CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

The problem of scheduling of resources like operators and machines in manufacturing systems has been studied over the last four decades. Methods based on priority dispatching rules, simulated annealing, particle swarm optimization algorithm, tabu search, genetic algorithm, artificial neural networks, linear programming, integer programming, graph theory and lagrangian relaxation techniques etc., have been proposed to solve the scheduling problems. This chapter reviews the literature on assembly job shop scheduling (AJSS) and Particle Swarm Optimization algorithm.

2.2 LITERATURE ON PDRs

Gere (1966) provided definition of various terms of job shop scheduling problems and has given several assumptions used in the scheduling research. These assumptions are widely used by researchers for simulation study of job shop scheduling. He has laid out basic definitions for a priority rule, scheduling rule and heuristics in his article and made an attempt to distinguish them.
**Priority Rule:** A priority rule or priority function is that function which assigns to each waiting job a scalar value, the minimum of which, among jobs waiting at a machine, determines the job to be selected over all others for scheduling. In the case of a tie, the job with smaller job number is selected.

**Scheduling Rule:** A scheduling rule dictates which job among those waiting for service is to be scheduled in preference to others. Scheduling a job means scheduling the next operation of the job. Priority rules comprise a proper subset of scheduling rules. A scheduling rule may include one or more heuristics in addition to or instead of a priority rule.

**Heuristics:** They are used to represent a rule of thumb.

His research study includes the use of eight priority rules in combination with three heuristics for due-date problems. He proposed eleven conjectures and tested them with twenty-five static and sixteen dynamic problems. He concluded that the use of heuristics may be effective in handling minimum make span problem and suggested that a simple rule should be used when there is little difference in effectiveness of the priority rules after they are combined with two or more heuristics.

Mellor (1966) in his review on job shop scheduling has also provided the definitions used in scheduling problems and put the scheduling problems into two classes as minimum make span problem and the due date problem and has cited the criteria used by the earlier researchers in the two classes. The measures of performance and scheduling goals used by other researchers are also provided in his review.
Adam et al. (1987) dealt with the design of priority rules for job shops that process multi-level assembly jobs. Specifically, it explores the means by which the structural complexity of jobs can be incorporated explicitly into priority rules to reduce job lead times. The authors have focused on the development of a class of priority rules that is aimed at reducing the staging delay. The class of priority rules that is developed is then used in combination with rules that are effective for the flow time component. The combined rule results in the improvement of the lead time performance. Authors also included experimental results on sets of jobs of varying degrees of complexity. These results provide a comparative perspective on the performance of priority rules.

Haupt (1989) gave a survey on heuristic priority rule based job shop scheduling.

Ramasesh (1990) presented a survey of simulation based research on dynamic job shop scheduling. It is concluded that sequencing rules which excel in simple job shops are not necessarily appropriate for assembly shops.

Reeja and Rajendran (2000a, 2000b) presented the development and evaluation of dispatching rules for scheduling in job shops manufacturing multi-level assembly jobs with the performance measures related to tardiness. They presented a new definition of 'operation due date' in the context of assembly jobs and use it in the development of dispatching rules. A simulation study is carried out to evaluate the performances of the existing and the proposed dispatching rules with respect to different measures of tardiness. They also measure their performances with respect to different measures of flow time and staging delays. The results of the study indicate that the proposed rules perform better than the existing rules.
Mohanasundaram et al. (2002) developed efficient dispatching rules to minimize the maximum and standard deviation of flow time and staging delay, and the maximum and the standard deviation of conditional tardiness of jobs. The dispatching rules are based on the computation of the earliest completion time of a job and consequently determining the latest finish time of operations on subassemblies of a job.

Thiagarajan and Rajendran (2003) addressed the problem of scheduling in dynamic assembly job-shops (manufacturing multilevel jobs) with the consideration of different holding and tardiness costs for different jobs. An attempt was made to develop efficient dispatching rules by incorporating the relative costs of holding and tardiness of jobs in the form of scalar weights. The primary objective of scheduling considered here was the minimization of the total scheduling cost consisting of the sum of holding and tardiness costs. The performance of the scheduling rules in minimizing the individual components of total scheduling cost was also observed.

Thiagarajan and Rajendran (2005) investigated dispatching rules with the consideration of different weights for earliness, tardiness and flow time of jobs for scheduling in dynamic assembly job-shops. They carried out an extensive simulation study for assembly job-shops that manufacture different types of multi-level jobs, with different levels of shop utilization and job due-date settings. They found dispatching rules for minimizing weighted mean sum of weighted earliness, weighted tardiness and weighted flow time of jobs.

Natarajan et al. (2007) developed new dispatching rules that minimize the performance measures for scheduling in dynamic assembly job shops with the consideration of different weights for holding and tardiness of jobs.
2.3 LITERATURE ON PSO

The PSO method is a member of the wide category of Swarm Intelligence methods (Kennedy and Eberhart, 2001), for solving Global Optimization (GO) problems. It was originally proposed by J. Kennedy as a simulation of social behavior, and it was initially introduced as an optimization method in 1995 (Kennedy and Eberhart, 1995). PSO is related with Artificial Life, and specifically to swarming theories, and also with Evolutionary Computation, especially Evolutionary Strategies and Genetic Algorithm. PSO can be easily implemented and it is computationally inexpensive, since its memory and CPU speed requirements are low (Eberhart et al., 1995). Moreover, it does not require gradient information of the objective function under consideration, but only its values, and it uses only primitive mathematical operators. PSO has been proved to be an efficient method for many Global Optimization (GO) problems and in some cases it does not suffer the difficulties encountered by other EC techniques (Kennedy and Eberhart, 1995).

Carlisle A. and Dozier G. (2001) presented an Off-The-Shelf PSO, which helps to understand the basics PSO.

Schutte et al. (2005) a parameter sensitivity analysis is performed for dynamic inertia and maximum velocity reduction in the interests of finding a reliable general purpose ‘off-the-shelf’ PSO for global optimization and it is shown that inclusion of dynamic inertia renders the PSO relatively insensitive to the values of the cognitive and social scaling factors.

2.4 LITERATURE ON GA

Gilkinson et al. (1995) proposed that genetic algorithms constitute the techniques available to solve job shop scheduling problems. Their efficiency, simple computational structure and inherent flexibility to utilize complex models make them good tools to generate satisfying solutions.

Hemant kumar and Srinivasan (1996) addressed an important problem of job shop scheduling for a real life situation using genetic algorithms. Branch and Bound algorithms for determining the optimal makespan have been developed and tested on small sized problems and dispatching rule based heuristic algorithms to minimize specific performance measures such as makespan, flowtime, tardiness, etc., are discussed to solve large sized problems. This paper addresses the problem faced by an organization and reports the solution of this problem using genetic algorithms (GA) and a combination of dispatching rules.

Dini et al. (1999) described a method based on genetic algorithms for generation and evaluation of assembly sequences. A fitness function which takes into account simultaneously the geometrical constraints and other important optimization aspects has been used to converge toward optimized assembly sequences. GAs are used here to drastically reduce the high computational time, usually necessary to evaluate the best assembly sequences.

Werner et al. (2003) attempted to evolve genetic algorithms by a particular genetic programming method to solve the classical job shop scheduling problem, which is a type of well known hard combinatorial optimization problems. The aim is to look for a better GA to solve job shop scheduling problem with preferable scores. This looking up procedure is done by evolving GA with genetic programming.
Ponnambalam et al. (2002) made an attempt to optimize the GA control parameters for job shop scheduling problems. The genetic parameters, namely, number of generations, probability of crossover, probability of mutation, are optimized relating to the size of the problems. If the number of jobs and the number of machines increases, the value of the control parameters must also to be increased. It is proposed that by using an appropriate range of parameters, the GA is able to find an optimal solution faster.

Guo et al. (2006) developed a mathematical model for the job shop scheduling problem in a mixed and multi-model assembly environment with the objective of minimizing the total penalty of earliness and tardiness. They also proposed a genetic optimization approach for the problem and evaluated its performance.

Dirk and Biewirth (2004) showed that a heuristic reduction of the search space can help the algorithm to find better solutions in a shorter time. Two ways of reducing a search space are investigated by considering short-term decisions made at the machine level and by long term decisions made at the shop floor level.

Pongcharoen et al. (2002, 2004) proposed GA based scheduling tool for a multilevel assembly job shop problem with multiple resource constraints. The GA includes a repair process that rectifies infeasible chromosomes produced during the evolution process. The tool generates a schedule that minimizes the penalties caused by early and late delivery of components, assemblies and the final product.

The literature survey on assembly job shop scheduling reveals that the quantum of research in this area is very limited even though most of the products manufactured in industries consists of both processing and assembly operations.
Population based search heuristics such as PSO and GA have emerged as powerful scheduling tools in the recent years.

2.5 SUMMARY OF THE LITERATURE SURVEY

The study of the literature has provided a need for further research in the area of job shops processing multi-level assembly jobs. It is evident from the literature survey that dispatching rules have been proposed to minimize the performance measures like mean lead-time and mean tardiness. Dispatching rules have been designed and studied keeping all customer orders with equal priority. The earlier study has not considered different customer priorities, which prevails as a common industrial practice.

All the earlier researchers have used hypothetical dynamic job shop and simulation methodology to evaluate priority-dispatching rules for processing multi-level jobs.

2.6 OBJECTIVES OF THE STUDY

Based on the critical survey of the available literature following objectives have been considered in this work.

1. To find optimum solutions using PSO and GA for multi – level assembly job shop scheduling problems that give minimum mean lead time and mean tardiness.

2. Determination of parameters of PSO and GA for assembly job shop scheduling that give minimum mean lead time, and means tardiness.

3. To explore the effectiveness of PSO and GA in finding optimal solutions in comparison with PDRs.

Chapter 3 describes in detail the principles of PSO and GA.