CHAPTER 6

CONCLUSION

Based on this extensive research the following conclusions are drawn.

6.1 PHASE – I (PRODUCTION AND CHARACTERIZATION OF NAMSS)

- Nitrogen alloyed martensitic stainless steel can be successfully produced using conventional induction furnace.
- Nitrogen alloyed martensitic stainless steel with nitrogen up to 0.125\% can be produced in the conventional induction furnace.
- The theoretical nitrogen solubility estimated by thermodynamic relationship could be achieved using the conventional induction furnace.
- Micro porosities were observed in the test castings when actual nitrogen content exceeds the theoretical nitrogen content.
- Quality tools like QFD and FMEA have been effectively used for martensitic stainless steel alloy design and for better process control.
- Hardness up to 472 HV can be obtained with melts containing 0.11wt\% nitrogen in the as cast condition.
6.2 PHASE – II (HEAT TREATED)

- Among all the hardening temperature 1000°C is the optimum temperature in obtaining high hardness up to 562 HV.
- All the hardened microstructure reveals martensite and ferrite.
- Higher hardness up to 562 HV obtained in melt M9 and the microstructure is also ferrite free.
- Hardness from 261 HV to 562 HV is obtained in the hardened condition based on the composition.
- Samples tempered from 100°C to 300°C do not reveal noticeable decrease in hardness.
- The tempered samples reveal tempered martensite structure for tempering temperatures between 400 - 650°C.
- Secondary hardening effect is noticed for samples M1, M3, M4 and the carbon content is lower for melts M1, M3 and M4.
- Melt 9 with C=0.22, Cr=16.8%, N=0.085% shows higher Ultimate Tensile Strength of 824 MPa and hardness of 446 HV with toughness of 44.7 Jules at -40°C.
- Fractographic analysis of melt M9 by SEM reveals, a clear ductile fracture which also shows better impact toughness.
- Melt M9 shows lowest wear rate with highest hardness.
6.3 PHASE – III (FORGED AND HEAT TREATED)

- Percentage reduction up to 52% is possible in the high Nitrogen martensitic stainless steels.
- All the forged samples reveal higher hardness when compared to the as cast hardness.
- Grain refinement is observed in all the samples after hot forging.
- The hot forged and hardened melt M9 reveals a hardness of 561 HV and it is the same value like the cast and hardened samples.
- All the hot forged and hardened samples reveal lower ferrite.
- Secondary hardening effect is not observed in M9, M10, and M11 after hardening and tempering of the forged samples.
- Hot forged, hardened, and tempered, HNMSS shows higher strength as high as 880 MPa compared to the cast and heat treated samples.
- Impact toughness is better for all the hot forged, hardened and tempered materials and clear Ductile to Brittle Transition (DBT) is observed in all the samples.
- Fracture analysis of hot forged, hardened and tempered samples reveals ductile fracture with more dimples for M9, M10, M11 and relatively more river type pattern for M1, M3, and M4.
- Hot forged, hardened and tempered samples of M9 show lower wear rate when compared to the cast, hardened and tempered samples.
- Melts M9 and M4 with higher nitrogen and higher chromium show better corrosion resistance.
6.4 SUGGESTIONS FOR FUTURE WORK

Nitrogen solubility can increase through optimized alloying element and the effect of nitrogen on NAMSS can be characterized. Carbon content can reduce it to very minimum. Erosion corrosion test can be conducted to improve the NAMSS for earth mover’s application can be made. Analysis of specific secondary phases - EDAX or EPMA and based on that characterization can be made. Texture analysis can take for HNMSS samples after hot forging and characterization. Effect of Molybdenum on NAMSS for corrosion can be attempted. Ductile to Brittle Transition curves can be developed for NAMSS with varying nitrogen content. TEM study can be incorporated.