CHAPTER 6

CONCLUSIONS

6.1 CONCLUSION OF THE STUDY

The following conclusions were drawn from the critical analysis of the Fe-C-Mn composite preform.

1. All the stresses namely the true axial stress, the true hoop stress, the true mean/hydrostatic stress and the true effective stress under triaxial stress state condition are found to be increasing with increase in the axial strain values.

2. The value of all the above stresses increased rapidly in the early stages of deformation and then continues to increase, but at a medium rate and finally it was very least as the deformation continues till the formation of crack.

3. The effective stress is found to be greater in magnitude comparing to the true axial stress, hoop stress and the mean/hydrostatic stress determined in the present investigation of triaxial stress state.

4. All the above stresses are found as tensile in nature except the true axial stress, under triaxial stress state condition. The mean or hydrostatic stress holds the lesser value among all the determined stresses.
5. The curves showing the relation between true hoop strain and true axial strain are formed generally as concave in nature and it is always placed below the inclined straight line which represents the ratio of hoop strain to axial strain as 0.50.

6. The axial stress required for cold deformation increases with the increasing value of the fractional theoretical density value for any given aspect ratio and the initial preform fractional density.

7. The curve between true axial stress and relative density represents, at the early stage of deformation, a higher rate of matrix work hardening and at the middle stage, a higher rate of geometrical work hardening and at the end of deformation once again there is a matrix work hardening is noted. This is because of initial resistant of matrix material to deform in the initial stage and then the metal flow in to the pores in the second stage and at the end of deformation the pores filled to the maximum extent.

8. The characteristic features of Poisson's ratio are classified into three stages. Stage-I describes a rapid rise in the values with little densification (matrix work hardening). Stage-II is treated as a steady-state condition, where most of the densification occurs with a small increase in the Poisson's ratio. Stage-III involves the stage where a rapid increase in the Poisson's ratio occurred without many enhancements in the density values in the deforming preforms. However, the tendency is shown to approach a limiting value of 0.50, which is the theoretically feasible value of the Poisson's ratio of P/M preforms.
9. In triaxial system, the lower aspect ratio preforms are showing higher stress values for all the stresses than the higher aspect ratio. So load-bearing capacity of lower aspect ratio is more than the higher aspect ratio preforms is established.

10. As the pore size is high, the geometrical work hardening has been observed to be very high when compared to matrix work hardening. This is the reason for higher geometrical work hardening behaviour for lower initial density preforms.

11. The initial relative density of the preforms plays a major role in the value of stresses and workability. Higher initial density preforms provided better deformation behaviour for all densification experiments.

12. The preforms having increased carbon content by keeping manganese as constant, the stresses namely true axial stress, true hoop stress, true mean stress and true effective stress increases up to 0.10% and then decreasing uniformly irrespective of any composites and aspect ratio. This is because of the formation of iron carbide and initial preform density are more at 0.10% of carbon content and due to that the strength is simultaneously increasing.

13. The instantaneous strain-hardening exponent value increases rapidly, reaches the peak value at low strains and then decreases up to the pore closing of the matrix material. Finally an increase is identified just before the fracture. Moreover, the similar trend is obtained for the instantaneous strength coefficient Vs the axial strain also.
14. The variation of strain hardening index and strength coefficient with respect to percentage of carbon content shows that the value of strain hardening index is peak at 0.10% carbon content irrespective of the manganese content. Then it reduces gradually by increase of carbon content and this trend is common for both the aspect ratios 0.45 and 0.60.

15. Even though so many compounds (Fe$_3$C, FeMri4, FeMn$_3$, MnC$_8$ and Mn$_5$C$_2$) were formed (identified by XRD process) at sintering process, the effect of iron carbide (Fe3C) plays a vital role for making the preform strength.

16. For all manganese content, the preform having 0.10% carbon exhibits higher initial relative density and hence the densification behavior is high. Also, the formation of iron carbide is more for the above P/M preforms.

17. When the manganese content is 0.20%, the values of flow stresses are in minimum level and it increases up to for 0.50% manganese content. Adding more manganese to the Fe-C-Mn P/M composite preforms (0.70 and 1.00%), it is proved that the values of stresses are reduced.

18. Among the iron based preforms tested by having different carbon and manganese content, Fe-0.10C-0.50Mn showed better workability and deformation behavior. This is because of more initial fractional density, higher pore closure, fine grains and more presence of Fe$_3$C matrix than other metallic compounds.
6.2 SUGGESTIONS FOR FURTHER STUDY

From the consideration of results of the present study, several additional areas may be worth for future investigation:

1. Studies on the workability of iron based composite material during hot upsetting under triaxial stress state condition.

2. Studies on the geometric work hardening and matrix work hardening during hot upsetting.

3. Workability studies on hybrid iron based composites to assess the influence of the third phase particle addition.

4. Comparative study to be conducted on the influence of nano particle instead of micro level particle as a reinforce element in the iron based composite.

5. Finite element method can be applied to predict the workability and deformation behaviour of iron based composites.