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Applying Simulation to Optimize Production Flows

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In this paper an optimization is carried out through simulation of the production flows of two production systems of lower rank. A methodology of simulation-optimization is developed, starting from the general methodology for achieving a simulation process. The system to be simulated is a new system, not an existing one that has to be improved.

Keywords: *simulation, optimization, production flow, simulation model, dialog window.*

1. Introduction

An industrial production system means a hierarchic system comprising of several interconnected production systems, the objective being the development of final products, in the requested deadlines, a certain specified quality and last but not least, in terms of efficiency [8].

The lower rank production system (LRPS) is a group of machines established on the basis of criteria [8].

The following main types of LRPS are known:

- Production line – in this case the criterion of establishment is the product obtained;
- Group of machines – the criterion of establishment is the process;
- Manufacturing cell – the criterion of establishment is the group technology.

2. Case Study

The case study to be presented in this paper consists of optimization through simulation of the production flows of the three LRPS. To obtain the data necessary for this simulation a design methodology of LRPS was developed, which contains six stages (that is the subject of another paper), namely [1]:

1. LRPS analysis;

2. Determining the type of processing;
3. Establishing production resources;
4. Determining the way to group the machines;
5. Placement of machines within LRPS;
6. Job shop scheduling (JSS).

There was not the question of designing an industrial production system, but of LRPS, located in hall section „Toolroom‟.

To finish the project, two essential conditions were set:

- The new placement takes into account the decommissioning of a space from section „Toolroom‟; where there are only necessary facilities to ensure the energy supply of machines.
- In the new location the existing equipments will be used, resulting from the decommissioning of some production halls of the company.

From the sorting program analysis, it appears that the main products to be made in the refurbished section are shown in table 1.

Table 1.

No. crt.	Product name	N_T [min/piece]	Q [piece/year]	Product symbol	Cell no.
1.	Threaded bolt 1	64	352	P11	C1
2.	Threaded bolt 2	35	2304	P12	C1
3.	Threaded bolt	128	128	P13	C1
4.	Bolt	85	128	P14	C1
5.	Fitting 1	100	2200	P21	C2
6.	Fitting 2	90	2200	P22	C2
7.	Nozzle	21	4400	P23	C2
8.	Nut	37	4400	P24	C2
9.	Fixing bush	25	24960	P25	C2
10.	Buffer	35	24960	P26	C2
11.	Coupling GS type A PN 160	6	2200	P31	C3
12.	Coupling GS type B PN 160	4	2200	P32	C3

In table 1 are specified the time norms (N_T) and the annual volume of production to be achieved (Q), as well as the production cell in which each product will be manufactured.

The work schedule of the workshop is:

- no. of working days: 5 days/week;
- no. of shifts: 2 shifts/day;
- no. of work hours: 8 hours/shift.

The final placement of the three LRPS within section „Toolroom", obtained from design, is shown in figure 1.

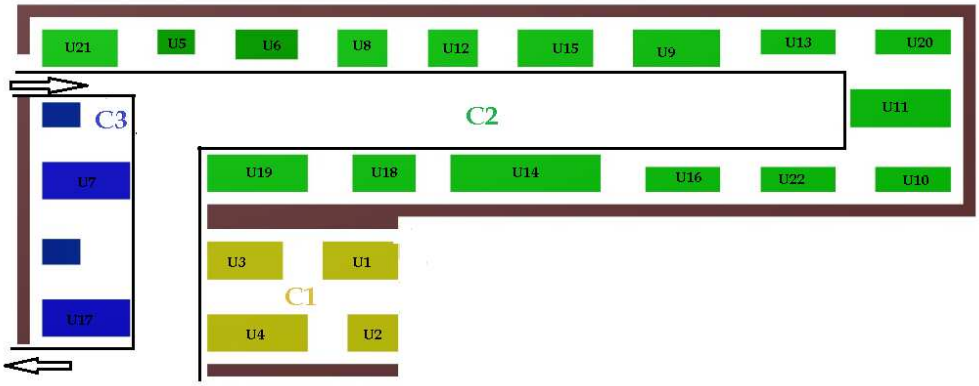

Figure 1. 2D Placement

3. Simulation methodology – optimizing production flows

The proposed methodologies to model and control a production system are not enough for optimization that is why we are heading to simulation. The simulation model is built to solve a problem, but only using simulation does not allow finding an optimal solution. It must be used in an optimization process. In this purpose, an optimization methodology is further developed.

Applying simulation to production flow optimization requires the following steps [1]:

1. Defining the objectives of the study flow;
2. Identifying and solving problems which arise in production flows – problems appear because of system size, complexity of relation with entities, but mostly because of random variables;
3. Establishing the resources used – a PC is required, the simulation programs oriented toward production flow and human resource (analysts, production manager, expert in production flows);
4. Modelling of resources deployed in the production process – Important information regarding the product that need to be collected are: operator times, preparation times (if they are not included in the operator times), range and nomenclature of the products, scrap and retouching rate. It then goes to choosing the pilot policies.
5. Modelling informational and decisional flows – using specific documents: manufacturing orders, files (kanbans).

General performance indicators and those aimed at different types of resources, will serve as flow optimization criteria of industrial production.

4. The simulation of production flow of manufacturing cells

In the previous section five steps were presented that are required to achieve the optimization process through simulation of the production flows.

The first two steps are handled by the chosen team to complete the project. This team must come back to the first two steps, but mostly to the second and to analyze them in detail. Triggering the project is done the moment in which the necessity of completing it is established and some objectives are proposed, which later, with the chosen team, are debated and concretely analyzed.

So, the project team (established in step 3) must retake and analyze the proposed objectives (step 1) and to identify, as well as propose solutions to solve problems which appear in production flows.

Can a team be chosen in the first step? The answer may be yes and no. Production manager and expert in production flows which can be a single person, it is known from the start of the project, but the analyst and program user can be established by the computer product that will be used. For an especially important project it is good to have another analyst in the project team, user of a simulator, so that in the end a comparative analysis can be done between models.

Modeling resources mobilized in the production process (step 4) is the most difficult step, so it is good to work with two analysts that can see and obtain a different model, depending on their vision.

A construction of three simulation models is proposed. It is mentioned that the manufacturing cell C1 is not taken into account, because it is composed of 4 machines, and type of production is small series.

Model 1:

To obtain the necessary data for simulation a work week comprised of 5 days with two shifts per day was chosen. Unitary time norms are those from the technological records. The number of carts is 3.

In figure 2 the simulation model associated to the first scenario is presented.

After a first simulation, the scoreboard performed using statistical blocks, shows that in C2, the two products that do not serve the previous assembly in C3, namely the product P25 and P26 are produced over a period of one week, 508 and 505 pieces. These data have not changed much even after 10 or even 100 replications.

Benchmarks that are transferred to the assembly cell C3, supports changes after that number of simulations performed. Thus, after a first simulation the number of assembled parts is 39 pieces – P31 and 53 pieces – P32. After 10 replications the following results were reached:

- 45 pieces from P31 and 49 pieces from P32;
- 549 pieces from P25 and 515 pieces from P26.

The simulation period is increased from one week to a month, so after the first replication we obtain the following results:

- 193 pieces – P31 and 180 pieces – P32;
- 2160 pieces – P25 and 2015 pieces – P26,

and after 10 replications we have an average of 188 pieces – P31, 191 pieces – P32, 2160 pieces – P25 and 2012 pieces – P26.

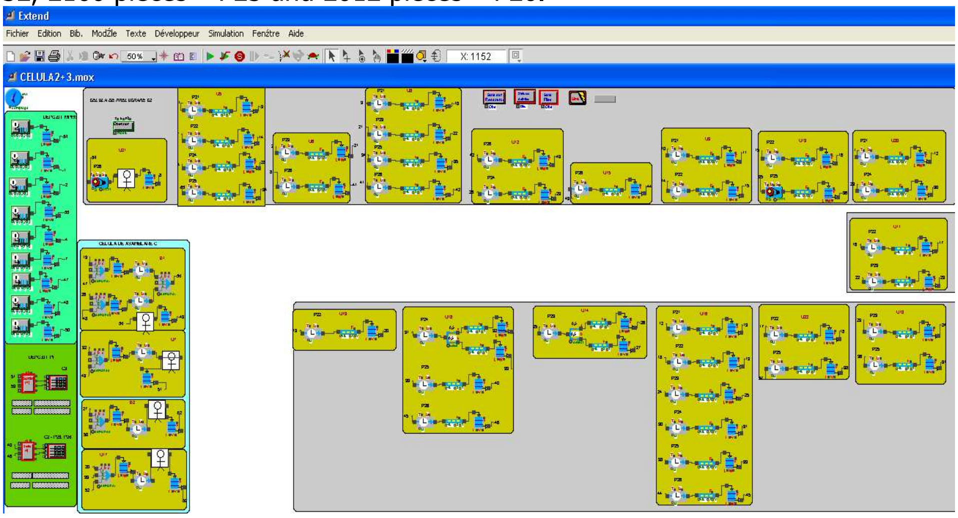

Figure 2. The model of processing cell C2 and assembly cell C3

In case of changing the number of carts, from 3 to 2 and then 1, after 10 replications we obtain a decrease in the number of products, especially those assembled. The number of products P31 decreases from 188 pieces to 180 and then to 163 pieces, and product P32, from 191 drops to 182, and then to 153 pieces.

Model 2:

After the results presented in the scoreboard, we resort to a few changes in the operator times of machines, for starters. An analysis is done changing operator times of product P26, from constant values to random values. Using uniform distribution, after 10 replications the number of products P26 dropeed to 616 pieces to 445 pieces. In the case where a single cart was used. When the number of carts rised to 2, the number of products P26 increased to 479 pieces.

In the case of applying other distributions, for example the exponential distribution, the results are visibly changed. This analysis illustrates an error committed often: neglect of random aspect and using medium values of parameters. Results, once implemented, can lead to catastrophic performances.

Rising the simulation period from a week to a month we obtain the following results, according to fig. 3:

- 180 pieces – P31, 192 pieces – P32;
- 2127 pieces – P25 and 2022 pieces – P26.

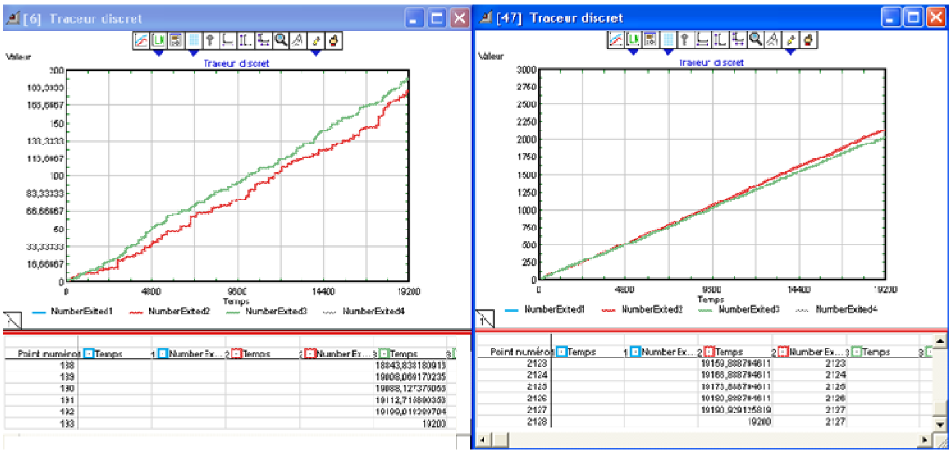

Figure 3. Simulation results for a month - P31, P32 (left) and P25, P26 (right)

Model 3:

Operation of a resource can be seen as a succession of good functioning periods (TBF) and breakdown – duration of reparation when the resource is out of service (TTR), according to figure 3. Each of these periods includes possible waiting periods (waiting for parts, tools, and the repairer). An analysis has been done and it was observed that the waiting times were increased before machine U13, to which block „Pannes aleatoires" was associated.

The average wait time increased from 2,30 to 3,25 minutes, and the maximum waiting time from 7 minutes to 21,22 minutes. The average length of the queue increased from 0.26 to 0.35 (fig.4).

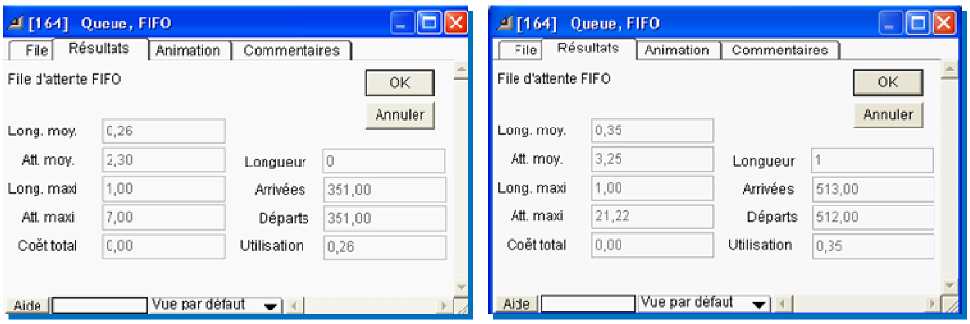

Figure 4. Dialog box of block *"Queue FIFO"*

A variety of analyzes can be performed, including aspects regarding operator tasks, aspects regarding the way to transfer parts from one job to another, aspects regarding storage places between machines.

6. Conclusion

In the case of designing a new production system, simulating flows can offer a valuable help. Of course, the first solution simulated is not necessarily satisfactory. Therefore, we need precise quantitative decision criteria which allow associating values of solutions and therefore comparing solutions between them. They serve also to focus research to a better solution. Costs, time frames, quality, flexibility, are among the most cited criteria.

These criteria must be translated as performance indicators that we must try to optimize in a simulation process.

Without explicitly targeting optimization, a study of flows through simulation can cover other aspects. A simulation model can play a dynamic support of formation. This is very useful in understanding the effect of stochastic aspects in system flows.

Information regarding the principal aspect of the stable resources (jobs, areas of storage/deposit) crossed by flow, but also the transfer resources (conveyors, carts etc.), must be gathered before the modeling for simulation.

General performance indicators and those that are aimed at the different types of resources will serve as optimization criteria of the production flow.

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