CHAPTER 7

CONCLUSIONS

Optimization procedures have undergone such enormous changes so that quantitative techniques and mathematical analysis have become integral parts of the optimization tool kit. Therefore, the objective of the study reported in this research work is to develop new algorithms, which solve various types of SP problems efficiently.

7.1 SUMMARY OF WORK DONE

In summary, the entire research work proposed the following two pronged approach for solving some special classes of stochastic optimization problems (including LPP) in an efficient manner:

(i) Obtaining optimal solution after removing redundant constraint(s) and/or objective function(s) from the given LPP/SP problem

(ii) Obtaining optimal solutions of CCFP, CCRSO, CCDEA problems through GAs, which avoid conversion of SP problems into equivalent deterministic programming problems.

7.2 CONTRIBUTION OF THE RESEARCH WORK

The following are the contributions of this research work.

(i) The proposed Direct method of solving LPPs uses the concept of maximum change criterion in the objective function instead of the rate of change of criterion which the Simplex algorithm adopts. The method starts with a construction of a matrix of intercepts of the decision variables. This matrix is then used to identify an advanced basis, which accelerates the speed of obtaining the optimal solution. That is, the matrix of intercept helps the Simplex method for commencing at a better initial basic feasible solution. The main advantage of the proposed method is the removal of some constraints and variables off the bay through the matrix of intercept and thereby reduces the original problem to a smaller dimension. "Dimensionality is a curse" in large scale linear and non-linear mathematical programming problems. This curb is reduced here to some extent. This contribution is new when compared to some of the earlier researchers' contributions where they also find advanced basis for obtaining speedy optimal solution but without reducing the dimension of the problem. Therefore there is saving in terms of computations, since the advanced basis makes the Simplex method to produce an optimal solution in lesser number of iterations. Another saving is, the lesser amount of memory needed for solving the reduced model of the problem.

(ii) The explicit use of linear fractional objectives, say for example in financial planning, can make multi-objective models to fit better "real world" problems. In these problems, some/all of the objective functions may be linear/non-linear in the decision variables. Moreover, the decision variables need not be deterministic as many decision-making problems involve uncertainty. Therefore, MONSFP models were presented and advocated a different solution method. The method used here converts probabilistic constraints into an equivalent deterministic constraints and stochastic fractional objective functions into their constraint forms. The resultant deterministic programming is linearized and then solved by specially developed "Redundancy algorithm and the proposed algorithm".

The main contribution of this method is that it identifies and eliminates redundant stochastic fractional objective function(s) while solving the MONSFP problems. Though there are few multi-objective programming approaches such as goal programming and interactive programming for solving MONFP problems, our approach differs from them by solving only the reduced model.

(iii) Many multi-objective programming problems when modelled embed redundant objective function(s) and constraint(s) and/or variables due to various reasons. Therefore there is a need for an integrated method which detects these redundancies. The method prescribed here identifies redundant stochastic fractional objective functions and redundant constraints and it has been developed with the intention of solving MONSFP problems and incidentally identifies and eliminates both redundant objective functions and redundant constraints, provided redundancy exists. The main motive for reducing a model is to solve a given problem with less computational effort, which is being fulfilled here.

(iv) The general formulations of CCFP problems and their corresponding parametric forms were presented. Besides this, a stochastic simulation has also been designed to check the feasibility of chance constraints. Finally, a solution procedure for solving CCFP problems with continuous random variables is presented here. As there was no specified procedure for solving CCFP problems, in which stochastic parameters could follow any continuous probability distributions, a new stochastic simulation based GA was proposed. The main advantage of this approach is that it is easy to grasp and there is no need to convert stochastic objective functions and/or constraints into their deterministic equivalents, where translation is usually a tough task or simply not possible.

(v) Finding the optimal redundancy that maximizes the system reliability is one of the important problems in reliability theory. A good deal of effort has been done in solving RAPs. The optimization techniques developed in the past have limited success in solving these problems, as they do not consider probabilistic constraints on the amount of available resources such as cost, weight and volume. Therefore, to optimize the reliability of a system, in this case, series-parallel system, then one has to take into account uncertainties. For this purpose, a problem specific stochastic simulation based GA is developed for finding optimal redundancy to an n-stage series system with m-chance constraints of the RAP. Various cases of randomness with known distributions such as Uniform, Normal, Exponential, Lognormal and Weibull distributions, when the resource variables are random, have been considered. The advantage of this algorithm is that it does not require deterministic equivalence of random resource vector.

Like other applications, exact solutions for reliability optimization problems are not necessarily desirable because exact solutions are difficult to obtain, and even when they are available the utility is marginal. A majority of the recent work in this area is devoted to developing heuristic algorithm such as GA for solving optimal RAPs. This is the motivation of using GAs. The proposed GA is more flexible in the sense that the practitioner is not limited to a single solution.

(vi) The mathematical programming-based DEA has often treated data as being deterministic. In response to criticism that in most applications there is error and random noise in the data, a number of mathematically elegant solution techniques to incorporate stochastic variations in data have been proposed. The P-model CCDEA models were introduced which include the concept of “Satisficing”. This is different from the other CCP models, which are restricted to E-model. The only exception is Cooper et al. (1996) which also involves the P-model. The main contribution here is the development of a stochastic simulation based GA for solving P-model CCDEA problems. Before this, a complete framework of GA was developed and to process chance constraints occurring in these problems a suitably designed Monte-Carlo simulation was developed. Through a combined framework of GA and Simulation, the success of GAs in processing non-linear and non-convex optimization problems such as CCDEA were exploited. The advantage of the proposed approach is that deriving the deterministic equivalent of the chance constraints and the objective function is not required. Hence, this approach is suitable for solving CCDEA with input and output data without any deterministic conversion. The approach was applied on the 'Indian banking system' problem and through the proposed GA results were obtained. It is hoped that the research described in this work might stimulate researchers in addressing the complex issues of efficiency evaluation under uncertainty.

7.3 SUGGESTIONS FOR FUTURE WORK

A number of interesting areas for future research work exist. The following are some suggestions for future research.

(i) Development of a unique algorithm for the identification of redundant objective function(s), constraint(s) and variable(s) in one stroke.

(ii) It may be desirable to extend the proposed GA to solve the V-model of CCFP problems.

(iii) The proposed genetic algorithm for solving the CCRSO problem can be suitably modified in such a way that one can introduce randomness on the left hand side of the chance constraints and also in the objective function, which is used to measure system performances such as mean system-life time, α - system life time and system reliability; secondly, many real life engineering problems actually do have multiple objectives, i.e., minimizing the cost, maximizing performance, maximizing reliability, etc., subject to satisfying several requirements. Taking a lead from this, the proposed algorithm may be extended to multi-objective reliability optimization problems with constraints having finite probability being violated.

(iv) In most of the DEA literature, many researchers have been using the E-model chance constrained approach to solve stochastic DEA problems. In the recent past, there are few articles on P-model chance constrained programming to DEA. None has yet essayed a choice of the "V-model" for which the objective is to minimize "variance" or "mean square error".

7.4 LIMITATIONS

(i) In the proposed redundancy algorithms (chapter 3), it is not easy to find deterministic equivalent of SP models in many cases.

(ii) It is very difficult to determine how much redundancy is present in a given model until it is solved.

(iii) Even though GA has been used (in the absence of conventional methods) for solving many complex CCP problems, it gives always approximate optimal solutions. Sometimes the GA method obtains the best solution after many generations and this solution is only an approximation of the global solution.

(iv) In mutation operation, chromosomes are not mutated at different positions. This means that only value of a variable in the chromosome is adjusted and others are not changed. Sometimes it affects the converging speed the optimal solution.

The Direct method proposed for solving LPP helps in obtaining a speedy optimal solution as it starts with a better initial basic feasible solution. The redundancy algorithm developed for identifying redundant objective functions and redundant constraints is not only unique but also efficient. The different stochastic simulation based GAs, developed for solving CCFP, CCRSO and CCDEA problems had the ability to provide a satisfactory solution and this was made possible by properly customizing the encoding, breeding operators, fitness function and the selection procedure.