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PERFORMANCE ANALYSES OF BASE STOCK CONTROLLED PRODUCTION SYSTEM USING SIMULATION

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Abstract: The objective of this paper is to develop a simulation model to study the performance of a typical single line multistage pull production system namely Base stock. The customer demand and setup number have an exponential distribution between: 160 and 360 products/day and 2 and 8 setups. The entire manufacturing line was simulated for 825 hours, which include 75 hours warm – up period. The performance measure is work in process (WIP). The simulation results indicate that the setup numbers have a smaller negative influence on the WIP and the influence of demand is bigger and positive.

1. INTRODUCTION

The Base Stock system was initially proposed for production systems with infinite production capacity and uses the idea of a safety stock, called buffer, between stages. In the Base Stock control system each stage of the production process must not exceed a certain level of the buffer stock. When a demand for a product arrives at the company, it is immediately transmitted to every production stage to authorize the start of production.

An advantage of this method is that it avoids information blockage by transferring the new demand to all production stages.

The disadvantage is that the number of parts in the system is unlimited.

2. THE CONCEPTUAL MODEL

The models of the system were built according to the descriptions previously given a few assumptions were made to simplify the simulation process. The most important assumptions were the following:

- Number of products – two products, PA and PB;
- The technological process needed for product manufacturing, that implies the same sequence of operations, table 1.

Table 1. The sequences of stage

No.	Stage	Number of workstations
1	Turning	1
2	Gear cutting	1
3	Chamfering	1
4	Brush gear	1

In order to accomplish the operations within the technological process a single machine is needed for each type of operation; the machines are placed in the order of accomplishing the operations within the manufacturing process.

- Processing time, table 2;
- Machine failure – down time, table 2;
- Changeover time, table 2;
- Setup time, table 2;
- The time needed for the operator’s lunch and rest, table 2;
- Machine failure – up time, table 2 - it shows the average time of good operation until a failure reappears, or the average time of good operation until a failure appears or between two successive failures, table 2;

- The running time of a tool – it is given by the longevity of a tool and is specific to each type of tool, table 2;
- Setup cost – 129.05 [u.m./h];
- Production cost - 96.5 [u.m./h]

Table 2. Production cycle times

No.	Stage	Processing time [mi/op.]		Breakdowns			*The time needed for the operator's lunch and rest* [mi/day]	*Machine failure – down time* [mi]	*The running time of a tool* [mi]
		Product PA	Product PB	*Machine failure – up time* [mi]	Setup time [mi]	*Changeover time* [mi]			
1	Turning	1.89	1.89	15	5	3.1	60	1002	378
2	Gear cutting	1.96	1.93	28	11	7.0		1083	7840
3	Chamfering	2.76	2.7	5	9	5.4		1231	29000
4	Brush gear	3.4	3.38	8	11	6.0		2195	19750

The Base Stock system functions as follows. When the customer's demand arrives at the system it is divided into 5 demands, each one is transferred to the control panel corresponding to each stage; the last one joins the final stock by demanding the transfer of another product to the customer. At this point there are two possibilities:

- If a container is available in stock Si, i=1..4, it is sent immediately to the next stage i+1 and stage i produces another container of parts to make up the base stock or to the customer for the last stage and this demand is satisfied.
- If no container is available in the stock, the demand is backordered and waits until a new container is available from the upstream stages.

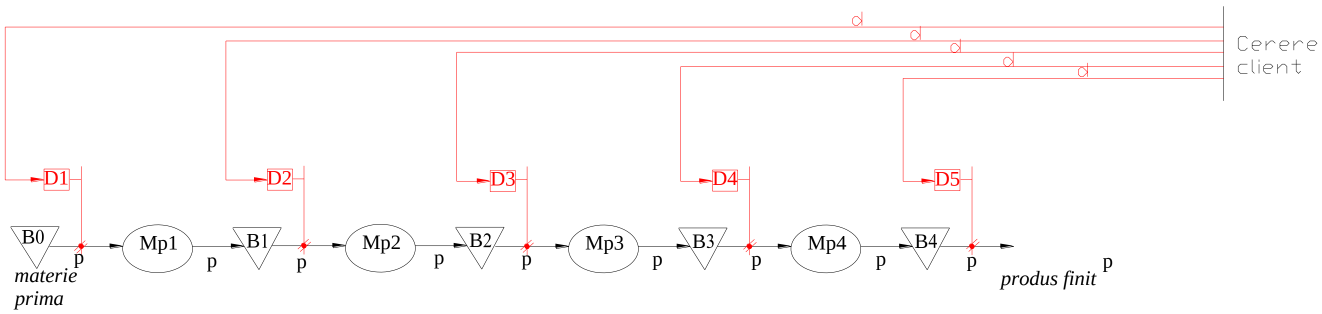

Fig.1. Base stock system

The operating mode of a Base Stock system is simple because it depends on only one parameter, the level of the base stock Si, i = 1,...., N. This parameter influences the transfer of containers downstream, but does not interfere in the transfer of information concerning the demand from upstream.

The level of the base stock will be the same during all working stages and its value depends on the customer's demand, table 3.

Tabel 3. Base stock

Demand	360 products	240 products	160 products
S_i – base stock	45	30	20

When a machine fails during a working stage, the demand process will continue to remove parts from the base stock and the downstream machines will work normally until they will need new parts. The upstream stages continue to receive information concerning the demand directly and they will operate and send parts in a normal way. So they will not be connected to restoring the stock in the stage where the failures appeared.

3. EXPERIMENT

Following the experimental researches regarding the dependence of the WIP on the demand, holding cost rate and setup number, we have established that the main WIP can be expressed by a relation, such as:

$$S_T = a \cdot D^b \cdot n_R{}^c \quad (1)$$

where a, b, c, are constant and D, and n_R represent the demand and the setup number.

This dependence may be linearized by logarithmation:

$$\lg S_T = \lg a + b \lg D + c \lg n_R \quad (2)$$

By substituting: lg(Fz) = Y; lg(a)=A_0; b=A1; lg(D)=X1; c=A2; lg(nR)=X2, we obtain the linear equation (3).

The values X1, X2, are known to be imposed values, and the value Y is measurable. In order to determine the equation one has to determine the A0, A1, A2 and A3 coefficients.

If the relation of dependence Y = Y(X1, X2) can be expressed by such an equation:

$$Y = A_o + A_1X_1 + A_2X_2 \quad (3)$$

then Y depends linearly on the X1, X2, X3 variables.

This equation represents the mathematical model chosen to characterize the process or the phenomenon. One can reach the linear dependence of a value with many variables through mathematical artifices.

Starting from the data presented in table 4, meaning the admission parameters of the process, we have established an experimental factorial and fractional plan of the type 2^2. This plan is presented in table 5.

Table 4. The values of the admission parameters of the process

The parameter		The real value	The normal value
Demand [EA]	D_{min}	160	-1
	D_{med}	240	0
	D_{max}	360	1
Number of setup	n_{Rmin}	2	-1
	n_{Rmed}	4	0
	n_{Rmax}	8	1

Table 5. The experimental plan

Exp.	The standardized values of the independent variables	
	D	n_R
1	-1	-1
2	1	-1
3	-1	1
4	1	1
5	0	0
6	0	0

The Wip is directly determined by simulations. After simulation the experimental data, table 6, obtained on the basis of the research plan presented in table 5, an empiric relation was obtained in what concerns the influence of the demand and number of setup on the main WIP.

Table 6. The values of the independent variables and those obtained for the dependent variable

Exp.	Real value		S_P
	D	n_R	
1	160	2	117
2	360	2	359
3	160	8	107
4	360	8	308
5	240	4	187
6	240	4	188

The relation obtained after working on the data in table 6 is:

$$Sp = 10^{-0.8631} \cdot D^{1.3431} \cdot {n_R}^{-0.0874}$$

Based on the regression relation obtained we have drawn diagrams of the type lgS_P=F(lgD), lgS_P =F(lgnR), these diagrams point out the influence that each input parameter has on the output parameter. These diagrams are presented in the following figures.

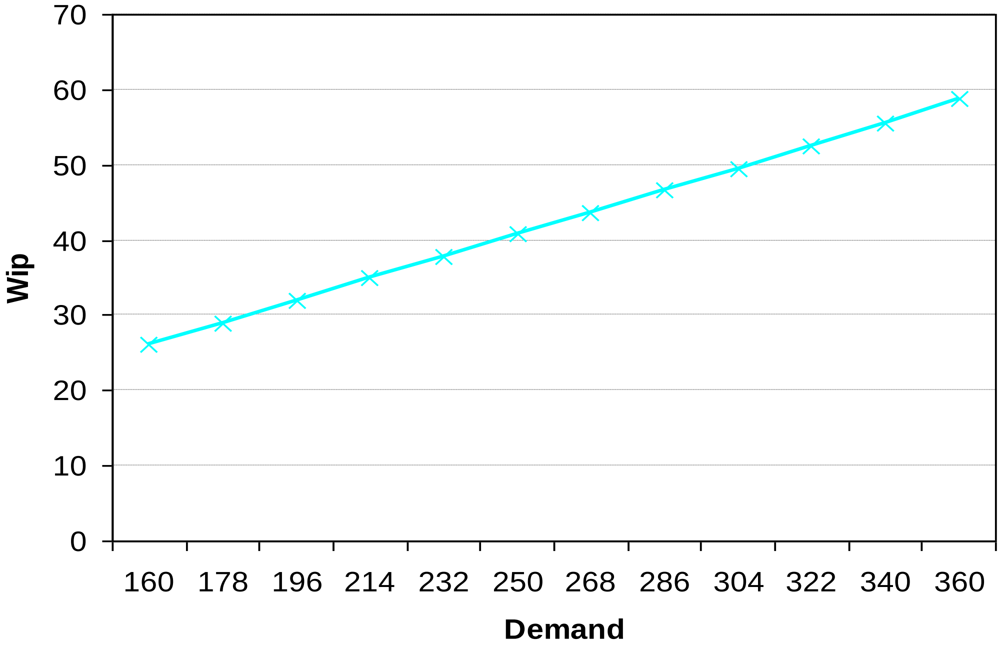

Fig. 2 The influence of the demand on the WIP

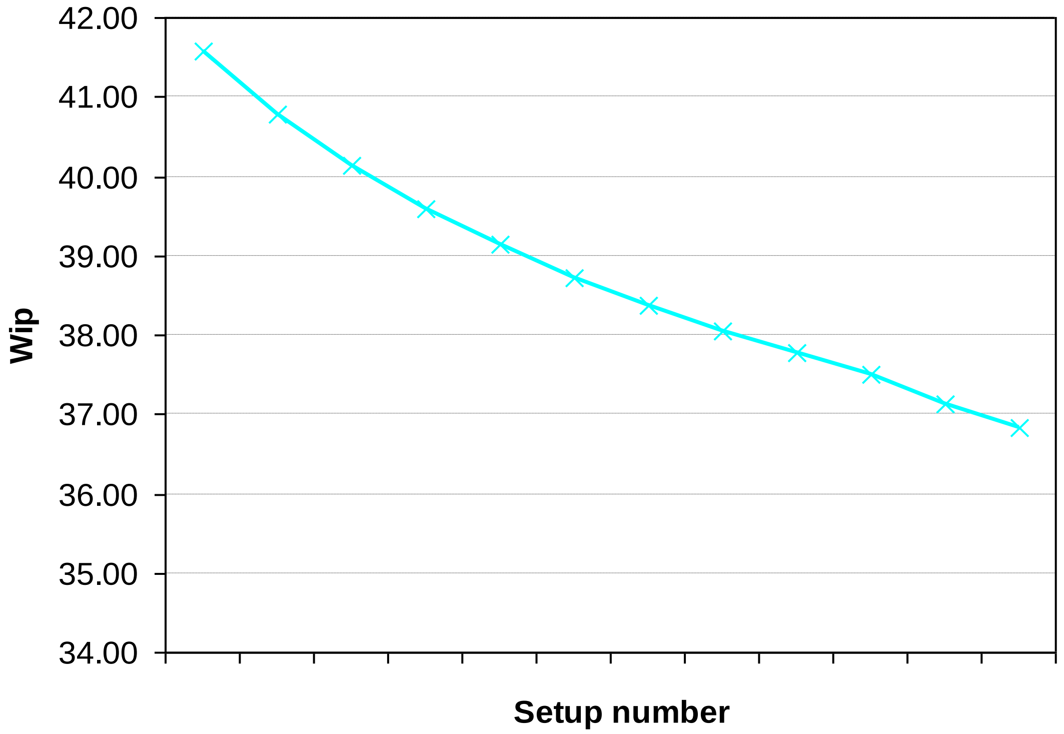

Fig. 3 The influence of the setup number on the WIP

5. CONCLUSIONS

By analyzing the figures 2 and 3 above we observe that the setup numbers have a smaller negatives influence on the main WIP. Another observation is that the influence of the demand is bigger and positive.

Following the experiments of the research plan and the analysis of the data obtained we draw the conclusions:

- the order of the influence of the input parameter on the output parameter is: the holding cost rate, the demand and setup number;
- the value of the WIP represents one of the assessing criteria of a production system's performances; this is why this study can be useful in choosing a production control method;
- in the case of the six tests of the plan, the values of the WIP obtained after the simulation correspond to the values of the WIP within a production system controlled with the help of the Base stock method;
- the function of the WIP determined, valid for all the characteristics of the system taken into consideration, as well as the results obtained, represent a set of data meant to help one establish the values of some parameters of the system in order to achieve certain values of the WIP thus, making possible the optimizing of the system.

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