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# An Approach in Development of System for Production Scheduling

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## ABSTRACT
This paper presents a system for production scheduling which is a part of production planning system. Production scheduling according to delivery time is specially considered and launch plans for parts are determined according to structural components. Using system of different applications and report types, developed program gives support for business decision making which considers production planning and scheduling.

## KEYWORDS
production scheduling, planning.

## INTRODUCTION
Production system performances largely depend on the way material flow is irganized through the same system, at the same time defining priorities or rules when and where the certain operation will take place. The level of a terminal plan quality is estimated by different, often conflicting criteria such as criteria based on the duration of the production cycle, the amount of supply in the process of production using the system resources, delivery deadline for the finished products or the criteria based on the expenses.
Production terminating problems are extremely complicated problems because of the complexity of the production systems structure, great number of variables which are the most important for functioning of these systems and their dynamic interactions, and necessity of making dynamic decisions in the process of system functioning when events of stochastic nature happen.
By terminating some of the operations which should be performed, adjusting of calculated working utilisation is done with resource capacities which are available in the certain time period. The aim is to gain an optimal disposition of preferable activities with available capacities and resources for the certain time period.

## DESCRIPTION OF PERFORMING SIMULATION EXPERIMENTS
Initial space of state which initiates egsecution of simulation model is described by attributes in the Table 1. In the same chart relevant information is given for the description of the state of the system in the monitoring period. Simulating programme is projected so as to ensure continual realization of logistic chain from the moment of acquisition of auxiliary goods, to the realization of work order in a factory and delivery of products to buyers. Simulating experiment begins with assumption that the necessary auxiliary goods are available at the entrance warehouse. Programme, regulated by automatically calculated priorities of work orders, completely depicting activities in a factory, defines information given in the Table 1.

Programme calculates priority of work orders in a pattern:

$$P_{RN_i} = d_i - T_{ti}, \tag{1}$$

where

$P_{RN_i}$ – priority of suitable work order,
$d_i$ – deadline of delivery of finished products - to the buyer $i$,
$T_{ti}$ – transportation time of finished products - to the buyer $i$.

After receiving the termin plan, on the basis of the time of the beginning of work order realisation, programme calculates the latest time of auxiliary goods ordering for each work order, on the basis of facts about responce time of suppliers. This termin plan defines in time and space coordinates of the modeling system complete logistic chain, fulfilling arranged deadlines of finished products delivery.

Next optimisation of system operating takes into account specific characteristics of modeling system. Preparation and termination time of product lines is 180 minutes and that is the time spent on their adjustement in changing the type of cultivating product. When plenty work orders are waiting to be laboured the programme is checking if in that group exists work order for which realisation product line is adjusted and chooses that one.

Before describing process of simulating experiments and final results performances of realised software should be emphasised which distinguish it from the classical software appliances offered on the market.

Thanks to the appliance of the object-oriented approach in the phases of analysis, modeling and programming, and the changes of the theory of the enlarged. Petries networks in all three mentioned phases simulating software very realistically depicts events in the real world. In that way identity of the modelling system is copied into the suitable identities of programme objects and modelling processes. This results in a way that by using this software while creating termin plan, terminer doesn't change usual way of thinking in dealing this, to it, very familiar problem. In designing this type of application, above all, following should be considered:

- The creator of termin plan has the greatest knowledge in the field of termination of the problem of the specific factory because he deals it daily and in a very long period of time.
- Sofware should ensure realisation of that knowledge into optimal control decisions.
- Software should allow the user widening of his knowledge, ensuring him necessary information.

These facts are not possible to apply sufficiently in the classical approach of designing this type of application for the general use which deals with this problem. Reason for this is that a certain group, many realistic systems are not possible to modelise to the level of abstraction which is necessary for making optimal control decisions on tactical and operative level. Software of general use can not modelise identity of each individual system, in other words, cpecificity relating its structure and functioning because they are on the lower levels of abstraction. So, only expert knowledge in the field of designing these applications (object-oriented metodology and Petries networks) joined with knoweledge from the field of industrial engineering and specific knoweledge and demands of users give sofwarer solutions of stisfactory, in other words high performances.

Next, very important characteristic which distinguishes the approach of designing this type of software, is that for his egsecution only the facts (available in the production and technological documentation ) about the starting space of state of the system are obligatory. All other facts about dynamics of change of the space of state of the system this software shows automatically. Software of general use, except when dealing with trivial problems, that is not the case, for the beginning of simulation experiment it is necessary to define (very often to foresee with the help of suitable models)many additional information. Again we are dealing with the complexity which results in much lower quality of the model with all negative consequences: control decisions which are far from optimal, low level of using the system performances and losses which are possible to avoid.

Having in mind characteristics of the modeling system the conclusion is that changing of the termin plan can be mostly influenced by facts which directly influence on priority of work order and those are:

- Delivery time of finished products to the buyer.

Table 1: *Described by the attribtes.*

| Initial space of state inserted by the user | Information created by software |
|---|---|
| Number of work orders in the system | Work order priority |
| Product type for every work order | Initial time of realization of work order |
| Ordered supply | Time of termination of realization of work order |
| Delivery deadline | Latest time of auxiliary goods ordering for every work order |
| Responce time of suppliers | Time reserve or latency for every work order |
| Transportation time to the buyer | Termin plan of factory utilisation |
| Duration time of every operation of the technological process | Quantity of required auxiliary goods for the realization of every work order |
| Product type for every product line | Necessary quantity that has to be in the warehouse at the beginning of the realization of termin plan |
| Additional priorities of work order | Level of usage of active resources |
| Line where the notice is predicted | Index of usage of factory performances |

- The size of the work order $i$.
- The transportation time to the buyer.

Changing the values of these three elements from 50-150 % on diagrams which follow certain changes of the following index of the system performaces are included:

- the average number of work order in the system (Fig. 1, 2 and 3).

Fig. 1 shows change of the average number of work orders in the system depending on the change of the transportation time of finished products to the buyer from 50-150 %. Value of basic time is index of 100 % (value 1 on the diagram) and those values can be seen on Fig. 1. Average number of work orders for that facts is 5,28 and the biggest digression from that value is noticed in increasing basic values for 150 % when average number of work orders is 4,83. The way in which transportation time of finished products to the buyer ($T_{ti}$) has influence on termin plan can be seen in the pattern for time priority of work orders (1).

It is clear that by increasing the transportation time time reserve is reduced, priority of work order and in the course of experiment the programme will change priorities in favour of the work order with more transportation time of finished products to the buyer.

Fig. 2 shows the change of the average number of work orders in the system depending on the change of the delivery deadline of finished products to the buyer. Diagram shows that a characteristic of this system is that by reducing the delivery deadline number of work orders is reduced in the system. This conclusion is indirectly confirmed also on Fig. 1.

## SIMULATION RESULTS

Creators of termin plans on the tactical level, and especially on the operative level are faced with very complex problems. Making control decisisons timely which are close to optimal is of the essential significance because those decisions activate assemblage of mechanisms functioning in the techno-

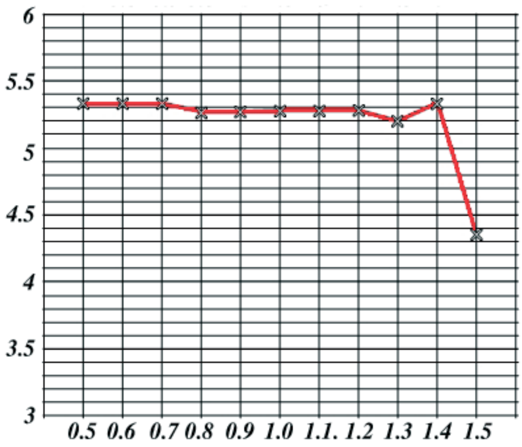


Fig. 1: *Change of the average number of work order in the system depending the change of transportation time of finished products to the buyer.*

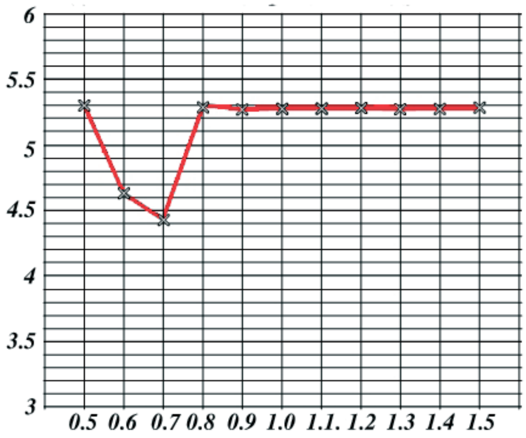


Fig. 2: *Change of the average number of work orders in the system depending on the change of the delivery deadline of finished products to the buyer.*

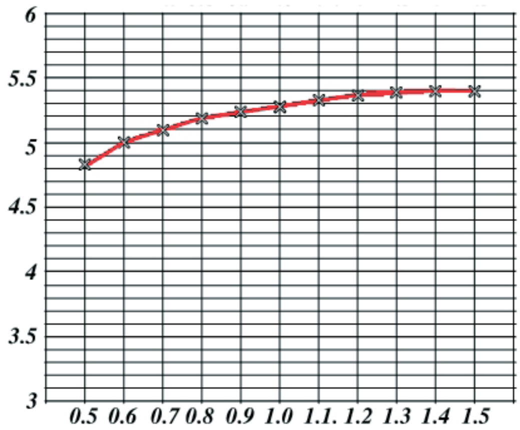


Fig. 3: *Change of the average time of work orders in the system depending on the change of the work orders size.*

logical systems. These decisions show in which degree performances of the system will be used, how much loses will be eliminated, whether the contracts with buyers will be fulfilled. We have already mentioned the complexity of the襲terminiing problem, and now it is said that its satisfying solution is impossible without simulating software. Software quality and control model directly determins quality of control decisions. For the initial facts given on Fig. 4 and the suitable termin plan shown on Fig. 5 disposition of time reserves is shown in suitable menu on Fig. 6. It is apparent that work orders 3 and 7 according to the given termin plan do not have timely delivery of products to the buyer and that the change of termin plan is necessary. First posibility offered by the suggested termin programme and which will be used for optimization of termin plan is change of priority of the work orders. Entering the right menu work order number three is given priority 1, and work order number 7 priority 4. After simulation experiment with the analysis of reserve, that there is no latency and that all buyers will

Simulation of the production process and the change of the level of storage

The summary of the existing values

| Priority = Number RN | Type Radiator | Command Ordered Amount | Day Term Delivery | Day Time Supply | Day Time Delivery |
|---|---|---|---|---|---|
| 1 | 4 | 1350 | 15 | 5 | 7 |
| 2 | 1 | 4500 | 18 | 5 | 3 |
| 3 | 1 | 980 | 22 | 5 | 10 |
| 4 | 3 | 4500 | 28 | 4 | 4 |
| 5 | 2 | 800 | 23 | 6 | 1 |
| 6 | 6 | 2650 | 26 | 6 | 3 |
| 7 | 6 | 1500 | 27 | 7 | 4 |
| 8 | 6 | 1600 | 35 | 5 | 2 |
| 9 | 3 | 1000 | 41 | 5 | 7 |
| 10 | 1 | 1300 | 38 | 7 | 2 |
| 11 | 2 | 3700 | 46 | 5 | 2 |
| 12 | 4 | 1450 | 49 | 7 | 4 |
| 13 | 2 | 2750 | 49 | 7 | 2 |
| 14 | 3 | 2000 | 55 | 5 | 3 |
| 15 | 4 | 1600 | 63 | 5 | 7 |
| 16 | 1 | 1800 | 71 | 5 | 2 |
| 17 | 5 | 1300 | 84 | 6 | 1 |
| 18 | 4 | 950 | 92 | 5 | 3 |
| 19 | 2 | 3500 | 114 | 5 | 1 |
| 20 | 2 | 1000 | 124 | 5 | 6 |

Fig. 4: *Index of actual values of work orders [2].*

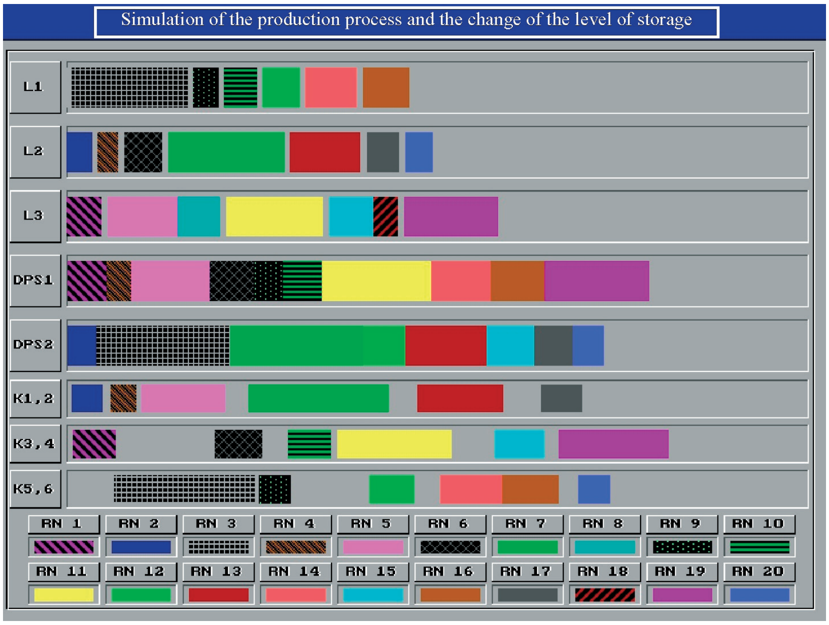


Fig. 5: *Optimal termin plan for the given terms.*

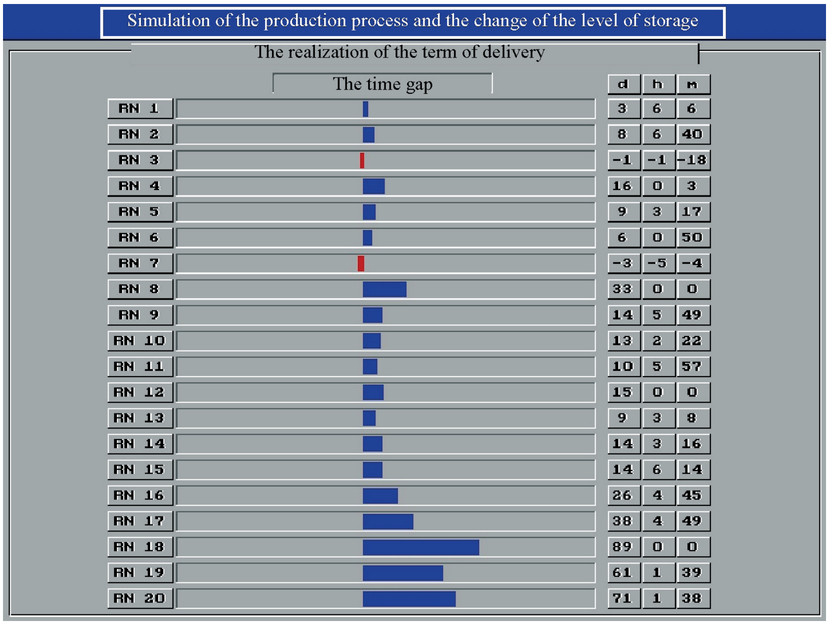


Fig. 6: *Time gap before correction [2].*

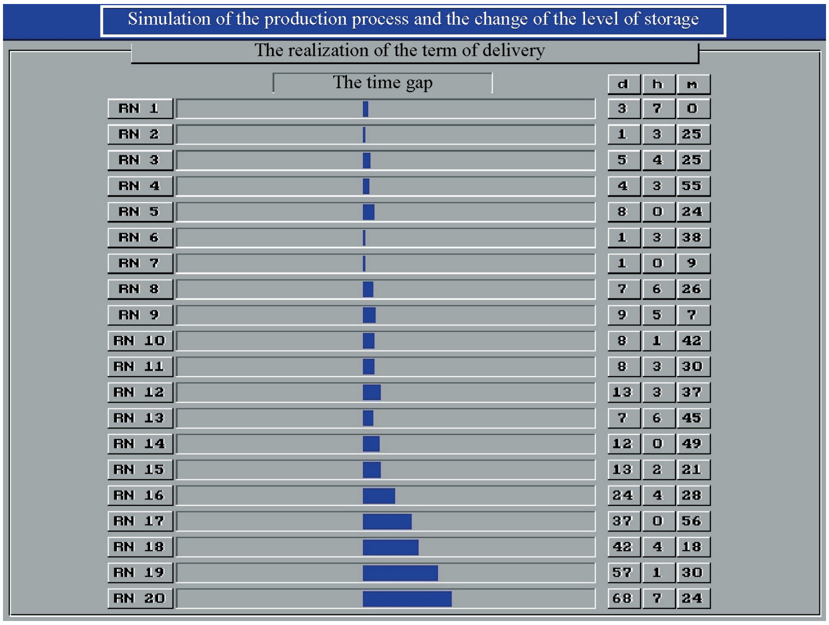


Fig. 7: *Time gap after correction [2].*

be timely equiped with the arranged supplies of products in case the termin plan is fulfilled. It is important to mention that for finding new termin plan terminer needs not more than ten seconds [2].

The following problem solved by means of the mentioned software is a problem of system performances usage. If we consider given termin plan Fig. 5 for the actual initial space of state Fig. 4 and after the analysis of the termin plans for random data it is easy noticable that the problem in the flow of work orders is through machines DPS1 and DPS2. They are used almost maximally and even so they dictate the total time of all work orders through the factory. As a possible solution equalization of time usage of their capacities is imposed.

Optimisation termin plan uses more thoroughly performances of the given technological system more adequately and the time saving is more than three days. With the concrete economic index, the utilisation of the using this simulation device could be demonstrated in this case.

## CONCLUSION

Nowdays business environment demands qick reaction to the buyer's demands with complete and exact information about delivery, production termination is the basis for successful completion of plan and is particularly significant for successful relations with buyers. The developed programme secures high level of synchronization of activities in phases of planning net needs, terminating production process nad monitoring business that is in progress.

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