Journal of Sound and Vibration (1998) **211**(3), 295–299

REPORT ON THE PROCEEDINGS OF 1996 INDIA–U.S.A. SYMPOSIUM ON EMERGING TRENDS IN VIBRATION AND NOISE ENGINEERING

R. SINGH

Acoustics and Dynamics Laboratory, *The Ohio State University*, *Columbus*, *OH* 43210-1107, *U.S.A.*

AND

B. C. NAKRA

Department of Mechanical Engineering, *Indian Institute of Technology*, *New Delhi* 110016, *India*

(*Received* 15 *October* 1997)

The joint symposium was held at the IIT Delhi on March 18–20, 1996, and focused on basic research issues and trends in the general area of vibration and noise engineering. Forty-two papers were selected for the three-day meeting on relevant topics including machine dynamics, diagnostics, vibro-acoustic analyses of structures and equipment, computational techniques, modal analysis, dynamic design concepts, passive and active damping, smart actuators and sensors, intensity techniques, and non-linear problems in vibration and acoustics. The impact of new and emerging technologies was illustrated through case studies and personal experiences. The workshop is expected to stimulate research and collaboration on a multi-national basis. Selected articles are published in this special edition of the journal for archival purposes and for dissemination to the global noise and vibration control community.

© 1998 Academic Press Limited

1. INTRODUCTION

The Indo–USA symposium was held at the Indian Institute of Technology, Delhi (India) on March 18–20, 1996. Chief objectives of the symposium were to exchange information and latest research findings, to discuss and identify key research questions/trends in vibration and noise engineering which must be addressed in the future, to provide an opportunity for a closer interaction between leading U.S. and Indian experts, and to facilitate collaborations.

The symposium was sponsored by the National Science Foundation of USA and various institutions of the Government of India. It was organized by the Indian Institute of Technology, Delhi (India) and The Ohio State University, Columbus (USA). The authors of this article served as the chief organizers, with R. Singh as the U.S. delegation co-ordinator and B. C. Nakra as the co-ordinator of the Indian delegation. Such a workshop was held for the first time in India, and virtually the entire Indian vibration and noise engineering community attended it. Over 100 delegates and observers participated, including 20 from research and development organizations and 31 from industry, covering mechanical, aerospace, civil, materials, and agricultural engineering disciplines. Twelve delegates travelled from the USA. Overall, 42 articles including state-of-the-art papers from 27 invited experts were presented on the following subjects: analytical methods,

0022–460X/98/130295 + 05 $25.00/0/sv971398 © 1998 Academic Press Limited

machinery dynamics, active control, acoustics and noise control, vibration damping, non-linear problems, experimental methods and diagnostics, and modal analysis and structural dynamic modifications. These were published in the proceedings [1] that were edited by Nakra *et al*. A single session format was used to ensure maximum possible discussion and interaction. The focus was on the latest technology and scientific research issues but presented through case studies, state-of-the-art review papers and personal experiences of the specialists. The organization of the symposium was similar to the 1993 Korea–U.S.A. Vibration Engineering Seminar [2] that was also attended by a majority of the U.S. delegation including the first author.

Selected papers from the proceedings [1] 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 Americas Editor, W. Soedel, co-ordinated and edited the entire issue and handled the reviews of the article by Rook and Singh [3]. 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, operational loads, compact and lightweight designs, and engineered materials. Experimental work is evolving very rapidly with the advent of high speed processors, signal processing and control modules, smart sensors and actuators, and digital instrumentation in general. Now 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 and reliable products, machines, and equipment is well recognized. Additionally, since the recent emphasis has been on the sound quality and vibration perception considerations, some cognitive techniques are being integrated into this discipline. For example, consumers may perceive quality of products such as automobiles and appliances in terms of their sound and vibration characteristics. Consequently, the industry must focus on two objectives: (1) to meet environmental/health regulations and standards, and (2) to design high quality, durable, competitive and customer friendly products. Such technical issues obviously impact upon the industrial competitiveness and global trade considerations as well. Much fundamental research is obviously needed to address the technological and societal issues as faced by modern vibration and noise engineers and practitioners.

The following three broad areas of basic research emerge. (1) Diagnostic and Experimental Techniques: modal testing, analysis and synthesis; fault detection or diagnostics for impending failures; acoustic and structural intensity techniques; optical techniques for vibration measurements; sound perception and quality issues; identification and quantification of nonlinear systems; etc. (2) Active Control and Smart Structures: 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) Analytical and Design Techniques: new or improved techniques to solve complex problems involving dynamic interactions; analysis and design of engineered materials; structural dynamic modifications and model updating; analytical methods for addressing sound–structure–fluid interactions; non-linear dynamics and chaos studies; etc. Progress in these areas is already being made by many independent researchers working on focused engineering problems. However, links must be established with other experts around the world. It was quite evident from the results of the successful 1993 Korea–U.S.A. Vibration Seminar that was also sponsored by the NSF [2].

India has been noted for its 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, diagnostics, machine dynamics, smart actuators, etc., has been lacking due to inadequate infrastructure and resources as well as limited opportunities available to Indian scientists to travel abroad. Yet the demands of global economy and competitiveness are forcing Indian industry and research organizations to apply the modern tools. In the area of noise and vibration, such tools are often expensive and they evolve on a very rapid basis.

It seemed that no international conference or an important national meeting on vibration and noise had taken place in India during the last decade. Obviously, there was a need to organize a symposium which could expose the Indian community to research at the cutting edge, and stimulate them to address noise and vibration problems of Indian industry and society. For instance, the issue of noise pollution is now attracting more attention because sound levels in most Indian cities have been increasing on a continuing basis. The most fundamental change in this regard can only be accomplished by designing quieter equipment and transport vehicles. Also, export and trade considerations require that 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 with international partners. One of the objectives of this symposium was to seek ways to identify common national interests and priorities in the area of noise and vibration control. It is believed that a discussion of the future problems is definitely in the interest of the entire community since a focused direction on several important science issues often emerges from such meetings [1, 2].

3. SALIENT OBSERVATIONS AND RECOMMENDATIONS

Based on the personal observations of several delegates, as recorded by a team led by S. Suryanaryan of the IIT Bombay, a summary of the salient observations and recommendations is as follows. (1) This symposium provided a unique forum between academia, practising engineers, researchers, and experts in vibration and noise engineering. The Indian community from academic institutes, research labs, and relevant industries was well represented. It was also noted with satisfaction that many institutions and organizations sponsored the event. (2) All sessions were very well attended, and the quality and standard of presentations were very high. The delegates in particular appreciated the timely publication and quality of the proceedings [1] and the offer of the *Journal of Sound and Vibration* to publish a special edition. (3) Vibration and noise engineering is an area that will demand significant research effort in the next century, keeping in view the stringent requirements on the reliability of newer products and utilities. Consequently, the importance of this discipline should also be viewed from the standpoints of design, production, and maintenance of equipment and plants. This needs to be brought to the attention of Indian funding agencies and private sector interested in producing world class products. (4) Efforts should be made to modernize instructional laboratories and to prepare students in the latest technology. However, since the cost of research equipment is rapidly increasing due to its sophistication, collaboration for inter-institutional use must be explored. (5) There is considerable scope and interest for collaboration in research, especially in the areas of machinery dynamics, active control, acoustics, vibration damping, nonlinear problems, condition monitoring and diagnostics, modal analysis and structural dynamic modification, etc. Each side (U.S.A. or India) has significant strengths in some of these areas, and research efforts may be of complementary type. (6) A strong need was

felt to continue workshops of this type on a periodic basis, say at a four-year interval, for an exchange of ideas and information. The planning process for the next symposium will begin soon.

4. CONTENTS OF THE SPECIAL ISSUE

Articles of this edition of the Journal are organized in a sequence that emphasizes the importance of the symposium theme. The first article by Allemang and Brown presents a unified approach to modal identification. Then Mitchell *et al*. discuss structural imaging concepts using laser scanning methods. Chu and Trethewey show procedures for making rapid design changes, based on an experiment based finite element method. Yet, another computationally efficient approach is proposed by Ravi *et al*. for damped structures. Rook and Singh present a computational strategy for vibratory power flow through joints and rolling element bearings. Then Parker and Mote discuss the eigensolutions of wave equations when perturbations are present in boundary conditions. Narayanan and Sekar discuss the semi-analytical methods for solving non-linear dynamic problems.

Subsequently, Munjal summarizes muffler analysis and design considerations, as carried out by his research team. Dickey *et al*. complement this by presenting new experimental and computational results for automotive silencers. Nakra summarizes the state-of-the-art on passive damping analysis and design. Then Baz presents active damping control concepts. Hall and Flatau discuss magnetic transducers to be used for active control of structures and then Narayanan and Senthil propose an optimal control scheme for a nonlinear suspension problem. Finally, letters to the editor present four technical notes on a variety of topics. Ramamurti and Rao discuss structural modification; Gupta and Singh address composite rotors; Manik examines the coupling loss factors in statistical energy analysis; and Srivastava and Kundra present an optimal structural modification procedure.

5. CONCLUDING REMARKS

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 contents, organizational considerations, and hospitality. Single session format focused lectures at the cutting edge of technology were cited as primary reasons for the success. Interestingly, differing emerging trends were noted by the American and Indian delegates; this was expressed by L. D. Mitchell of Virginia Tech, on behalf of the U.S. delegation. For instance, papers by Indian authors concentrated more on conditioning monitoring, Fourier analysis applications, rotor dynamics, and theoretical analyses. Conversely, the U.S. delegation discussed issues related to active vibration and noise control, spatial domain measurements, gear/system dynamics, etc., using a combination of analytical and experimental approaches. Also, the U.S. delegates felt that the Government of India should seriously consider proposals on computerized literature searches, internet databases, research equipment upgrades, and instructional grants. It was felt, some changes in the Indian infrastructure and policies are needed to encourage application of 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.

ACKNOWLEDGMENT

We would like to thank the following institutions for sponsoring this symposium: IIT Delhi (India); National Science Foundation (USA); The Ohio State University (USA); Department of Science and Technology (Government of India); All India Council for Technical Education; Indian National Science Academy; Council of Scientific and Industrial Research (India); Aeronautical R & D Board (India); Thapar Corporate R & D Centre (Patiala); Central Mechanical Engineering Research Institute, Durgapur; DLF Industries Ltd. (Faridabad); Mahindra & Mahindra (Bombay); IIT Bombay and IIT Madras. The authors thank co-organizers and colleagues, K. Gupta and T. K. Kundra of IIT Delhi, who made this symposium possible through careful planning and execution. Additionally, the following individuals from IIT Delhi are acknowledged for providing assistance: V. S. Raju, U. R. K. Rao, V. P. Agrawal, N. T. Asnani, K. Athre, T. K. Datta, Y. Nath, N. Tandon, and G. S. Yadava. We also wish to thank the following individuals for their help in making this symposium possible: O. Shinaishin, M. Lueck, and D. P. Garg of the NSF (USA); P. C. Maxwell of the U.S. Embassy in Delhi; A. P. Kulshreshtha and S. Gupta of DST (India); and R. N. Panda of MHRD (Government of India). In particular, authors and referees should be recognized for their contribution and patience. Finally, all of us gratefully acknowledge editors and staff of the *Journal of Sound and Vibration* and especially W. Soedel and P. E. Doak, for their role in facilitating this special edition.

REFERENCES

1. B. C. Nakra, R. Singh, K. Gupta and T. K. Kundra 1996 Emerging Trends in Vibration and Noise Engineering. *Proceedings of INDO–US Symposium on Emerging Trends in Vibration and Noise Engineering*, Indian Institute of Technology, New Delhi, India, March 18–20. ISBN 81-7023-532-4. New Delhi, India: Allied Publishers.
2. J. M. Lee and R. H. Lyon (organizers) 1993 *Proceedings of the Korea–US Vibration Engineering Seminar*. KAIST, Taejon, Korea, March 22–24.