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Development of Flowshop Scheduling Simulator

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Abstract

Scheduling or production scheduling is an important activity in production process. Production scheduling is an activity that determine the efficiency of production process. With a good production scheduling, the production process will be running smooth and benefit in cost. With the growing scale in number of jobs and machines on production floor, manual scheduling is irrelevant these days. So a software is required to do a scheduling activity and simulating the result. Scheduling is an activity of allocating resources or machines to run some tasks in specific time range[1]. The result of scheduling is a sequence of jobs that used for reference in determining on how to run a production process. There are several criteria in scheduling process, one of them is minimizing make span [2] or the total amount of time to process all the jobs. The production process has two major flow type, they are flowshop and jobshop.

Flowshop production flow is a production flow type which a sequence of jobs processed on an array of machine. In flowshop production flow every job on the sequence will be processed on every machine on the machine’s array, while on jobshop, every job is processed based on the requirement and characteristic of the job. Scheduling in flowshop production flow can be done using many methods. The flow shop can be done using Nawaz Enscore Ham (NEH)[3] method, Palmer[4] method, and Gupta[5] method. Those method prioritizing a job with biggest total of processing time to be processed first.

The previous paper [6] compare the performance of these three methods. In this paper, we develop the flowshop scheduling simulator to make it easy to visualize the running process of these algorithm. The software simulates the result of flowshop scheduling process in a form of gantt chart animation. Gantt chart is used for simulating the flow of production scheduling process. By using simulation, user can see the whole scheduling planning, estimate the completion time of each job, see the total processing time or makespan, and know the tardiness of each job. Similar with the previous paper [6], NEH algorithm constantly works best compare with Palmer and Gupta algorithm in various types of problems.

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I. INTRODUCTION

In textile industies, *n* jobs $J = \{J_1, J_2, J_3, \dots J_n\}$ come into queues to be processed in *m* machines $M = \{M_1, M_2, M_3, \dots M_m\}$. Each machine has its own functionality. For example cutting, sewing, folding, and packing machines. Each job has to be processed in each of these machines in a certain sequence. For example, first each job has to go to the cutting machine. After it is done, the job must go to be processed next in the sewing machine, and then to the folding machine, and finally to the packing machines. Each of these jobs has its unique identifier, arrival time, due

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date, and processing time in each machine. The goal is how to arrange all of these jobs in the queues so that it can optimize some objectives. The objectives can be to minimize the total processing time of all jobs in all machines (it's called makespan) and the total tardiness of all jobs.

Scheduling is the art of planning so that the objectives can be achieved. In this research, the objective is to minimize the total processing time of all jobs to be done (makespan) and to minimize the tardiness of all jobs. If the makespan can be minimized, it can reduce the total running cost of a textile industry. If the tardiness of each job can be reduced, it can increase the satisfaction of the customers.

The rule to create the schedule is called heuristics. The previous paper [6] compare some heuristics used in textile industries. In this paper, three heuristics are used as the based to create the flowshop process simulation, namely: NEH, Palmer, and Gupta algorithm.

II. FLOWSHOP SCHEDULING PROBLEM

Flowshop scheduling is a class of scheduling in which there are *n* jobs to be processed in *m* machines. Each job must be processed in each of these machine based on a certain sequence. Flowshop problems are characterized by the processing time PT_{ij} of jobs i on machine j, where $1 \leq i \leq n$ and $1 \leq j \leq m$. Each machine m_j can only process one job j_i at a time. Each job can only be processed by one machine at a time. Once a machine has started processing a job, it will continue running on that job until the job is finished.

Given:

- *n* jobs $J_1, J_2, J_3, \dots J_n$
- *n* respective due date $d_1, d_2, d_3, \dots d_n$

Goal:

- Minimize makespan
- Minimize tardiness

Fig. 1. shows the illustration of flowshop scheduling problem with four types of machines, and 5 jobs that must be done in each of these machines. The processing sequence is start from the machine 1, continue to machine 2, machine 3, and finalized in machine 4. The value along the X axis shows the timeline of the scheduling process. Each job is represented as a single color in the chart and must be processed sequentially from machine 1 until machine 4 to be complete. For example, job 1 start at time 0 in machine 1, and continue to machine 2 at time 26, and then start at time 60 machine 3, and continue in machine 4 until it's complete at time 88. Job 2 can only be processed in machine 1, after job 1 is finished. The same rule apply to all the jobs in the queue. Based on this constraint, the total time needed to finish all the job in 4 machines is at time 522. The total time to process all the jobs in queue is called makespan.

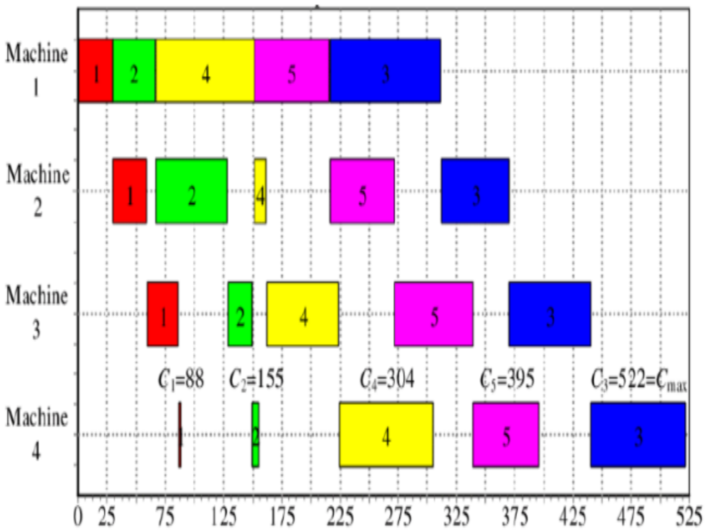

Fig. 1. Flowshop scheduling with 4 machines and 5 jobs

III. FLOWSHOP SCHEDULING ALGORITHM

There are various algorithm to solve flowshop scheduling problem. Three algorithm discussed in the previous paper [6] are: NEH (Nawaz Enscore Ham), Palmer, and Gupta.

III.1 Nawaz Enscore Ham (NEH) Algorithm

This algorithm is proposed by Muhammad Nawaz, E. Emory Enscore Jr, Inyong Ham in 1983 [3] and has awarded as the best algorithm in permutation flowshop problem. This algorithm is based on the longest processing time heuristics. It means it choose the job with the longer processing time to be executed first than the other job with shorter processing time. The complete algorithm can be seen in Algorithm 1.

Algorithm 1: NEH Algorithm
1. Add the processing time of a job on machine 1 until machine *m*. Then it will be *n* values show the total processing time of *n* jobs.
2. Sort decending this *n* total processing time of *n* jobs.
3. Start to process the job with the longest total processing time to be executed first.
a. Enumerate all the possibilities permutation
b. Calculate the sparsial makespan for all the permutation possibilities
c. Choose the arrangement with the minimum makespan.

III.2 Palmer Algorithm

November-December 2019
ISSN: 0193-4120 Page No. 6208 - 6214

This algorithm is proposed by Palmer in 1965, and works based on a value called slope index. This value determine which job should be executed first.

Algorithm 2: Palmer Algorithm

1. Calculate the slope index of each job with this formula:
   $$SI_i = \sum_{k=1}^{m} (m - (2 \times k - 1)) \times PT_{ik}$$
   where
   SI_i: slope index of job J_i
   m: total number of machine
   k: step number k of job J_i
   PT_{ik} : processing time of job J_i step k
2. Sort descending the jobs in the queue start from the largest to the lowest slope index.
3. Process each job based on the sequence produce in step 2.

III.3 Gupta Algorithm

This algorithm is proposed by Gupta in 1972. Similar like Palmer, Gupta algorithm works based on slope index, except it is weighted.

Algorithm 3: Gupta Algorithm

1. Calculate the weight of each job (e_i) based on this formula:
   -if $PT_{i1} \geq PT_{im}$ then $e_i = -1$
   -if $PT_{i1} < PT_{im}$ then $e_i = 1$
2. Calculate the slope index of each job with this formula:
   $$SI_i = \frac{e_i}{\min(PT_{i1} + PT_{i2}, \dots, PT_{i(m-1)} + PT_{im})}$$
   where
   SI_i: slope index of job J_i
   m: total number of machine
   PT_{im} : processing time of job J_i step m
   e_i: weight of job J_i
3. Sort descending the jobs in the queue start from the largest to the lowest slope index.
4. Process each job based on the sequence produce in step 2.

IV. The Objectives

The objective of the scheduling in this research is to minimize tardiness and makespan. The formula to calculate tardiness is:

$$T_i = \max\{C_i - d_i, 0\} \quad (1)$$

where

C_i: the completion time or the earliest time at which job J_i is completely processed.

d_i: due date of job J_i

$C_i - d_i$: the lateness of job J_i

So tardiness is the maximum lateness of all jobs in the queue.

Makespan is maximum completion time of all jobs in the queue. The formula to calculate makespan is:

$$C_{max} = \max\{C_1, C_2, C_3, \dots C_n\} \quad (2)$$

where

C_i: the completion time or the earliest time at which job J_i is completely processed.

V.RESULTS AND DISCUSSION

This paper use Taillard's benchmark problem [7] as the study cases, i.e. problems with 5, 10, and 20 machines and from 20 to 500 jobs. Taillard's benchmark problem size is greater than that of the rare examples published. Such sizes correspond to real dimensions of industrial problems.

Some experiments are conducted to see the result of execution process of NEH, Palmer, and Gupta algorithms. These experiments use Taillard's benchmark flowshop scheduling problems [7] that consist of various numbers of jobs and machines.

V.1. Flowshop Scheduling Simulator

Fig. 2 until Fig. 9 show the result of flowshop scheduling simulator developed by using NEH, Palmer, and Gupta algorithms. The result is in the form of animation that shows the simulation of the whole process from time 0 until all the jobs are finished to be processed.

V.2. Flowshop Scheduling Statistics

Fig. 2 until Fig. 4 show the simulation result of flowshop scheduling developed by NEH, Palmer, and Gupta algorithms with 10 machines and 50 jobs. Fig. 5 summarize Fig. 2 until Fig. 4 in the report form.

Fig. 6 until Fig. 8 show the simulation result of flowshop scheduling developed by NEH, Palmer, and Gupta algorithms with 20 machines and 100 jobs. Fig. 9 summarize Fig. 6 until Fig. 8 in the report form.

Only two types of problems are shown in this paper. In fact, several experiments with various number of jobs and machines are conducted to see these three algorithms' performances. Similar with the previous paper [6], experiments show that NEH algorithm perform constantly the best, followed by Palmer and Gupta algorithm.

TEST Engineering & Management
November-December 2019
ISSN: 0193-4120 Page No. 6208 - 6214

Fig. 2. Final result of NEH execution process with 10 machines and 50 jobs

CONCLUSION

This research build the flowshop scheduling simulator and statistics that shows the animation of the whole jobs execution from time zero until all jobs in the queue are finished to be processed. Experiment results give similar conclusions with previous paper [6] that NEH constantly perform the best compare with Palmer and Gupta algorithm. It constantly produce the minimum makespan and tardiness.

REFERENCES

[1] K. Baker, "Introduction to sequencing and scheduling", Wiley, Canada, 1974.

[2] S. Parveen, H. Ullah, "Review on Job-Shop and Flow-Shop Scheduling using Multicriteria Decision Making". Journal of Mechanical Engineering, ME 41, No.2 (2010), 130-146, 2010.

[3] T. P. Hong, P. Y. Huang, G. Horng, "Using The LPT and The Palmer Approaches to Solve Group Flexible Flowshop Problems", IJCSNS International Journal of Computer Science and Network Security, Vol 6, No.3A, 98-104, 2006.

[4] P. G. Srinivasan, "Flowshop Scheduling Heuristics Palmer, Campbell Dudek Smith Algorithm", Operations and Supply Chain Management Department of Management Studies Indian Institute of Technology, Madras, India, 2012.

[5] L. Leemis, S. Park. "Discrete-event Simulation: A First Course", 3rd edition. Pearson Prentice Hall, Canada, 2006.

[6] C. E. Nugraheni, L. Abednego, "A Comparison of Heuristics for Scheduling Problems in Textile Industry", Jurnal Teknologi Vol 78, No 6-6, 2016.

[7] E. Taillard, "Benchmark for Basic Scheduling Problems", ORWP89/21 Dec. 1989.

November-December 2019
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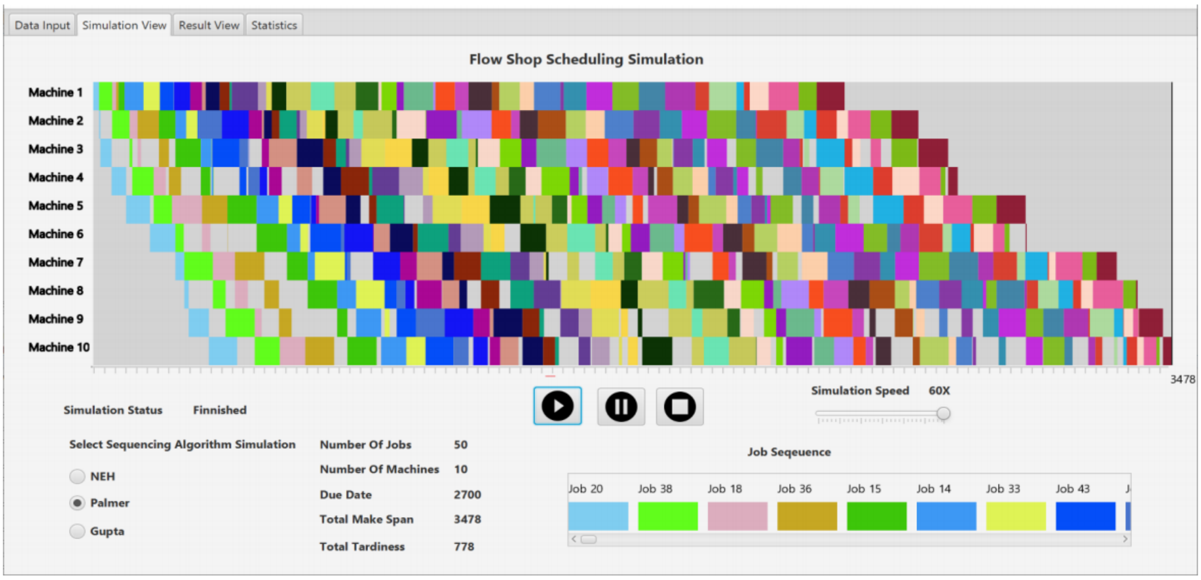

Fig. 2 Final result of Palmer execution process with 10 machines and 50 jobs

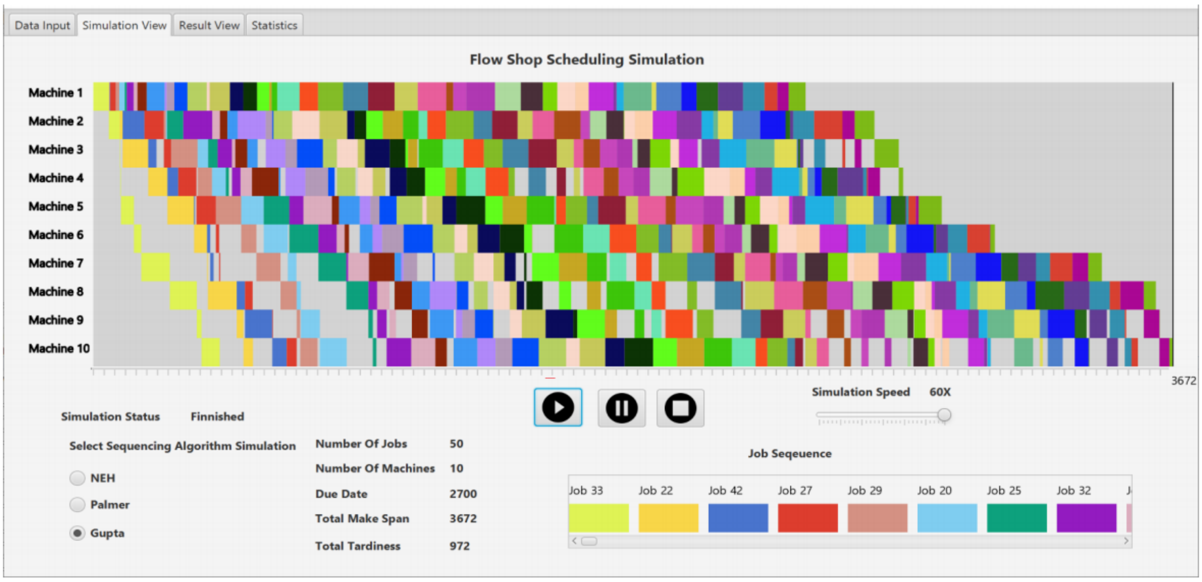

Fig. 3. Final result of Gupta execution process with 10 machines and 50 jobs

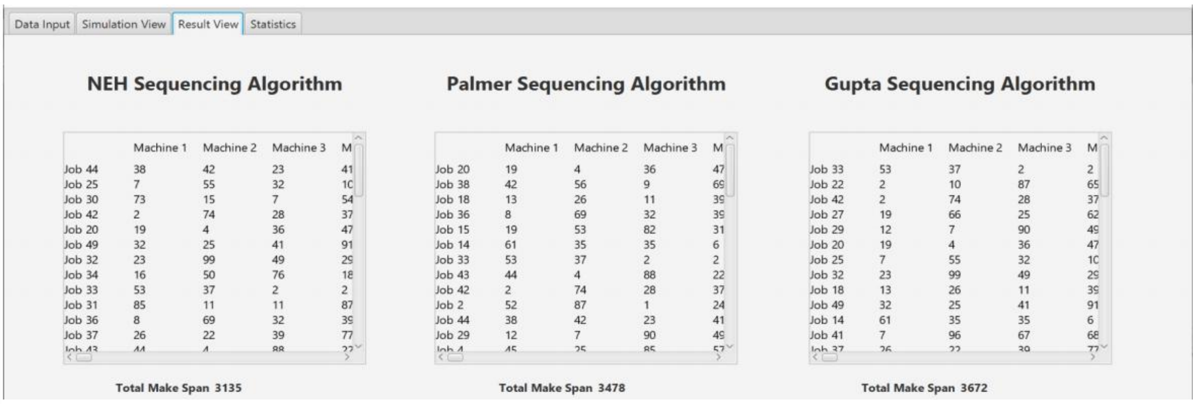

Fig. 4. Final result of NEH, Palmer, and Gupta execution process with 10 machines and 50 jobs

November-December 2019
ISSN: 0193-4120 Page No. 6208 - 6214

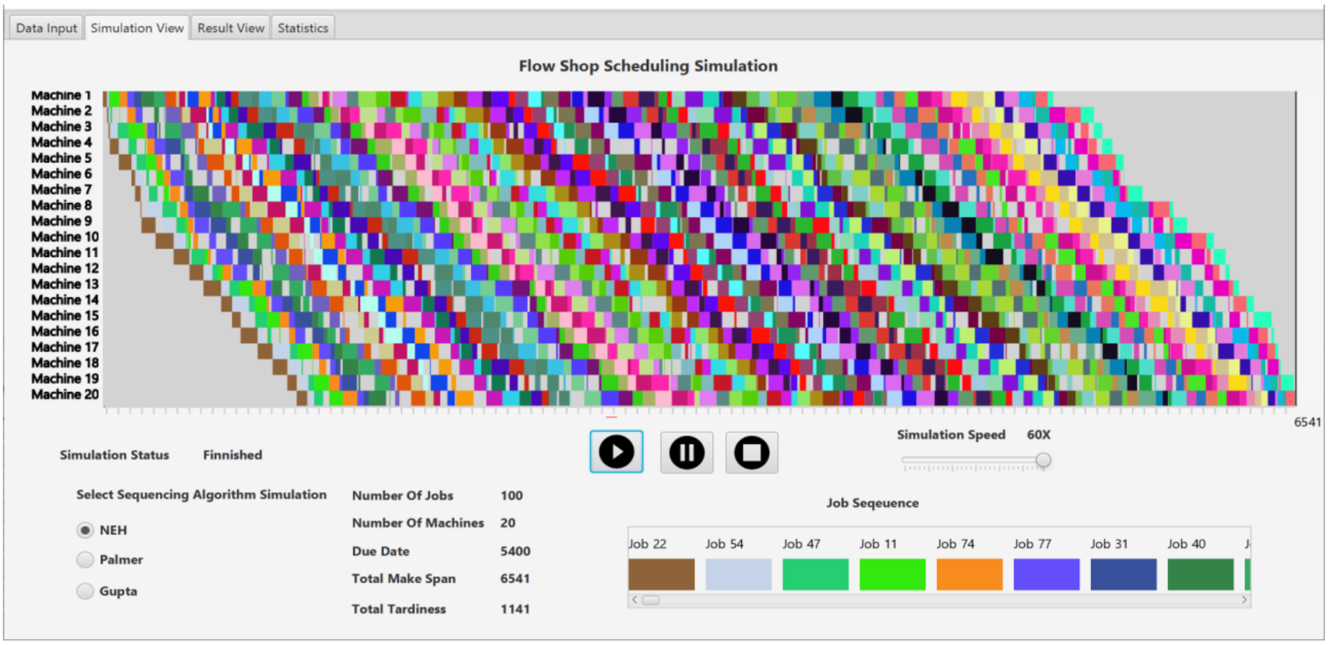

Fig. 5. Final result of Palmer execution process with 20 machines and 100 jobs

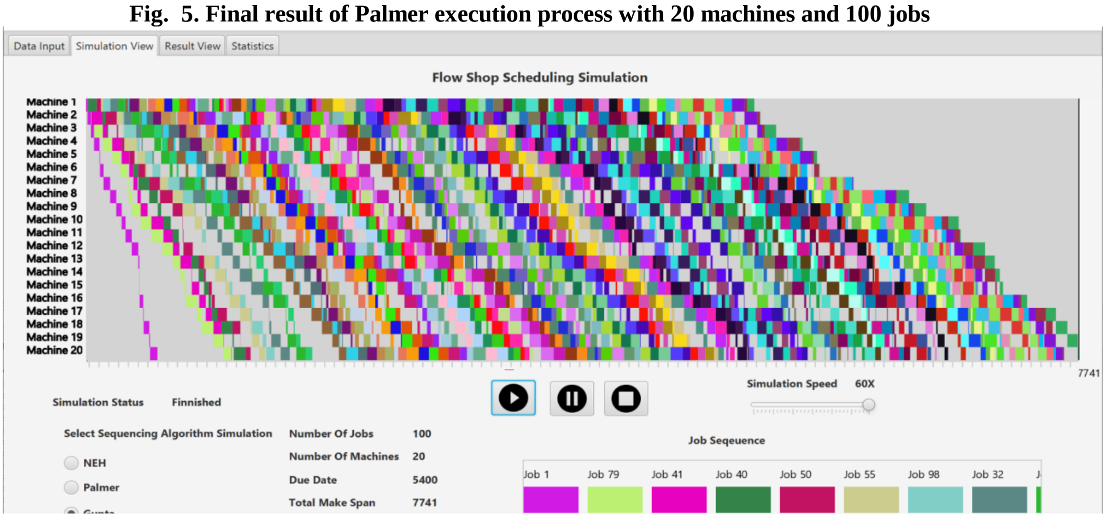

Fig. 6. Report result of NEH, Palmer, and Gupta execution process with 20 machines and 100 jobs

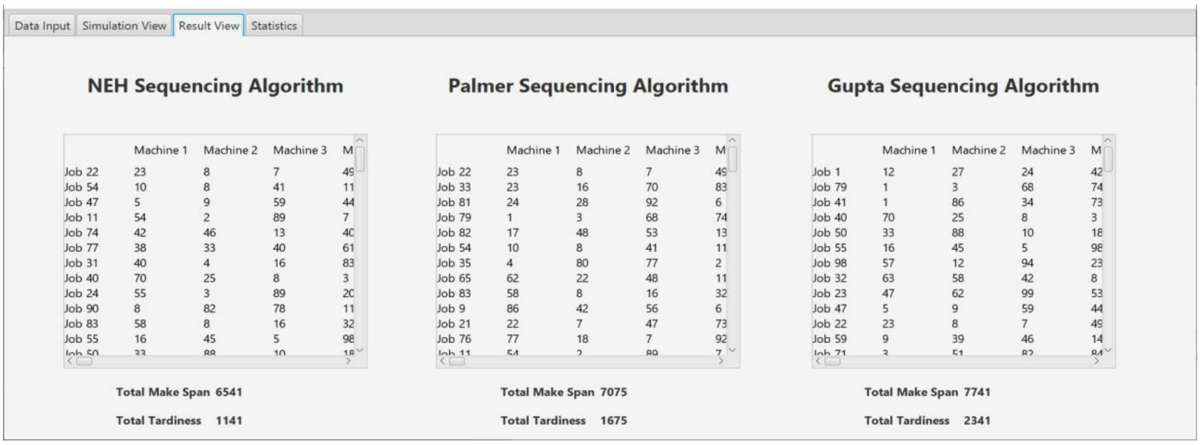

Fig. 7. Final result of Gupta execution process with 20 machines and 100 jobs

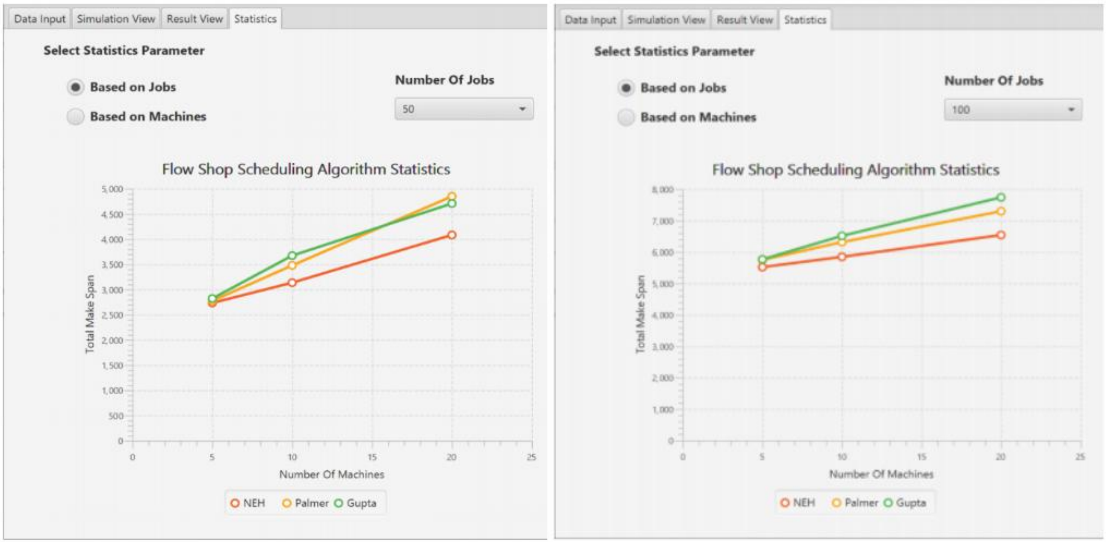

Fig. 8. Statistics of NEH, Palmer, and Gupta for 50 jobs (left) and for 100 jobs (right)