Chapter 8
Summary and Future Work

8.1 Introduction

This Chapter of the thesis entitled "Tensile and Low Cycle Fatigue Behavior of Modified 9Cr–1Mo steel" summarizes the important observations and also includes suggestions for future research.

8.2 Summary

Systematic investigation was carried out on tensile and low cycle fatigue behavior of modified 9Cr–1Mo steel at different temperatures and strain rates. The important observations made on different aspects are listed at the end of respective chapters and major findings related to the work are given here. The major findings is divided into two parts and summarized below:

8.2.1 Tensile Behavior

The modified 9Cr-1Mo steel in normalized and tempered condition is found to exhibit dynamic strain ageing over the temperature range from 250–400 °C, based on the its anomalous behavior such as plateau/peak in yield, tensile strength, minima in ductility, serrations in stress–strain curves, negative strain rate sensitivity and Snoek peak in internal friction. Typical features of dislocations; like bowing and loop formation are also observed in the region of DSA. Nitrogen element was identified responsible for the occurrence of DSA.

The typical rosette fracture with central fibrous zone, radial cracking at different angular interval resulting from longitudinal splitting and very fine shear lip zone is observed in the temperature range from -70 to 80 °C. Longitudinal splitting occurred due to formation of voids and their coalescence around the carbides particles along the prior austenite grain/lath boundaries and the stress distribution in the necked region. This fracture is found to be independent of texture and strain rate.

8.2.2 Low Cycle Fatigue Behavior

The modified 9Cr–1Mo steel exhibits cyclic softening irrespective of strain amplitude, strain rate and temperature. However, inverse dependence of strain rate on cyclic stress response, fatigue life, plastic strain amplitude and fatigue crack propagation is observed. This suggests occurrence of DSA under cyclic deformation at 300 °C.

Cyclic softening is attributed to transformation of tempered lath martensite structure to cell structure. Also there is decrease in dislocation density at room temperature, in addition to above factors annihilation of dislocations at 300 °C. Several other factors contributed to LCF behavior of this steel at 600 °C such as coarsening of carbides, grain rotation and annihilation of dislocations. The formation of cell structure is found to be strongly dependent on the strain amplitude. It increased with increase in strain amplitude. The modified 9Cr–1Mo steel exhibits transition from non–Masing to Masing behavior at ±0.375% at RT and 300 °C and it is associated with change in the equiaxed cell structure at low strain amplitudes to elongated cell structure at high strain amplitudes.

Inter striation spacing is found to increase with increase in strain amplitude at all the test temperatures. Oxidation of the steel is observed at 600 °C. The reduction in fatigue life at low strain rate may be due to increase in the severity of the oxidation at 600 °C.

8.3 Suggestions for Future Work

The following suggestions are made for future investigations based on the present investigation:

- Simulation of the rosette fracture in tensile deformation.
- Prediction of low cycle fatigue results at different temperatures using different models.
- Creep fatigue interaction study of this material at different temperatures.
- Examination of the microstructural stability.