques, followed by an article on the estimation of modal parameters by Fladung, Phillips and Allemang. Finally, five brief articles (in the letters to the editor format) are included. Blough's paper is a survey of the rotating machinery methods which is followed by a paper on chatter recognition by Schmitz. The next two articles involve damping with Rao and Saldanha examining turbine blade damping and Garg and Anderson using active/passive techniques for vibration suppression. The edition is rounded off with a paper by Kahraman, Kharazi, and Umrani on gear dynamics. The breadth of topics offers an informative and in-depth view of current problems being researched in the area of noise and vibration control.

5. Concluding remarks

The chief objectives of the symposium were successfully achieved, and indeed all delegates and observers felt this was one of the best international meetings they had attended based on technical content, opportunities for informal discussions, organizational considerations, industrial tours, and hospitality. Single session format focused lectures at the cutting edge of technology were cited as primary reasons for the success as well as the informal workshop sessions where in-depth, pertinent discussions developed between the presenter and the audience. Differing emerging trends were, however, noted by the American and Indian delegates: Indian papers tended to focus more on modal analysis, rotor dynamics, and theoretical analyses; whereas the US delegates tended to focus on issues related to system dynamics, active vibration and noise control, spatial domain measurements, etc. using a combination of analytical and experimental approaches. It was felt that some changes in the Indian infrastructure and policies are needed to encourage application of basic research and to foster an improved linkage between industry, academia, and government. These recommendations can easily be extended to many nations around the world. Readers of the *Journal* are encouraged to send comments and suggestions to the authors of the summary report or individual papers.

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Appendix A. List of participating institutions

A.1. United States

Academia: The Ohio State University, Purdue University, Pennsylvania State University, The University of Iowa, Virginia Polytechnic Institute and State University, Duke University, University of Maryland, Michigan Technological University, University of Cincinnati, The University of Toledo, University of Illinois at Urbana-Champaign.

Industry: General Motors, Ford Motor Company, Boeing, Sikorsky Aircraft Corp., Dow Chemical, Owens Corning, Delphi Automotive, GE Aircraft Engines, Goodrich Aircraft Wheels and Brakes, Lear Corporation, Copeland Corporation, The Modal Shop, Inc., RH Lyon Corp., ArvinMeritor, Sika Corporation, Honda Corporation.

National Agencies: National Science Foundation, National Institute of Standards and Technology, National Institute of Occupational Safety & Health, US Army Research Office, National Composites Center.

A.2. India

Academia: Indian Institute of Technology, Delhi; Indian Institute of Science, Bangalore; Indian Institute of Technology, Madras; Indian Institute of Technology, Kanpur; Indian Institute of Technology, Bombay (Mumbai); Indian Institute of Technology, Roorkee; B.R.A. Regional Engineering College, Jalandhar; Motilal Nehru Regional Engineering College, Allahabad.

Industry: QuEST India Pvt. Ltd., Bangalore; Vimanapura PO, Bangalore.

National Agencies: Naval Science & Technology Laboratory, Combat Vehicle Research and Development Establishment, Chennai.

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