CHAPTER 7

CONCLUSION AND SCOPE FOR FUTURE WORK

7.1 CONCLUSIONS

In this thesis, efficient optimization techniques based on swarm intelligence and evolutionary computation principles have been proposed for design optimization of SRM. Most of the work reported in literature focuses on single objective optimization intended to improve one or another performance parameter. However, to achieve enhanced design, there is a need for simultaneous optimization of two or more such performance parameters. The approach presented in this thesis deals with multi-objective optimization of SRM using weighted sum approach and true multi-objective approach. The two multi-objective approaches presented in this work will aid the design engineers in selecting the best method for obtaining the optimal dimensions of SRM according to the application requirement. PSO and DE techniques are applied to solve the optimization problem using the weighted sum approach. To achieve faster convergence towards global optimal solutions and to avoid the problem of getting trapped to local optima, the standard PSO and DE technique has been further improved by incorporating the concept of repellor and craziness factor in case of PSO and introducing chaotic sequences in case of DE. One of the major goals in multi-objective optimization is to find a set of well distributed optimal solutions along the true Pareto-optimal front. In this aspect, an attempt has been made to apply NSGA-II to determine the tradeoff solutions between different objectives. The above algorithms are applied to two common design optimization problems of SRM and the results
indicate the suitability of the proposed optimization techniques to determine the optimal design.

For optimizing the design of SRM, there is a need for accurate performance prediction. In this work FEA technique and analytical method are used to predict the performance of SRM. For checking the effectiveness of FEA, the results obtained are compared with the experimental results. The flux linkages vs. current characteristics obtained by FEA agree satisfactorily with the experimental values. To validate the results of analytical model the results obtained for two 8/6 machines are compared with results of FEA. The closeness of flux linkages vs. current characteristics and the average torque obtained by the two approaches confirm the application of analytical method for performance prediction of SRM.

The problem of determining optimal pole arc to minimize torque ripple is formulated as a multi-objective optimization problem with due considerations to average torque, torque ripple and copper loss. The multi-objective problem is reduced to a single objective problem with predefined weight factor and solved using enhanced PSO and DE algorithm. FEA is used for performance prediction during the optimization routine. The results of optimized design reveal significant improvement in the performance of SRM when compared with the initial design. The optimized design was analysed using FEA and the results confirmed the goals of the multi-objective optimization.

The enhanced optimization algorithms are applied to determine optimum design of SRM considering the design and performance parameters to suit the need for EV applications. Analytical technique is used to predict the performance of SRM during the optimization routine. The performance analysis of optimum design is done using FEA and the results confirm the application of optimization procedure.
The results obtained in chapter 4 and 5 provide an insight into the performance of PSO and DE techniques using weighted sum approach for design optimization of SRM. The performance of different algorithms with respect to the above problems were analysed in terms of convergence, solution quality and statistical accuracy. The results indicate that the PSO approach with craziness factor combined with chaos and chaotic DE approach perform better for both the design optimization problems. Thus the two techniques can be applied to determine optimum design of SRM when the designer has a predefined set of preferences for different objectives.

When the designer requires a complete picture of tradeoffs, a large number of optimization runs with different weight combinations are essential to get a set of Pareto-optimal points. Multi-objective optimization with all the design objectives taken into account, gives the designer a complete overview. To enable evaluation of tradeoff solutions between different problem objectives through identification of the Pareto front, a first attempt has been made to investigate a multi-objective approach using NSGA-II for design optimization of SRM. Analysis of projected views of the Pareto fronts, give a very clear picture of the objectives trade-off, helping the designer to choose the design, best matching his requirements. NSGA-II has been able to generate around 30 Pareto-optimal designs across the span of the Pareto front in one run of the algorithm for the two optimization problems considered. The results of Pareto front obtained using NSGA-II for the two problems agree with the results obtained with weighted sum method and validate the application of NSGA-II to determine various viable designs for performance enhancement of SRM.

This thesis presents the results of FEA carried out on SRM with special pole face shapes. The special pole face shapes include stator pole taper, stator pole with non-uniform air gap, rotor notch and rotor pole shoe.
The effect of variation of design parameters corresponding to pole shapes on average torque and torque ripple are analysed. From the results it is observed that there is significant improvement in average torque and reduction in torque ripple for the structure with stator pole taper. Further, it is observed that stator pole face with non-uniform air gap produces minimum torque ripple. However average torque produced by the design is reduced. Hence, to improve the average torque, a stator pole taper design with non-uniform air gap is proposed. The proposed design shows significant improvement in the torque characteristics of SRM.

7.2 SCOPE FOR FUTURE WORK

- The design optimization techniques presented in this work focus on the enhancing the electromagnetic characteristics of the machine. The vibration and thermal aspects of the machine can be incorporated to get desired performance.

- To enhance the performance of SRM drive the turn-off and the turn-on angles can be optimized using multi-objective optimization approach.

- The suitability of hybrid optimization techniques combining PSO and DE with respect to optimal design and control aspects of SRM can be analyzed.

- The performance of NSGA-II can be compared with PSO and DE based multi-objective optimization algorithms.

- To improve the torque characteristics and efficiency of SRM, a detailed design and analysis with new materials and novel structures can be performed.