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APPLICATION OF SIMULATION TOOL FOR SCHEDULING IN ENGINEERING

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Keywords: simulation software, scheduling, engineering
Abstract: This article is focused on the possibility of application of simulation tool for scheduling in manufacturing plants. Introduction of this article describes the function of attributes of the jobs or machines – dispatching rules. After that it is created the general overview of the most common used scheduling software in the manufacturing plants. The last part of this article is dedicated to practical example of application the scheduling software in the manufacturing plant.

1 Introduction

Planning establishes what, how, where and in what order work will be performed, while scheduling sets forth who and when. Construction planning is the development of a feasible operational design for completing the work [3]. The process involves the selection of work sequence and methods, and provides information for the scheduling process [1]. Scheduling determines the timing and specific sequence of tasks necessary to carry out the plan [2]. The schedule is a result of the planning process and reflects the selected plan. Scheduling is an important planning activity in manufacturing systems to help optimise the usage of scarce resources and improve the customer satisfaction (Figure 1). In the engineering there is applied the scheduling software that use the simulation scheduling software with dispatching rules (Table 1). Dispatching rule is a function of attributes of the jobs or the machines [4]:

- Job attributes: weight, processing time, due date, etc.
- Machine attributes: speed, number of jobs waiting for processing, total amount of processing waiting in queue, etc.

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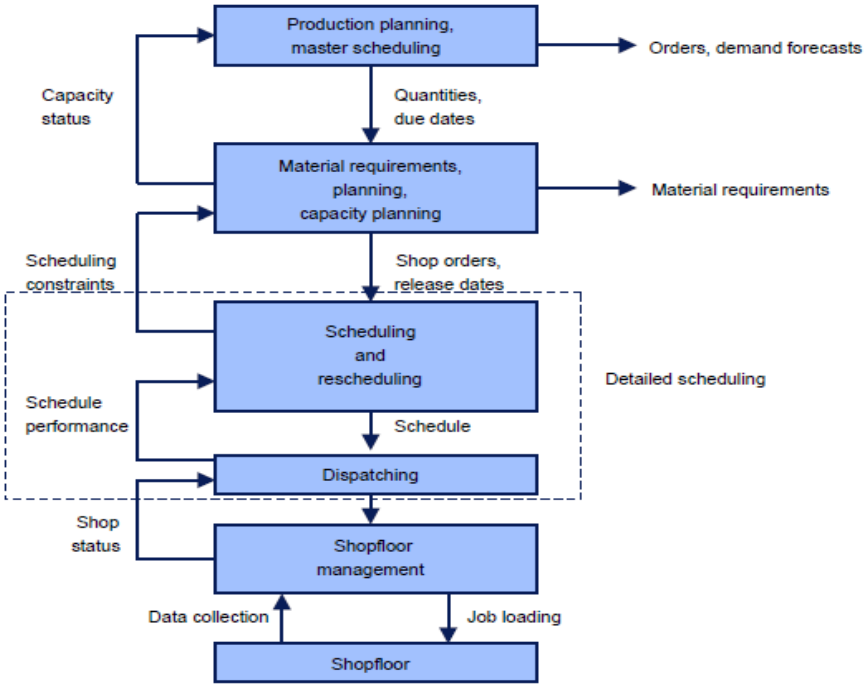
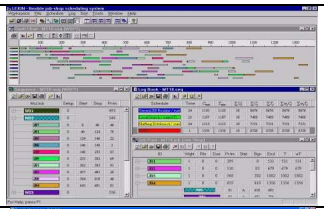
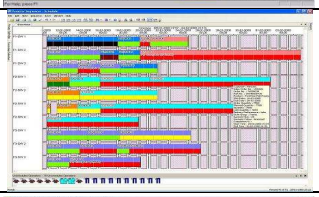
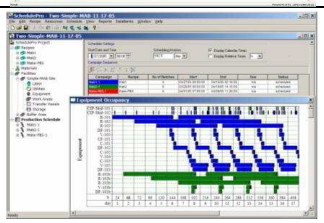
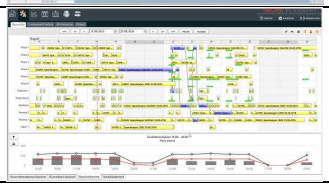


Figure 1 Flow diagram in manufacturing system

Table 1 The most used scheduling software in engineering

LEKIN		- heuristic methods - dispatching rules - 6 basic work environment - 60 standard benchmark problem - graphic presentation of results: Gantt charts - import and export of external algorithms
Preactor Scheduling Software		- minimization of production time - minimization of costs - maximization of operation efficiency - rules for planning - output: Gantt charts
SchedulePro		- final capacity planning - reducing cycle time - capacity analysis - maintenance planning - graphical interpretation: Gantt charts - analysis: sources (material, worker, etc.), using of machines
Seiki Software		- minimization of production time - creation sequence of production - ensure accuracy of supply - avoiding bottleneck - reduction semi-products
Delfoi Planner		- reduction lead time - reduction work in progress - increase accuracy of supply - monitoring all changes directly by software

2 Scheduling software LEKIN

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.

Short description of scheduling software Lekin:

- 6 basic workspace environments: single machine, parallel machines, flow shop, flexible flow shop, job shop, and flexible job shop.
- A set of sample problems.
- More than 60 standard benchmark problems from different sources.
- Smooth input of user problems.
- Various dispatching rules and heuristics.
- Gantt chart with drag-and-drop support.
- Graphic tool for comparative analysis of different schedules.
- Complete graphic printouts.
- Easy attachment, import and export of external algorithms.

In the scheduling software Lekin there are used the following dispatching rules [4]:

- *Earliest Due Date* – EDD - selects the next job from the queue based on their due date.
- *First in First Out* –FIFO - selects the next job from the queue based on their arrival time at the current machine.
- *First Come – First Served* – FCFS - the first job to arrive at a work center is processed first
- *Longest Processing Time* – LPT - the job with the longest processing time is processed first
- *Shortest Processing Time* – SPT - selects the next job from the queue based on their processing times at the current machine
- *Weighted Shortest Processing Time* – WSPT - sequences jobs in nonincreasing order of their weight-to-processing-time ratios
- *Critical Ratio* – CR - selects the next job from the queue based on their relatively available time divided by the total remaining process time of the job

The main menu of scheduling software Lekin provides the six frameworks: single machine, parallel machines, flow shop, flexible flow shop, job shop and flexible job shop. The overview of the above mentioned frameworks is presented in the following figure (Figure 2).

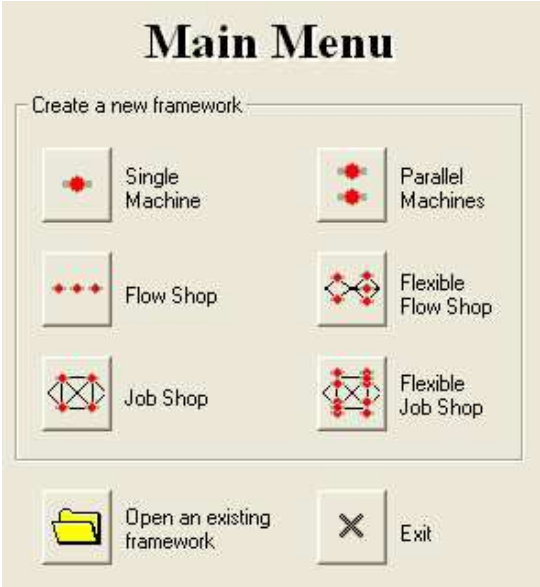


Figure 2 Main menu of scheduling software Lekin

The scheduling software Lekin uses for scheduling the Gantt charts. It is a type of bar chart which provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project. The horizontal axis of Gantt chart is a time and the vertical axis is a task. In the engineering there is quite often used for scheduling of production time. In the following part of this article is presented the example of application this software for determination of optimal production time.

3 Application of scheduling software in engineering

In this case, it was used the flow shop framework for the illustration of application the scheduling software Lekin in the manufacturing plant – production of bearings. In the following table there is presented the machine production time of manufactured parts - bearings. The total production time (Table 2) will be optimized by several dispatching rules which are described in the previous part of this article.

Table 2 Production time in seconds

Operation	Bearing 1	Bearing 2	Bearing 3	Bearing 4
No. 1	0	2.9	21	2.9
No.2	26	0	0	0
No.3	2.9	0	14	3.6
No.4	0	155	17	16
No. 5	3	0	0	0
No. 6	0	3.6	43	47
No. 7	0	0	37	38
No. 8	0	0	0	49
No. 9	30	44	41	55
No. 10	12	22	45	18
No. 11	60	60	60	60
No. 12	7	3	3	3
No. 13	60	60	60	60

Production process was optimised by three dispatching rules: EDD, LPT and CR (Figure 3, Figure 4, Figure 5). In the following figure there are presented the Gantt charts after the application of above mentioned rules.

Legend to the following Figure 3 - 5:
Grey colour – Bearing 1, Red colour – Bearing 2
Green colour – Bearing 3, Blue colour – Bearing 4

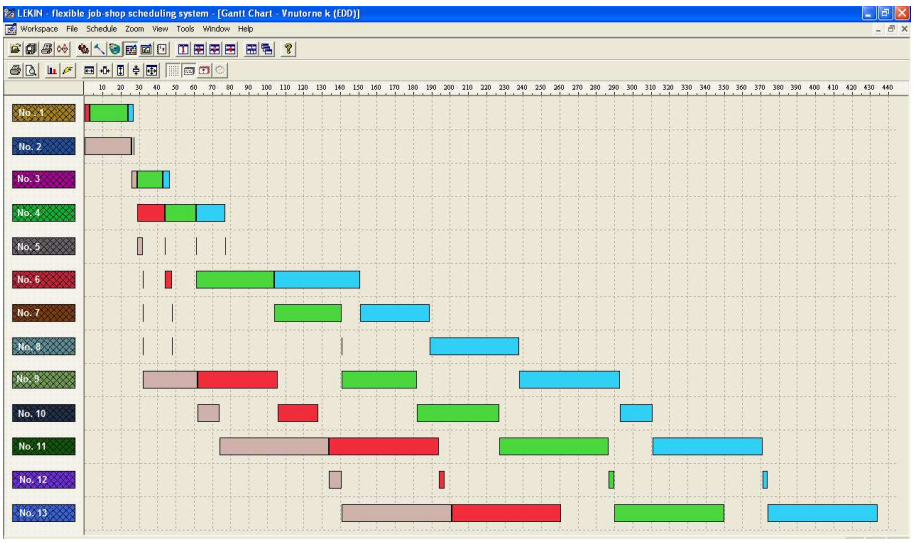


Figure 3 Optimization of production process – EDD dispatching rule

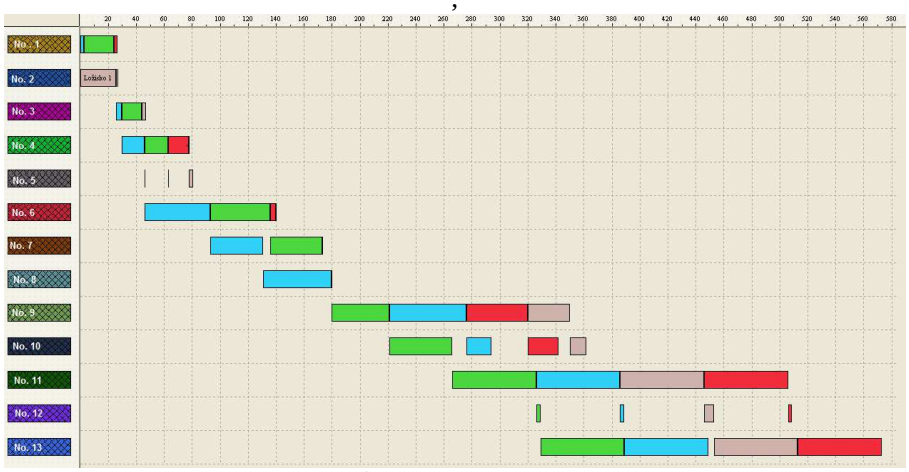


Figure 4 Optimization of production process – LPT dispatching rule

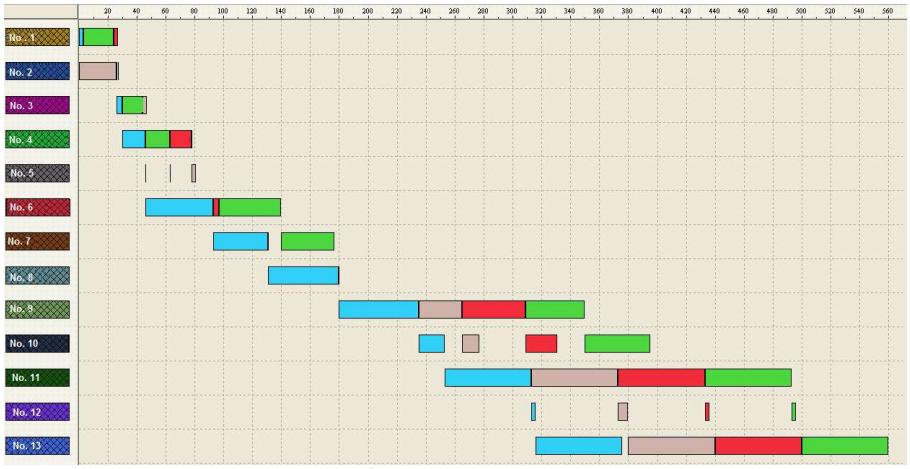


Figure 5 Optimization of production process – CR dispatching rule

In the following table (Table 3) there is presented the evaluation of previous production time and production time after the use of dispatching rules.

In the following figure (Figure 6) there is presented the final values of optimised production time after the application of dispatching rules. The red line above the bar, there is presentation of value of previous production time.

The above mentioned table and figure present that the biggest time saving is generated after the application of EDD dispatching rules. The time saving is about 32% from total value of previous production time. At least save by applying the LPT dispatching rule.

Table 3 Evaluation of production time

		Production time [s]	Difference between previous time and after the application of rules	Percentage value of saved production time
Previous production time		640	-	-
Production time after application of dispatching rules	EDD	435	205	32,03 %
	CR	560	80	12,5 %
	LPT	570	70	10,94 %

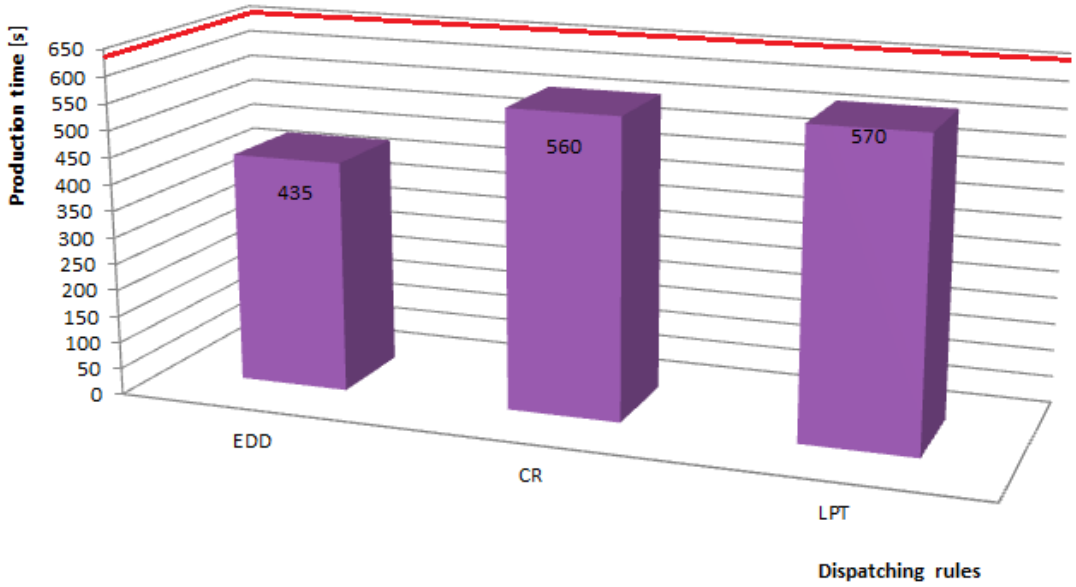


Figure 6 Production time after the application of dispatching rules

Conclusion

Scheduling plays an important role in most manufacturing and production systems. [8] It involves resources and time which must be addressed concurrently to satisfy constraints. [6][7] This article was focused on application of simulation tool for scheduling in engineering. The first part of article it was described the theoretical analysis of scheduling, dispatching rules and simulation tool for scheduling - Lekin. The next part of article described the application of scheduling software in manufacturing, namely in engineering. It was used three dispatching rules to the optimisation of production time. From the evaluation it was selected the EDD dispatching rule as the most optimal solution for this production. The time saving is about 32% from total value of previous production time. Simulation is a powerful tool that can be employed when designing and selecting scheduling strategies. [4] It is necessary to use this tool for evaluation, innovation and optimization of manufacturing processes, costs, scheduling, etc.

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