THE PULL CONTROL SYSTEMS. A SYSTEM DYNAMICS PERSPECTIVE.

Authors
Adolfo CRESPO MARQUEZ
Rafael RUIZ USANO
José MANUEL FRAMIÑAN TORRES
Ricardo ZUBIRIA DE CASTRO

Dpto.Organización Industrial y Gestión de Empresas
Escuela Superior de Ingenieros
Universidad de Sevilla
Avda. Reina Mercedes s/n. 41012-Sevilla (SPAIN)
Fax: +34-5-4556883
E-Mail:crespo@cica.es

ABSTRACT

The goal of this article is to build a System Dynamics model of a production line under long-pull control systems. These models are presently being completely tested under different scenarios. The long-pull control systems appear to offer a higher performance than KANBAN based systems in those environments where perfects material flow cannot be assured.

1. Introduction.

Selecting a suitable pull control system becomes an interesting concern for those processes in which the complexity can greatly influence the behavior and overall system performance (Ruiz-Usano, Crespo & Framiñán, 95).

The kind of "pull effect" is a consequence of the manufacturing organization and describes the system behavior. For each particular manufacturing and business environment, the choice of a proper behavior , i.e. how system reacts facing exogenous uncertainty, permits the achievement of flexibility, lightness, lean manufacturing, and therefore, increases the system performance.

This paper studies the behavior of a production system controlled by different pull schemes, KANBAN/pull and CONWIP/long- pull systems.

2. The Pull Systems nowadays.

At present, pull systems are widely used for local production control and they are generally integrated within the global plant production system. It is common, for instance, to find these pull structures forming part of a higher MRP company logic structure, with a lower indenture level. This type of configuration is frequently named hybrid schemes, which generally require, push(orders) and pull(cards) signals in order to release the jobs (YAMAHA Synchro MRP) (Hall, 1986).

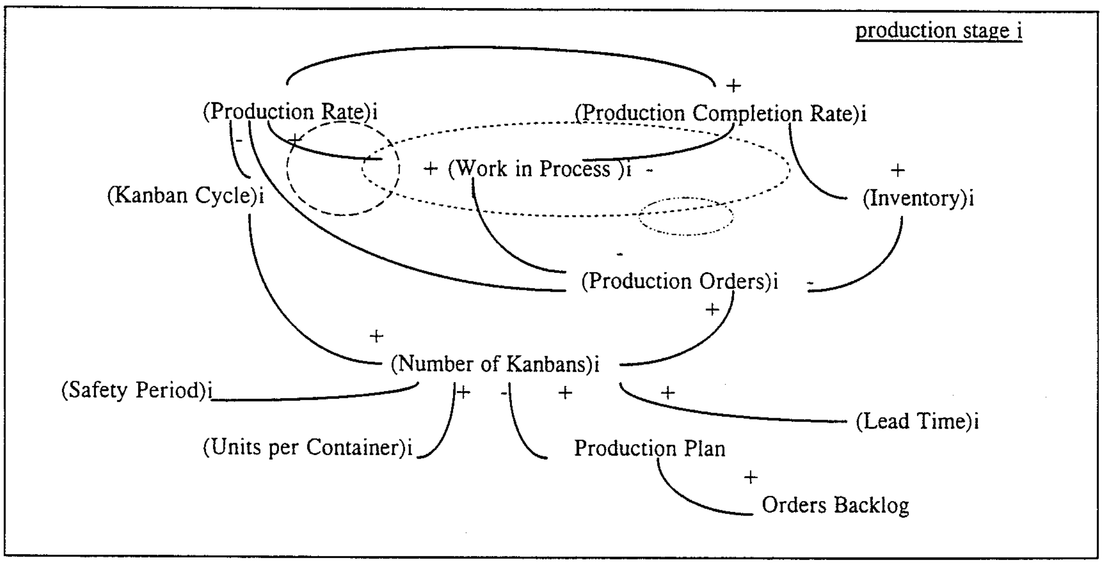
KANBAN and CONWIP are cards driven pull production systems. The use of cards (production / withdrawal) in the production/assembly line generates an effect of pulling the materials flow from the last stages backwards until it reaches the initial ones.

CONWIP (Spearman, Hopp & Woodruff, 1990) is an approach very similar to KANBAN (Monden, 1983), the main differences between both systems are:

- CONWIP utilizes only one type of card to control all the processes (long-pull system). KANBAN uses a different card per process.
- The number of CONWIP cards depends on system capacity features, not on the production plan for a given planning period, as KANBAN does.
- CONWIP releases a job only when the following conditions simultaneously occur: there are free production cards and a positive orders backlog exist. KANBAN only requires the existence of production orders (cards) and inventory in the previous stage.

3. The System Dynamics Models.

3.1. KANBAN Model Casual Diagram.



This diagram shows interaction among variables of a production stage (the global model includes three production stages), where three feedback loops can be appreciated. The influence of the production plan in the stage production rate, through the the variable "Number of Kanbans", is also described.

$$Nki = (PP/Uci)(Lti + Cki)(1+SSi)$$

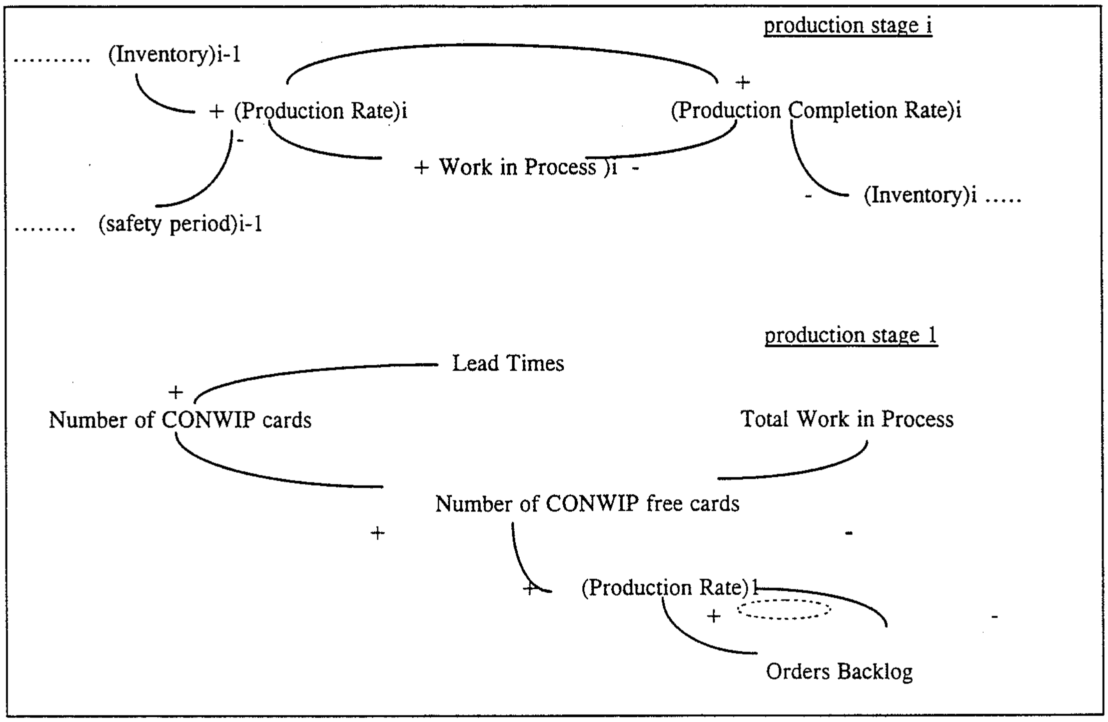
Where:

Nki:	Number of Kanbans in stage i
PP:	Production Plan
Uci:	Unit per Container in stage i
Lti:	Lead time of the stage i
Cki:	Kanban Cycle of stage i
Ssi:	Safety Period for inventory of finished parts in the stage i

The variable "Number of Kanbans" is modified according to the planning period considered in the plant. When a new planning period starts, the variable

“Production Plan” is updated considering the available information about the market demand.

3.2. CONWIP Model Casual Diagram.



This diagram describes how the number of CONWIP cards only influences the first stage production rate, and this rate will push the rest of the subsequent production stages.

In case of CONWIP systems, it is demonstrated that the suitable number of cards to use does not depend on the production plan, but on lead times. For instance, it has been suggested (Ruiz-Usano, Framiñán & Crespo, 1995):

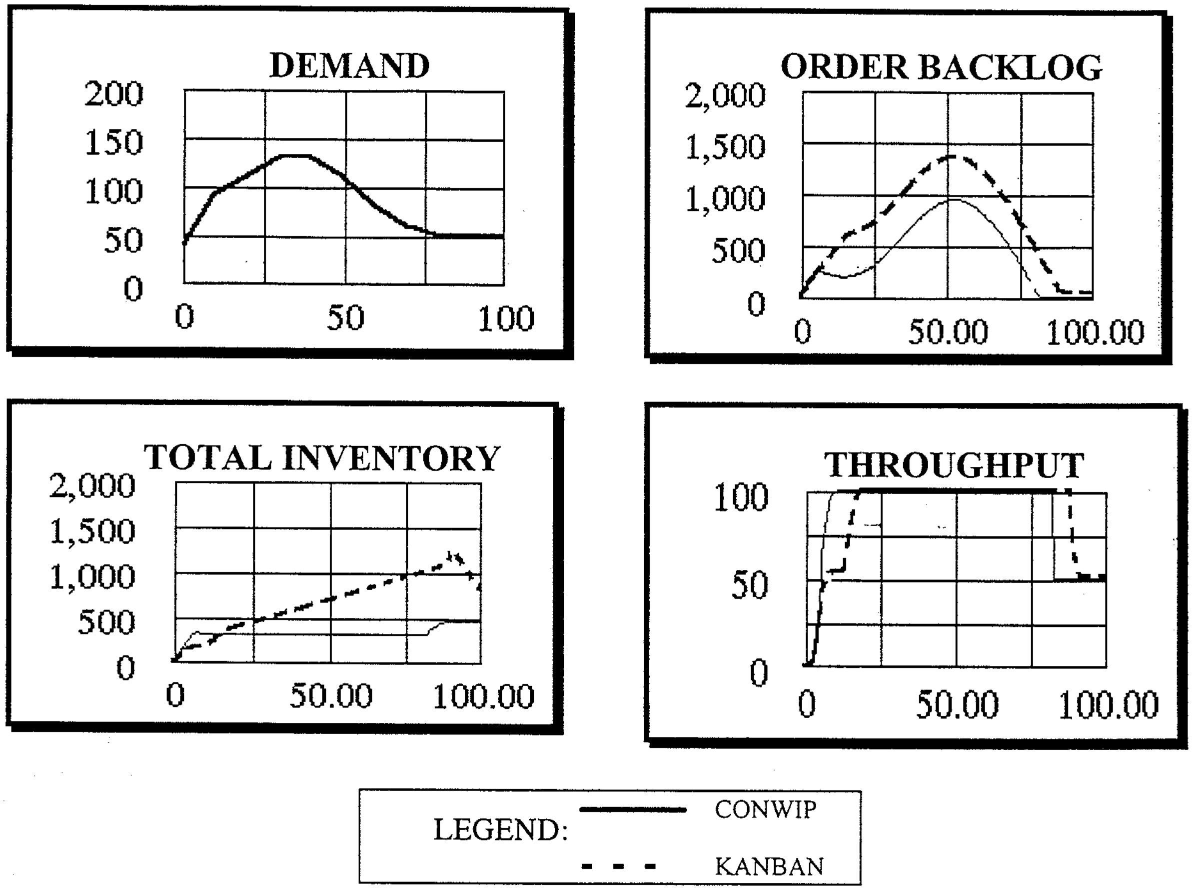
$$\text{Nunber of CONWIP Cards} = \left(\sum_i Lti\right)/Lt_{bn}$$

Where,

Lti : Lead time of stage i
Lt_{bn} : Lead time of the bottleneck stage

4. Experiments.

The experiment presented in this paper contains several undesirables situations which may appear in a manufacturing plant, like great demand variations, bottlenecks or eventual demand higher than plant capacity. The topology of the line is simple, consists of three production stages in line (flow shop), which have an inventory of finished parts between each stage and the subsequent one. Orders backlog and materials flow are exactly equal modeled for both systems KANBAN and CONWIP. A planning period of one week is considered for the KANBAN system.



5. Conclusions.

Simulation results demonstrate that CONWIP reacts earlier to great demand variations, achieves lowers limits of total inventory in the system, and sustains similar values for the throughput. Therefore, the average lead time for the whole process, and the kind of selected scenarios, reaches better values with the utilization of CONWIP systems instead of KANBAN.

6. References.

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