CHAPTER - II

SURVEY OF LITERATURE
2.1 INTRODUCTION

The reliable performance of a system for a mission under various conditions is of utmost importance in many industrial, military and everyday life situations. Although the qualitative concepts of reliability are not new, its quantitative aspects have been developed over the past two decades. Such development has resulted from the increasing needs for highly reliable systems and safer, cheaper components.

There exist several methods to improve the System Reliability using large safety factors, reducing the complexity of the system, increasing the reliability of components through a product improvement program, using structural redundancy and practicing a planned maintenance and repair schedule. A good deal of effort has been centered in the field of Optimal Redundancy Allocation.
Generally the Reliability of a system can be maximized subject to the cost constraint in two different situations. When the Component Reliabilities are given, to determine the number of Components in each stage are given to determine the Component Reliabilities. In Reliability Optimization literature, most of the works have considered the former situation and a few works are reported by making use of the later situation.

The author in this thesis presents the status of the art of literature on System Reliability Optimization with Redundancy and also on the available scanty literature on Integrated Reliability Models with Redundancy. The earlier review works are reported by Frank A Tillman, Ching-Lai Hwang and Way Kuo (1977) based on System Configuration and by Optimization Techniques.

The major focus of recent work is on the development of Heuristic Methods and Metaheuristic Algorithms for Redundancy Allocation problems and little work is directed toward exact solutions of such problems. To the best of knowledge, all of the Reliability Systems considered in this area belong to the class of Coherent Systems and the literature on Reliability Optimization for Redundant Systems due to Way Kuo and V Rajendraprasad (2000) can be classified into seven categories.
2.2 CLASSIFICATION OF OPTIMIZATION OF SYSTEM RELIABILITY MODELS: BY HEURISTIC METHODS

2.2.1. Heuristics for Redundancy Allocation: Special Techniques developed for Reliability problems


2.2.2. Metaheuristic algorithm for Redundancy Allocation:
Perhaps the most attractive development in 1990s.

2.2.3. Exact algorithms for Redundancy Allocation
or Reliability Allocation: Most are based
on Mathematical Programming Techniques

F.A. TILLMAN (1969) presented an optimization method using
IP with constraint reliability problems and with several
modes of failure and in (1979) proposed reliability
optimization by generalized lagrangean function and
reduce gradient methods. Y. NAKAGAWA AND MIYAZAKA (1981)
proposed surrogate constraints algorithm for reliability
optimization problem with two constraints. M.S. CHERN AND
R.H. JAN (1985) applied parametric programming to
reliability optimization problems. F. JERZY (1986)
demonstrated a problem in reliability optimization. D.S
RAI et al (1991) proposed redundancy optimization model of a
k-out-of-n: G system with common cost failures. K.B. MISRA
(1991) presented an algorithm to solve IP problems which
is an efficient tool for reliability design. K.B. MISRA
(1991) presented an efficient approach for multiple
criteria redundancy optimization problems. M.S. CHERN et al
(1991) presented a parametric non linear integer
an optimal assembly of a series parallel system. K.K.
GOVAL AND R.A. AGGARWAL (1993) presented a lagrangean
multiplier method for an optimal reliability model. K.
MISRA AND V. MISRA (1994) established a procedure for solving
general integer programming problems. C. MOHAN AND K. SHANKAR

2.2.4. Heuristic for Reliability-Redundancy Allocation: A difficult but realistic situation in Reliability Optimization


2.2.5. Multi-Objective System-Reliability Optimization: An important but not widely studied problem in Reliability Optimization.

2.2.6. Optimal Assignment of Interchangeable Components:
A unique scheme that often takes no Effort


2.2.7. Others: Including Decomposition, Fuzzy Apportionment and Effort Function Minimization.


2.3 THE OPTIMIZATION OF SYSTEM RELIABILITY MODELS WITH REDUNDANCY CAN BE CLASSIFIED DUE TO FRANK A TILLMAN, CHING LAI HWANG AND WAY KUO (1977) AS

i) Classification of system Reliability Models with redundancy (By system configuration).

ii) Classification of system Reliability Models with redundancy (By optimization Techniques).

2.3.1. CLASSIFICATION OF SYSTEM RELIABILITY MODELS WITH REDUNDANCY: (BY SYSTEM CONFIGURATION)

The classification regarding optimal System Reliability Models with redundancy can be classified as

A. Series Configuration
B. Parallel Configuration
C. Series - Parallel Configuration
D. Parallel - Series Configuration
E. Stand By Configuration
F. Complex(Non-Series, Non-Parallel, including Bridge Network)
A. SERIES CONFIGURATION:

The functional operation of Series Configuration depends upon the proper operation of all system components. Even if one component fails in the Series System the complete system fails. A lot of work has been reported in this area due to its simplicity in configuration. To mention F. MOSKOWITZ & J. B. MCLEAN (1956) explained the method of some Reliability aspects of system design with respect to the Series Configuration. R. GORDON (1957) provided an optimum component redundancy for maximum System Reliability. I. R. N. HEES & I. H. W. MEERENDONK (1961) suggested a procedure for optimal Reliability of parallel multi component systems. M. SASAKI (1962) explained a new method of obtaining higher System Reliability, also (in 1963) developed an easy allotment method for achieving maximum System Reliability. L. R. WEBSTER (1964) proposed Reliability model for optimal allocation and in (1967) proposed an optimum system Reliability model establishing the relation between system Reliability and its cost effectiveness. A. J. FEDEROWICZ & M. MAZUMDAR (1968) used Geometric programming technique to maximize the System Reliability achieved by redundancy. P. M. GHARE & R. E. TAYLOR (1969) considered the problem of determining the optimal redundancy for
Reliability in Series System. F.A. TILLMAN (1969) used integer programming for constrained Reliability problems with several models of failure.


B. PARALLEL CONFIGURATION:

The functional operation of Parallel Configuration depends upon the proper operation of any one component in the system. A system can have several paths to perform the same operation and the satisfactory performance of any one of these paths is sufficient to ensure the successful operation of the system. If all components fail in the Parallel System the complete system fails.


C. SERIES – PARALLEL CONFIGURATION:

Series – Parallel System is one in which 'n' components are connected in Series and 'm' such Series connections are connected in Parallel to form the System. P.A. JENSEN (1970) considered Series – Parallel configuration networks to optimize system Reliability. A.C. NELSON, J.R. JAMES, R. BATTIS & R.L. BEADLES (1970) developed a computer Program which provides bounds for System Reliability. The Algorithms are based on the concepts of success paths and cuts sets. D.B. BROWN (1971) developed a computerized Algorithm for
determining the Reliability of Redundant configurations. Procedure has been given for generating the Reliability function directly from the Boolean Algebra transmission function. K.B. MISRA (1972) provided a simple Algorithm for finding Reliability Optimization of a Series - Parallel System. Reliability Allocation problem in a Series-Parallel System studied by ALICE YALAoui et al to improve the system Reliability. A theoretical condition for obtaining optimum allocation is developed. Since this condition is too restrictive we secondly proposed an alternative approach based on an approximated function and the results of the model.

D. PARALLEL - SERIES CONFIGURATION:

Parallel - Series Configuration is one in which ‘n’ stages are connected in Series and components are connected in Parallel at each stage. R.E. BELLMAN & S. DREYFUS (1958) shown how the functional equation technique of Dynamic Programming may be used to treat a class of problems that arise in the construction of multi component devices. G.BLACK, F. PROSCHAN (1959) developed a simple procedure for Optimal System Redundancy. J.D. KETTELLE (1962) explained the Least - Cost allocation of Reliability Investment. F. PROSCHAN & T.A.BRAY (1965) determined Optimum Redundancy under multiple constraints.
F.A. TILLMAN (1966) has applied Integer Programming approach to solve the Reliability Optimization Problem.


presented a useful procedure for solving non-linear Integer Programming problems.


E. STAND BY CONFIGURATION:

Standby Configuration has the same form as a mixed Series - Parallel Configuration. However, the Parallel 'm' Series subsystems are not all active at the same time. The reported literature on this topic is F.MOSKOWITZ, J.B.MCLEAN (1956) proposed system design for Reliability Redundant models. D.F.MORRISON (1961) established a Redundancy Model and solved for the optimum allocation of spare components in the system. F.A.TILLMAN (1966) presented the constrained Reliability Optimization problems with their solutions using Integer Programming. L.R. WEBSTER
(1964) developed a system to choose optimum system configuration and in (1967) proposed an optimum System Reliability Model establishing the relation between System Reliability and its Cost effectiveness.


F. COMPLEX (NON SERIES - PARALLEL) INCLUDING BRIDGE NETWORK:

presented a new approach for System Reliability Evaluation using parametric representation of Probability in two dimensions. Y.H.KIM & K.E.CASE & P.M.GLARE (1972) established a method for the computing complex system Reliability. K.K.AGGARWAL (1976) developed an Algorithm for optimum allocation of redundancies in general systems. The Algorithm is applicable for any system configuration where subsystems are composed of identical Parallel elements.

2.3.2. CLASSIFICATION OF SYSTEM RELIABILITY MODELS WITH REDUNDANCY: (BY OPTIMIZATION TECHNIQUES)

The Reliable performance of a system for a mission under various conditions is of utmost importance in many industrial, military and everyday life situations. Although the qualitative concepts of Reliability are not new, its quantitative aspects have been developed over the past four decades. Such developments have resulted in increasing need of better Optimization Techniques. Hence the classification regarding Optimization Techniques for obtaining optimal system configuration be classified as:

1. Integer Programming
2. Dynamic Programming
3. Maximum Principle
4. Linear Programming
5. Geometric Programming
6. Sequential Unconstrained Minimized Technique (SUMT)
7. Modified Sequential Simplex Pattern Search
8. Lagrangean Multipliers & Khun - Tucker conditions
9. Generalized Lagrangean Function
10. Generalized reduced Gradient
11. Heuristic Approach
12. Parametric Approach
13. Pseudo - Boolean Programming

1. INTEGER PROGRAMMING:

Even though Integer Programming yields integer solutions, the transformation of non-linear objective functions and constraints into a linear form is difficult. In addition the Integer Programming Technique do not guarantee that optimal solutions can be obtained in a reasonable time. The work reported using Integer Programming Technique are R.E.GOMORY (1958) proposed an algorithm to obtain Integer solution for a set of linear problems. P.J.KOLESAR (1967) developed a multi component system in Reliability theory by making use of Linear Programming. F.A.TILIMAN, J.M.LIITTSCHWAGER (1967) considered a set of constrained Reliability problem and formulating it through Integer Programming approach to optimize system Reliability. A.M.GEOFFRINION (1969) recommended an improved implicit enumeration approach for Integer Programming problems.

2. DYNAMIC PROGRAMMING:

Dynamic Programming Technique is a computational method for optimizing multistage decision process. Dynamic Programming has dimensionality difficulties that increase with the number of state variables and it is hard to solve problems with more than three constraints. The literature available where researchers used Dynamic Programming has a tool to solve the Reliability problems are R.BELLMAN & S.DREYFUS (1958) have developed the functional equation technique of Dynamic Programming used to treat a class of problems that arise in the construction of multi component devices. D.E.FYFEE, W.W.HINES, N.K.LEE (1968) using Dynamic Programming approach proposed system Reliability
allocation presenting computational algorithms to optimize system Reliability.


3. MAXIMUM PRINCIPLE:

L.T.FAN, C.S.WANG, F.A.TILLMAN & C.L.HWANG (1967) used a variation technique to obtain an optimum Redundancy of the parallel system. In their work the objective function is to maximize the system profit. A simple computational procedure is suggested for the optimum design of the multistage parallel systems by this method. K.B.MISRA (1972) provided a simple algorithm for finding reliability optimization of a series parallel system. F.A.TILLMAN, C.L.HWANG, L.T.FAN & S.A. BABALE (1968) developed a method for system Reliability subject to multiple non-constraints.
4. LINEAR PROGRAMMING:

Few researchers used Linear Programming technique tool for solving Reliability Optimization problems. V. SELMAN & N.T. GRISAMORE (1966) developed an analysis for optimum System Reliability by Linear Programming. P.J. KOLESAR (1967) also used Linear Programming technique for Reliability of multi component system.

5. GEOMETRIC PROGRAMMING:

Geometric Programming Technique is restricted to problems that can be formulated by polynomial functions. A.J. FWEDEROWICZ & M.MAZUMDAR (1968) used geometric Programming technique to maximize the system Reliability achieved by Redundancy. K.B. MISRA & J.SHARMA (1973) also used a new Geometric Programming formulation for a Reliability Optimization Problem.

6. SEQUENTIAL UNCONSTRAINED MINIMIZATION TECHNIQUE:


7. MODIFIED SEQUENTIAL SIMPLEX PATTERN SEARCH:


8. LEGRANGEAN MULTIPLIERS AND KUHN - TUCKER CONDITIONS:

9. GENERALIZED LAGRANGEAN FUNCTION:

W. KUO (1977) suggested Optimization techniques for System Reliability with Redundancy. The Lagrangean Method is used in his approach for solving System Reliability Problem.

10. GENERALIZED REDUCED GRADIENT:

W. KUO (1977) suggested Optimization techniques for System Reliability with Redundancy. The Lagrangean Method is used in his approach for solving System Reliability Problem for the Parallel - Series Configuration.

11. HEURISTIC APPROACH:

The technique Heuristic Approach gives an optimum solution in most cases without much special computational effort but the solution may not be global optimum. J. SHARMA & K.V. VENKATESWARAN (1971) developed a simple computational procedure for Allocating Redundancy among the subsystems so as to achieve maximum Reliability of a multi stage system subject to multiple constraints, which need not be linear. K.K. AGGARWAL et al (1975) presented a new Algorithm for the Heuristic solution of Redundancy Optimization problems. K.K. AGGARWAL (1976) also developed an Algorithm for optimum allocation of Redundancy in a general system.
12. **PARAMETRIC APPROACH:**


13. **PSEUDO - BOOLEAN PROGRAMING:**


2.4. **CLASSIFICATION OF SYSTEM REALIABILITY MODELS WITH REDUNDANCY: (BY STRUCTURE OF OPTIMIZATION PROBLEMS)**

The literature reported in sections 2.3.1 and 2.3.2 can also be categorized as "System Reliability Models with Redundancy in respect of its structure of Optimization" and is classified hereunder:

A. Optimum Reliability allocation for a Series System

B. Optimum Redundancy Allocation, maximization of System Reliability subject to Cost Constraints.

C. "Cost" minimization problems subject to System Reliability Constraint.

D. System Reliability Maximization for a Non Series - Parallel System - Reliability Allocation and Redundancy Allocation.

E. Maximization of System Profit: Maximization of the ratio of 'System Reliability' to 'Power demand of the System'.