Chapter II
Solving Machine Loading Problem of FMS:
An Artificial Intelligence (AI) Based Random Search Optimization Approach

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ABSTRACT

Artificial intelligence (AI) refers to intelligence artificially realized through computation. AI has emerged as one of the promising computer science discipline originated in mid-1950. Over the past few decades, AI based random search algorithms, namely, genetic algorithm, ant colony optimization, and so forth have found their applicability in solving various real-world problems of complex nature. This chapter is mainly concerned with the application of some AI based random search algorithms, namely, genetic algorithm (GA), ant colony optimization (ACO), simulated annealing (SA), artificial immune system (AIS), and tabu search (TS), to solve the machine loading problem in flexible manufacturing system. Performance evaluation of the aforementioned search algorithms have been tested over standard benchmark dataset. In addition, the results obtained from them are compared with the results of some of the best heuristic procedures in the literature. The objectives of the present chapter is to make the readers fully aware about the intricate solutions existing in the machine loading problem of flexible manufacturing systems (FMS) to exemplify the generic procedure of various AI based random search algorithms. Also, the present chapter describes the step-wise implementation of search algorithms over machine loading problem.

MACHINE LOADING PROBLEM IN FMS

Conceiving incomputable thrust in the market, and unassailable pressure from the competitors, it becomes worthy to the managers of modern manufacturing systems to analyze their systems critically. Time effective production with the least involvement of the cost has become a key issue in the automated manufacturing systems to strive hard in the market. Loading decisions play crucial role in inducing such behavior by processing the job in a feasible sequencing schedule. Effective loading decisions are particularly important in the large and complex manufacturing systems. In this chapter, we present an analytical study of the loading decisions of one of the most widespread domain of manufacturing systems, termed as flexible manufacturing systems, abbreviated as FMS. According to Stecke (1983), machine loading problem is one of six post release decisions of a flexible manufacturing system that is known for its computational complexity and high variability. A typical FMS consists of a set of highly automated *numeric control* (*NC*)-machines along with a material handling device both under the supervision of a centralized computer system (see figure 1). The highly sophisticated machine tools render the FMS to have wide range of manufacturing operations and allow simultaneous production of multiple part types maintaining a high degree of machine utilization (Tiwari, Hazarika, Vidyarthi, Jaggi, & Mukopadhyay, 1997). Machine-loading problems in flexible manufacturing deal with the assignment of various resources (fixture, pallets, tools, automated guided vehicles (AGVs), machine, etc.) to the operation of different part types planned for production in a given planning period. Loading problems in manufacturing deal with the assignment of various resources (machines, tools, fixtures, pallets, etc.) to the operations of different part types that are already planned for production in a given planning horizon. Deci-

sions pertaining to loading problems have been viewed as tactical level planning decisions that receive their inputs from the preceding decision levels; namely, grouping of resources, selection of part mixes, aggregate planning that generates the inputs to the succeeding decisions of scheduling resources, and dynamic operations planning and control (Rai, Kameshwaran, & Tiwari, 2002). Therefore, it can be construed that loading decisions are acting as an important link between strategic and operation level decisions in manufacturing. Van Loovern, Gelders, and Van Wassenhove (1986), Kusiak (1985), Singhal (1978), and Whitney and Gaul (1984) discuss the interrelationships of various decisions and their hierarchies in a flexible manufacturing environment. Liang and Dutta (1993) address the part selection and machine loading problem simultaneously, which was separately treated by previous researchers. A number of researchers have addressed the part selection problem using various methods (Hwang, 1986; Kusiak, 1985; Stecke, 1986; Sawik, 1990), whereas, formulations and solution methodologies for various scenarios and combinations of parameters relating to the loading problem in an FMS have attracted the attention of numerous researchers including Liang and Dutta (1993), Tiwari et al. (1997), Laskari, Dutta, and Padhye (1987), Mukhopadhyay, Midha, and Krishna (1992), Chen and Askin (1990), Shanker and Tzen (1985), Shanker and Srinivasulu (1989), Ram, Sarin, and Chen (1990), Chen and Chung (1996), and so forth. Part selection, machine loading, and tool configurations are three different but interlinked problems that are connected by common restrictions such as tool magazine capacity, job-tool machine compatibility, and available machining time. However, for the clarity of the problem, most researchers have treated part selection, machine loading, and tool configuration in a discrete manner.

More generally, an FMS loading problem can be defined as:

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