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Flexible Job Shop Scheduling Problem in Manufacturing

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1 Abstract

This paper addresses a real assembly cell: the AIP-PRIMECA cell at the Université de Valenciennes et du Hainaut-Cambrésis, in France. This system can be viewed as a Flexible Job Shop, leading to the formulation of a Flexible Job Shop Scheduling Problem (FJSSP).

In a general way, the Flexible Manufacturing System (FMS) offers the possibility to create the products "AIP", "LATE" and "BELT". The FMS is composed by five workstations, each one being able to perform a set of operations, that are linked using a conveyor system. The transportation between stations is achieved using a shuttle which is able to transport one product at the time, being released after the product processing conclusion.

Six components are available in this FMS: Plate, Axis_comp, I_comp, L_comp, r_comp and screw_comp. There are seven types of jobs that can be manufactured, they are denoted by: “B”, “E”, “L”, “T”, “A”, “I” and “P”. The components are used to manufacture the seven types of jobs.

In this specific problem, each job (i.e. the product) has a set of operations that can be done in a set of machines. There are eight manufacturing operation types: Plate loading, Axis mounting, r_comp mounting, I_comp mounting, L_comp mounting, Screw_comp mounting, Inspection and Plate unloading. For example, I_comp mounting means that the I component must be mounted on the plate. Additionally, it is also assumed that each job has an operation list that needs to be processed in a specific order.

Machines are responsible for the completion of manufacturing operations to do the jobs. Some machines are able to complete the same manufacturing operation, while some manufacturing operations can be completed on a single machine. Each machine is continuously available as the system start and each machine can process only one operation at time. The cell is composed of five machines: M_1: loading/unloading unit; M_2, M_3 and M_4: three assembly workstations; M_5: automatic inspection unit.

The problem consists in finding a operations schedule on the machines, taking into account the precedence constraints minimizing the batch makespan, i.e., the finish time of the last operation completed in the schedule.

To solve the flexible job shop the genetic algorithm (GA) was used. As opposed to many other optimization methods, genetic algorithm works with a population of solutions instead of one single solution. In the GA the solutions are combined to obtain new solutions until obtain a satisfactory solution. The genetic algorithm is a stochastic method, whose mechanism is based on the simplifications of evolutionary process observed in nature: crossover, mutation and selection.

The GA uses crossover process, where the genes of the best individuals are crossed with genes from other individuals which also have good performance. The algorithm also applies the concept of mutation, thus improving the optimization process by introduction values that were not present in the previous generations. Finally, the genetic algorithm select the best individuals to participate in the next population.

The genetic algorithm was applied to solve the flexible job shop problem proposed in this work with the objective of finding the global solution of the optimization problem.