ANALYTICAL METHODS FOR CALCULATING DIMENSIONAL UNCERTAINTY IN ULTRASONIC TESTING

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Abstract

This paper depicts a project undertaken in the offices at Defence Research development Organisation (DRDO), Gas Turbine Research Establishment (GTRE)) Bangalore. Non-Destructive Testing (NDT) methods are used to determine the integrity and reliability of parts without impairing their future usability. They can be classified as methods used for the detection of Surface, Internal anomalies. Ultrasonic Testing is a versatile NDT method which can be used for both the above purposes and use high-frequency sound waves (above 20 KHz) to penetrate the object and conduct the examination. This method was selected for the purpose of estimating the associated dimensional uncertainties while sizing the defects. Specimens were manufactured with artificial holes of 0.5 mm diameter and varying depths in cylinders made out of work-house aerospace materials of Ti-64 (blades and disks of a compressor), Su-718 (Super alloy used for hot end parts) and S-80 (stainless steel used for gear parts) in conformance to international standards. These blocks were subjected to Contact and Immersion Ultrasonic Testing methods. Transducers (probes) of two different frequencies (5 MHz and 10 MHz) were chosen for both the methods to understand the effect of probe sensitivity on the uncertainty estimation. For each of the blocks conducted three different trials for the measured depth of defect Vs actual depth of defect and values were tabulated. Regression Analysis was chosen for obtaining the Type-A uncertainty owing to the availability of limited data and linear relationship among the variables, while Type-B was derived from standard statistical calculations specified in "Guide to Expression of Uncertainty in Measurement" (GUM) as per ISO 17025 and combination of random and systematic errors. Standard uncertainty was calculated for both Type-A and B methods. Combined uncertainty was derived which represents the contribution of ultrasonic system, calibration blocks along with measurement results. The expanded uncertainty represents the combined uncertainty with a confidence interval of k=2 (i.e. 95 % confidence level).The combined and expanded uncertainty were obtained by Type B method. It was analysed and concluded that Type-A is conservative in approach and under estimates standard uncertainty values, whereas Type-B results in higher estimates. The results show that the uncertainties are sensitive to variations associated with material attenuation property, defect diameter, probe frequency.

Keywords: Non-Destructive Testing, Uncertainty, Ultrasonic Testing, Mean, Standard Deviation, Regression.