CHAPTER 6

CONCLUSION

The optimization of power coefficient of horizontal axis wind turbine with NACA airfoils have been performed by varying the parameters like wind velocity, angle of attack and tip speed ratio. The horizontal axis wind turbine of one MW capacity is designed based on BEM method and considered for optimization. An Iterative method and Genetic Algorithm have been successfully employed in the optimization process. However the results and discussions are presented in the previous chapter, the overall conclusion of the research work is presented below.

1. The correlations for the calculation of coefficient of lift and drag for NACA 4 series airfoils are developed and modified using experimental data. The results are validated with the experimental work. In the optimization process of power coefficient using Genetic Algorithm the modified correlations are used.

2. The effect of Reynolds number on sliding rate is studied by varying Reynolds numbers from 100000 to 200000 in steps of 25000 for various NACA airfoils 4410, 4412, 4414, 4416, 4418 and 4420. The modified correlation is used for calculating sliding rate. The optimum angle of attack corresponding higher sliding rate for various Reynolds numbers is identified. The effect of angle of attack on coefficient of lift is also predicted for the above NACA
airfoils. At higher angle of attack, the lower thickness airfoils have maximum lift coefficient than higher thickness airfoils. The maximum coefficient of lift of 1.621 is obtained for NACA airfoil 4410 at 15° angle of attack further it decreases as the angle of attack increases.

3. Horizontal axis wind turbine with the capacity of one MW is designed and used for optimization of power coefficient. The chord and twist distributions are calculated using BEM theory. An Iterative method is employed for optimizations of coefficient of lifts and drag for NACA 2415 and NACA 4410. The wind velocity is varied from 5 to 25 m/s in steps of 5 m/s and the angle of attack varied from 0° to 19°. The results of NACA 2415 are compared with experimental results for validation and the results of NACA 4410 are validated with the results of developed correlations.

4. The convergence of axial and tangential flow factors are predicted for various wind velocities and the converged value is used for optimization of the power coefficient. The variations of axial and tangential flow factors are presented for two airfoils of NACA 4410 and NACA 2415. It is observed that the axial flow factor and the wind velocity follow the inverse proportionality relation for both the airfoils. The tangential flow factor is higher at increased wind velocity and reduces at lower wind velocities.

5. The optimization of the power coefficient is carried in two cases for wind turbines. In the first case, the coefficient of drag and tip loss correction factor are considered and in the second case coefficient of drag is assumed as zero and tip
loss correction factor as one. The predictions are presented in Chapter 4. The power coefficient is maximum value of 0.57 for NACA 4410 and 0.575 for NACA 2415 for the case (ii).

6. The optimization of power coefficient is carried out for wind turbines using Genetic Algorithm for varying the parameters like wind velocity, tip speed ratio and angle of attack. The NACA 4410, NACA 4420, NACA 4430 and NACA 4440 airfoils have been considered. The optimization process is carried out in three categories. In the first category, all the parameters are varied with specific limits. In the second category, the tip speed ratio and angle of attack are varied by keeping the wind velocity as constant. In third category, the insensitiveness of the GA parameters has been analyzed for various possibilities of mutation and cross over probabilities. The maximum power coefficient of 0.45 is obtained for NACA 4410 at wind velocity of 10 m/s. It is identified that the results are insensitive to the possibilities of cross over and mutation. The proposed Genetic Algorithm approach reduces the computational time considerably and eliminates the cumbersome experimental procedures.
6.1 SUGGESTIONS FOR FURTHER RESEARCH

The present work can be extended further and made available for the wind turbine manufacturing industries and users. However, the work can be extended in different areas; the scope of the work is presented below.

1. The correlation can be developed for calculating coefficient of lift and drag for 6 series NACA airfoils and ‘S’ series airfoils.

2. In the present work, one MW wind turbine is considered and the same work can be extended for higher capacity wind turbines.

3. In the present work, the two dimensional analysis is performed in CFD. This approach can be extended to three dimensional analyses of wind turbine blades.

4. In the present work, the optimization of power coefficient is carried out using the Genetic Algorithm. The evolutionary algorithms like PSO and Ant colony algorithms can be tried.

5. In the present method, the segmentation of the blade using BEM is employed for analysis. Hence, the blade with multi airfoil sections can be considered for analysis and optimization.