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Reduced Inventories, High Reliability and Short Throughput Times by Using CONWIP Production Planning System

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***Abstract*—**CONWIP (constant work-in-process) as a pull production system have been widely studied by researchers to date. The CONWIP pull production system is an alternative to pure push and pure pull production systems. It lowers and controls inventory levels which make the throughput better, reduces production lead time, delivery reliability and utilization of work. In this article a CONWIP pull production system was simulated. It was simulated push and pull planning system. To compare these systems via a production planning system (PPS) game were adjusted parameters of each production planning system. The main target was to reduce the total WIP and achieve throughput and delivery reliability to minimum values. Data was recorded and evaluated. A future state was made for real production of plastic components and the setup of the two indicators with CONWIP pull production system which can greatly help the company to be more competitive on the market.

***Keywords*—**CONWIP, constant work in process, delivery reliability, hybrid production planning, PPS.

I. Introduction

THE every day problem of almost every manufacturing enterprise is planning and controlling of manufacturing process in the company. That is the important process that consists of several sub-processes that are in tune and work to complement with each other, and it is necessary to plan and control them. When something changes in production, it is necessary that all production processes must accommodate the change.

Otherwise, 4 main problems occur, namely:

1. Customer's failure to deliver the product at the right time
2. Incomplete removal of resources
3. Large inventory in stock
4. Interim extension of time

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All these problems in production can be avoided by action called as PPS (Planning and production control systems), which are solved in this article.

II. Problem Statement

Assessing the actual situation in the company shows low reliability and small throughput in production. As long as these problems are not solved, resources have to be increased, the usage of potential falls down, this means redundancies, low delivery reliability will lead to the lost of customers and longer throughput time will make the production more expensive. It means dramatically ends, but very trustworthy if the production will not work effectively and responsibly and will not give a great focus on production planning.

III. Goal and Application

Goal of this article is to present the reader the planning and the control systems and the production processes in the easiest way. To describe a hybrid push-pull CONWIP system, his comparison with other planning systems on the example of planning and present implementation of CONWIP system to medium sized manufacturing enterprise engaged in the manufacture of products from thermosets.

IV. Production Planning and Control Systems (PPC)

Production planning without production control is like a bank without a bank manager, planning initiates action while control is an adjusting process, providing corrective measures for a planned development. Production control regulates and stimulates the orderly materials in the manufacturing process from the beginning to the end. [3]

Production planning systems (PPS) are a specialized form of decision support system (DSS). There are available over 100 commercial systems. The purpose of a PPS is to take manufacturing requirements, match them with a model of the factory or the supply chain and, using various algorithms and technology, and craft a work sequence either automatically or with manual intervention. [7]

Production planning may be defined as the technique of foreseeing every step in a long series of separate operations, each step to be taken at the right time and at the right place and each operation to be performed in maximum efficiency. It helps entrepreneur to work out the quantity of material manpower, machine and money requires for producing predetermined level of output in a given period of time. [8]

PPS process consists of [8]:

1. Routing
2. Scheduling
3. Loading

A. Routing

Under this, the operations, their path and sequence are established. To perform these operations, the proper class of machines and personnel required are also worked out. The main goal of routing is to determine the best and the cheapest sequence of operations and to ensure that this sequence is strictly followed. In small enterprises, this job is usually done by entrepreneur himself in a rather ad-hoc manner. Routing procedure involves following different activities. [8]

1. An analysis of the article to determine what to make and what to buy.
2. To determine the quality and type of material
3. Determining the manufacturing operations and their sequence.
4. A determination of lot sizes
5. Determination of scrap factors
6. An analysis of cost of the article
7. Organization of production control forms

B. Scheduling

It means working out of time that should be required to perform each operation and also the time necessary to perform the entire series as routed, making allowances for all factors concerned. It mainly concerns with time element and priorities of a job. [7]

C. Loading

The next step is the execution of the schedule plan as per the route chalked out, it includes the assignment of the work to the operators at their machines or work places. So loading determines who will do the work as routing determines where and scheduling determines when it shall be done. Gantt Charts are most commonly used in small industries in order to determine the existing load and also to foresee how fast a job can be done. The usefulness of their technique lies in the fact that they compare what has been done and what ought to have been done.

Most of a small scale enterprise fail due to non-adherence to delivery schedules, therefore they can be successful if they have ability to meet delivery order in time which with no doubt depends upon production of quality goods in right time. It makes all the more important for entrepreneur to judge ahead of time what should be done, where and when thus to leave nothing to chance once the work has begun.[7]

D. PPS Methods

For each production, it is necessary to know, which kind of method of the planning system is the right one. The PPS methods are pushing (MRP), pulling (KANBAN) or hybrid (CONWIP).

1. Push System

The material is supplied to the individual workplaces according to a predetermined schedule, respectively plan, regardless of its actual need instant, i.e. material is printed, an effort to exploit the maximum production capacity for work so may create unnecessary and accumulate reserves. Such planning is MRP (I, II) system. [3] For better understanding is shown a schema from push system in Fig. 1.

Fig. 1 Way of how FUSH system works

2. Pull System

The material is supplied to individual workplaces based on the instant need, the material is pulled, it is processed immediately, it is not stored, and therefore does not supply (such as KANBAN system). [3] For better understanding is shown a schema from push system in Fig. 2.

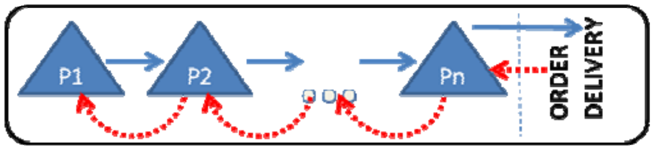

Fig. 2 Way of how PULL system works

3. Hybrid System

The system uses the principle of pull and push to eliminate bottlenecks. Under "bottleneck" refers the weakest link of company. This area which is in the situation of any particular load will cause difficulties, and without removing it is impossible to grow. It may take the form of a concrete example of the production machine, improper organization of the business, inappropriate supply chain, etc... (for example CONWIP system). [1] For better understanding is shown a schema from push system in Fig. 3.

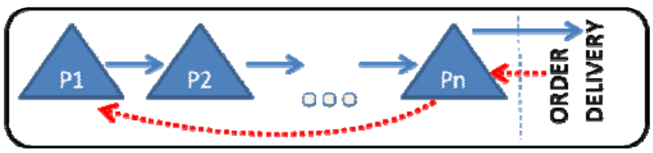

Fig. 3 Way of how HYBRIDE system works

V. CONWIP

CONWIP (Constant Work In Process) combines the advantages of KANBAN (shorter lead times and reduced inventory), but is applicable to a wider range of production systems. CONWIP is a generalization of the principle of KANBAN. The card is inserted into the container at the entrance to the production system and released at the output of the production system. [4]

While KANBAN system checked each procedural step separately, CONWIP defined using signals / card maximum inventory level in the so-called "Loop". Signal flows at the beginning and gives a signal to the pressure for further production when previous orders are fulfill. This “Loop” is also called a “RoP” (Reorder point). In the KANBAN system, this is not possible, because the KANBAN system checks each operation separately. In some cases, particularly in complex manufacturing systems where is large number of processes shared for many different types of production, CONWIP system leads production to lower total stock than the KANBAN system. [4]

CONWIP system uses a single global system for inventory control cards anywhere in the flow. Material enters the CONWIP system only when the requirement is assigned by signal card. The same card authorizes the movement of stocks across the stream to the final destination. When the final product leaves the process, the card is returned back to the beginning of the loop and the outlet stream to another material.

Under the term "raw material" we understand a work in progress from the previous processes, contracts, orders, information, that any entity to which it is happening controlled transformation process. An important aspect of CONWIP system is that the control does not happen on every separate process steps. This is a control process for simplified management and easier to control as a whole unit, as compared to competitive systems MRP, ERP, or also KANBAN system. Moreover, thanks to defined number of cards in the system is clearly defined "Maximum stock level". System, how CONWIP works, is shown in Fig. 4. [4]

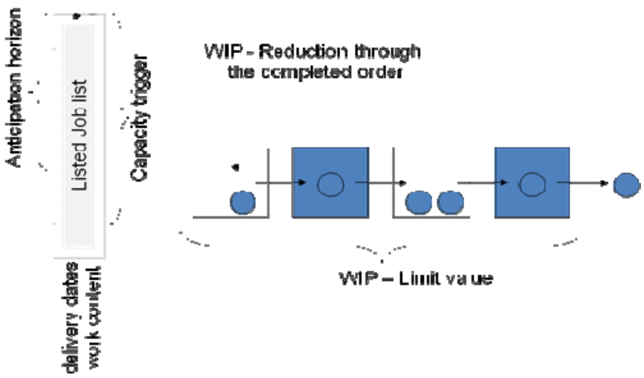

Fig. 4 Way of how CONWIP works [4]

VI. Improving of Reliability and Throughput with CONWIP

Improving the reliability and throughput using CONWIP planning system lies in the fact that manufacturing orders are pushed to the production processes , but only to the extent that the production volume reached its maximum. After the release of the finished order, there can be pushed another commands in to the production. New order can be pushed to the production not only when there is enough space, but also after a signal, or after crossing a minimal state level of the stock. We simulate the 3 methods of production planning: MRP, KANBAN and CONWIP. Simulated production line consisted of 6 stations: material preparation, coating, painting, assembly, finishing station and finished goods stock. In the simulated game with MRP production planning, we got the results shown in Table I.

TABLE I
First MRP Result Table

mrp_1	Stock	Utilization	Time/Piece
Stock	53,9	47%	32,5
WIP	42,8		
Finished goods	11,0		
5_Finishing	14,3	63%	7,4
4_Assembly	6,9	29%	4,7
3_Paintwork	6,7	43%	6,3
2_Surface preparing	10,8	55%	7,4
1_Cutting	4,1	46%	6,7
Delivery reliability		81%	

At MRP planning we are looking at three parameters and they are the transition plan, the batch size and the security status of stock. In our case, we did not have the parameters of the transition plan and safety stock. It was set up just a batch size of 100pcs and length of play / production which was 12 minutes. As the table shows out after manufacture, our state of stock was at 53.9 pcs, utilization 47% and time spent on one product was 32.5 seconds. The worst record in the table is order delivery reliability to customer. Reliability remained only on 81% of all orders. To reduce inventory and increase reliability, it is need to change parameters in planning with MRP. We have changed the batch size in half. Measured data from the second round are reported in Table II.

TABLE II
Second MRP Result Table

mrp_2	Stock	Utilization	Time/Piece
Stock	25,3	45%	31,0
WIP	19,7		
Finished goods	5,5		
5_Endfertigung	5,1	44%	6,2
4_Baugruppenfert.	3,7	36%	4,8
3_Lackierung	4,7	51%	7,1
2_ Surface preparing	4,0	42%	5,9
1_Cutting	2,3	48%	7,0
Delivery reliability		100%	

As in Table II spit out, after manufacture our state of stock stood at 25.3 pcs, the utilization is 45% and time spent on one product is 31 seconds. Visible change was observed in the data inventories and reliability of order fulfillment. The stock is on 25.3 pcs and reliability at 100%. This record has shown us what can do a batch size variation in production. The pull system is based on production KANBAN cards and also they are the main parameters of this system. Number of KANBAN containers and number of products per container (batch size). The results of the pull planning system are shown in Table III.

As in Table III spit out, after manufacture our stock stood at 25.2 pcs, utilization at 52% and time spent on one product was 36.4 seconds. Compared to observed data of inventory with push system, it is roughly unchanged, but unlike the delivery reliability has deteriorated on 81%. Deployment of KANBAN containers was according to the balance and not by orders.

TABLE III
FIRST KANBAN RESULT TABLE

kanban_1	Stock	Utilization	Time/Piece
Stock	25,2	52%	36,4
WIP	18,4		
Finished goods	6,9		
5_Finishing	5,3	46%	6,6
4_Assembly	4,4	36%	5,1
3_Paintwork	2,3	70%	9,6
2_Surface preparing	4,4	58%	8,5
1_Cutting	2,0	50%	6,6
Delivery reliability		81%	

KANBAN is a pull system that means the customer orders are already known in advance and are not produced on store as it is in push system but they are made to order. After harmonization of orders, there has been determining the required number of KANBAN containers for the products and a next production was simulated, but with new parameters. The results are shown in Table IV. From the data, it spits out that the stock fell from 25.2 pcs to 19.7 pcs. Utilization is 45% and the time needed to produce one product is 33.7 seconds.

TABLE IV
SECOND KANBAN RESULT TABLE

kanban_2	Stock	Utilization	Time/Piece
Stock	19,7	45%	33,7
WIP	10,6		
Finished goods	9,1		
5_Finishing	3,6	47%	6,9
4_Assembly	1,4	40%	5,9
3_Paintwork	1,7	54%	8,1
2_Surface preparing	1,9	49%	7,4
1_Cutting	2,0	35%	5,4
Delivery reliability		100%	

As a final planning system we used CONWIP. Which settings also consists of two basic parameters: WIP Limit: stock per line and Anticipation horizon: the period per line. In our case, we did not take into account the anticipation horizon, but only the WIP limit. Production results are shown in Table V. From the data, it spits out that the stock is 15.3 pcs, utilization is 47% and the time required to produce one product is 33 seconds. We must not forget also on ability to fulfill orders the in this case it is at 100% success rate. Of all the rounds of production in which we simulate planning systems, has nothing changed in the processes, only the method of planning.

TABLE V
CONWIP RESULT TABLE

conwip_1	Stock	Utilization	Time/Piece
Stock	15,3	47%	33,0
WIP	7,8		
Finished goods	7,6		
5_Finishing	2,0	48%	6,9
4_Assembly	1,4	38%	5,2
3_Paintwork	1,3	47%	6,6
2_Surface preparing	1,9	52%	7,5
1_Cutting	1,3	49%	6,8
Delivery reliability		100%	

VII. FUTURE USING IN REAL PRODUCTION

Future using of CONWIP planning system in medium sized companies can be very helpful to plan and control their production with staying at low stock values, more efficient work, and optimization of process and with low costs. Give the customer best quality for the best price. In the future is preparing a concrete example of using MRP push system with a hybrid CONWIP system in a medium-sized company which is engaged in the processing of plastics. Using push system to produce in to the buffer and using CONWIP system to produce from buffer via assembly and packing process to final product store. The whole MRP and CONWIP system is shown in Fig. 5.

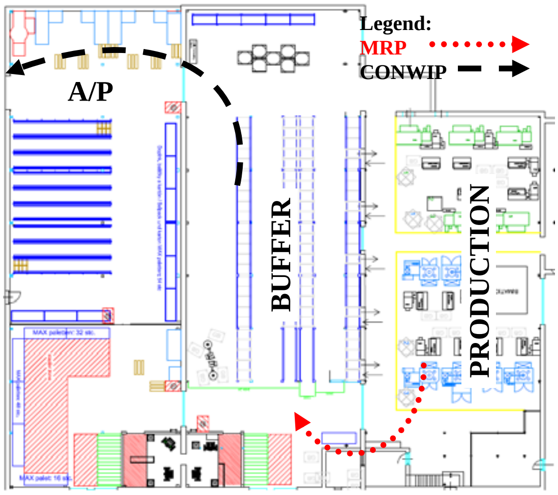

Fig. 5 MRP and CONWIP system in example company, A/P – Assembly and Packing

VIII. Conclusion

Medium size industries have a challenge to manufacture products at economical prices. They need to embrace management principles surrounding production processes, and planning systems which are effective for the products manufactured by them. An upfront planning and study of the critical factors of the manufacturing processes help them to identify areas of risk so that necessary planning and control procedures are put in place. This will eventually help the medium size entrepreneur to eliminate the wastages and increase the production, productivity and profits. Manufacturing with suitable production planning and control systems can clearly change the way of progress. Minimize inventory in stock, achieve better throughput, fulfill order in specified period and optimized utilization.

References

[1] Ajorlou, S.; Shams, I. & Aryanezhad, M. G. (2011). Optimization of a Multiproduct Conwip-based Manufacturing System using Artificial Bee Colony Approach. In: *Proceedings of the International MultiConference of Engineers and Computer Scientists 2011* Vol II, IMECS 2011, March 16-18,2011, Hong Kong. ISSN 2078-0966, ISBN 978-988-19251-2-1

[2] Gregor, M. & Košturiak, J. (1994). *Just-in-Time : Production philosophy for good management*. Bratislava : Vydavateľstvo Elita, 1994. ISBN 80-85323-64-8, 299 s.

[3] http://www.ipaslovakia.sk, (2006). Chromjaková Felicita. Push and pull system of production control. *Accessed on: 2012-6-15*

[4] Jodlbauer, H. (2008). *Production optimization: Value-creating and customer-oriented planning and control*. Springer; Wien. ISBN 978-3-211-72752-2

[5] Koblasa, F. & Manlig, F. (2009). Job shop scheduling problem with multi-shift work system. *ACC Journal*, 1/2009, s. 15-23, TU v Liberci, ISSN 1803-9782

[6] Manlig, F. & Gottwaldová, A. (2006). The experience of simulation games in teaching. In: *Strojírenská technologie*. č.4, r. XI, 2006. s. 28..31 ISSN 1211-4162

[7] McKay, N. K.; Black, W. G. (2007) The evolution of a production planning system: A 10-year case study. In: *Computers in Industry* 58(8-9): 756-771

[8] Pasko, J. & Gaspar, S. (2007). Theory of the welding process automation. In: *European and international standards in technical documentation.* Elba, Presov, Slovakia, 2007 s. 148-151.

[9] R.L. Laforge, C.W. Craighead, Computer-based scheduling in manufacturing firms: some indicators of successful practice, In: *Production and Inventory Management Journal 41* (1) (2000) 3–24.