COMPARISON AND DISCUSSION ON NONCONTACT ULTRASONIC SENSORS: INTRODUCTION

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Abstract: This paper will provide a historical perspective on the evolution of noncontact sensors and an introduction to three review papers in the areas of laser based transduction (Monchalin, IMI, Canada), air coupled transduction (Bhardwaj, Ultran USA) and electromagnetic transduction (Alers, Sonic Sensors, USA). The three papers will be followed by a panel discussion in which the above speakers will be asked by the moderator/audience to compare attributes, advantages, and limitations and other attributes of these noncontact transdutive approaches.

Introduction: Noncontact transduction has long been one of the holy grails on ultrasonic NDT/NDE. Traditionally, the excitation of ultrasonic waves requires at least fluid contact with a part, e.g. a water couplant during immersion testing or a thin layer of a viscous fluid during contact testing. However, over the last 30 years, novel physical ideas have led to various forms of couplant-free transduction. Included are direct electromagnetic interactions with metal or magnetic materials, laser-based techniques taking advantage of ablation or thermal expansion in excitation and interferometric strategies on detection, capacitive microphones for detection on metals, and air-coupled transducers for all materials. Although generally of lower efficiency than fluid-coupled piezoelectric transducers [1, 2], the absence of a couplant leads to many advantages such as the ability to operate at elevated temperatures, on a moving part, and at a distance. To the author's knowledge, capacitive microphones have been used primarily in the laboratory. However, the other three techniques have seen significant development and are now available from a number of commercial sources for industrial use.

Results: This session will provide the audience with an overview of each of these three forms of industrially used, non-contact transduction processes, followed by a panel discussion of their relative advantages, disadvantages and application niches. The session will be introduced by a historical perspective, noting some of the major steps in the evolution of the technologies. Three 20 minute papers will then follow, describing the current status of laser based (Monchalin, IMI, NRC, Canada), air coupled (Bhardwaj, Ultran, USA) and electromagnetic (Alers, Sonic Sensors, USA) techniques [3-5].

Discussion: The session will conclude with a panel discussion designed to elucidate the similarities and differences of the techniques, their advantages and disadvantages, and the applications best suited to each. The panelists will be the three primary speakers. Each will be given the opportunity to answer a series if questions posed by the moderator related to such operational issues as sensitivity, surface requirements, cost, degree of lift-off tolerated, ability to operate in pitch-catch versus through transmission, ability to operate at elevated temperatures, ability to excite various types of waves, with or without mode purity, etc. The floor will then be opened to question from the audience.

Conclusions: Noncontact ultrasonic sensors have come a long way, from curiosity-driven research to extensive practical use. These advances have been driven by better understanding of their physical principles of operation developed by researchers in the field, improved enabling technologies driven by advances in other areas of engineering, and a more experienced user community able to conceive and implement practical applications. It is hoped that the reviews/discussions to be presented in this session will be another important step in the journey from curiosity to practice.

References:

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Quantitative Nondestructive Evaluation, Vol. 14A, D.O. Thompson and D.E. Chimenti, eds. (Plenum Press, NY, 1995) pp. 967-974.
3. J.-P. Monchalin, "Non Contact Generation and Detection of Ultrasound with Lasers," Proceedings of the 16th World Conference on Nondestructive Testing, 2004.
4. M. Bhardway, "Evolution of Piezoelectric Transducers to Full Scale Non-Contact Ultrasonic Anaylysis Mode," Proceedings of the 16th World Conference on Nondestructive Testing, 2004.
5. G. Alers, "Electromagnetic Induction of Ultrasonic Waves: EMAT, EMUS, EMAR," Proceedings of the 16th World Conference on Nondestructive Testing, 2004.