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Initial Sequence Strategy for Constructive Heuristics Using Gantt Chart

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Abstract: There are many ways that a sequence in a constructive heuristic can be interpreted. Factors on the sequencing will always affect directly by its own initial variable that it set by using a certain heuristic. The constructive heuristics of Nawaz, Enscore and Ham (NEH) introduced in 1983 has been a long-standing favourite among researchers and industry in order to solve a flowshop scheduling method. In fact, the NEH still being futher studied by many researchers to improve the heuristic performance. The idea of this study was to introduce a modified heuristics from NEH that is able to surpassed the makespan of the NEH heuristics by having a shorter makespan as the objective of the study. The modified heuristics used a new method to arrange the initial sequence. Using the modified heuristics, the best sequence possible was then selected to be compared against the NEH heuristics. Results were obtained using Microsoft Excel with the Taillard's dataset to obtain the needed sequence for both heuristics and were compared using Gantt chart for better visualisation. The end results shows that modified heuristic was able to achieve a shorter makespan when compared to NEH heuristics with the specific sequence that yield a difference of between 3 to 4 percent in this study. Involving all the scope of the study it was able to have a shorter makespan. The result of the study can enable more sequence-based variable to be use in solving a flowshop scheduling problem.

Keywords: Sequence, NEH, Makespan, Heuristics

1. Introduction

Flowshop is a conventional manufacturing system where the order of job processing was determined by the arrangement of the machines used [1]. Within a flowshop sequencing problem, the optimisation of certain performance measures revolves around a sequence of jobs that has to be pre-determined. To lead to a stable or even utilisation of resources, rapid turn-around of jobs and minimisation of in-process inventory, requires some of the performance measures to be prioritized such as mean flowtime or equivalently, total flowtime. Such flowshop problems can be varied based on the condition obtained at hand where different methods may be used for the situation.

Since the problem that is being investigated relates to a flowshop problem it is stated that a popular simple heuristic for minimizing makespan in the general permutation flowshop problem was

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presented by Nawaz et al. (we refer to this heuristic as NEH in the following), which outperformed other algorithms that were developed previously. Minimizing makespan and minimizing total flow-time have often been considered as objectives for flowshop scheduling problems in the past [2]. These objectives were considered as the main point of solving a flowshop problem. The NEH heuristic comprise of two stages, one, the sorting (prioritizing) phase and two, the insertion phase. During the sorting phase, it was ideal to sort the total processing time in descending order. Thus, from the insertion phase, a sorted list was used to the determined the sequence where the jobs were added to an existing partial sequence [2].

1.1 Problem Statement

The Nawaz, Encsore and Ham algorithm (NEH) which proposed by Nawaz et al. (1983) is considered as mainly useful. It was suggested that the NEH heuristic is regarded the best heuristic for permutation flowshop problem where it is based on Johnson's Algorithm [3]. Thus, having to test which is the best heuristics for the method require flowshop problems to be used as a testing stage. This is supported due for flowshop scheduling seems to be, up to now, one of the best heuristics for the problem, due to its extensive use as initial solution of metaheuristics or as a reference procedure for other constructive heuristics [4].

The initial sequence refers to the placements of jobs optimally for each machine which can be different with having endless of permutation solution which can be different to the NEH solution. Sequences still plays a part in optimisation. Optimisation of certain performance measures has to be based on the job sequence [1]. Criterion of performance measures include mean flowtime or, equivalently, total flowtime, which is known to lead to stable or even utilisation of resources, rapid turn-around of jobs and minimisation of in-process inventory. The performance is then placed in a Gantt chart. The data obtained will be converted into the stated Gantt chart where it shows the completion time of each process. The Gantt chart displayed from each heuristic applied would be easier to be analysed. The above researchers suggested that the NEH can further be enhanced if better variety of initial solutions approach can be found. In response to the above researcher's recommendation, this project work is conducted to study a few varieties of initial solutions to be used for the NEH with the intention to obtain a better flowshop solution.

1.2 Objective

The objectives of the study were to identify the lowest completion time from the variety of initial sequences for constructive heuristics as well as to evaluate the performance of the new constructive heuristic against the NEH heuristics.

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

2.1 Case Study

Understanding of method comparing two different heuristics was important as shown by previous study that set to minimize the makespan of heuristics. The analysis was done by using Microsoft Excel and the results are compared using the Gantt chart processed by the same software mentioned. The performance of the sample heuristics was measured based on the makespan or the completion time of the last job.

2.2 Methodology

The program of Microsoft Excel was used as to obtain a general sequence that can be manipulated easily using Taillard's dataset as to acquire the result. An optimum scheduling can be obtained for

minimizing completion time. The methods start with computing the sum of processing times of n-jobs for each of m- machines. The job was rearrange based on total processing time from longest to shortest.

2.2.1 NEH heuristic & Modified heuristic sequence arrangement

The sequence arrangement for NEH heuristics takes one set of Taillard's data and taken all machines for consideration of processing time where total processing time was evaluated. The evaluated processing time was then arranged in an ascending order from shortest processing time to highest processing time for the job sequence. The data was then extracted into a start stop data table before translating it into a gantt chart. The sequence arrangement for modified heuristics also takes the same data set as NEH heuristics but only taking certain machines into consideration for it processing time. This may require trial and error method since the possibility of taking every possible combination would take much time. The data for modified heuristics were also extracted into a start stop data table.

2.3 NEH heuristic & Modified heuristic comparison

The NEH data section only require processing time, sequence arrangement. and start stop data. After obtaining the start stop data, the data was then put into a Gantt chart where the total makespan for each machine can be seen with the occurrence of idle time between each job were presented with empty spaces. The modified heuristics would go through the same thing of getting the initial sequences. This however is not permanent as the sequences can be changed for better result to be obtained if deemed necessary. The data of start and stop of each method was then visualise into a Gantt chart where it can be shown in Figure 1 and Figure 2. The steps taken for 10 machines 20 jobs and 20 machines 20 jobs would follow the same steps as shown for 5 machines 20 jobs.

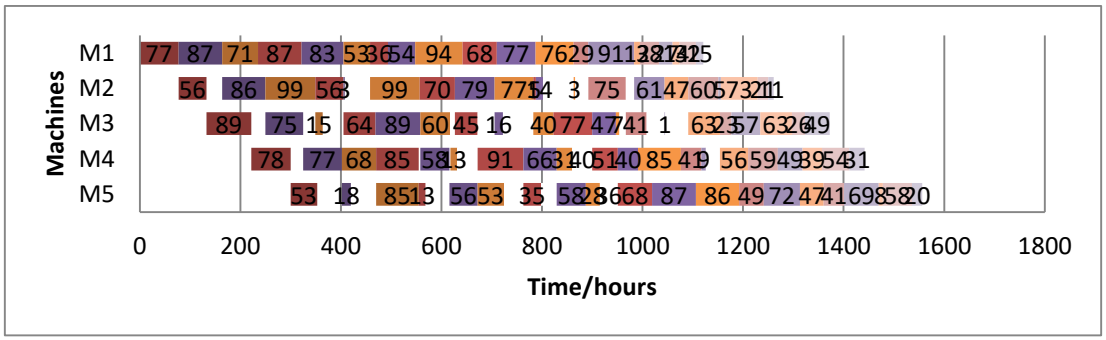

Figure 1: NEH sample result of 5 machines 20 jobs

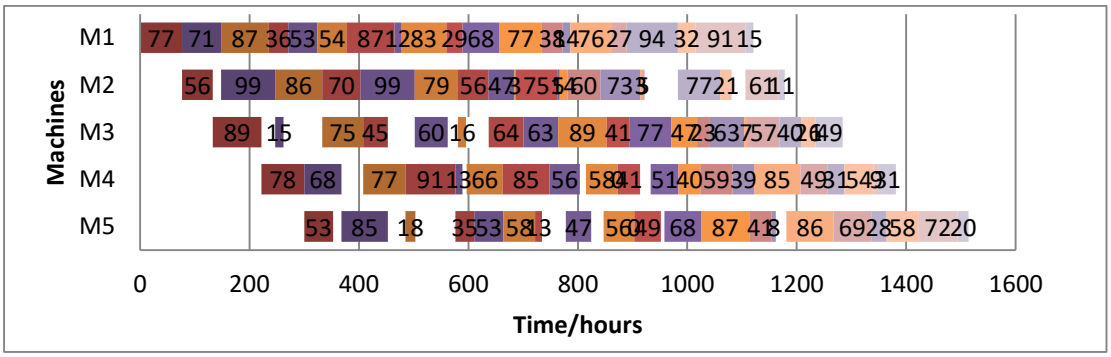

Figure 2: Modified heuristic sample result of 5 machines 20 jobs

$$f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right) \quad \text{Eq. 1}$$

Each numbered equation should be in its line and be separated from the surrounding text by the default line spacing. Eq. 1, as are all equations, should be referenced in the text.

3. Results and Discussion

3.1 Results

Table 1: Summary table for 5 machines 20 jobs extracted from Gantt chart

Item	NEH Heuristics	Modified Heuristics	
Machine Involves in Sequencing Factor	All	M2, M3, M4 and M5	M3, M4 and M5
Machine End time (Time/hours)	1556	1578	1509

Table 2: Summary table for 10 machines 20 jobs extracted from Gantt chart

Item	NEH Heuristics	Modified Heuristics	
Machine Involves in Sequencing Factor	All	M7, M8 and M9	M7, M8, M9 and M10
Machine End time (Time/hours)	1943	1993	1879

Table 3: Summary table for 20 machines 20 jobs extracted from Gantt chart

Item	NEH Heuristics	Modified Heuristics	
Machine Involves in Sequencing Factor	All	M10, M11, M12 and M13	M10, M11 and M12
Machine End time (Time/hours)	2727	2708	2613

The results presented in Table 1, Table 2 and Table 3 shows the total processing time involving these selected machines that were only taken into account and is sorted from highest processing time to lowest. Thus, the result obtained from start to finish and, the time taken were compared. The best machine end time for the modified heuristics were taken and was presented in the following sub chapter.

3.2 Analysis data

From the data gathered, the performance of the modified heuristics and NEH can be observed based on the following method:

The analysis of best performance of modified heuristics would be taken and measured by percentage of time improvement from the NEH heuristics using the end time. Results using the following formula of Equation 1 will be shown in percentage:

$$\frac{NEH\ Heuristics\ End\ Time\ -\ Mod.Heuristics\ End\ Time}{NEH\ Heuristics\ End\ Time} \times 100\% \qquad \text{Eq. 1}$$

A sample of calculation for percentage analysis of performance time completion using data from 5 machines 20 jobs obtained from Table 1 data were shown using Equation 2 below.

$$\frac{1556 - 1509}{1556} \times 100\% = 3.02\% \qquad \text{Eq. 2}$$

The modified heuristics performance results percentage calculated from data in Table 1, Table 2 and Table 3 were tabulated as shown in Table 4:

Table 4: Results table for Percentage Analysis of Performance Time Completion

Percentage Analysis of Performance Time Completion		
5 machine 20 jobs	10 machine 20 jobs	20 machine 20 jobs
3.02 %	3.29 %	4.18 %

3.3 Discussions

From the tables and figures shown we can deduce that the completion time for both heuristics' method were almost comparable with the modified heuristics having a slight advantage in speed of completion time. For modified heuristics, two sets of data were compared and the one with the shortest makespan were chosen when comparing with the NEH heuristics. It was observed that, the scheduling with some sequence in modified heuristics can experience a lag when comparing makespan with NEH heuristics Despite this, the best sequence from the modified heuristics was faster as it was compared to the sequence of NEH methods for which it was recorded to produce better results within 3 to 4 percent difference from the NEH. This was supported when the lowest value obtained with problem size of 5 machines 20 jobs was 3.02% while the highest percentage difference obtained with the larger problem size of 20 machine 20 jobs was 4.18%. Observing the modified heuristics end times were faster than the NEH heuristics, this would be taken as a positive outcome since it would be interpreted as a reduction for end time for which turns into much more production in a given time [6]. The results obtained are parallel to the findings of similar nature such as noted by previous study [5][6][7]. The papers as mentioned in literature review uses NEH heuristics to compare their results which in terms of their findings were able to comprehensively obtain a shorter makespan by deriving their heuristics from NEH. Thus, the modified heuristics shows some potential of the heuristics to be even more optimised than its previous version.

4. Conclusion

Many flowshop scheduling problem are being dive into so as they strive to find the best possible optimization to having the most optimized schedule as possible. In a flowshop scheduling problem, it is considered that the selection of sequencing plays an important part in getting the best out of the modified heuristics. Thus, this study shows that for production field up to a problem size of 20 jobs were able to be solved for the optimization purpose. The problem discussed in this study was solved by using modified heuristics to obtain the initial sequences arrangement phases needed to minimized the makespan and thus compared with the NEH heuristics.

The performance of the modified heuristics was better as discussed from the previous chapter. For 5 machine 20 jobs, sequences involving only M3, M4 and M5 in modified heuristics gives out much better result than NEH and the M2, M3, M4 and M5 configuration. For 10 machine 20 jobs, sequences involving only M7, M8, M9 and M10 in modified heuristics gives out much better result than NEH and the M7, M8 and M9 configuration. For 20 machine 20 jobs, sequences involving only M10, M11 and M12 in modified heuristics gives out much better result than NEH and the M10, M11, M12 and M13 configuration. All of the modified heuristics are able to undercut the makespan of NEH with the suitable sequences. This study has definitely shown the potential that the modified heuristic approach is able to reduce the completion time for a flowshop scheduling problem.

Acknowledgement

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Appendix

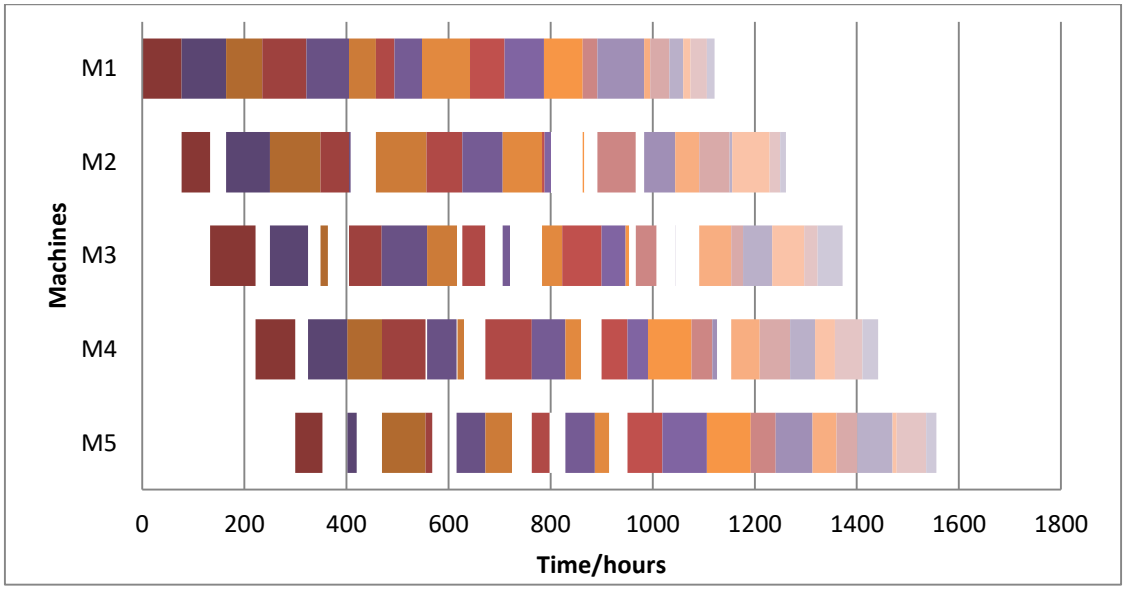

Figure of NEH result of 5 machines 20 jobs (Gantt Chart)

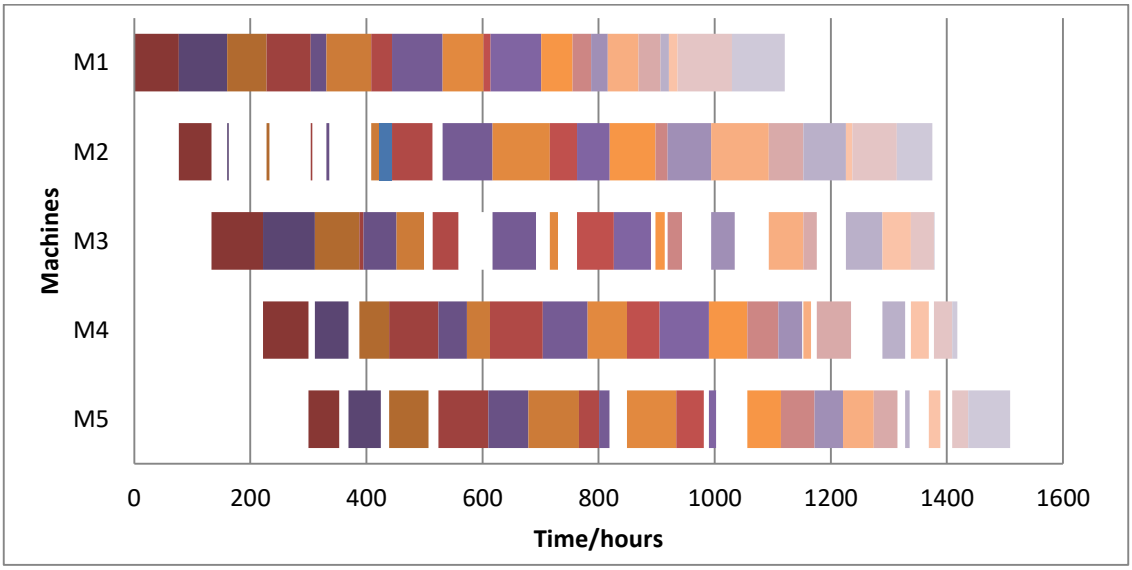

Figure of selected modified heuristic result of 5 machines 20 jobs (Gantt Chart)

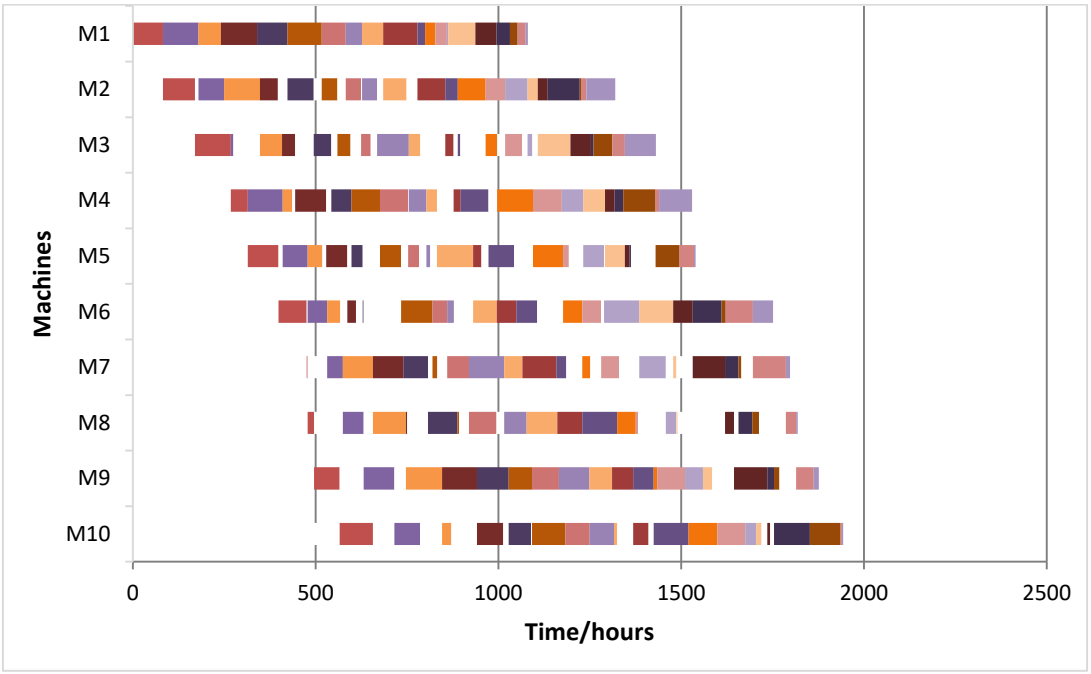

Figure of NEH result of 10 machines 20 jobs (Gantt Chart)

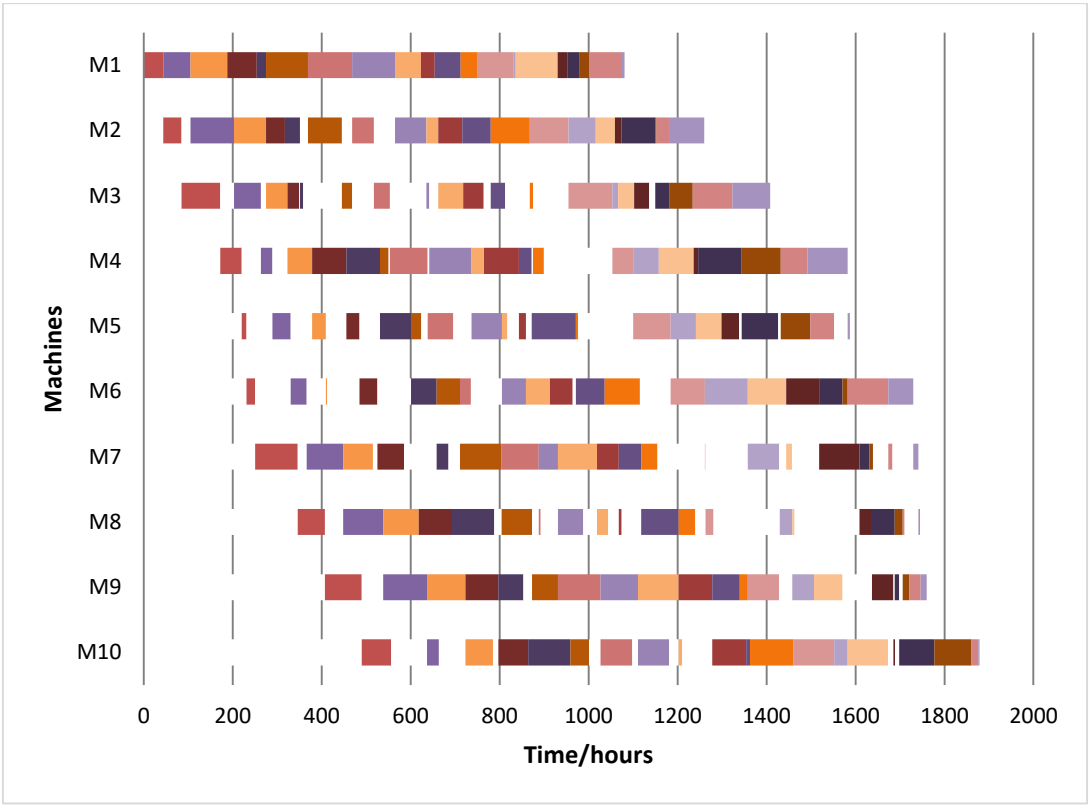

Figure of selected modified heuristic result of 10 machines 20 jobs (Gantt Chart)

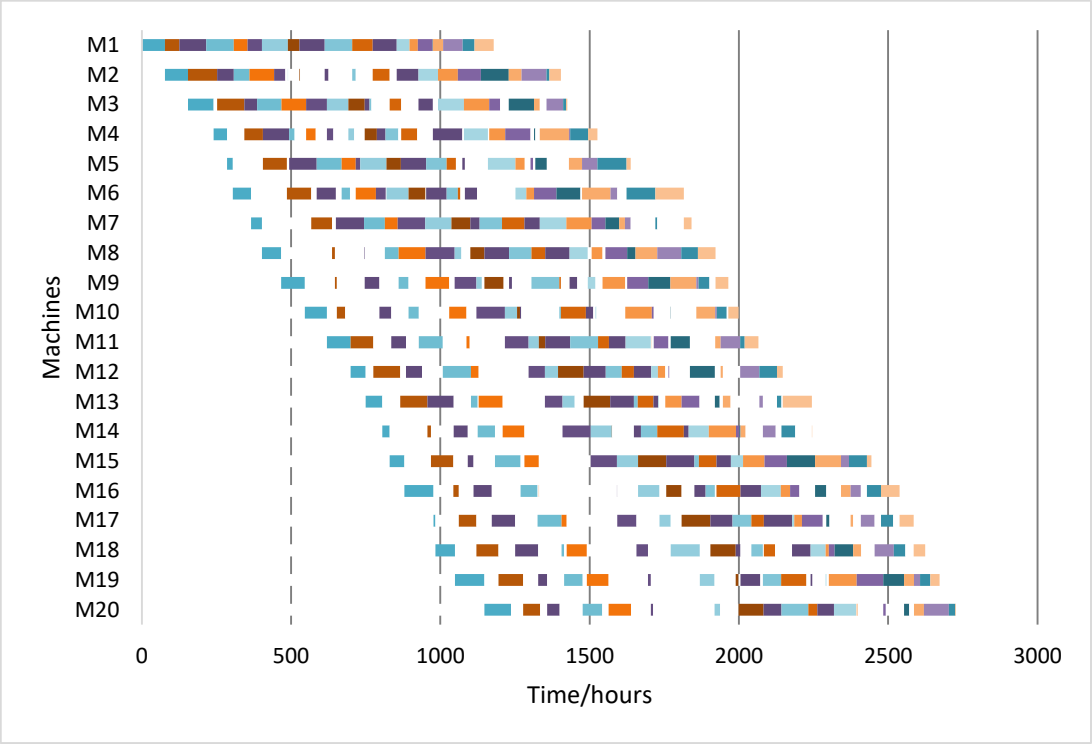

Figure of NEH result of 10 machines 20 jobs (Gantt Chart)

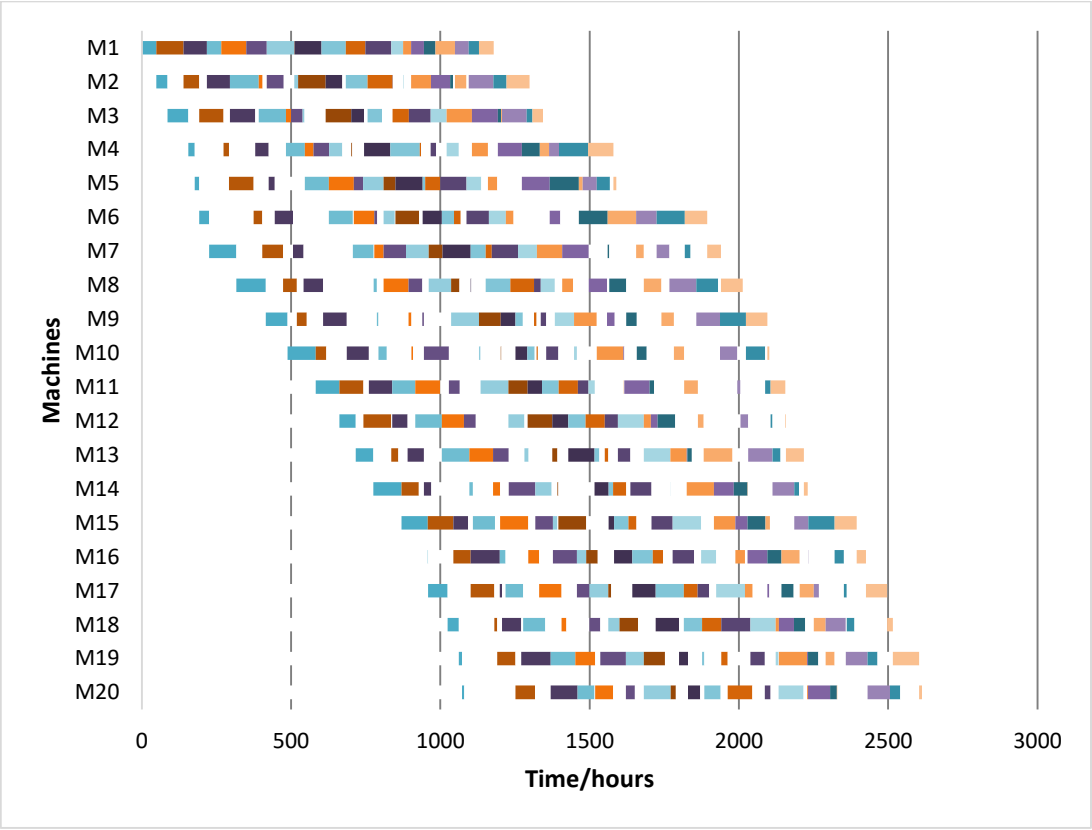

Figure of selected modified heuristic result of 10 machines 20 jobs (Gantt Chart)

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