International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-4, Issue-2, February 2016

Optimization of job shop schedules using LEKIN® scheduling system

Rai Siva Sai Pradeep

***Abstract*— The paper deals with the study of various scheduling methods, study of LEKIN® scheduling software and its application as an educational tool which could be effectively used to introduce the students to scheduling theory and its applications in practical situations . At First, various scheduling techniques are considered to solve real time engineering problems in a company. Process flow for various products in an engineering company` will be thoroughly studied and recorded. The input data required for the preparation of schedules and for analysis of job shop production would be collected from the engineering company. Then using LEKIN® scheduling software, various schedules are derived with respect to various dispatching rules, such as Shortest Processing Time, Longest Processing Time, Earliest Due Date, Least Slack, First Come First Serve and Random Selection etc. rules. The obtained schedules are compared based on performance measures, like Make Span, Mean Flow Time, Mean Tardiness, Maximum Tardiness, Mean Lateness etc.**

***Index Terms*—Scheduling, LEKIN®.**

I. INTRODUCTION

1.1 Introduction to Scheduling

Scheduling is the allocation of start and finish time to each particular order .Scheduling is an important tool for manufacturing and engineering, where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment. Production scheduling aims to maximize the efficiency of the operation and reduce cost. A job is characterized by its route, its processing requirement and priority. In a shop scheduling the key issue is to decide how and when to schedule. Job may or may not be scheduled based on the shortest processing time. Scheduling is categorized into

a. Single machine scheduling
b. Parallel machine scheduling
c. Flow Shop Scheduling
d. Flexible flow shop scheduling
e. Job Shop Scheduling
f. Flexible job shop scheduling

1.1.1 Single Machine Scheduling:

It is the process of assigning a group of tasks to a single machine or resource. The tasks are arranged so that one or many performance measures may be optimized.

1.1.2 Parallel Machine Scheduling:

If there is more than one machine is available for processing the jobs. It does not matter which machine a job is assigned to, but it cannot be processed on more than one machine at the Same time. Such machines are known as parallel machine scheduling.

Rai Siva Sai Pradeep, Mechanical Engineer,KL University, Andhra Pradesh India, Phone/ Mobile No.9154541888.

1.1.3 Flow Shop Scheduling:

In flow shop scheduling there are a set of m number of jobs and n number of machines, where a strict sequence of operations for each job is followed. A minimal downtime and minimal waiting time are the constraints in the continuous flow of processes. Production facilities are generally found to be using flow shop scheduling problems. A scheduling problem for flow shop is a generalized version of the problem for job shop scheduling of flexible manufacturing systems. Here each machine has the ability to perform more than one operation for a particular job.

1.1.4 Flexible Flow Shop Scheduling

The flow shop scheduling in which duplication of machine is possible comes under flexible flow shop scheduling.

1.1.5 Job Shop Scheduling

In the classical job shop problem, a finite number of jobs are to be processed by a finite number of machines. Each job consists of a predetermined sequence of operations, which will be processed without interruption for a period of time on each machine. The operations corresponding to the same job are processed according to their technological sequence and none of them will be able to start processing before the preceding operation is over. There is no initial machine that performs only the first operation of a job, nor is there a terminal machine that performs only the last operation of a job. A viable program is an assignment of operations in time on a machine without violation of restrictions workshops. A make span is defined as the maximum time for completion of all jobs.

The job shop schedule provides a set of resources to tasks over time. In recent years, lot of research has been done in this field of operational research. It mainly focuses on finding ways to give jobs to the machines that meet certain criteria and an objective function is optimized. So far a 100 percent perfect method to get the optimal solution in any kind of workshop programming has not been obtained.

Constraints involved in a job shop scheduling problems:

- A job should not visit the same team more than once.
- Presence of no precedence constraints on operations of different jobs.
- Operations ones started can't be interrupted.
- Each machine can process only one job at a time.
- Each job must go through a particular predefined sequence of operations
-

1.1.6 Flexible Job Shop Scheduling

The job shop scheduling in which more than one machine of a type can be used is called flexible job shop scheduling.

II. Sequencing of Jobs

The set of jobs are processed, those have different operations. According to their processing time due dates these jobs scheduled to minimize make span. There are following rules selected from many existing priority scheduling rules to obtain optimum sequence.

2.1 First come – First Serve Rule (FCFS)

The job which arrives first enters service first. It is simple, fast and fair to the customer. The major disadvantage of this rule is that it is least effective as measured by traditional performance measures as a long job makes others wait resulting in idle downstream resources and it ignores job due date and work remaining.

2.2 Shortest Processing Time (SPT)

The job which has the smallest operation time enters service first. Advantages of this rule is that it is simple, fast, generally a superior rule in terms of minimizing completion time through the system, minimizing the average number of jobs in the system, usually lower in- process inventories (less shop congestion) and downstream idle time (higher resource utilization), and usually lower average job tardiness and disadvantages is, it ignores downstream, due date information, and long jobs wait (high job wait –time variance).

2.3 Earliest Due date (EDD)

The job which has the nearest due date, enters service first (local rule) and it is simple, fast, generally performs well with regards to due date, but if not, it is because the rule does not consider the job process time. It has high priority of past due jobs and it ignores work content remaining.

2.4 Critical Ratio (CR) Rule

Sequences jobs by the time remaining until due date divided by the total remaining processing time. The job with the smallest ratio of due date to processing time enters service first. The ratio is formed as (Due Date-Present Time)/ Remaining Shop Time where remaining shop time refers to queue, setup, run, wait and move times and current and downstream work centers. It recognizes job due date and work remaining (incorporates downstream information) but in this sequencing, past due jobs have high priority, does not consider the number of remaining operations.

2.5 Longest Processing Time (LPT)

The job which has the longest operation time enters service first. Advantages of this rule is that it is simple, fast, generally a superior rule in terms of minimizing completion time through the system, minimizing the average number of jobs in the system, usually lower in- process inventories (less shop congestion) and downstream idle time (higher resource utilization), and usually lower average job tardiness and disadvantages is, it ignores downstream, due date information, and long jobs wait (high job wait –time variance).

Our goal is to generate such a schedule in the process of job shop scheduling using LEKIN® scheduling software using various dispatching rules as mentioned above and to explore the chances to minimize the make span i.e. the time length of the schedule, in which all the operations of each job is completed for an engineering company

III. ABOUT LEKIN® SCHEDULING SOFTWARE

LEKIN® is a scheduling system developed at the Stern School of Business, NYU. Major parts of the system were designed and coded by Columbia University students. LEKIN® was created as an educational tool with the main purpose of introducing the students to scheduling theory and its applications. Besides that, the system's extensibility allows (and encourages) to use it in algorithm development. The project has been directed by Professor Michael L. Pinedo, Professor Xiuli Chao and Professor Joseph Leung. This development has been partially supported by the National Science Foundation.

Machine environment involves

- Single machine
- Parallel machines
- Flow shop
- Job shop
- Flexible flow shop
- Flexible job shop

Dispatching rules used in LEKIN® include EDD, MS, LPT, SPT, WSPT, ATCS, and CR rule.

3.1 Terminology in LEKIN®

3.1.1 Processing Time (tj)

It is the time required to process Job J. The processing time, tj will normally include both actual processing time and setup time.

3.1.2 Ready Time (rj)

It is the time at which job J is available for processing. The ready time of a Job is the difference between the arrival time of that job and the time at which that job is taken for processing.

3.1.3 Due Date (dj)

It is the time at which the job J is to be completed.

3.1.4 Completion Time (Cj)

It is the time at which the job J is completed in a sequence. The performance measures for evaluating schedules are usually functioning of job completion Time. Some, Sample performance measures are Flow time, Lateness, Tardiness Etc.

3.1.5 Flow Time (Fj)

It is the amount of time job J spend in the system. Flow time is a measure which indicates the waiting time of the jobs in the system. This in turn gives some idea about in process inventory due to a schedule. It is the difference between the completion time and ready time of a job J.

$$Fj = Cj – rj$$

3.1.6 Lateness (Lj)

It is the amount of time by which the completion of job J differs from the due date.

$$Lj = Cj – dj$$

3.1.7 Tardiness (Tj)

Tardiness is the lateness of the job J if it fails to meet its due date, or Zero, otherwise

$$Tj= \max \{0, Cj – dj\}$$

3.2 Interfaces of LEKIN®

3.2.1 Job Pool Window
3.2.2 Sequence Window
3.2.3 Gantt Chart (Schedule) Window
3.2.4 Graphical User Interface

IV. APPLICATION OF LEKIN®

Here we use the scheduler for solving the job shop scheduling problems in a company, the general job shop scheduling mathematical model without the machine availability constraint. In general, variable are as follows:

•Make span as C_{max}

•The Maximum Tardiness as T_{max}

•The Total Number Of Late Jobs ∑Uj

•The Total Flow Time ∑Cj

•The Total Tardiness ∑Tj

•The Total Weighted Flow Time ∑Wj Cj and Total Weighted Tardiness as ∑Wj Tj

Gantt chart

Devised by Henry Gantt in 1910s, Gantt chart is the representation type of bar chart used to represent a feasible schedule of a scheduling problem. Gantt chart also provides the details about the precedence of operations under taken by the Jobs in various machines.

Gantt chart is an apt medium for portraying a resultant schedule in a small problem, but a problem with large number of activities that is very difficult to represent the schedule. Gantt does not represent the relative size of work items or the total size of the project. Therefore, it becomes too tough in some cases to compare two projects with the same number of time of completion.

4.1 Scheduling for an Engineering Company

4.1.1 Profile

PRAKASA SPECTRO CAST (P) LTD is an ISO 9001:2008 certified company, est. in 1996 at Vijayawada

4.1.1.1 Machines Available

S.No	Equipment	No. Of Machines
1.	Lathe	8
2.	Milling Machine	4
3.	Shapers	2
4.	Grinding	
	Pedestal Grinder	3
	Outside Grinder	1
	Inside Grinder	1

4.4.1.2 Operations

Jobs	
1	Pattern making (Shrinkage Allowance + Draft + Pattern + Tapper)
2	Molding
3	Pairing
4	Knock Out
5	Heat Treatment
6	Fettling
7	Grinding
8	Marking
9	Turning
10	Milling
11	Slotting
12	Drilling and shaping
13	Final Inspection

4.1.2 Problem Definition

4.1.2.1 Routing

Job 1	1	2	3	4	5	6	7	9	10	11	12	13
Job 2	1	2	3	4	5	6	8	9	10	12	13	-
Job 3	1	2	3	4	5	6	8	9	10	11	13	
Job 4	1	2	3	4	5	6	7	11	12	-	-	-
Job 5	1	2	3	4	5	6	7	11	12	-	-	-
Job 6	1	2	3	4	5	6	8	10	12	13	-	-
Job 7	1	2	3	4	5	6	8	10	12	13	-	-
Job 8	1	2	3	4	5	6	7	9	10	11	12	13

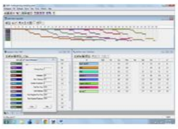
4.1.2.2 Processing Time

Jobs	1	2	3	4	5	6	7	8	9	10	11	12	13
1	38	8	1	3	10	16	2	1	32	16	32	32	5
2	32	16	1	3	16	16	-	1	32	16	-	30	5
3	39	12	1	2	16	16	-	1	32	16	30	-	5
4	42	10	1	5	20	20	-	-	-	-	26	-	5

5	48	8	2	4	18	10	-	-	-	-	20	-	5
6	40	14	1	2	14	12	-	-	-	14	-	30	5
7	35	12	2	3	10	14	-	1	-	12	-	26	5
8	42	16	3	5	8	10	3	-	30	15	20	28	5

4.1.3 Scheduling by LEKIN® scheduling system

EDD



MS

FCFS

LPT

SPT

4.4.4 Results and Discussion

4.4.4.1 Performance Analysis

Dispatching Rules	Make Span	Max. Tardiness	No. Of Late Jobs	Total Flow Time	Total Tardiness
E.D.D	420	260	8	2397	1117
M.S	387	227	8	2344	1064
F.C.F.S	420	260	8	2397	1117
L.P.T	387	227	8	2344	1064
S.P.T	478	247	8	2367	1087

4.4.4.2 Inference

i) Make Span is low when LPT rule is followed
ii) Max Tardiness is low when LPT rule is followed
iii) Number of late job will be low for SPT
iv) Total flow time will be low when LPT rule is followed
v) Total Tardiness is low when LPT rule is followed

V. SUMMARY

This current work with the case study focuses on the scheduling of jobs by LEKIN® scheduler under various dispatching rules such as MS, LPT, SPT, WSPT, ATCS, and CR rule .The Scheduler effectively generated outputs under the above mentioned dispatching rules for Prakasa Spectro Cast (P) LTD from which the optimum solution could be inferred. The above case study strengthens the LEKIN® practical use as an educational tool with the main purpose of introducing the students to scheduling theory and its applications in real time situations.

REFERENCES

[1] Production and operations management by R.Paneerselvam, Chapter 4 Job shop scheduling

[2] Brucker P., 1995. Scheduling algorithms 2nd edn. Springer. Berlin Heidelberg New York.

[3] Garey M., et al, 1976. The complexity of flow shop and Job shop scheduling. Mathematical Operation Research 1, pp. 117-119.

[4] Brandimarte P., 1993. Routing and scheduling in a flexible job shop by taboo search.

[5] Brucker P., 1994 A branch and bound algorithm for Job shop problem.

[6] Discrete Applied

[7] Carlier J., Pison E., 1989.An algorithm for solving Job shop problem. Management Science, 35: 164-176

[8] Blazewickz J., 1996. The Job shop scheduling Problem: Conventional and new solutions techniques. European Journal of Operational Research, 931-30

[9] Choi I. and Choi, D., 2002. “A local search algorithm for job shop scheduling problems with alternative operations and sequence dependent setups”. Computer and industrial engineering, 2, 43-58

[10] Erscher J.F., Roubellat J.P., Verntes , 1976. Finding some essential characteristics of the feasible solutions for a scheduling problem. Operational research, 24, pp. 774-783

[11] Heurik E., Jarisch B. and Thole M., 1994. Tabu search for the job shop scheduling problem with multipurpose machines. Operation research Spectrum, 15, pp. 205-215

[12] Mastrolli M. and Gambardella C. M., 2000. Effective neighborhood functions for the flexible jobshop problem. Journal of scheduling, 3(1), pp. 3-20.

[13] Koonce D. A. and Tsai S. C., 2000. “Using data mining to find patterns in genetic algorithm to a job shop schedule”, Computer and industrial engineering, 38, pp. 361-374.

[14] Holthaus O. and Rajendran C., 1990. “A comparative of study of dispatching rules in Dynamic flow shops and job shops”. European journal of operational research, 116, pp.156-170.

[15] Ohta H. and Nakatani T., 2006. “A heuristic job shop scheduling algorithm to minimize Total holding cost of completed and in progress products subject to no tardyjob”. International journal production economics, 11, pp. 19-29.

[16] Caumond A., Lacomme P., and Tchernev N., “A memmetic algorithm for job shop with time lag”. Computer and operational research.

[17] Jansen K., Mastrolilli M. and Oba R.S., 2005. “Approximation scheme for job shop scheduling problem with controllable processing time”. European journal of operational research, 1672, pp. 97-319.

[18] Guinet A., 2000. “Efficiency of reduction of job shop to flow shop problems”. European journal of operational research, 125, pp. 469-485.

[19] Drobouchevitch I.G. and Strusevich V.A., 2000. “Heuristic for the two stage job shop scheduling problem with a bottleneck machine”. European journal of operational research, 123, pp. 229-240.

[20] Ganesen V.K., Siva Kumar A. I., and Srinivasan G., 2006. “Hierarchical minimization of completion time variance and makespan in job shops”. Computer and operations research, 33, pp. 1345-1367.

[21] Jasan C. H. and Chen J. S., 2005. “Mixed binary integer programming formulations for the reentrant job shop scheduling problem”. Computer and operational research, 32, pp.1197-1212.

[22] Ganesen V. K. and Sivakumar A. I., 2006. “Scheduling in static job shops for minimizing mean flow time subject to minimum total deviation of job completion times”. International journal production economics, 103, pp. 633-647.

[23] Pham D.N. and Klingert A., 2008.” Surgical case scheduling as a generalized job shop scheduling problem”. Europian journal of operational research, 185, pp. 1011-1025.

[24] Watanabe M., Ida K., and Gen M., 2005. “A genetic algorithm with modified crossoveroperator and search area adaptation for the job-shop scheduling problem”. Computerandindustrial engineering, 48, pp.743-752.

[25] Koonce D.A. and Tsai S.C., 2000. “Using data mining to find patterns in genetic algorithmsolutions to a job shop schedule”. Computer and industrial engineering, 38, pp.361-374.

[26] Genesee V. K., Sivakumar A. I., 2006. “Hierarchical minimization of completion timevariance and makespan in job shops. Computer and operational research, 33, pp.1345-1367.

[27] Information from official page-http://web-static.stern.nyu.edu/om/software/lekin/