Machine Tool Scheduling Problem for Reconfigurable Manufacturing System (RMS)

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ABSTRACT
This paper provides a novel approach of production scheduling considering the reconfigurable machine tools. In dedicated Manufacturing lines (DML) and flexible manufacturing systems (FMS) do not meet the challenges up to expected level because of short comings in their implementation procedurals like lack of support for product variation, scalable production capacity and high production cost, RMS provides the solution in designing a new manufacturing system with scalable flexibility and functionality which is needed in the manufacturing industry. This paper studies the problem of Machine tool scheduling of different operations in for the selected product in reconfigurable manufacturing systems (RMS). The objective is to minimize the make span of the product by segregating and scheduling the similar operations of product. To solve the existing problem in the production scheduling different heuristic approaches are developed for simulation, models are evaluated for the performance.

INTRODUCTION

Manufacturing processes is value addition to the raw material which converts low value input parts into high value finished products using available resources such as machines, tools, and energy and manpower. In manufacturing systems, some machines are dedicated for some common machine operations like drilling, boring, milling and treading. This type of manufacturing systems is called dedicated manufacturing lines. For medium scale production this DML systems gives satisfactory profits, to enhance the revenues the flexible manufacturing systems (FMS) are into the manufacturing sector. But, FMS is still not satisfactory due to high cost of production and it also not provide generalized flexibility in the manufacturing setup (Koren, Y., et al., 1999). In the present scenario the main goal of any organization is to earn profit. If the set goal wants to be reached, meeting customer demands completely and in time and offering them high-quality products is must. Production scheduling plays a major key role to achieve the necessary competitiveness and fulfill the given task. But the production scheduling issues are very complex because of the continuous changing needs of customers and the existing constraints in different metal manufacturing industry. Number of researchers has been published, following the appearance of Gantt chart that discusses the models and methods for solving production scheduling problems. In the literature on production scheduling various models and methods are used: mathematical programming (Harjunkoski, I. and I.E. Grossmann, 2002) and artificial intelligence. The models mentioned in the literature can be classified as deterministic and stochastic, and as static and dynamic. The published papers treating the production scheduling problem deal with different types of production. (Erel,
E. and J.B. Ghosh, 2007; He, C., et al., 2005) studied a single machine batch scheduling problem, and the objective of established model is to minimize the maximum lateness. In the paper the authors compare various methods for the flow-shop scheduling problem with the late work objective function. (Blazewicz, J., et al., 2005; Blazeicz, J., et al., 1998) have studied the problem of scheduling a multiprocessor task model with parallel work on several processors that is often used in modern manufacturing system is discussed and they have applied scheduling in time windows for the objective function of maximum lateness and schedule length. Golenko-Ginzburg et al., (1997) have discusses the job shop scheduling problem doe flexible manufacturing system. To solve the job-shop scheduling problem a new time and memory efficient representation of the disjunctive graph is given in the paper. T’ Kindt et al., (2003) discuss the optimization of multiple conflicitous criteria for flow shop scheduling problem. In the literature researchers are elaborated the activities scheduling problem aiming at minimizing the project duration with the possibility to perform the activities in several variants. The project scheduling problem classification is also given. Allahverdi et al., (1999) have studied the scheduling problem with the setup time included, in contrast to most models that disregard the machine setup time or consider it as part of the processing time and also studied the family scheduling model which includes the setup times when there are family setup times aimed at minimizing total earliness and total tardiness. Leung et al., (2007) have studied the problem of scheduling orders with various priority rules.

ElMaraghy (2005) made an attempt to compare RMS and FMS, concluded that the detailed customized flexibility in RMS is possible. Galan (2008) have studied to group the products into families and to schedule the families using RMS. Meng (2010; Oğuz, C. and M. Fikret Ercan, 1997; Wang, J.-B. and L.-L. Liu, 2009) made an attempt to proposes a model for the RMS by applying colored timed object-oriented Petri nets. Abbasi et al., (2011) have studied to propose a mixed integer nonlinear programming model to determine. Lot of size and corresponding configurations. They have used a genetic algorithm-based procedure is developed to solve the model. Azab et al. (2011) have developed and integer model, they have considered operations sequencing in RMS to minimize changeover time while satisfying a number of precedence constraints in their model.

2.1 Problem Definition:

This paper deals with production scheduling issues in machining shop. The machining of engine blocks (Milling, Drilling, Boring, Threading and honing) is a combined continuous discrete production with processes: loading and unloading the job, changing tools, shifting job into different machines measuring and checking the features generated. Fig.1 gives a scheme of production lines in the machining shop. The production process consists of five production lines with ten different machines for production of engine blocks.

Fig. 1: Engine Block Production line in Machine Shop

Tasks set to the production of engine blocks scheduling system are:
- To calculate the available machining capacity for the total of 24 hours,
- To group products according to similar features
- To group products according to dimensions of features
- To open production order with the similar features grouped as mentioned above
- To create daily plan for production based on work shifts
- To schedule daily production for the lines and available capacities of machines
Machine shops cause bottlenecks. Bottlenecks are identified as critical manufacturing resources and scheduled first. The mathematical model and algorithm for engine block machining scheduling is developed based on algorithm with adjustment to the specific problem of scheduling machine shop.

The objective is to find feasible production schedule

Let $F_o = \{i \in O\}$ be a set of features which can be produced by the same machine and $D_o = \{m \in P\}$ be a set of items with similar dimensions. Thus the items are grouped to production order $O$.

The following notation is used

2.2 Indices:
- $i = 1... I$ Items
- $j = 1... J$ Operations
- $l = 1... L$ Production lines
- $m = 1... M$ Machines
- $O = 1... O$ Production Orders
- $t = 1... T$ Periods

2.3 Parameters:
- $dd_{i,o} =$ delivery date for item $i$ and order $o$ 
- $K_i =$ tardiness of item $i$ [day]
- $k_{lj} =$ utilization factor of machine $m$ on production line $l$
- $\bar{c}_{l} =$ available capacity of machine $m$ in a day $t$ [hours]
- $c_{l} =$ capacity of machine on production line per hour [no. of items / hour]
- $n_{s} =$ available number of machines type
- $n_{s} =$ number of hours in shift $s$
- $s_{st} =$ number of shifts in a day
- $O^t =$ number of overtime hours
- $Pr(i) =$ priority of item $i$
- $q_{lm} =$ quantity of items $i$ from one machine [number]
- $q_{lo} =$ quantity of items $i$ per production order $o$ [number]
- $q_{lt} =$ quantity of produced items $i$ in period $t$ [number]
- $q_{lt} =$ orderd quantity of item $i$ [number]
- $q_{lt} =$ inventory of item $i$ in period $t$ [number]
- $Q_{oe} =$ total quantity of engine blocks machined
- $Q_{le} =$ quantity of engine blocks machined for line $l$
- $Q_{ol,m} =$ quantity of items machined for one feature in machine $m$ on line $l$
- $t_{ij} =$ processing time of operation $j$ of item $i$ [hours]
- $t_{l,f} =$ processing time of feature in machine $m$ on production line $l$ [hours]
- $t_{l,f} =$ duration of machining of item $i$ for machine $m$ on production line $l$
- $tm_{m} =$ time of assuring necessary quantity of machining type
- $tm_{m} =$ start time of machining operation of item $i$
- $tm_{m} =$ start time of feature machining in machine $m$ on production line $l$
- $tz_{i,o} =$ finish time of item $i$ on production order $o$
- $tz_{i,o} =$ finish time of machining
- $\tau = $ transportation time between one work station and another work station
- $\tau_{l,f,m} =$ time between feature machining

2.4 Decision Variables:
- $x_{i,m} =$ binary variable, $x_{i,m} = 1$ if item $i$ is produced in machine $m$, otherwise $x_{i,m} = 0$
- $y_{l,f,m} =$ binary variable, $y_{l,f,m} = 1$ if operation $f$, is produced in machine $m$, otherwise $y_{l,f,m} = 0$
- $y_{l,i} =$ binary variable, $y_{l,i} = 1$ if operation $i$, is produced in line $l$, otherwise $y_{l,i} = 0$

The Mathematical Model is formulated as follows.

Minimize
3.1 Model Evaluation:
In this section briefly explains the evaluation of the developed model for minimizing the make span of the machining of engine block. This model need to be evaluated using advanced software’s like CIPLEX for both similar features in size and complexities in producing them. In the present paper only considered for the study of the production scheduling problem in flow shop scheduling using RMS.

3.2 Data Collection:
The real data have been collected from the production head that is responsible for production planning for the flow shop scheduling problem. The data such as processing time, Due date, weight of the job with demand and sequence dependent set up time for execution of developed model. Using this collected data the developed model is going to evaluate in the next step and the same considered in the next paper.

Conclusion:
The study has been done on the problem of scheduling of different operations in reconfigurable manufacturing systems (RMS). The assumptions which has been made that a manufacturing system is available with set of machines. This manufacturing system is designed to manufacture variety of features in any selected component. Here the system requires reconfiguration to switch from one feature of operation to another feature, which needs some changes in the system. This changes are highly depends on the sequence of two consecutive features machining. An attempt has been made on studying this problem, by formulation of mathematical model by considering the sequence of operations.

REFERENCES


