CHAPTER 7

SUMMARY AND SUGGESTIONS FOR FUTURE WORK

7.1 INTRODUCTION

This chapter of the thesis summarizes the important observations and includes suggestions for the future research.

7.2 SUMMARY

Detailed study was carried out on surface nanostructuring, electrochemical corrosion, hot corrosion at 400, 500 and 600°C and LCF behavior of nanostructured alloy Ti–6Al–4V. Nanostructure was produced through USSP using hard steel balls of 3 mm diameter. Systematic investigation was carried out on the above aspects. LCF behavior of the alloy Ti–6Al–4V in non-USSPed, USSPed and USSPed + stress relieved conditions (400 ºC for 1h) was carried out at room temperature, at different total strain amplitudes and a constant strain rate of $5\times10^{-3}s^{-1}$. The important observations made on different aspects are listed at the end of the respective chapters and the major findings are summarized below:

7.2.1 Surface Nanostructuring

Surface nanostructure was induced in the Ti–6Al–4V alloy by ultrasonic shot peening for different durations, from 0.25 to 30 minute, and the modified surface was characterized by optical and transmission electron microscopy. The shot peened surfaces were examined also by XRD for phase transformation and compressive

residual stress resulting from USSP. Grain refinement was observed to nano scale due to USSP without any phase transformation. However, surface cracking was observed in the sample subjected to USSP for long duration of 30 minute. Surface roughness and compressive residual stress was increased with the duration of USSP. Microhardness of the 30 minute shot peened surface was increased by ~34%, however, the increased hardness level was reduced by ~14%, following stress relieving treatment (400°C for 1h).

7.2.2 Electrochemical Corrosion

The corrosion resistance was found to be highest in Ringer's solution for the sample USSPed for 1 minute, among all the specimens subjected to USSP for different durations from 0.25 to 30 minute, due to rapid formation of a highly protective and uniform passive layer. However, corrosion resistance was decreased from longer durations of USSP. The localized damage of the surface from excessive USSP led to fall in corrosion resistance of this alloy, in spite of the development of nanostructure in the surface region. Corrosion resistance of the USSPed samples was reduced following stress relieving treatment at 400 °C for 1h. The nanostructured surface promoted formation of highly effective surface layer of TiO_2.

7.2.3 Hot Corrosion

The oxide layer of corroded samples changed with temperature. The hot corrosion resistance was found to be higher in the USSPed specimens as compared to that in the non-USSPed ones. 100%NaCl salt had most detrimental effect on corrosion resistance of the both non-USSPed as well as USSPed samples. Corrosion resistance was highest of the sample sprayed with 75%Na_2SO_4+25%NaCl mixed salts as compared to those sprayed with 100%NaCl salt and 90%Na_2SO_4+5%NaCl+5%V_2O_5 mixed salt. The

corrosion resistance of USSPed samples increased due to double oxide layer. The main corrosion products were characterised as TiO_2, Al_2O_3, V_2O_3, Ti_2O_3, V_2O_5, and VO_2 in both, non-USSPed as well as USSPed samples.

7.2.4 Low Cycle Fatigue Behavior

Yield and tensile strength were increased by 3.6% and 4.7% respectively due to USSP. Ductile fracture was shown in the both, non-USSPed and USSPed tensile tested samples. Fatigue life was increased significantly, nearly by four times, in particular at the lowest strain amplitude following USSP. LCF life was improved due to surface nanostructuring with associated compressive residual stress. Fatigue life was reduced after stress relieving treatment at 400 °C for 1h. Continuous cyclic softening was there at the higher strain amplitudes. Initial cyclic hardening was observed at the lower strain amplitudes for all the conditions; the non-USSPed, USSPed and USSPed+SR. Dislocation pile-ups were observed in the non-USSPed and USSPed samples at lower strain amplitude (±0.65%). Individual dislocations were observed in USSPed sample at ±0.65% strain amplitude. Planar slip and intersections of planar slip were observed at higher strain amplitude (±0.80) in the both, non-USSPed and USSPed samples, due to continuous softening till fracture.

7.3 SUGGESTIONS FOR FUTURE WORK

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

- Electrochemical corrosion of the alloy Ti–6Al–4V at different concentrations of NaCl in aqueous solution.

- Low cycle fatigue behavior of the alloy Ti–6Al–4V at high temperatures in the non-USSPed, USSPed and USSPed+SR conditions over a wide range of strain amplitudes.
- Characterization of high cycle fatigue of USSPed samples of the alloy Ti–6Al–4V at different stress levels.
- Detailed study on the role of USSP on fatigue crack initiation in high cycle fatigue of the alloy Ti–6Al–4V.