ABSTRACT

Nondestructive evaluation (NDE) plays an important role in ensuring structural integrity of engineering components through detection and sizing of flaws. It is very important to detect flaws in components at the early stages to prevent catastrophic failures. Eddy current (EC) NDE technique is simultaneously influenced by several variables such as surface roughness, variations in probe lift-off, variations in electrical conductivity and magnetic permeability and variations in geometry, apart from flaws. These variations produce large amplitude noise and thus, often mask information from shallow surface flaws as well as deep seated flaws. Although EC imaging is helpful, detection of shallow surface flaws in the presence of such composite noise is challenging.

Removal of noise in EC images is time consuming, as it involves the use of several methods of processing depending on the sources of noise. The reported literature on processing of EC images, influenced by noise, is limited to handling one disturbing variable at a time. Information related to processing of composite noise in EC images is scarce in open literature. This demands development of image processing approaches for automated removal of noise in EC images while retaining maximum possible information related to flaws.

This thesis presents the development of image processing approaches for noise reduction in EC images of surface flaws in AISI type 316 Stainless steels. It incorporates spatially adaptive noise filtering using multiresolution analysis by Discrete Wavelet Transform (DWT). It explores Independent Component Analysis (ICA) technique that involves separation of sources of noise based on their statistical independence.

Extensive studies have been carried out on the EC images acquired from plates, weld plates and thin walled tubes made of AISI type 316 stainless steels to develop the DWT
and ICA based approaches. Performances of these approaches have been evaluated using Noise Reduction Percentage (NRP) and Signal to Noise Ratio (SNR).

This thesis proposes a hybrid image processing approach by combining the advantage of the noise reduction ability of DWT based approach and the flaw retention ability of ICA based approach. A significant enhancement in flaw amplitude has been achieved by the proposed hybrid approach as compared to the individual processing approaches. The hybrid approach is found to be noise tolerant to variations in lift-off up to $\leq 1.5$ mm.

The efficacy of the proposed hybrid approach has been successfully demonstrated on EC images acquired at various frequencies (20 kHz, 75 kHz and 150 kHz) using probes of 3.0 mm, 5.0 mm and 20.0 mm diameter. The denoising capability of the proposed hybrid approach has been successfully validated on the influence of composite noise from variation in lift-off and wall thickness (geometrical variations) in thin wall SS tubes. The applicability of the proposed hybrid approach has been evaluated for enhancement of sub-surface flaws and natural crack.

The hybrid approach proposed in this thesis has significantly enhanced the flaw detection sensitivity. It has also provided better insight into the existence of statistical dependency and utilization of dependency for enhanced effective separation of flaw information. The approach proposed in this thesis can be applied to EC images of flaws of varying orientation, width and depth and can be extended to other NDE images.