Chapter 1

Introduction

The aim of this work was to investigate the use of magnetic property measurements as a nondestructive tool for microstructural evaluation in power plant steels. A survey of the existing literature pointed to Barkhausen noise as a suitable property for investigation. A new model for Barkhausen noise from power plant steels was proposed and tested using previous published data. New data for further model testing were generated from $2\frac{1}{4}$Cr1Mo and 11Cr1Mo (wt. %) power plant steel samples. Detailed characterisation of the grain structures in these steels was carried out to study the role of grain boundaries in Barkhausen noise. Experiments on an oxide dispersion strengthened alloy, in which the grain size and oxide particle distribution could be varied separately, were used to give further clarification of this.

Power plant conditions and the physical metallurgy of power plant steels are discussed in Chapter 2, which also reviews some of the existing methods of nondestructive microstructural evaluation.

The concept of magnetic domains is essential for understanding the microstructural dependence of magnetic properties. The theory of domains is given in the first half of Chapter 3. Observations of the interactions between the domain structure and microstructural features appear in the second half.

Chapter 4 introduces the magnetic properties commonly used in microstructural characterisation, including magnetic hysteresis and Barkhausen noise. Previous work on the relationships between microstructural features and magnetic properties is reviewed, with particular emphasis on studies of

Barkhausen noise in tempered martensitic steels.

Insights from one of these studies were used as the basis for a new model of the microstructural dependence of the Barkhausen signal in tempered steels. Chapter 5 summarises existing models of hysteresis and Barkhausen noise, describes the derivation of the new model and gives details of model testing using published data from the literature.

Chapter 6 describes the preparation of power plant steel samples. Optical micrographs, hardness and coercive field data and estimates of the microstructural feature sizes are given in this chapter. A subset of the samples were selected for more detailed characterisation using the technique of Orientation Imaging Microscopy in the scanning electron microscope. Chapter 7 explains the basis of this technique and presents micrographs and analysis.

Barkhausen noise experiments on the power plant steel samples are described in Chapter 8. The data generated were used to fit the new model; the results are given in Chapter 9.

Chapter 10 gives details of experiments performed on an oxide dispersion strengthened alloy with the aim of understanding the role of grain boundaries and particle dispersions in hysteresis and Barkhausen noise.

Chapter 11 summarises the findings of this study and gives suggestions for future directions in which this work can be taken. The code of the model fitting program and a description of its operation are given in the Appendix.