CHAPTER 7: CONCLUSION

In this chapter the major outcome of the present investigations are summarized.

The following are the important conclusions of the present research work:

1. The plastic deformation and densification level of the sintered plain carbon steel is the highest under both hot and cold forging conditions.

2. Addition of the alloying element Cr to plain carbon steel leads to reduction in densification and plastic deformation as a result of the precipitation of Cr carbide.

3. Addition of the alloying element Mo enhances the densification levels of Fe-C-Ni steel during cold and hot upset deformations. Nickel promotes austenitic grain structure in the forged alloys.

4. Enhanced plastic deformation but reduced densification is observed during cold repressing in the case of the alloys containing Ni & Mo. The reduction in deformation is attributed to the presence of carbides of Cr & Mo, which impede both pore and material movement.

5. Addition of Ni alone to plain carbon steel lowers the deformation as well as the percentage theoretical density during cold and hot forging. Incomplete densification of the alloy is indicated by the presence of numerous fine and rounded pores (both intergranular and trans-granular) in the microstructures.

6. High formability index of the Fe-C-Cr-Ni-Mo steels for cold upsetting is an indication of enhanced formability due to the combined effect of Cr, Ni & Mo.
7. There is a reduction of formability index of Fe-C for cold repressing due to the addition of Cr, Ni & Mo, as a result of which this alloy undergoes reduced plastic deformation during cold repressing. Formation of Cr & Mo carbides, rounding off of pores during deformation and restriction to material flow by the die wall are the factors, which have contributed towards the above.

8. In general, the formability index of the various alloys is higher for hot upsetting compared to cold deformation process. Among the alloys studied, the plain carbon steel has the highest formability index irrespective of the type of deformation.

9. ANN can be used as a tool for predicting the deformation, densification & formability of the P/M steels. This is evident from the correlation coefficient values of closer to unity obtained for the ANN predicted results.

10. ANN tool will help the manufactures predict the P/M steel characteristics without conducting extensive, time-consuming experiments.

11. Sinter-forged plain carbon steel with addition of Cr as alloying element can attain tensile strength values of the order of 1373MPa, but with lower impact strength. This alloy undergoes mixed mode of fracture (both brittle and ductile).

12. Among the alloys studied, the plain carbon steel has the lowest tensile strength, hardness and the highest impact strength coupled with a pure ductile fracture.
13. Sinter-forged low-alloy steels obtained through mixed elemental powders sintered at lower temperature are found to exhibit superior mechanical properties compared to wrought steels of similar compositions.

14. Adopting sintering followed by forging process, and thereby avoiding complex repressing and resintering processing steps, superior mechanical properties can be imparted to low-alloy P/M steels containing Cr or Cr–Ni–Mo processed through elemental powders.

In summary, the mechanical properties of the alloys considered for the present research prepared out of elemental powder mixes, sintered at lower temperature, without complex repressing and resintering cycles are superior to those of the conventional wrought materials of near similar compositions, containing Cr, Ni and Mo. Hence, the low alloy steels considered in the present research work can be considered as replacement for the wrought materials of similar composition used for structural & automotive applications. The workability studies on these alloys, such as deformation, densification and formability under cold and hot forging, presented in the present research work, will be useful for the selection of the deformation parameters for the forging operations.