ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume X (XX), 2011, NR1

COMPARISON BETWEEN TREE PULL CONTROL SYSTEMS: KANBAN CONWIP AND BASE STOCK

Ana Rotaru
University of Pitesti, ana_c_rotaru@yahoo.com

Keywords: Kanban, conwip, base stock, controlled, system, performance

Abstract: There exists controversy on the superiority of pull control systems. Kanban, Conwip and Base stock systems are focused on and analyzed in this paper. Using simulation experiments, i compare the performance of Kanban Conwip and Base stock for a multi-stage, multi-product manufacturing system. In this system the customer demand, holding cost rate and setup number have an exponential distribution between: 160 - 360 products/day, 12.5 - 35% and 2 - 8 setup numbers. The entire manufacturing line was simulated for 825 hours, which include 75 hours warm – up period. I show that the optimal control system is of Base stock type with respect to the reference work in process.

1. INTRODUCTION

The best known pull type production control system is the Kanban method [4], [1]. The Kanban method was originally used in Toyota production systems in the mid-seventies and is often considered to be closely associated with the Just in Time approach [6], [3]. In the Kanban control system, production authorization cards, called Kanban, are used to control and limit the release of parts into each production stage. The advantage of this method is that the number of parts in every stage is limited by the number of kanbans associated to that stage. Its disadvantage is that the system cannot respond quickly enough to the changes in the demand of customers.

The way a Kanban production system works is the following:

- when the customer's demand/demand to release a container from the stock of stage i arrives at the system, it demands the release of a container from the final stock/the inter-operational stock, Si, fig. 1;
- the container is released to the customer/next stage and the Kanban card attached, Ki, is removed and transferred upstream asking the release of a container of parts from the stage stock i-1, and, at the same time, authorizing the production of a new container in that stage.

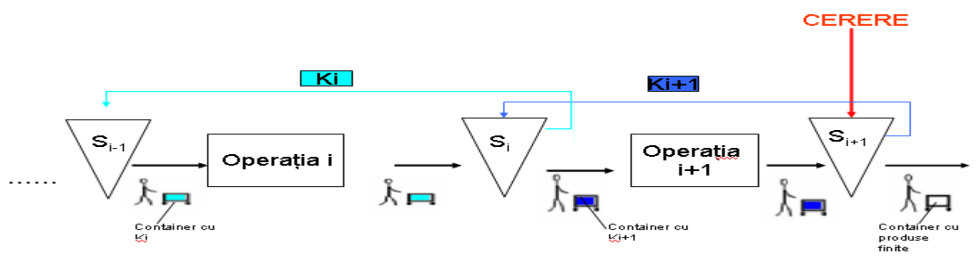


Fig. 1 Kanban method

This control method limits the inter-operational stock to a maximum fixed for each processing stage; the maximum is equal to the number of kanbans that exist in that stage. Therefore, it is essential to determine an optimal number of kanbans, so that the inter-operational stock is minimized, but does not affect the level of customer service [2].

In 1990, Spearman proposed a new push type control system, called CONWIP (Constant Work-In-Process), [5]. It uses a single card to control the entire production. The operating mode of a Conwip control system is the following:

- when the customer's demand arrives at the system, it demands the release of a container of parts from the final stock;

- the container is released to the customer and the Conwip card attached is removed and sent to the first stage of the production process;
- when the card arrives at the first stage, it authorizes the entry into the system of a new container with semi-finished products and authorizes the production a new container.

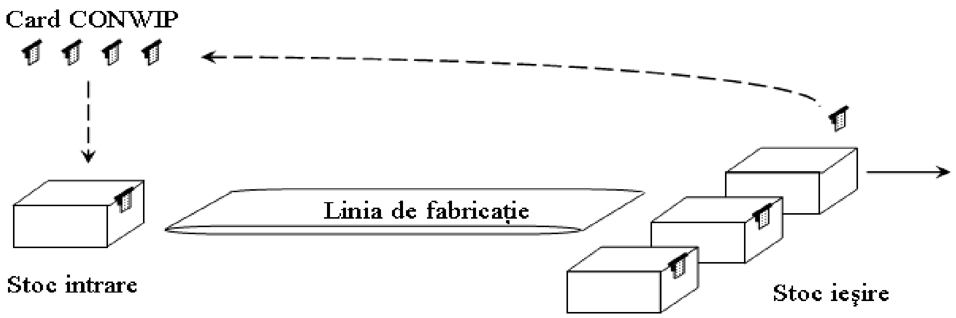


Fig. 2 Conwip methode

The Conwip method can be compared to a kanban made of a single card and can be considered a pull type production system, at the end of the process, and a push type production system, at the beginning of the process. The Conwip method represents the constant amount of products of a flow, for a single technological flow, regardless of the mixed series of products (production is adjusted; the amount of products on a flow does not vary).

The advantages of the CONWIP method are: you can work with different products in small production series, it allows solving irregular demands, it is less vulnerable to demand and process variables, it is less vulnerable to production breaks, it prevents bottlenecks, it is easy to implement and manage. The disadvantage of the CONWIP method is that the stock of the system cannot be controlled individually.

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 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

In the system there will circulate 4 conwip cards and 4 cards kanbans for product PA and 4 conwip cards and 4 cards kanbans for product PB.

The capacity of containers depends on the customer's demand and it's the same with base stock level.

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:

$$S_T = a \cdot D^b \cdot n_R{}^c$$

(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:

$$\lg S_T = \lg a + b \lg D + c \lg n_R$$

(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	The parameter		The real value	The normal value
Demand [EA]	D_{min}	160	-1	Number of setup	n_{Rmin}	2	-1
	D_{med}	240	0		n_{Rmed}	4	0
	D_{max}	360	1		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_{PK}	S_{PC}	S_{PBS}
	D	n_R			
1	160	2	240	239	117
2	360	2	540	538	359
3	160	8	241	240	107
4	360	8	540	540	308
5	240	4	360	360	187
6	240	4	361	361	188

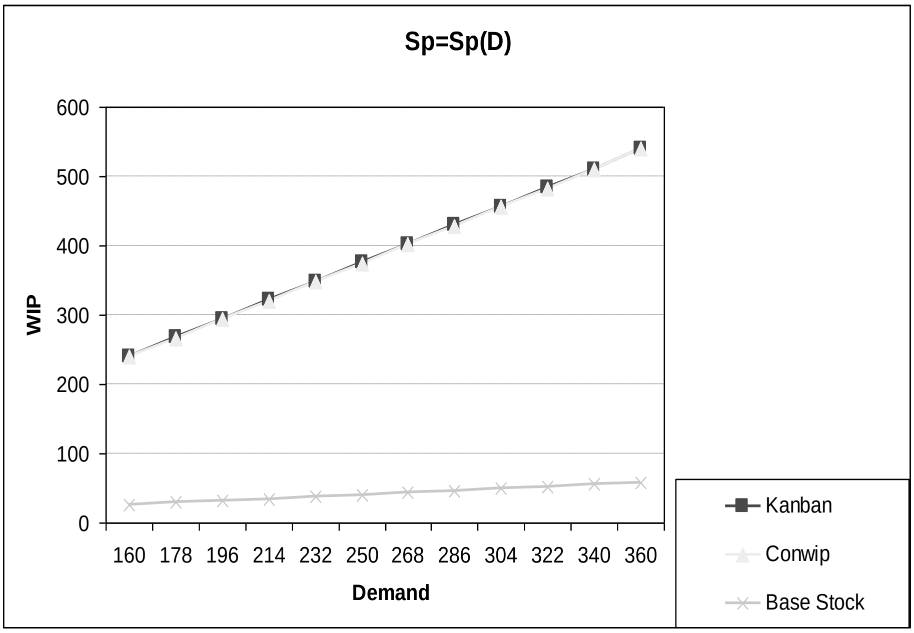
The relation obtained after working on the data in table 6 is:

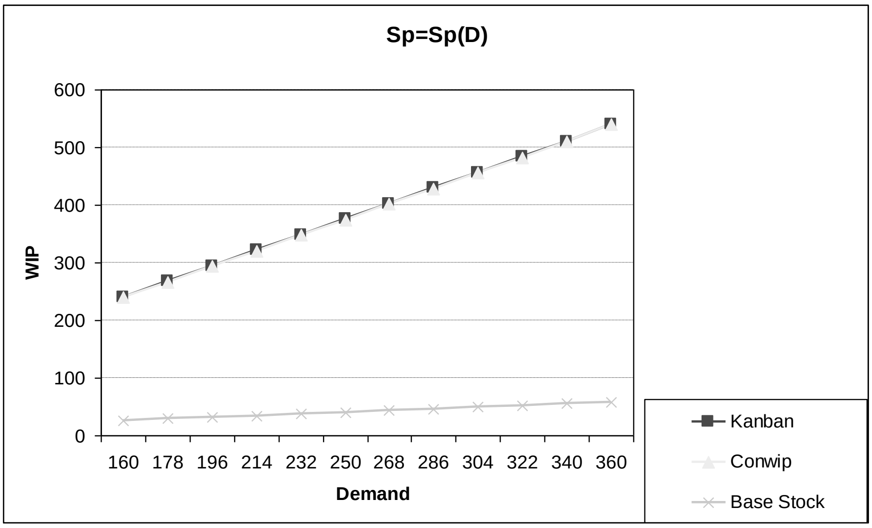
$$Sp_K = 10^{0.1817} \cdot D^{0.9974} \cdot n_R^{\ 0.0014}$$

$$Sp_C = 10^{0.1733} \cdot D^{1.0002} \cdot n_R^{\ 0.0028}$$

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

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.





5. CONCLUSIONS

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

- Kanban and Conwip methods lead to the same level of the inter-operational stock at the variation of the daily customer demand;
- the highest inter-operational stock is obtained with the Kanban and Conwip methods, regardless of the level of the daily customer demand; the lowest inter-operational stock is obtained when the Base Stock method is used;
- in the case of the Kanban and Conwip methods, the variation of the daily customer demand has the greatest influence on the inter-operational stock,

unlike in the case of the Base Stock method when it has the least influence;

- the variation of the number of adjustments made during a day does not have a significant influence on the inter-operational stock in the case of the Kanban and Conwip methods; in the case of the Base stock method an increase of the number of adjustments leads to a decrease of the inter-operational stock.

References

[1]. Berkley B.J., 1993, Simulation Tests of FCFS and SPT Sequencing in Kanban Systems, Decision Sciences 24

[2] Choi S. 1998. Material flow system integration in EOQ, ELSP, and Kanban Production. Columbia: University of Missouri-Columbia

[3] Groenvelt H., 1993. The just-in-time system. Handbooks in Operations Research and Management Science 4.

[4] Shigeo Shingo, Andrew P. Dillon (Translator), 1998. A Study of the Toyota Production System from an Industrial Engineering Viewpoint. Ed. Hardcover.

[5] Spearman, M. L., D. L. Woodruff, et al., 1990. CONWIP: a pull alternative to kanban. International Journal of Production Research 28.

[6] Zipkin P., 1989. A kanban-like production control system: analysis of simple models. Research Working Paper No. 89-1, Graduate School of Business, Columbia University, New York.