

Integration of Job Release Policies and Job Scheduling Policies in Assembly Job Shop Scheduling

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Abstract - This paper focuses on scheduling an assembly job shop which processes end-items with bills of materials. Order release represents the first stage of control which determines the timing of release of orders into the shop floor while dispatching represents the second stage of control which determines the processing sequence of jobs waiting before different machines. This research proposes an integrated approach of job release policies and dispatching rules. A simulation model of a realistic assembly job shop has been developed for the purpose of experimentation. An order release policy using the concept of backward scheduling is adopted. Six dispatching rules from the literature are incorporated in the simulation model. End-items with single-level, two-level, and three-level assembly structures are considered. The performance of the shop is evaluated using mean flow time and mean tardiness. Firstly, the simulation is run under various dispatching rules without considering the order release policy. Secondly, the simulation is run under various dispatching rules with the integration of order release policy. The analysis of results reveals that there is a reduction in mean flow time and mean tardiness for the integrated approach.

Keywords: Assembly job shop, simulation, order release policy, dispatching rules.

1. INTRODUCTION

Scheduling can be defined as the allocation of resources over time to perform a collection of tasks. Scheduling specifies sequence and timing, normally expressed in terms of a set of start and due times. Assembly job shop can be considered as a generalization of job shop in that it not only includes serial operations but also assembly operations. In an assembly job shop, final products are assembled from sub-assemblies. Sub-assemblies may in turn be assembled from lower levels of components. In a multi-level assembly job, a higher level item cannot be processed unless all preceding lower level items have been completely processed and assembled together. It also implies that an item may have to wait for its parallel items/components before the required assembly (or subassembly) operations can take place. This structural complexity associated with assembly-type jobs introduces problems related to coordination and

spacing that do not exist when dealing with string-type jobs considered in the conventional job shop scheduling. Several studies have been carried out in the area of Assembly Job Shop Scheduling Problem (AJSSP). Different Methodologies such as priority dispatching rules, heuristics and meta-heuristics are used to solve AJSSP. Major studies have adopted priority dispatching rules. The priority dispatching rules represent the stage of control which determines the processing sequence of jobs waiting before different machines.

Sculli et al. (1987) reported a case study of an assembly shop in a dynamic environment based on optimal combination of due date assignment rule and sequencing rule. The research of Fry et al. (1989) has shown that there is a strong relationship between product structure complexity and performance measures. Three types of product structures namely flat product structure, tall product structure and complex product structures are included in many research works. Reeja and Rajendran (2000a), and Reeja and Rajendran (2000b) proposed two priority rules called operation synchronization date rule and a new version of operation due date. Thiagarajan et al. (2003) studied the effect of the minimization of the sum of weighted earliness, weighted tardiness and weighted flow time of jobs in a dynamic system environment. Lu et al. (2011) described the combination of order review/release mechanism and dispatching rules in an AJSSP.

Order release represents the first stage of control which determines the timing of release of orders into the shop floor while dispatching rules represents the second stage of control which determines the processing sequence of jobs waiting before different machines. From the literature review, it is evident that there is not much work done in AJSSP by integrating pre-shop floor control policies and shop floor control policies. This study focuses on this problem.

The rest of the paper is organized as follows. Section 2 provides the problem description. Section 3 describes the development of simulation model. Section 4 provides the details of experimentation, results obtained and the inferences drawn. Section 5 presents the conclusions.

2. PROBLEM DEFINITION

The main objective of integration of job release policies and job scheduling policies in assembly job shop scheduling is to minimize the mean flow time and mean tardiness. The performance measures are defined as follows:

$$\text{Mean flow time} = \sum_{i=1}^N (C_i - A_i) / N$$

$$\text{Mean tardiness} = \sum_{i=1}^N \text{Max}(L_i, 0) / N$$

Where C_i is the completion time required for the job i , A_i is the arrival time of the job i , L_i is the lateness of the job i , N represents total number of jobs

2.1 System Configuration

The assembly job shop considered for the development of simulation model includes seven work centers with two identical machines in each work center, and one assembly work center with two assembly machines. The product structure considered are single level assembly having components uniformly distributed between [2-5], two level assembly having components uniformly distributed between [2-3], [4-6] and three level assembly having components uniformly distributed between [3-5], [2-3], [2-3].

2.2 Product data

Figure 1 shows the product structures of the products considered.

- The routing of the jobs is taken as random, with each work center having equal probability of being chosen
- Job arrivals are generated using a Poisson process
- The number of operations for each item/subassembly is uniformly distributed between 2 and 7
- The process times of the items/subassemblies are drawn from a uniform distribution in the range of [1-20]
- The assembly operation time at any level varies uniformly from 5 to 20 time units

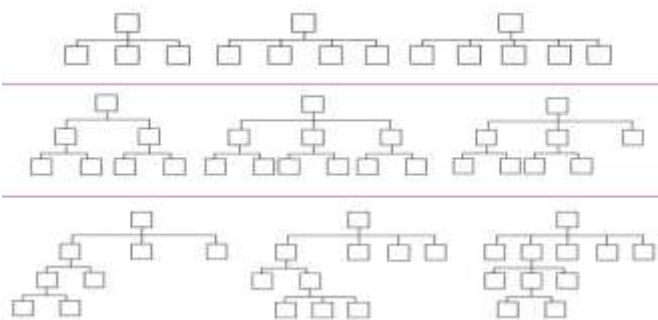


Figure 1: Product structure of the products

2.3 Assumptions

- Each machine/workstation can perform only one operation at a time on any item/subassembly
- The jobs revisit machines only after at least one assembly operation is carried out
- There are no limiting resources other than machines/workstations
- Machines are available continuously, i.e., there are no machine breakdowns

2.4 Order release policy

The present study uses the concept of backward scheduling for releasing jobs for processing. In backward scheduling, scheduling starts from the due date of each job and schedules backward in time. It involves processing of all parts as late as possible. An example of backward schedule approach is material requirements planning. In this study, components of jobs of single, two, and three level assembly structure are released to the floor shop when it is required, based on the difference between the time of critical and non-critical components. Suppose a job consists of two components say, A and B, out of which A is critical and B is non-critical. A takes a time unit of 90 while B takes 60 time units. Based on backward schedule approach, component A will be released first while B will be released to the shop after 30 time units. This reduces unnecessary waiting time and hence reduces mean flow time and means tardiness.

2.5 Priority dispatching rule

The dispatching rules used in this study are the following:

- FIFO (First In First Out): Components that arrive at a machine earliest will be processed first.
- SPT (Shortest Processing Time): Components with the shortest processing time will be processed first.
- JDD (Job Due Date): Products with the earliest due date will be processed first. The equation for the due date setting is given as

$$d_i = t_i + c \times l_i$$

Where d_i is the due date of the job i , c is the allowance factor ($c = 2$), l_i is the critical path time of the job i .

- FASFS (First Arrival into System First Served): Components that are released into the shop floor earliest will be processed first.
- TWKR (Total Work Remaining): Products with least amount of remaining processing time will be processed first.
- ECT (Earliest Completion Time): Products with the earliest completion time will be processed first.

3. DEVELOPMENT OF SIMULATION MODEL

Simulation models are developed for the assembly job shop for each product structure. The logic of simulation

models is shown in Figure 2. Job arrival is created using Poisson distribution. For each job, a job number is assigned. Based on the job number, parts will be created; then for each part, its corresponding sequence and processing time are assigned. Parts will move to the machines according to the sequence and they will be processed if the machine is idle, otherwise sort the parts queue in front of machine as per dispatching rules. After all components of a job are ready, they are moved to the assembly shop and assembly process will be done, if the assembly machine is free; otherwise, sort the queue in front of the machine as per dispatching rule.

3.1 Simulation settings

The simulation for each priority rule is replicated 20 times. The warm-up period is set as the completion of first 250 jobs. Each replication includes 1000 job completion.

4. RESULTS AND DISCUSSION

Firstly, the models developed are run under various dispatching rules without considering the order release policy for the simulation settings. Secondly, the models developed are run under various dispatching rules with the integration of order release policy. The mean flow time and mean tardiness values obtained for both the cases are shown in the Tables 1-6.

Table 1: Mean flow time for single level assembly Structure

Dispatching rule	Mean flow time without integration of order release policy	Mean flow time with integration of order release policy
ECT	377.30	307.86
FASFS	377.42	125.56
FIFO	652.90	125.55
JDD	376.55	118.05
TWKR	137.86	117.70
SPT	445.44	166.60

Table 2: Mean tardiness for single level assembly Structure

Dispatching rule	Mean Tardiness without integration of order release policy	Mean Tardiness with integration of order release policy
ECT	104.14	55.06
FASFS	103.99	21.72
FIFO	181.95	21.84
JDD	103.83	20.49
TWKR	41.37	20.45

SPT	126.21	29.43
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Table 3: Mean flow time for two level assembly structures

Dispatching rule	Mean flow time without integration of order release policy	Mean flow time with integration of order release policy
ECT	328.17	230.90
FASFS	328.82	232.15
FIFO	720.84	291.62
JDD	328.58	230.88
TWKR	303.47	267.88
SPT	417.29	323.30

Table 4: Mean tardiness for two level assembly structure

Dispatching rule	Mean Tardiness without integration of order release policy	Mean Tardiness with integration of order release policy
ECT	121.68	55.35
FASFS	121.90	55.35
FIFO	269.16	71.65
JDD	121.84	54.56
TWKR	110.36	65.29
SPT	188.49	76.46

Table 5: Mean flow time for three level assembly structures

Dispatching rule	Mean flow time without integration of order release policy	Mean flow time with integration of order release policy
ECT	277.46	215.35
FASFS	277.73	216.10
FIFO	751.60	291.80
JDD	277.78	217.35
TWKR	129.08	148.56
SPT	407.49	472.46

Table 6: Mean tardiness for three level assembly structure

Dispatching rule	Mean Tardiness without integration of order release policy	Mean Tardiness with integration of order release policy
ECT	106.33	43.06
FASFS	106.67	43.06
FIFO	302.03	120.33
JDD	106.51	43.49
TWKR	51.49	29.09
SPT	188.49	76.45

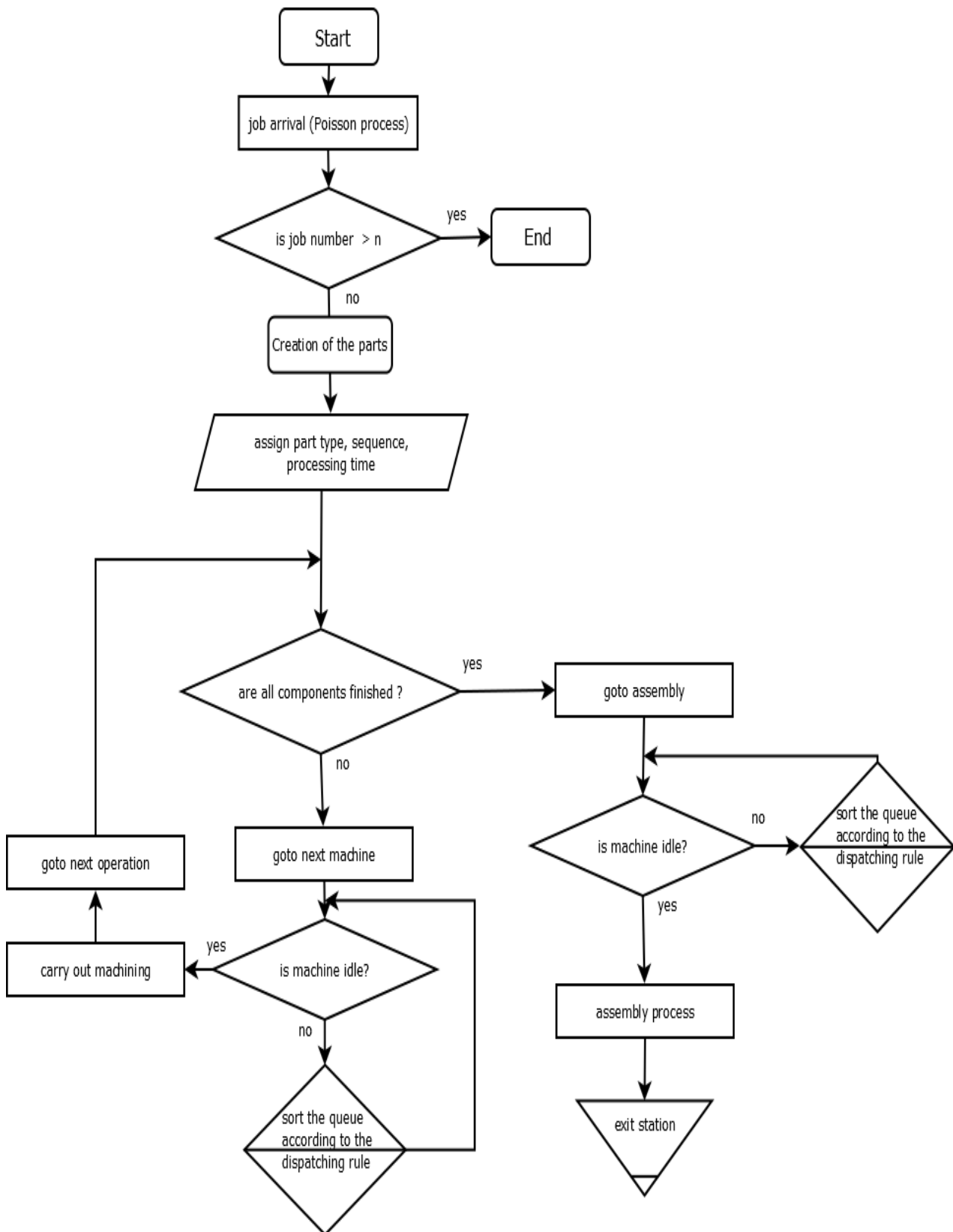


Figure 2: Flow chart for the simulation models

It is observed that there is a decrease in mean flow time and mean tardiness by considering the concept of backward scheduling i.e., when the components are released to the floor shop only at the required time, under various dispatching rules.

5. CONCLUSION

In this paper, assembly job shop scheduling problem for single, two, three and combined level assembly structure is considered with the objectives of minimization of mean flow time and mean tardiness. The concept of backward scheduling is used as the order release policy. Different dispatching rules are used for scheduling jobs in machines. Analysis of simulation model reveals that configuration of order release policy and dispatching rule leads to better performance of the assembly job shop for the performance measures, namely mean flow time and mean tardiness. The simulation model developed in the present study can be used as attest bed for conducting simulation experiments. In the present study, one release policy is considered for experimentation. Other order release policies and dispatching rules can be considered in future studies.

ACKNOWLEDGEMENT

We express our extreme sense of gratitude to Dr. T. Mathavaraj Ravikumar, Principal, Vidya Academy of Science and Technology Technical Campus, Kilimanoor for his guidance and constant inspiration.

We wish to sincerely thank Mr. Bijeesh P., HoD in charge Department of Mechanical Engineering Department, VAST TC, Kilimanoor for his immense support and motivation.

We are thankful to all the faculty members of Department of Mechanical Engineering for their help and cooperation. Special thanks to all our trade instructors, classmates and friends at VAST-TC who stood by our side during the endeavour.

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