Chapter-7
Summary and Suggestion for Future Work

Summary and Suggestion for future work

7.1 Introduction

This chapter summarizes the important observations presented in the thesis and gives brief incitement of the scope of future research to be carried out.

7.2 Summary

7.2.1 Oxidation Behavior

The cyclic oxidation behavior of low nickel nitrogen stabilized austenitic stainless steel (Fe-18Cr-21Mn-0.65N) was studied up to 100 h from 400-700°C in static and dynamic humid air environment. The oxidation rate was lower in the specimens exposed at 400 and 500°C and increased rapidly for the specimens exposed at 600 and 700°C. Oxidation from 500 to 700°C resulted in formation of duplex oxide layer, with Mn oxide at the top and spinel of Mn, Fe, Cr, and O ($CrFeMnO_4$, Fe_2MnO_4, $FeMn_2O_4$) at the bottom. Increasing flow rate causes decrease in oxidation rate at 700°C which was attributed to Cr evaporation from the oxide layer. There was cellular precipitation of HCP chromium nitride (Cr_2N) at 600 and 700 °C, while at 500 °C, faceted globular morphology was observed. This steel is oxidation resistant up to 500°C; therefore, it can be used in air/moist air environment cyclically up to 500°C for 100 h, without the risk of harmful precipitation.

7.2.2 Metal Dusting

Metal dusting features of the austenitic stainless-steel Fe-18Cr-21Mn-0.65N, with extremely low nickel, was studied in the temperature range of 400-700 °C, for 300 h in high carbon activity (ac > 1) syngas environment (75%H_2+25%CO). In reducing atmosphere at 400 and 500°C, heavy depositions of carbon due to high activity of carbon resulted in pits formation of shallow depth. Metal dust contains metal and oxide particles embedded in the carbon filaments. Higher temperatures of 600 and 700°C resulted in formation of two layers oxide of Mn and its spinel, which inhibited carbon deposition in environment a_c>1. The presence of few metal carbides/oxides showed that initially the

process started with carburization reaction but later oxidation of these carbides took place. The alloy exhibited Type III mechanism of metal dusting in which initial carburization and then selective oxidation of metal carbides takes place. In reducing atmospheres of CO and H_2, the alloy exhibited resistance towards metal dusting and can be used below 500℃.

7.2.3 Solid Particle Erosion Behavior

High temperature erosive wear behavior of the pre-oxidized high manganese nitrogen stabilized austenitic stainless steel (Fe-18Cr-21Mn-0.65N) was studied at three different impingement angles of 60°, 75° and 90° at 400 to 700 °C. In erosive atmosphere the erosion rate increased. It was 3.6g/g for the unexposed condition and 7.65g/g for that oxidized at 700℃, at the impact angle of 60°, owing to deterioration of tensile strength at 700℃. Erosion rate increased with decrease in impingement angle. High temperature exposure reduced the tensile strength and hardness of the material due to precipitation of harmful chromium nitrides (Cr_2N). Ploughing/ metal cutting at lower impingement angle was primary mechanism of erosion while at normal angle of impingement craters and ridge formation led to material removal. Compared to conventional 316 austenitic stainless steel, the Fe-18Cr-21Mn-0.65N steel performed better in high temperature erosive atmosphere and can be used up to 500℃.

7.2.4 Potentiodynamic Corrosion Behavior

The effect of exposure at intermediate temperature from 400-700℃ for 100 h, on corrosion behavior of the Fe-18Cr-21Mn-0.65N austenitic stainless steel was studied in 0.5 M NaCl solution. The results were compared with solution annealed samples (unexposed). In aqueous chloride medium, this material showed resistance against corrosion in solution annealed condition whereas with increase in exposure temperature and time, corrosion current density increased. Pitting was primary mechanism of corrosion of the unexposed material and that exposed up to 500℃. On the other hand, intergranular attack with pitting,

accelerated corrosion, from preexposure at 600 and 700℃. This material is not recommended for use in chloride medium in pre-exposed condition at elevated temperature as well as in the solution treated condition.

7.3 Suggestions for Future Work:

1. The following suggestions are made for future work on Fe-18Cr-21Mn-0.65N austenitic stainless steel, based on the present investigations:
2. Long-time exposure Study of oxidation and metal dusting, following longer exposures at 400 and 500℃.
3. Effect of composition of gas mixture ($CO+H_2$) on the metal dusting behavior.
4. Effect of surface modification techniques such as ultrasonic shot peening on oxidation and metal dusting behavior.
5. Longer time study in erosive atmosphere (> 20 min).
6. Fatigue behavior of pre-exposed samples in oxidizing and metal dusting environment.
7. Effect of cold working on behaviour of Fe-18Cr-21Mn-0.65N austenitic stainless steel in different atmosphere.