ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume IX (XIX), 2010, NR2

PERFORMANCE ANALYSES OF CONWIP CONTROLLED PRODUCTION SYSTEM USING SIMULATION

ROTARU Ana
University of Pitesti, Faculty of Mechanics and Technology, Department of Management and Technology
e-mail: ana_c_rotaru@yahoo.com

Keywords: CONWIP, controlled, system, performance

Abstract: CONWIP (CONstant Work In Process) control system uses a single card type to control the total amount of WIP permitted in the entire system. The Conwip system it is a generalization of a Kanban system and can be viewed as a single stage Kanban system. In the framework of this paper are presented and analyzed the performance of Conwip controlled system using simulation

1. INTRODUCTION

The simulation, modeling and analysis of manufacturing systems for performance improvement have become increasingly important during the last few decades. Modern computer aided simulation and modeling tools help to visualize, analyze and optimize complex production processes using computer animations within a reasonable amount of time and investment.

Simulation modeling is the principal means of exploring production control used in this research. Numerous sources describe the use of simulation for predicting performance, comparing alternatives, and optimizing system designs. Law and Kelton [1] a well-known text on discrete-event simulation, discusses the simulation of manufacturing systems. In many cases, simulation studies have been used to gain insight into the behavior of manufacturing systems under different types of control policies (e.g., different dispatching rules) or to determine the accuracy of analytical models. Vollmann, Berry, and Whybark [3] review a number of results, for instance.

Thus, discrete-event simulation is an important tool for evaluating different production control policies. Moreover, finding a production control policy that achieves the best tradeoff between customer service, work-in-process inventory, cost and other performance measures is a difficult task.

Simulation models are used in this paper to illustrate the mechanics of pulling within systems, and give the reader a “hands-on” approach toward studying CONWIP pull systems.

Spearman and Zazanis [2] provide a more advanced discussion of push, pull, and CONWIP production systems and present theoretical motivations for the improved performance of pull systems over traditional push systems. They contribute analytical results for the types of pull systems considered in this paper, and offer several conjectures that the reader is encouraged to consider while studying the pull simulation models presented herein.

- There is less congestion in pull systems.
- Pull systems are inherently easier to control than push systems but can be conceptually more difficult to model.
- The benefits of a pull environment owe more to the fact that WIP is bounded than to the practice of “pulling” everywhere.

Next we will present and analyse the performances of a production system controlled with the help of the Conwip method through total cost.

The total cost is defined by a great number of variables (values), among which certain connections are established. The relation of dependence between these process values is defined function of the system and has the following form:

$$Y = F(X_1, X_2, ..., X_k) \tag{1}$$

where X_j, j = 1, 2, ..., k, represent the values independent of the system (the input values of the process taken into consideration), these values can be the stock cost, the clients demand, the period of equipment breakdowns etc. Y represents the dependent variable (the resultant value of the system taken into consideration, the total cost), while F is the form of the dependence relation (exponential, polynomial etc), which in connection with the name of the dependent variable is called the function of the dependent variable.

These functions "F" can be established theoretically or experimentally. The theoretical ones are introduced by definition or deduced due to economical reasons and they may lead most of the time to results which are very different from the experimental ones. The experimental functions are determined based on experimental results and can have various forms, generally using polynomial or polytropical regression functions.

2. FORMULTE MODELS

The development of CONstant Work In Process (CONWIP) control has highlighted the benefits of control policies that pull work into the facility in response to demand while limiting inventory. The theoretical justification for this approach has been provided primarily for serial and assembly systems with simple, standardized routings. However, the benefits of capping inventory can be expected to accrue in job shops as well. Limiting the amount of WIP reduces storage, finance and record keeping costs, allows the quick identification of quality problems, and permits a rapid response to machine breakdowns, material shortages or worker unavailability. Pull policies simplify scheduling and allow customer or downstream internal demands to dictate directly what is produced and when.

The CONWIP control mechanism can be modeled as a queuing network with two types of synchronization stations. Each product type has an input synchronization station for raw parts and an output synchronization station for finished goods. At the input station, a queue of raw parts is synchronized with a queue of authorization cards for that product type. When both a raw part and an authorization card are available, the card is attached to the part and the part is released to the manufacturing system. The output station synchronizes a customer order queue with a queue for finished products, so that as soon as one of each is available, the product is released to fill the order. Upon a finished product's release, its authorization card is detached and immediately returned to that product type's input station. Figure 1 shows an open queuing network with four synchronization stations for a CONWIP controlled job shop with one product types.

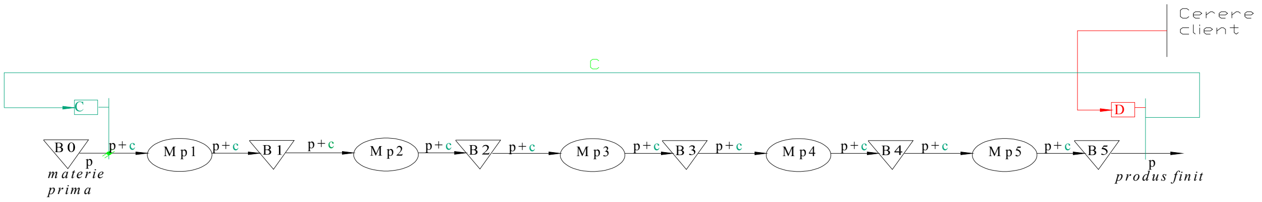

Fig.1. Conwip system

A few assumptions were made to simplify the simulation process. The most important assumptions were the following:

- The five stages are in series, each stage has only one supplier and one customer
- There is an infinite supply of row parts at the input of the production input.

- Information is transmitted instantly
- Transportation within and between workstations is instantaneous
- The system produces a single part
- Conwip are associating with the part
- Any conwip detached at the output of a stage is immediately available for the upstream stage, there is not return delay
- There is no setup time in each machine
- Part authorized for loading follow a first come first serve (FIFO) dispatching policy at all machines.

3. EXPERIMENT

Following the experimental researches regarding the dependence of the total cost on the demand, machining failure and holding cost and dependences of this, we have established that the main total cost by lathing can be expressed by a relation, such as:

$$Y = A_0 + A_1 \cdot D + A_2 \cdot H + A_3 \cdot Mf + A_4 \cdot D \cdot H + A_5 \cdot D \cdot Mf + A_6 \cdot H \cdot Mf + A_7 \cdot D \cdot H \cdot Mf$$

(2)

then Y depends linearly on the X_1, X_2, X_3 variables.

This equation represents the mathematical model chosen to characterize the process or the phenomenon.

Starting from the data presented in table 1, meaning the admission parameters of the process, we have established an experimental factorial and fractional plan of the type 2^3. This plan is presented in table 2.

Table 1. The values of the admission parameters of the process

The parameter		The real value	The normal value
Demand [EA]	D_{min}	90	-1
	D_{med}	145	0
	D_{max}	200	1
Holding cost, [$/ea]	H_{min}	3.5	-1
	H_{med}	2.35	0
	H_{max}	1.2	1
Machining failure [h]	Mf_{min}	1.2	-1
	Mfmed	3	0
	Mf_{max}	4.8	1

Table 2. The experimental plan

Exp	Real value							Normal value						
	D	**H**	**Mf**	**DH**	**DMf**	**HMf**	**DHMf**	**D**	**H**	**Mf**	**DH**	**DMf**	**HMf**	**DHMf**
1	90	1.2	1.2	108	108	1.44	129.60	-1	-1	-1	1	1	1	-1
2	200	1.2	1.2	240	240	1.44	288.00	1	-1	-1	-1	-1	1	1
3	90	3.5	1.2	315	108	4.2	378.00	-1	1	-1	-1	1	-1	1
4	200	3.5	1.2	700	240	4.2	840.00	1	1	-1	1	-1	-1	-1
5	90	1.2	4.8	108	432	5.76	518.40	-1	-1	1	1	-1	-1	1
6	200	1.2	4.8	240	960	5.76	1152.00	1	-1	1	-1	1	-1	-1
7	90	3.5	4.8	315	432	16.8	1512.00	-1	1	1	-1	-1	1	-1
8	200	3.5	4.8	700	960	16.8	3360.00	1	1	1	1	1	1	1
9	145	2.35	3	340.75	435	7.05	1022.25	0	0	0	0	0	0	0
10	145	2.35	3	340.75	435	7.05	1022.25	0	0	0	0	0	0	0
11	145	2.35	3	340.75	435	7.05	1022.25	0	0	0	0	0	0	0
12	145	2.35	3	340.75	435	7.05	1022.25	0	0	0	0	0	0	0

The total cost is directly determined by simulations. After simulation the experimental data, table 3, obtained on the basis of the research plan presented in table 2, an empiric relation was obtained in what concerns the influence of the demand, holding cost and machining failure on the main cost total.

Table 3. The values of the independent variables and those obtained for the dependent variable

Exp	**Real value**							**CT**
	D	**H**	**Mf**	**DH**	**DMf**	**HMf**	**DHMf**	
1	90	1.2	1.2	108	108	1.44	129.60	37489.6
2	200	1.2	1.2	240	240	1.44	288.00	32229.9
3	90	3.5	1.2	315	108	4.2	378.00	51760.1
4	200	3.5	1.2	700	240	4.2	840.00	47665.5
5	90	1.2	4.8	108	432	5.76	518.40	36364.7
6	200	1.2	4.8	240	960	5.76	1152.00	31707.3
7	90	3.5	4.8	315	432	16.8	1512.00	49645.3
8	200	3.5	4.8	700	960	16.8	3360.00	46944.2
9	145	2.35	3	340.75	435	7.05	1022.25	41737
10	145	2.35	3	340.75	435	7.05	1022.25	41737
11	145	2.35	3	340.75	435	7.05	1022.25	41736
12	145	2.35	3	340.75	435	7.05	1022.25	41733.3

The relation obtained after working on the data in table 3 is:

$$\mathrm{CT} = 35102.66 - 53.91 \cdot \mathrm{D} + 6027.38 \cdot \mathrm{H} - 212.08 \cdot \mathrm{Mf} + 3.56\mathrm{DH} + 0.47\mathrm{DMf} - 197.72\mathrm{HMf} + 0.86\mathrm{DHMf}$$
(3)

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

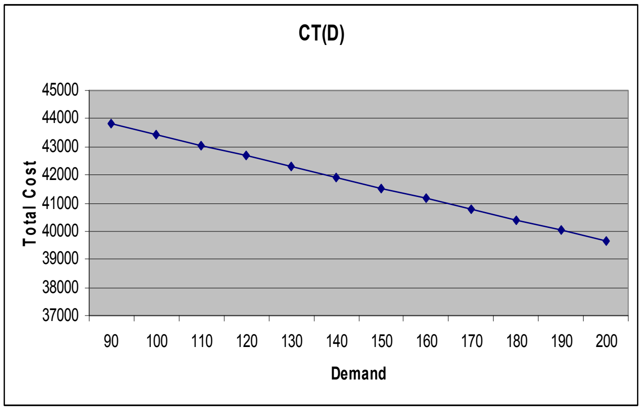

Fig. 2 The influence of the demand on the total cost

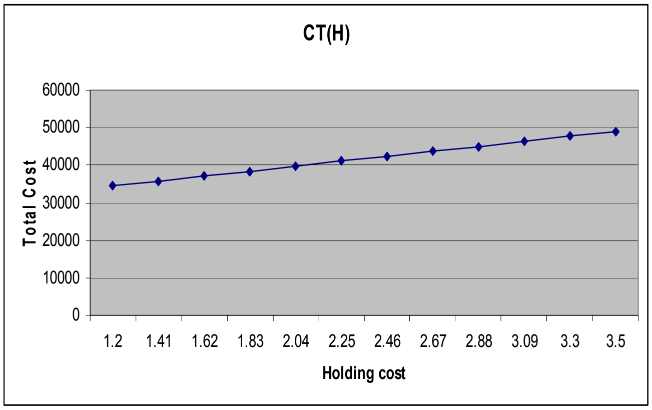

Fig. 3The influence of the holdin cost on the total cost

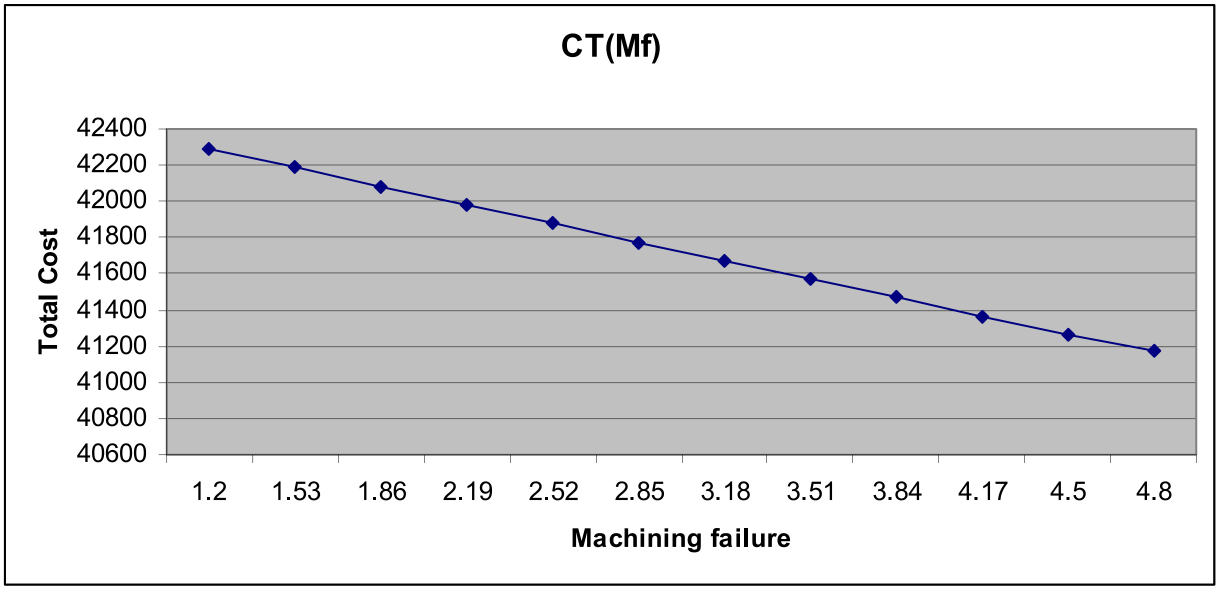

Fig. 4 The influence of the machining failure on the total cost

5. CONCLUSIONS

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

- by taking into account the slope of the dependence lines, $\alpha_{TC=F(C)} = 86^0 27'$, $\alpha_{TC=F(HC)} = 87^0 59'$ and $\alpha_{TC=F(Dmp)} = 86^0 57'$, the order of the influence of the input parameter on the output parameter is: the stock cost, the average period of equipment breakdowns and the demand;
- the function of the total cost was determined after having chosen a model of the production system controlled with the help of the Kanban method and after following an experiment plan containing twelve tests;
- in the case of the twelve tests of the plan, the values of the total cost obtained after the simulation correspond to the values of the total cost within a production system controlled with the help of the Kanban method;
- the value of the total cost 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;

- the function of the total cost 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 total cost, thus, making possible the optimizing of the system.

REFERENCES

[1] Law, A. M. and W. D., Kelton, 2000, *Simulation Modeling and Analysis, 3rd edition*, McGraw-Hill, New York.

[2] Spearman, Mark L. and Michael A. Zazanis, "Push andb Pull Production Systems: Issues and Comparisons," *Op. Res.*, Vol. 40(3), pp. 521-532, May-June 1992.

[3] Vollmann, T. E., W. L., Berry, and D. C., Whybark, 1997, *Manufacturing Planning and Control Systems*, 4th ed. New York: Irwin/McGraw-Hill.