52 韓國非破壞檢査 第2卷 第2號, pp.52~55, 1982

韓國標準研究所의 非破壞 試驗計劃

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Nondestructive Testing Programs at Korea Standards Research Institute

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Korea Standards Research Institute (KSRI) was established in December 1975 as a primary standards laboratory in Korea. The institute acts as the central authority on all the national measurement standards, and provides the essential basis for the scientific, technological development of the nation by establishing and maintaining the national measurement standards.

Importance of NDT Standards Programs

Failures of machines and structures are costly and usually occur unexpectedly causing loss of properties and/or human lives. Therefore, in an effort to prevent accidents and thus to minimize unexpected expenditure NDT is often employed for quality inspection of industrial products during their manufacture and operation.

Nuclear power plant is a typical example where reliable NDT is essential. It is natural for Korea, who has no oil resources, to rely heavily on nuclear power to meet the increasing needs of energy. Currently there is one nuclear power plant in operation, 8 units are in construction and by 1991 more than ten units are planned to be in operation. By that time about 60% of electric power demand will be met by nuclear power. NDT has been also in great demand in heavy- and chemical industries expanded extensively during the last decade. As a result the demand for better standards for reliable NDT is greater than ever.

In order to develop and maintain better NDT standards and thereby to improve the reliability of NDT a laboratory was established at Korea Standards Research Institute in 1980. The standards programs of the NDT laboratory have been appreciated by industries as they begin to realize the importance of the quantitative and reproducible nondestructive testing.

There are two important parameters defining the nondestructive inspection: the inspection threshold and the inspection uncertainty. The inspection threshold is the discrimination level which is set to discriminate among classes of thing. In a simple case it is yes or no point. The inspection uncertainty is a measure of the uniformity of the inspection method; that is a measure of how well one can make the discrimination with a particular system.

The level of inspection threshold drives two cost factors towards opposite directions. As the inspection threshold gets higher, the number of rejected articles increases raising the production cost whereas the probability of accidents or failures decreases lowering the unexpected expenditure. The total costs can be minimized when proper threshold is established.

The inspection uncertainty also plays an important role in determining the total cost. Even if proper threshold is established, larger the measurement uncertainty greater the number of articles discriminated mistakenly. Sometimes serviceable articles could be rejected, and results in raising the production cost. At other times unserviceable articles may be accepted, which may cause trouble during the operation and requires the unexpected expenditure. Consequently the total cost can be minimized when proper threshold is established and also when the inspection uncertainty is reduced.

Our NDT standards programs can be grouped into two projects, one being related to inspection threshold the other to inspection uncertainty. First project is the research and development of NDT technology in relation to the mechanical properties of material, fracture mechanics in particular. This study would help to establish proper standards for inspection threshold. Second project is to provide the industries with calibration services and reference materials. These services would help to reduce inspection uncertainty and thereby make the nondestructive testing to be reliable.

NDT Research in Relation to the Mechanical Properties of Material

Fracture mechanics technology provides a modern engineering tool for dealing with various factors involved in the structural reliability of equipment or components. For many years, structures were designed according to a zero-defects philosophy. Recently, fracture mechanics design procedures have been adopted to recognize that defects are present in any structure and they will not be expected to lead to failure unless they exceed a certain size determined by the properties of the material and the loads during its service life. It is then required to detect, with high validity, those flaws exceeding this critical size. This can be performed with quantitative nondestructive measurement, which constitute a vital part of modern fracture mechanics analysis. Followings are the NDT research activities at KSRI in relation to the fracture mechanics.

Recently an experimental work has been initiated for recently developed composite materials to study the fracture instability in the presence of a crack. The essence of the approach is to relate the stress field developed in the vicinity of the crack tip both to the applied stress on the structure and to the critical size of defect necessary to cause failure. In this study the shape and the orientation of cracks should be characterized quantitatively by using NDT.

Work is also in progress to characterize the acoustic emission signal. In this study, waveform charac-

teristics of acoustic signal expected to the emitted by a moving defect in glass will be theoretically predicted and compared with experimental results. The experimental technique developed in this study will be employed for the improvement of transducer calibration.

In another study, conventional parameters for acoustic emission signal analysis are also investigated to characterize the crack opening displacement. From a fracture mechanics and structural reliability analysis point of view, the ultimate development of this NDT tool has a tremendous potential. For example, if it becomes possible to establish quantitative correlations between some acoustic emission signal for a crack propagation in a structure and fracture toughness, one can then use this information to evaluate the remaining life of the structure using fracture mechanics analysis.

The effect of stress on hardness of metal is being investigated by employing ultrasonic hardness measurement technique during tension test. With this increased knowledge about the materials response to loading under real conditions, we are learning how to extract the maximum performance from the available materials and thereby optimize their usage. Along with the current research, our concern will be also directed toward the development of improved NDT methods for material property characterization.

Calibration Services and SRM Preparation

NDT, like other quality control processes, is a method by which we compare the unknown with the known. The "known" we generally refer to as calibration sources or standard reference materials (SRM). Equipment calibration and calibration source are prerequisite for the reliable nondestructive testing.

The calibration of equipment and the preparation of SRM require measurements in various fields such as X-radiation, electrical properties, magnetic field strength, sound properties and optical properties. As national standards organization, KSRI has the measurement capabilities with high accuracy in these fields and the measurements are traceable to those of international standards organizations. The calibration services and SRM that KSRI provides are, therefore, traceable to the international standards. Our calibration services and SRM in relation to the radiography testing and ultrasonic testing will be discussed briefly.

Radiography

A poor quality radiograph, which has been produced by using inadequate SRM or testing procedure, may not have the sensitivity or clarity necessary to reveal many indications which could significantly affect the serviceability of the test object. Since the effectiveness of flaw detection is greatly dependent upon radiographic quality, it is very important that poor quality radiographs be recognized during the course of film review and that only those radiographs of satisfactory quality be accepted for interpretation.

Apparatus for measuring film density is an absolute necessity for these jobs and it should be cali-

brated frequently. Thus, X-ray film step tablets are prepared at our institute and supplied to industries for on-site calibration of densitometers. The calibration service of the film step tablets is also available. For the proper exposure adjustment of welded part radiography step wedges are also prepared as SRM and supplied to industries.

Ultrasonic

Pulse-echo ultrasonic techniques offer great potential for detecting and evaluating material defects nondestructively. However these methods are sensitive to the characteristics of measurement equipments and the condition of the reference artifacts used.

Our emphasis is placed on the characterization of transducers and reference blocks. Currently transducer calibration service is available for spectral characteristics and beam profile. For the calibration of ultrasonic reference blocks, the reflection characteristics can be compared with those of our interim aluminum reference blocks which were intercompared with those of National Bureau of Standards in the United States. We also provide industries with technical assistance for the ultrasonic testing of specific test pieces.

Conclusion

The success of nondestructive testing in industry depends on the proper use of standards. Standards are used to calibrate equipments, to assure reproducible results and to help determine what is acceptable and what is not. The objective of NDT program at KSRI is to develop better NDT standards and to maintain the measurements traceability to the international standards.