A Comparative Analysis of Various Optimization Methods for a Sequencing Problem

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Abstract: In this research work, a comparative analysis using different methods for a sequencing problem is carried out analytically. a special type of sequencing problem i.e. n Job × 1Machine Problem is investigated for the optimality of different measures of effectiveness. It was observed that Makespan remains unaffected. Mean flow time of job, in-process inventory, mean waiting time, mean lateness, maximum lateness and number of tardy jobs are dependent on the method employed. In this research, SPT method was found to be better than FCFS, EDD and WSPT methods. Here, main focus of researcher is to find out best possible method by comparing various analytical methods.

Key –Words: *Sequencing, Job, Inventory, Time*

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I. INTRODUCTION

Basically sequencing is defined as selection of an appropriate order in which a given number of customers can be served. Here, customer needs not to be humans only. Computers waiting in repairing shops, letters in a post office to be dispatched, and vehicles in a service center are some examples of customers in a sequencing problem. In our day to day life, we encounter several sequencing problems. Theory and analysis of sequencing is still an emerging area in the field of operation research. There may be various types of sequencing problems: Processing n Jobs on a single machine problem, processing n Jobs on 2 machine problems, processing n Jobs on 3 machine problems and processing n Jobs on m machine problem. In Production, Planning and Control (PPC), main aim of manager is to process waiting jobs with available resources so as to optimize measure of effectiveness.

II. LITERATURE SURVEY

Sanjeev Gill and Rajiv Kumar has applied Genetic algorithm with the mixing of other local search. It was observed by them that performance of Genetic algorithm mainly depends upon genetic operators and setting of parameter used. They made an attempt to develop new genetic operators for the sequencing problem and analyze the optimality parameter.

Noorul Haq and Radha Ramanan have used Artificial Neural Network in order to optimize bi criteria of make span and total flow time in environment of flow shop sequencing. They have shown that ANN yields a better quality of solution to that of traditional heuristics methods.

Chakraborty and Laha have discussed use of NEH algorithm to optimize make span in problem of permutation flow shop sequencing. Computational work done by them has revealed that there is considerable improvement in the optimality of the solution while maintaining the same level of complexity in algorithms.

Naderi et. al. have used SA algorithm in a scheduling problem of hybrid flow to optimize total time of completion and total tardiness including sequence dependent set up. Their algorithms were found to have superiority over the other SA algorithm.

Eren has investigated use of a bi criteria in scheduling problem of m-machine flow shop with sequence dependent setup times for optimization of the weighted sum of total completion time and make span. He could prove that the special heuristic for all number of jobs and machines was more effective.

Panneerselvam Senthilkumar and Sockalingam Narayanan have presented a survey of scheduling problem of single machine with uniform parallel machines. This single machine scheduling problem with uniform parallel machines basically consists of n jobs, each having single operation, for which jobs are to be processed on m parallel machines with different speeds. Parallel machines in such a case can be regarded as proportional machines or related machines.

III. CALCULATIONS

Here we have taken a real life sequencing problem (Processing n Jobs on a single machine problem) and we will solve it by different methods: Shortest Processing Time (SPT) Rule, Weighted Shortest Processing Time (WSPT)

Rule, First Come First Serve (FCFS) Rule, and Early Due Date (EDD) Rule. Consider a problem:

Jobs (J_i)	**J_1**	**J_2**	**J_3**	**J_4**	**J_5**	**J_6**	**J_7**
Processing Time (T_i) in days	6	9	7	4	11	15	8
Due Date (D_i)	16	11	16	26	19	40	44
Importance Weight (W_i)	1	2	3	1	2	3	2

SPT Rule: In this rule job with least processing time is picked up first and so on. By this rule optimal sequence will be

Job	**J_4**	**J_1**	**J_3**	**J_7**	**J_2**	**J_5**	**J_6**
Processing Time (T_i)	4	6	7	8	9	11	15

So mean flow time $= 27.86\ days$. Makespan = 60 days.
Thus, Average in process inventory $= 3.25$ units
Waiting time for each job is given by

Job	**J_4**	**J_1**	**J_3**	**J_7**	**J_2**	**J_5**	**J_6**
Waiting Time	0	4	10	17	25	34	45

$$So, mean\ waiting\ time = 19.29\ days$$

Lateness of each job

Job	**J_4**	**J_1**	**J_3**	**J_7**	**J_2**	**J_5**	**J_6**
Lateness	-22	-6	1	-19	23	26	20

So, $Mean\ lateness = 3.28\ days$. Maximum lateness = 26
And number of tardy jobs = 4 (**J_3, J_2, J_5, J_6**)
WSPT Rule: In this rule jobs are processed in the ascending order of their weighted processing time. Here sequence is

Job	**J_3**	**J_4**	**J_7**	**J_2**	**J_6**	**J_5**	**J_1**
Weighted Processing Time (T_i/W_i)	2.33	4	4	4.5	5	5.5	6
Processing Time (T_i)	7	4	8	9	15	11	6

So, $Mean\ flow\ time = 31.71\ days. Makespan = 60\ days$.
Thus, Average in process inventory $= 3.7$ units
Waiting time for each job is given by

Job	**J_3**	**J_4**	**J_7**	**J_2**	**J_6**	**J_5**	**J_1**
Waiting Time	0	7	11	19	28	43	54

$$So, mean\ waiting\ time = 23.14\ days$$

Lateness of each job is :

Job	**J_3**	**J_4**	**J_7**	**J_2**	**J_6**	**J_5**	**J_1**
Lateness	-9	-15	-25	17	3	35	44

So, $Mean\ lateness = 7.14\ days$. Maximum lateness = 44
And number of tardy jobs = 4 (**J_1, J_2, J_5, J_6**)

FCFS Rule: In FCFS Rule Jobs are served on the basis of their entry order. So, sequence will be

Job	**J_1**	**J_2**	**J_3**	**J_4**	**J_5**	**J_6**	**J_7**
Processing Time (T_i)	6	9	7	4	11	15	8

So, $Mean\ flow\ time = 31.14\ days. Makespan = 60\ days$.
Thus, Average in process inventory $= 3.63$ units
Waiting time for each job is given by

Job	**J_1**	**J_2**	**J_3**	**J_4**	**J_5**	**J_6**	**J_7**
Waiting Time	0	6	15	22	26	37	52

$$So, mean\ waiting\ time = 22.57\ days$$

Lateness of each job is :

Job	**J_1**	**J_2**	**J_3**	**J_4**	**J_5**	**J_6**	**J_7**
Lateness	-10	4	6	0	18	12	16

So, $Mean\ lateness = 6.57\ days$. Maximum lateness = 18
And number of tardy jobs = 5 (**J_2, J_3, J_5, J_6, J_7**)
EDD Rule: In this method jobs are processed in the order of ascending due dates. Here sequence will be:

Job	**J_2**	**J_1**	**J_3**	**J_5**	**J_4**	**J_6**	**J_7**
Processing Time (T_i)	9	6	7	11	4	15	8
Due date	11	16	16	19	26	40	44

So, $Mean\ flow\ time = 32.57\ days. Makespan = 60\ days$.
Thus, Average in process inventory $= 3.8$ units . Waiting time for each job is given by

Job	**J_2**	**J_1**	**J_3**	**J_5**	**J_4**	**J_6**	**J_7**
Waiting Time	0	9	15	22	33	37	52

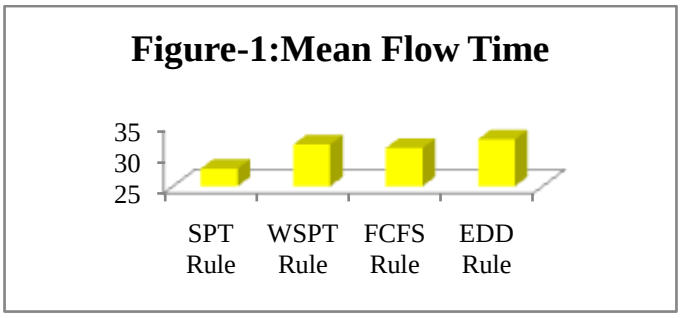
$So, mean\ waiting\ time = 24\ days$. Also, Lateness of each job is:

Job	**J_2**	**J_1**	**J_3**	**J_5**	**J_4**	**J_6**	**J_7**
Lateness	-2	-1	6	14	11	12	16

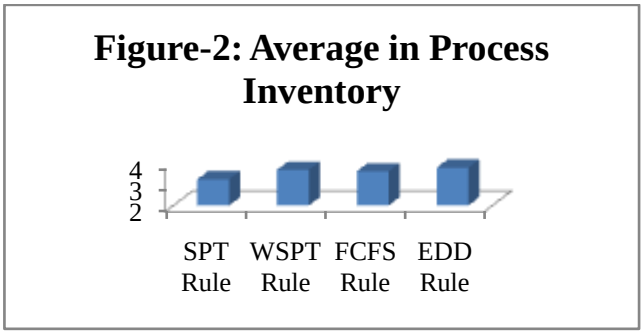
So, $Mean\ lateness = 8\ days$. Maximum lateness = 16
And number of tardy jobs = 5 (**J_4, J_3, J_5, J_6, J_7**)

IV. RESULTS AND DISCUSSION

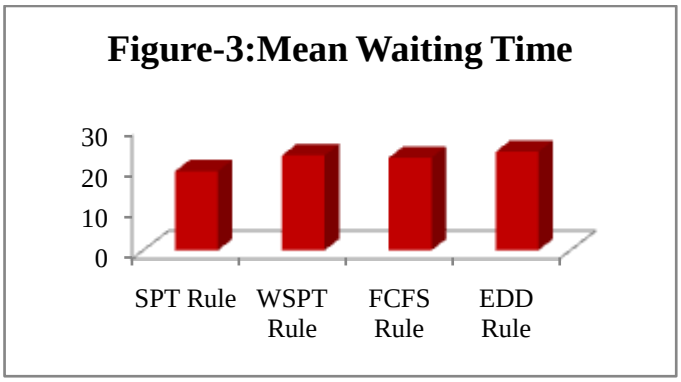
Results of problem under consideration are discussed with the help of graphs shown below:



It can be seen that mean flow time id minimum for SPT rule and maximum for EDD Rule. But, it does not happen in all the cases. It basically depends on processing times and due date.



Obviously, in process inventory is minimum for SPT rule and maximum for EDD rule. So, we can say that variations in average in process inventory are similar to the variations in mean flow time.



Again, we can observe that mean waiting times are almost very close to each. Variations are in a narrow range (20-25).

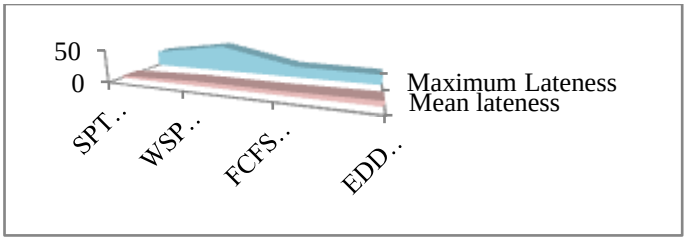


Figure – 4: Mean Lateness Vs Maximum Lateness

From, figure-4 it can be understood that maximum lateness is maximum for WSPT Rule and minimum for EDD Rule. On the other hand mean lateness is minimum for SPT Rule and almost same for remaining three methods.

V. CONCLUSIONS

On the basis of investigations carried out in the research above under consideration, we can conclude that no method is superior in all the aspects. In overall, we can say that SPT Rule is better than others. Till date, no well defined method exist which will yield optimal solution in all the conditions.

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