High Sensitivity Ultrasonic NDE Method for Early Detection of Creep Damage in Alloy Steel Steam Systems in Power Plants

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ABSTRACT
Creep is the time-dependent, thermally assisted deformation of a component operating under stress. Metal pressure components such as boiler tubing, headers, and steam piping in power plants might operate at thermal conditions conducive to causing creep damage over the operating life of the component. To ensure safe and reliable operation of such components in service, utilities periodically use non-destructive evaluation (NDE) techniques to inspect these components for damage. These inspections are largely targeted at detecting late stage creep damage in which cracking is active in the component and provides qualitative rather than quantitative data. Recent advances in NDE technology have provided enhanced capabilities for incipient creep failure detection. In this work we seek to develop a high sensitivity NDE system that will apply time reversal focusing (TRF) and full matrix capture (FMC) ultrasound testing techniques that have already shown a capability to identify early stage creep damage, and to produce a library of defects with the aim of providing inspection limits and the probability of detection for the technique and thus enable accurate life cycle prediction for components under inspection. For this purpose, an analysis of specimens with a range of creep induced damage has been performed with the aim to generate a specimen set with representing Type IV creep damage in an early stage of damage. Modelling and experimental validations were performed that determine the amplitudes of the ultrasound signals reflected by small diameter reflectors with dimensions down to 5 microns. The experiments have shown that small cracks with dimensions close to several micrometres, caused by creep damage, should be detectable using ultrasonic focusing transducers with frequencies 25-50MHz. Future signal analysis work (including FMC and TRF) and mechanical scanning prototype system design for in-situ testing are envisaged and presented.

CONCLUSIONS
The general object of the project partly presented in this work is the development of a novel inspection technique enabling detection of creep damage defect in early stages of their growth. Solution of such task requires detection of very small defects with dimensions starting with several micrometres up to several tens of micrometres. The task is partially simplified by the fact that not a single crack, but some cloud or line of them should be detected. Preliminary analysis of the different inspection methods has shown that only several of them in principle enable detection of so small reflectors. The current state analysis have demonstrated that the most promising technique detection of creep damage is measurement of the back scattered signals using high frequency focused transducer, while the effective power and usefulness of the FMC and TRF algorithms are still under investigation. However in order to estimate possibilities of this technique, further theoretical and experimental investigations should be carried out and parameter of ultrasonic system which meets the requirements of the project should be determined and optimized.