Comparing Kanban, CONWIP, and Hybrid Pull Systems

Comparación de Kanban, CONWIP y Sistemas Híbridos Pull

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ABSTRACT

This paper remarks the relevance of the simulations and the differences between the control production system CONWIP and Kanban in a production line. This paper focuses in different points of view of the control production system in goods production Industries which use Pull Systems as a support for a more thorough review of the article to be applied.

Key words: Work in process (WIP), Constant work in process (CONWIP), Pull production systems, Push production systems, JIT production planning system, Kanban.

RESUMEN

En este trabajo se señala la importancia de las simulaciones realizadas y las diferencias entre los sistemas de control de la producción CONWIP y Kanban en una línea de producción. Este documento se centra en los diferentes puntos de vista del sistema de control de producción en las industrias de bienes que utilizan los sistemas *Pull* como soporte para una revisión más a fondo para ser aplicada.

Palabras clave: El trabajo en proceso (WIP), El trabajo constante en el proceso (CONWIP), sistemas de producción *Pull*, Sistemas de producción Push, Sistema de planificación de la producción JIT, Kanban

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1. INTRODUCTION

Since the beginning of enterprises, companies have always searched for the highest benefits possible, precisely due to the fact that it is the main objective of every business: to profit. To achieve this, managers, researchers and experts have acknowledged a series of factors through which the final outcome will be maximized, some of which are highest incomes as possible can be, and/or lowering costs as much as their structural system allows them.

That's how ambitious projects held up to the idea that constantly producing and storing goods in order not to waste incoming demand would increase their sales, and hence, their final incomes. This method is called: A Push System; a system in which the manufacturing process "pushes" the products towards the client, until the moment in which the client buys it.

However, more recent studies have shown that this method may sometimes incur in constant production costs while sales remain variable and dependent to demand behavior and have developed a new philosophy which focuses not mainly in selling the most, but basically in avoiding extra costs like for instance, keeping excess inventories of work in process, which increase the probability of having the goods damage, be lost, or decaying time before it reaches the final client, making a forecasted sell, to be inflated and to actually earn less than was expected. These are called Pull Systems: A system in which the production is ran up to a certain point, and won't continue until the demand "pulls" the goods, having the process start again to replace the now missing products.

Pull Systems are strongly associated with Low-or-None Inventory Philosophies such as Lean Manufacturing, Just-In-Time (JIT), among others, which at the same time, may be accomplished with supporting control systems like Kanban, CONWIP (Constant Work In Process), Base-Stock, and so on [1].

Kanban, meaning card or marker in Japanese, is a widely known and recognized type of pull system. A Kanban pull system is sometimes referred to as the Toyota Production System (just-in-time manufacturing using a Kanban pull system). A Kanban pull system uses card sets to tightly control work-in progress (WIP) between each pair of workstations. Total system WIP is limited to the summation of the number of cards in each card set. Basically, a certain amount of cards is assigned to each process, and every process will only release these cards when the following processes takes the current process' production away, triggering a signal for the previous process to replace what has been sent. It is a very practical system when demand is highly fluctuating.

CONWIP pull system, on the other hand, uses a single global set of cards to control total WIP anywhere in the system. Material enters a CONWIP system only when demand occurs, and the raw Material receives a card authorizing entrance; the same card authorizes the material to move through the system and complete Production. When the final product leaves the system, the card is released, allowing new material to enter the system as new demand occurs [2]. Some authors believe that CONWIP efficiency is not inherently superior to “push” system efficiency. Instead, the release mechanism used for the “push” system has a significant impact on which system will perform better. Utilization levels and processing time variability also affect the relative performances [3].

2. REVIEW AND ANALYSIS

In the article to be analyzed, “Comparing Kanban, CONWIP, and Hybrid Pull Systems through Simulation Studies”, the authors, Yue Huang, Huang-da Wan, Glenn Kuriger and F. Frank Chen, take the case of one of a real life company’s assembly line, in which beverage dispensing machines are produced, in order to compare both Kanban and CONWIP control system’s performance in different scenarios, in order to propose and/or evaluate whether a hybrid Kanban-CONWIP system alternative could enhance their strong points and minimize their flaws, hence resulting in a more robust, better performance control system.

The article mentions that even though the comparison of the methods are done through simulation of a real process (Through Rockwell Automation Arena Software), different hypothetical scenarios of said process are considered (For example, varying the location of bottleneck process in the assembly line) in order to increase the certainty of the given results.

The authors describe the modeling assumptions, which are in fact, general assumptions applied when dealing with CONWIP and Kanban Systems, in order to make quicker/easier translations from the model to its interpretation, as for instance, each card (whether it is Kanban or CONWIP) represents one and only one part, thanks to which the number of cards in the line will help interpret immediately the number of parts in the system. Next, they detail each control system’s Simulation Logic, having a main difference between them as Kanban assigns a certain cards number for every single station in the process, while CONWIP is, in a sense, a more open philosophy, in which the objective is to keep the Work In Process constant throughout the whole line, independently to how many cards are assigned to which stages (Usually, the last station generates a certain number of cards and sends it to the first station to regulate the new production orders only after products exit the system).

Three main variables were used to compare the systems’ performances: Throughput Rate (The amount of units produced during the simulation time), Average Work in Process and Number of Cards. A system’s evaluation will result more attractive when it generates the highest Throughput rate possible, with the lowest WIP possible, and using the least amount of cards.

When the simulations were ran, the results obtained indicated that in both systems, increasing the number of cards doesn’t necessarily increases system throughput, as when saturated (this saturation is strongly related to the system's bottleneck, which is supported by the theory of constraints), increasing number of cards will only increase WIP, whilst remaining throughput relatively constant. Also that for the real case, Kanban system appeared to have better results in terms of WIP than CONWIP when equal throughput conditions are met; however for cases in which critical WIP (Again, theory of constraints) is lower than the number of stations in the line, CONWIP is recommended.

Having these results evaluated from the different scenarios' simulation results, the authors proceeded to try to determine a hybrid combination that could obtain the best qualities of each system, and/or reducing their flaws; or in other words, they attempted to empower them together. They offered three main hybrids, which will be quoted next:

- Hybrid I: The bottleneck is managed by Kanban and other stations by CONWIP.
- Hybrid II: The first station through the bottleneck is managed by CONWIP and the stations after the bottleneck are managed by a separate CONWIP.
- Hybrid III: The first station through the bottleneck is managed by Kanban and the stations after the bottleneck are managed by CONWIP.*

Given the three possible scenarios evaluated (Bottleneck at the front, Bottleneck in the middle, and Bottleneck at the end) and the three new proposed hybrid combinations, there are nine more scenarios to evaluate, four of which were discarded by the authors due to similarities with full Kanban or full CONWIP systems, as shown by the article's Table1.

Table 1. Various designs of pull system investgated in this research

System Design	BottLeneck at the Beginning	BottLeneck in the MiddLe	BottLeneck at the End
Pure Kanban	X	X	X
Pure CONWIP	X	X	X
Hybrid Type I	X	X	X
Hybrid Type II	Equivalent to CONWIP. not repeated	X	Equivalent to CONWIP. not repeated
Hybrid Type III	Equivalent to CONWIP. not repeated	X	Equivalent to Kanban. not repeated

Source: Developed by the authors

* Comparing Kanban, CONWIP, and Hybrid Pull Systems through Simulation Studies; Huang, Yue WAN, Hung-da. Kuriger, Glenn. Chen, Frank. Center for Advanced Manufacturing and Lean Systems. San Antonio, Texas, United States of America.

After running the proposed hybrid systems, the authors got the results for every combination in terms of Throughput, WIP and cards. They also did a Summary Table comparing which combinations had better performances than others in terms of Throughput and WIP as shown in Table 2, brought next.

Table 2. Summary of comparison among system

BottLeneck Location	Highest Throughput	Lowest WIP Level
Front	Hybrid I, CONWIP (Hybrid II)	Kaban, Hybrid I
Middle	CONWIP, Hybrid I, Hybrid II	Kanban, Hybrid II, Hybrid III
End	CONWIP (Hybrid II)	Kanban (Hybrid III) slightly better

Source: Developed by the authors

From it, the authors concluded that none of the arrangements appeared to be significantly dominant versus the others, but seems like the Hybrid II system had a very balanced performance, meaning that doesn't force the system to sacrifice Throughput for Work in Process nor vice-versa, but is instead, a generally good option for when the variability of the system (referring as to bottleneck appearances in the process) is high or unknown.

Among the strengths of the article, may be found, for instance, the fact that it gives a real life applicability that supports theoretical advances in research, dealing with the theme of hybrid systems made out from combining pull control systems such as "An evolutionary approach to select a pull systemamong Kanban, Conwip and Hybrid", written by E. Guary, H. Pierreval and P. Kleijnen; in which the authors proposed also a hybrid between CONWIP and Kanban, and through simulation models found out that a CONWIP integral control systems may result in enhanced performance if combined with few local Kanban control systems. The present article may help the comparison of results stated before, yet on this occasion being applied to a given reality.

It is also to be found interesting one of the author's conclusions, in which they discovered that for a regular production line, arranging a CONWIP control system before the bottleneck, and a Kanban system afterwards, could result more profitable to be implemented, depending on the bottleneck's position, which is certainly useful information for companies that stick together with a full pull system, whether they currently manage CONWIP or Kanban. Nonetheless, it is important to point out that the company should still analyze the cost impact of such implementation, calculating system structure change, learning curves, an so on, given that the authors only consider Throughput, WIP and card number variables.

The authors could be criticized after having ran the first set of simulations without considering machine breakdowns while including it on the second set of runs. This action not only takes away their results' consistency, as if whether the results could be directly compared or not, but also denotes lack of research planning, giving the readers the idea that machine breakdowns weren't initially considered, yet added on the last moment without taking into account the already gotten results.

As a feedback, could be added that the researched area of knowledge could have been enriched, or could in fact, be improved if the authors, or future authors include among the evaluated factors, bottleneck variation according to real variation due to processing time standard deviations instead of theoretically bottleneck relocation; consideration of variable's randomness viewed from a stochastical point of view; or even consider flow lines consistent of few parallel production lines and some incoming branches from previous subassemblies, since the authors didn't focus much on subassemblies' work in process, which could end up affecting the entire production line.

This last consideration, was, for instance, included in Yaghoub, Khojasteh and Ghamari's model, published in their paper "A performance comparison between Kanban and CONWIP controlled assembly systems" in which the researchers did include the implementation of control systems for a Production Line formed by a set of sub-assembly processes. Even though Yaghoub, Khojasteh and Ghamari didn't work with a combination of a Kanban-CONWIP hybrid, they did conclude that for sub-assembly lines designating shared CONWIP cards to the start of the branching processes may outperform a regular CONWIP in which the cards are distributed evenly; in the case of a Kanban control system, they found that a proper distribution of Kanban cards throughout the system may result in a better performance than CONWIP systems. Both conclusions may be thought of when planning to breed them together, as optimizing each individually might affect the final result after merging them [4,5].

3. CONCLUSIONS

There are many studies in the literature for comparing production control systems to determine the superior: Kanban and CONWIP, however, as [6] announced, the comparison results between Kanban and CONWIP in the literature seem to be contradictory.

Pull systems and more specifically, Kanban and CONWIP hybrid control systems are debated themes in which deeper research is required; as for what research has shown, there is still not found which method definitely outperforms the other, or which is the proper combination of them together.

Many papers have not taken into account that very different factors are to be evaluated, other than just throughput rates and work in process, when deciding on which system to implement and how. Some of these additional factors may include the cost of implementation and time to recover the investment of said system, the variety of products the company works with and their specific production processes, variables like job delays, demand behavior, plants layout and storage capabilities, production flexibility, among others.

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