COMPARISON IN PRODUCTION PLANNING OF THE CLASSICAL METHOD AND RL ADVANCED ALGORITHMS

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Abstract. In this paper a comparison of optimization methods, conventional and advance algorithms in production scheduling is investigated. Target is to use Reinforcement learning (RL) method in production planning optimization and to detect influential parameters in both methods used for selected production optimization. Two simulations are conducted: first is done with the use of classical methods for technical planning and other is focused on the use of RL method in combination with genetically algorithm (GA). Simulation is done with Tecnomatix EM plant Simulation software and efficiency of used methods will be analyzed on a furniture factory plan. Focus of simulation is the internal warehouse system of mentioned factory.

Introduction

In present way of planning and doing business it is a god practice to monitor and optimize the production and processes before and during production. Main reason for this approach is establishing sustainable and robust production, process and business model. The capability to predict and plan optimum production load and investment of new equipment or modification of job shop layout can keep a company competitive and capable of better positioning on a global market. This paper is describing manufacturing optimization of wheel-chair assembly process [1] and gives considerations to critical parameters for optimization.

The main issue was how to optimize internal stock piles in process. Reinforced learning method in combination with genetically algorithm was chosen. This method was very efficient on autonomous mobile robot. Method was used for optimization of movement through space where area was changeable, barriers are not constant parameter. Generally speaking RL is based on reinforced feedback signal which in this case robot is receiving from environment. It means that after each robot's step it gets more and more useful information through feedback signal. All data are separated on "good" and "bad" data pools. Example: If robot can pass then that is good data and if it can't pass then that is bad data. Data from "good pool" will be used in future and data from "bad pool" should be decomposed. Good data will be processed with GA to get best solution [1]. Target should be assigned before operation is started. Time shift should also be defined.

Production system

First in our concept was establishment of the basic technological process [2]. Technological process can be separated on four main sub processes: seat mounting, base mounting, shoulder mounting and final assembling. All components are shown in table down below (Table 1), while Fig. 1 represents the main production process. Each one of sub processes is composed of few smaller processes which are presenting additional operations. Between processes sub buffers are entered and they represent temporally warehouses, this is done in order to reduce bottlenecks and free faster producing machines for additional operations. One of aims is optimization of quantities of raw material that is used in process and completion of sub parts in dependence of quantity which is needed for final products. Necessity for that kind of optimization is taken from two main inquiries: space decrease and decrease of needed stock for raw material and subparts [2] while improving the rate of production. Buffers should be placed on the job shop and parts should be produced in order to fully utilize production capabilities. The solution lies in adequate circulation of product parts; however this is difficult to calculate therefore Em-plant software was used for optimization.

Table 1. Build of material

No.	Mark	Type	Quantity
1	METAL RING	position	1
2	PLASTIC RING	position	1
3	LEGG	position	5
4	WHEEL FRAME	position	5
5	WHEEL SET	set	5
6	SPINDLE	position	1
7	SEAT HUB	position	1
8	NET DOWN	position	1
9	NET UPPER	position	1
10	BASE SHOULDER	set	2
11	TRIANGLE SHOULDER	set	2
12	FILLER	position	240

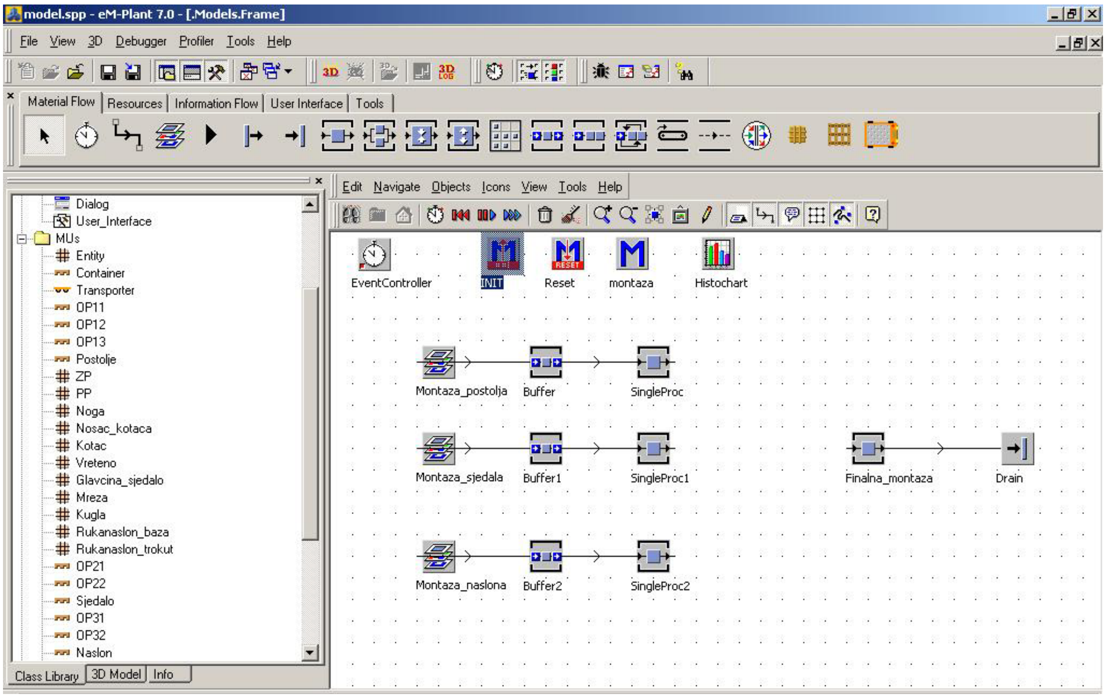

Fig. 1 Main process

Results

Process was monitored with bottleneck analyzer tool which is prefabricated Em-plant module. Assumption was that all internal warehouses are the same size. As we can see from Fig. 2 Final mounting process is on hold for almost 100 % of time.

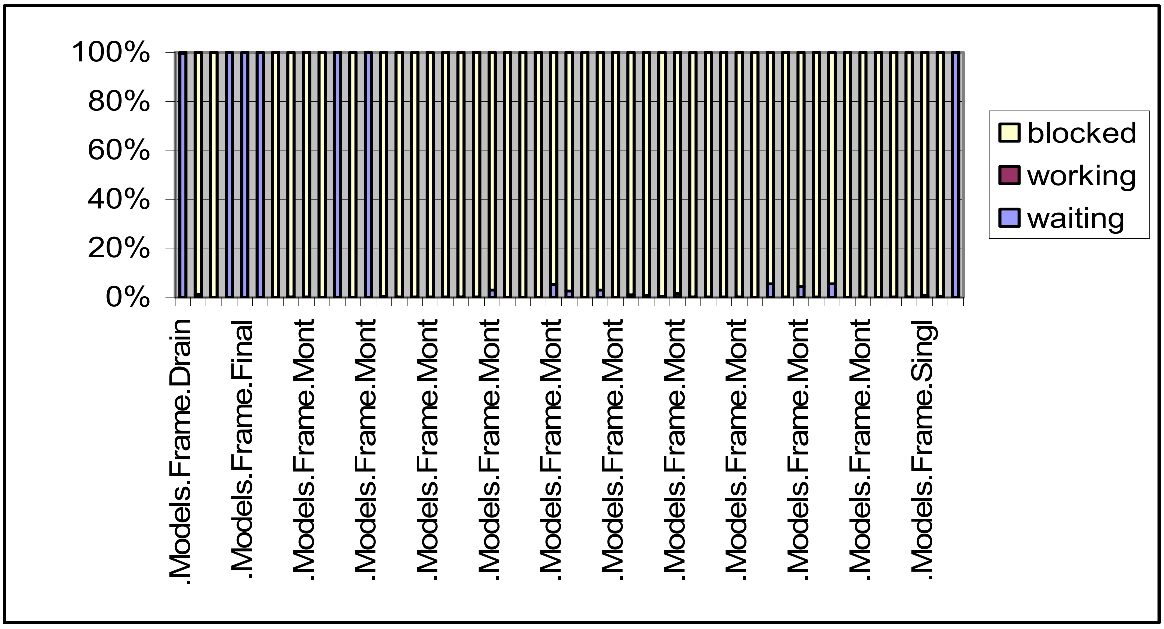

Fig. 2 Results before optimization

Optimization

Problem which is presented in this article could be solved on more than one way but generally speaking on presented case can be solved with classical methods which are based on empirical and experimental data or evolutionary algorithms can be used. When evolutionary method is planed, empirical data are welcome for first setup of process to reduce the time of optimization [3, 4].

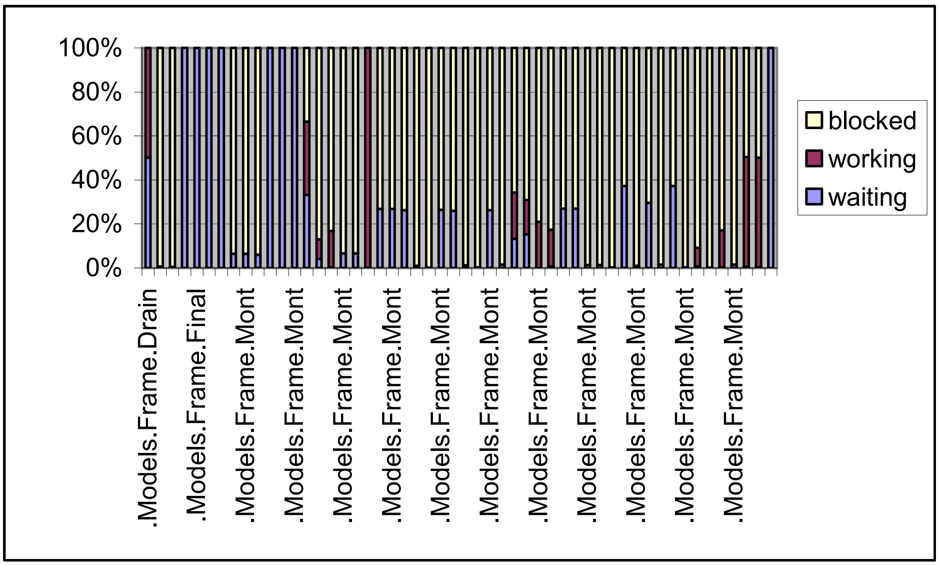

Fig. 3 Results after optimization

First step was to determine where bottle necks in process are. In that step it is used "Bottleneck Analyzer" which is prefabricated Em-plant module. For optimization is chosen RL method. In paper prefabricated model "GAWizard" is used which are using Q method of reinforcement learning "Equation 1". Q RL method is targeting on decreased value of future awards which are gained from environment [5]. Used model can be redefined on the customer demand. Symbol "s" is presenting state, symbol "a" is presenting action and symbol "r" is presenting reward. Graphical performances of "improved" process are shown on Fig. 3, [6, 7].

$$Q(s_{t-1},a_{t-1}) \leftarrow Q(s_{t-1},a_{t-1}) + \alpha \left[r_{t-1} + \gamma \max_{at} Q(s_t,a_t) - Q(s_{t-1},a_{t-1}) \right] \quad \text{Eq. (1)}$$

Conclusion

It is visible that process was blocked for almost 98 % of process time before optimization and that after optimization idle time is decreased on 50 %. Based on those results it is visible that process is for 51% improved with optimization. Lot of parameters is not shown because authors are obligated to keep business information confidential. In this article only one cycle of optimization is done, but it is obvious that the largest performance jump in process is on first cycle. Complete production model is prepared for integration in larger business model. Future development of this project should be in following directions: this production model should be optimized for several more times and after that it should be integrated in larger business model. This business model should involve suppliers as well.

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