Chapter 7

Conclusion, Summary and Future Prospects

This chapter summarizes all conclusions drawn from different models and calculations performed as a part of this thesis and also addresses the possibilities of further work in this direction. The detailed chapter wise conclusions are given at the end of each chapter.

The research work presented in this thesis deals with the study of “Mathematical Modeling of Creep in Rotating Discs of Composites and Functionally Gradient Materials”. In this thesis, models have been developed to find stress and strain rate distributions in a rotating disc made of aluminum /aluminum alloy matrix reinforced with silicon carbide in the form of particulates. For this study constitutive equations for composite have been developed using different yield criteria as described in the chapters. To compute stress and strain rate distributions in a rotating disc, the equilibrium equation of the continuum mechanics and the constitutive equations have been solved.
7.1 Conclusion and Summary

The present thesis can broadly be divided into four phases.

In the first phase of the thesis, analysis has been carried out for an isotropic rotating disc made of particulate reinforced composites where the creep behavior has been described by the threshold stress based creep law. The values of stress exponent $n$ have been taken as $3$, $5$ or $8$. The constitutive equations for an isotropic composite have been developed using von Mises criterion of yielding and the impact of stress exponent on the stress and strain rate distributions in a rotating disc have been investigated. On the basis of results obtained in this phase the choice of exponent $8$ have been made for the material of the disc. At various temperatures, the creep response in lightweight aluminium base particle reinforced composite rotating disc can be brought to the level required for a given application by controlling both particle content and particle size. The work done in this phase has been published as Effect of Stress Exponent on Creep in an Isotropic Rotating Disc of Al-SiCp in Bulletin of the Calcutta Mathematical Society, Vol. 101(6), 2009.

The processing of composites often involves cooling from high temperature resulting in the residual stress. So the analysis of the steady state creep in a rotating disc made of composites containing SiC particulates have been carried out in the presence of residual stress using Hoffman yield criterion in the second phase. The creep behavior of the disc has been described by Sherby law and the value of stress exponent $8$ was chosen on the basis of result of work done in the first phase. In this phase it is concluded that the presence of the residual stress does not significantly
affect the stress distributions but it definitely effect the strain distributions in the disc rotating at high temperatures. This work has been published as *Creep Analysis of an Isotropic Rotating Al-SiC Composite Disc Taking into Account the Phase Specific Thermal Residual Stress* in the *Journal of Thermoplastic Composite Materials*. Online First published on September 9, 2009 as doi: 10.1177/0892705709345938, Sage Publisher, U.K.

In the third phase of the thesis, analysis of creep in a rotating disc made of FGMs having non-linear distributions of silicon carbide from inner to outer radius have been carried out. The results have been compared with the available results for linearly decreasing reinforcements having the same average particulate content and also with disc having uniform particulate distribution. The strain rate remains almost same throughout the functionally graded disc having linear or parabolic distribution of particle content, whereas it changes drastically for non FGM disc. Thus steady-state creep responses of FGM disc is better than that of uniform disc having the same average particle content. But this work shows that the steady state creep response for FGM disc having parabolic distribution of particle content is even better than that of linear distribution. This work has been published as *Creep Analysis Of An Isotropic Functionally Graded Rotating Disc* in *International Journal of Contemporary Mathematical Sciences* Vol. 5, no. 9, pp. 419-431, 2010.

In the fourth phase of the thesis, analysis of creep in a rotating disc made of anisotropic material have been carried out. Further the analysis has also been carried out for FGM disc made of anisotropic material having non-linear distributions of silicon carbide from inner to outer radius using Hill yield criterion. It is concluded
that the stresses and strain rates depend upon the material anisotropy and the strain rates are minimum when particle content is distributed parabolically. Thus steady state creep rates can be controlled well by the suitable distribution of particle content. This work has been published as *Creep Behavior of an Anisotropic Rotating Disc of Composites* in *International Journal of Contemporary Mathematical Sciences* Vol. 5, no. 11, pp. 509 - 516, 2010.

Overall it is concluded that while designing rotating disc, material isotropy, anisotropy and the nature of the distribution of reinforcement plays a crucial role and therefore it should be taken care of.

### 7.2 Future Scope of work

The work done in this thesis allows the computation of strain rate and stresses at different points of a disc rotating at high speeds and working at elevated temperatures and hence life-time of variety of machine parts can be improved using these concept. For example, life-time of discs rotating at elevated temperatures in space crafts, rotors, turbines etc. can be improved taking care of material isotropy/anisotropy and the distribution of reinforcement.

This work can be extended to investigate the steady state creep behavior of rotating discs made of other composite material. Analysis of creep behavior on discs having variable thickness and having different profiles may be performed in continuation of this work. Further this can be extended to study the impact of residual stresses having different distributions of reinforcements in rotating discs. The analysis
may be extended for creep behavior of rotating cylinder subjected to internal pressure as well as external pressure. At this point it can only be concluded that extensive research work is needed in this direction both in theoretical and experimental areas. One can use softwares like ABAQUAS and ANSYS to find stresses and strain rate distributions at different points in the rotating disc made of composites. Primary creep can also be taken with steady state creep.

As a last word, this thesis sets up a stage to perform several rigorous experiments and studies to establish the controlled strained behavior which is a primary requirement for the design of machines parts. The theoretical models and conclusions that have been developed in this work are helpful to pursue such studies. This work actually lays a base for the constructive work in the area of Creep research in general and the Creep of rotating discs of composites at elevated temperatures in particular.