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An Effective Algorithms for Optimization of Process Planning and Scheduling: A Review

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Abstract— The main objective of this paper is to present an effective algorithms to address the manufacturing problems. This paper provides the information about how various authors, researchers, scientists have implemented algorithms in various manufacturing system. This study involves a rigorous review of recent works carried out using different types of algorithms in optimizing the process planning and scheduling. The outcome of this study will help in the manufacturing sector to determine the best algorithm that is best suited for their optimization problems.

Keywords— Algorithm, Process Planning, Scheduling, optimization.

1. INTRODUCTION

Reducing the time from start to delivery by eliminating the source of waste in the work flow is one of the basic concepts. A manufacturing function that can be employed to handle such tasks is manufacturing process planning (MPP). This work focuses on a study of an optimization approach that can be used to address issues that are critical in providing an optimal match of activities and resources in a multi resource manufacturing line that produces multiple parts with reconfigurable flows. Such issues include: process selection, process sequencing and part load scheduling, i.e. the order of processing multiple parts [1]. All these factors caused the manufacturing industry to become highly competitive and new market entries from low wage countries have put pressure on management to make changes in their operating business [2]. One way by which manufacturing plants adapt to those environmental dynamics is the engagement in manufacturing process innovation [3].

Traditionally, process planning and scheduling for parts were carried out in a sequential way, where scheduling was done after process plans had been generated. Considering the fact that the two functions are usually complementary, it is necessary to integrate them more tightly so that performance of a manufacturing system can be improved greatly [4]. Process planning for prismatic parts is a very complex and difficult process. For a prismatic part with complex structures and numerous features, process planning involves selecting machining operations for every feature and sequencing them considering precedence constraints, choosing available manufacturing resources, determining setup plans, and machining parameters, and so forth. In Computer-aided process planning systems, these activities can be carried out simultaneously to achieve an optimal plan, thus the manufacturing efficiency could be largely increased or the production cost could be decreased. So, process planning problem is well known as a combinatorial optimization problem with constraints. With the advance of computer technology, some artificial intelligence (AI) techniques are used to solve combinatorial optimization problem. For example, some bioinspired algorithms are applied in complex decision-making process of solve combinatorial optimization problem [5, 6].

Optimization, in general, is a process of finding the best feasible solution to a problem. An optimization problem can be viewed as a task, the goal of which is to configure a set of given parameters to reach an optimal solution of the given problem and, simultaneously, meet the predefined criteria. The global optimization [7, 8] is a process where such solution is required with the condition that no better solution exists. Solutions are termed bad and good in terms of an objective to which they are optimized. The field of optimization has grown rapidly in recent decades.

2. REVIEW ON PROCESS PLANNING AND SCHEDULING

In General, the manufacturing process is planned in a static manner, whether it is prepared by human or with computer assistance. However, due to the dynamic fluctuation of customer demands in the market, manufacturing enterprises are facing difficulties in rapidly responding to Market changes. Thus, it might be useful if the process plan could be dynamically modified to consider the current state of the manufacturing system so as to study the manufacturing performance in unpredictable situation. For the purpose of increasing the responsiveness of manufacturing systems to handle unstable market changes, the integration of Process planning and production scheduling concept has been introduced [9]. Process planning and production planning are the links between product development and production. However, there is no single definition of these terms and they differ between type of production as well as organization. This work considers only metal cutting using CNC technology. The overall concept of process planning can be divided into many different sub-levels, where one such categorization is made according to the constraints that restricts the possible selections during process planning [10].

Production scheduling is the activities performed in manufacturing companies to manage and control the execution of the production process. Scheduling has to consider operations sequences, machine load and availability of machines. This means that scheduling is based on predetermined process planning. Process planning determines the manufacturing process routing and acts as a bridge between product design and manufacturing. That is, it is a process of allocating resources and operations for manufacturing of products. Process planning and production scheduling activities in a job shop are closely related to each other, but typically they have been handled independently. Process planning has been done without considering the current capacity of the shop in terms of effective use of resources. Also, scheduling has been performed without regard to the opportunities that alternative process plans can provide for acceleration of production flows. In scheduling, an alternative process plan enables the allocation of operations to other machines with flexibility of, thus reducing the possibility of the collision between a job and a machine [11]. when the level uncertainty and randomness in the system increases. A general rule is that as the uncertainty increases, the value of scheduling deceases [12]. Trying to predict and optimize the behavior of a complex system with many uncertainties and high level of randomness is in most cases a waste of time and resources. On the other hand, for more stable systems, putting more effort into scheduling often can improve performance and the use of advanced optimizing methods might in these cases be appropriate. How scheduling is performed also depends on the management of the company and the organization around the scheduling function. Some companies may not have an explicit scheduling method; it is just something that is done implicitly by for instance the workers or shop floor management, while others have very strict approaches that are decided upon by the management. How the schedule is used can also differ between companies and also between different users in the same company. Besides the obvious use on the shop floor other potential uses are to determine system capacity for a higher level production planning system, where the generated schedule is used to determine the feasibility of the production plan or by the sales department to determine if an order with a given lead time should be accepted [13].

3. DIFFERENCE BETWEEN PROCESS PLANNING AND SCHEDULING

The difference between planning and scheduling is a somewhat blurred area and the definition to some degree varies between different sources in the literature. The general idea is that planning is done at a higher, aggregated level over longer time periods and that scheduling involves more details and is done over shorter time periods. As the MPC activities proceed from planning to scheduling each step adds more details and brings the initial demands closer to being executed on the shop floor. Planning uses expected demands and forecasts and therefore always contains some level of uncertainty. As the plans evolve through the planning and scheduling process and details are added, that uncertainty is gradually removed.

Process planning and scheduling used to link product design and manufacturing are two
of the most important functions in a manufacturing system. A process plan specifies what manufacturing resources and technical operations/routes are needed to produce a product (a job). The outcome of process planning includes the identification of machines, tools and fixtures suitable for a job, and the arrangement of operations and processes for the job. Typically, a job may have one or more alternative process plans. With the process plans of jobs as input, a scheduling task is to schedule the operations of all the jobs on machines while precedence relationships in the process plans are satisfied [14]. Although there is a close relationship between process planning and scheduling, the integration of them is still a challenge in both research and applications. Process planning and scheduling are two key techniques of the development of distributed and collaborative manufacturing [15]. Although process planning can enhance productivity of manufacturing systems and scheduling can optimise process series, some researches showed that the separated process planning and scheduling systems could not improve the productivity of manufacturing system largely [16, 17].

Traditionally, the integration and interactions of process planning and scheduling are through an iterative and empirical fashion. The process planning system first generates a reasonable process plan for each part. Crucial processes in the system include determining suitable manufacturing resources (machines and tools), selecting set-up plans and sequencing machining operations of the part. The scheduling system then specifies the schedule of manufacturing resources on each operation (job) of the parts according to the

importance of jobs, availability of resources and time constraints. It is usually difficult to produce a satisfactory result in a single iteration of the execution of the two systems. For the process planning system, the decision of selecting machines and tools is usually made based on objectives to achieve the minimal manufacturing cost and ensure the good manufacturability of a part [18].

4. REVIEW ON EFFECTIVE ALGORITHMS

Genetic Algorithm (GA) is effective and robust method for solving many optimization problems. However, it may take more runs (iterations) and time to get optimal solution. The execution time to find the optimal solution also depends upon the niching-technique applied to evolving population. The information about how various authors, researchers, scientists have implemented GA on GPGPU (General purpose Graphics Processing Units) with and without parallelism. Many problems have been solved on GPGPU using GA. GA is easy to parallelize because of its SIMD nature and therefore can be implemented well on GPGPU. Thus, speedup can definitely be achieved if bottleneck in GAs are identified and implemented effectively on GPGPU [19].

Conflict avoidance (CA) plays a crucial role in guaranteeing the airspace safety. To minimize the risk of premature convergence being faced by current approaches and obtain higher quality solutions, an effective strategic framework based on a memetic algorithm (MA), which can markedly improve search capability via a combination of population-based global search and local improvements made by individuals. In addition, a specially designed local search operator and an adaptive local search frequency strategy are proposed to improve the solution quality. Furthermore, a fast GA is presented as the global optimization method. Empirical studies using real traffic data of the Chinese air route network and daily flight plans show that our approach outperformed the existing approaches including the GA based approach and the cooperative coevolution based approach as well as some well-known memetic algorithm based approaches [20].

The continuous growth of air traffic has led to acute airspace congestion and severe delays, which threatens operation safety and cause enormous economic loss. Flight assignment is an economical and effective strategic plan to reduce the flight delay and airspace congestion by reasonably regulating the air traffic flow of China. However, it is a large-scale combinatorial optimization problem which is difficult to solve. In order to improve the quality of solutions, an effective multi-objective parallel evolution algorithm (MPEA) framework with dynamic migration interval strategy is presented [21].

A competitive memetic algorithm (CMA) is proposed to solve the multi-objective distributed permutation flow shop scheduling problem (MODPFSP) with the makespan and total tardiness criteria. Two populations corresponding to two different objectives are employed in the CMA. Some objective-specific operators are designed for each population, and a special interaction mechanism between two populations is designed. Moreover, a competition mechanism is proposed to adaptively adjust the selection rates of the operators, and some knowledge-based local search operators are developed to enhance the exploitation ability of the CMA [22].

An optimization algorithm is a procedure which is executed iteratively by comparing various solutions till the optimum or satisfactory solution is found. Accepting the best solution after comparing a few design solutions is the indirect way of achieving optimization in many industrial design activities. There is no way of guaranteeing an optimal solution with this simplistic approach. Optimization algorithms on the contrary, begin with one or more design solutions supplied by the user and then iteratively check new design solutions, relative search spaces in order to achieve the true optimum solution [23].

The study involves a rigorous assessment of catalogues of recent works carried out using different types of evolutionary algorithms in optimizing the scarce water resources in the semi-arid regions with particular reference to irrigation water management. The behavior and outcome of these techniques under different application types are discussed explicitly. Issues that need to be addressed with respect to the performances of these techniques during different iteration processes are also discussed. The study covers different application areas which include irrigation water allocation and scheduling, irrigation planning with special focus on crop planning and pattern; reservoir operations and irrigation water distribution network. Arid and semi-arid regions experience low annual rainfall and therefore it is imperative to optimize the available water resources for agricultural purposes via irrigation so as to promote food security. The outcome of this study will help stakeholders in the irrigation sector to determine the best evolutionary algorithm that is best suited for their optimization problems [24].

5. CONCLUSIONS

The focus is brought on problems related to the design, organization, and management of the manufacturing system. From the recent published literature, the author has identified the following types of problems as the most addressed: production planning and scheduling of the manufacturing system.

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