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IMPLEMENTING JIT PHILOSOPHY IN PUSH BASED PRODUCTION SYSTEM

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Abstract:
It is commonly known that implementing JIT philosophy in manufacturing environment involves a pull mechanism like Kanban card. However, one of the underline JIT principles focuses on creating and keeping stability of production system. Therefore, by sensing the production system status before making decision on releasing new work order into the system can be applied and achieve JIT philosophy without implementing pull mechanism such as Kanban which requires a significant change in several areas in production system. In this article, CONWIP (Constant Work-In-Process) concept is applied in tradition push based production system where MRP (Material Requirement Planning) is utilized as key control mechanism. In order to validate the impact of CONWIP concept, simulation model of case study production line is developed in order to take consideration of stochastic nature of the production process in evaluating the performance of CONWIP production system. As a result, CONWIP based production system outperforms current push based production system. In addition, the CONWIP's control parameters are also developed based on the statistical relationships between system throughputs and those controlled parameters. Then, a production planning framework is developed to provide guidance in setting appropriate parameters based on production status. Also in CONWIP controlled system, production planner can accurately predict the job's delivery time.

Keywords: CONWIP, JIT control mechanism, constant work-in-process.

1. INTRODUCTION

Traditional push based production control approach, MRP, has been originally designed for driving the system throughput rate directly corresponding to customer demand and high utilization of system capacity. Since, system capacity is often an agreement between sales & marketing department and planning & production department where stochastic events, such as breakdown, process variation etc., rarely included in system capacity agreement. As a result, most push based production control system like MRP does not closely tracking production system. Overtime or incomplete work orders are added into production plan in order to compensate the impact of those stochastic events. However, it is often found that impacts of stochastic events are accumulating rather disappearing by adjusting production plan or allowing overtime. This directly impacts the quality of service to customer in term of late delivery or postpone shipment.

In contrast, a pull based production control mechanism, such as Kanban or CONWIP (Constant Work-in-process), works in the opposite direction. A CONWIP collect the status of WIP and maintain level of WIP according to designed settings. CONWIP control mechanism has been designed trying to attain the WIP level constantly as much as possible by limit the number of job introduced in to the system. CONWIP will only allow the job entering the system only when there are another one exiting (Hopp and Spearman ,1996) .

Theoretically, the CONWIP has been proved its outperforming over MRP in perspective of less WIP accumulation and shorter & stable production lead time under simple production system with single work station, single route assumption. However in the real manufacturing situation, environment factors couldn't be that simple. The existence of stochastic process time , multiple rework routes , yield variation effect , back and forth job repairing activity are all inducing vulnerability of the system. Does the CONWIP still practically outperform under those noises? This paper will demonstrate the MRP-CONWIP performance comparison and analysis taking in account the effect of the randomness.

2. BACKGROUND

2.1 Constant Work-In-Process (CONWIP)

Little's Law (Little, 1961), one of universal manufacturing theorem, constructed to evaluate the 3 main manufacturing system's parameters, Work In process, Throughput rate and cycle time relationship.

$$WIP = TH \times CT \qquad (1)$$

Where : WIP represents the amount of Work In Process

: TH Represents the throughput rate of the production system

: CT Represents the cycle time, the duration each unit spent traveling throughout the system.

This Little's law is broadly applicable, in that it can be applied to a single station, a line or an entire manufacturing plant. This relationship will hold over the long term as long as those three variables are measured in consistent units. According to (1), there are a relationship between WIP and CT. If TH cannot be increased (due to limited capacity), increase in WIP only contribute to longer cycle time. As a result, CONWIP concept has been created to control the level of WIP in order to keep both high utilization at bottleneck station at acceptable and stable cycle time.

2.2 Case Company

A case company is as multi-national electronic contract manufacturer in particular Fiber Optical / Medical device. All process parameters and design of production equipments in this case company have been well designed and calibrated in closed collaboration customer, which could not be initially deviated unless deviation authorization is granted directly from customer. The customer will directly consign the critical equipments relating to product quality. Most of the customer deals, when additional equipments is required to ramp up the production capacity. The case company will be responsible to procure those equipment with the cost afforded by the customer. Once, the planner receive the confirmed order from customer. The order of the raw material and other required production resource preparation would be immediately planned given the suggestion from company ERP system the ORACLE. ORACLE software is originally designed under the Push base planning, MRP protocol. With associating to the ORACLE, planner will release the work order to production floor and drives the flow of materials with MRP mechanism until get the unit exit the production line. Before considering push system control mechanism, work in Process amount and Time to delivery to customer are both the key indicators for measuring the planning activity performance for this case company.

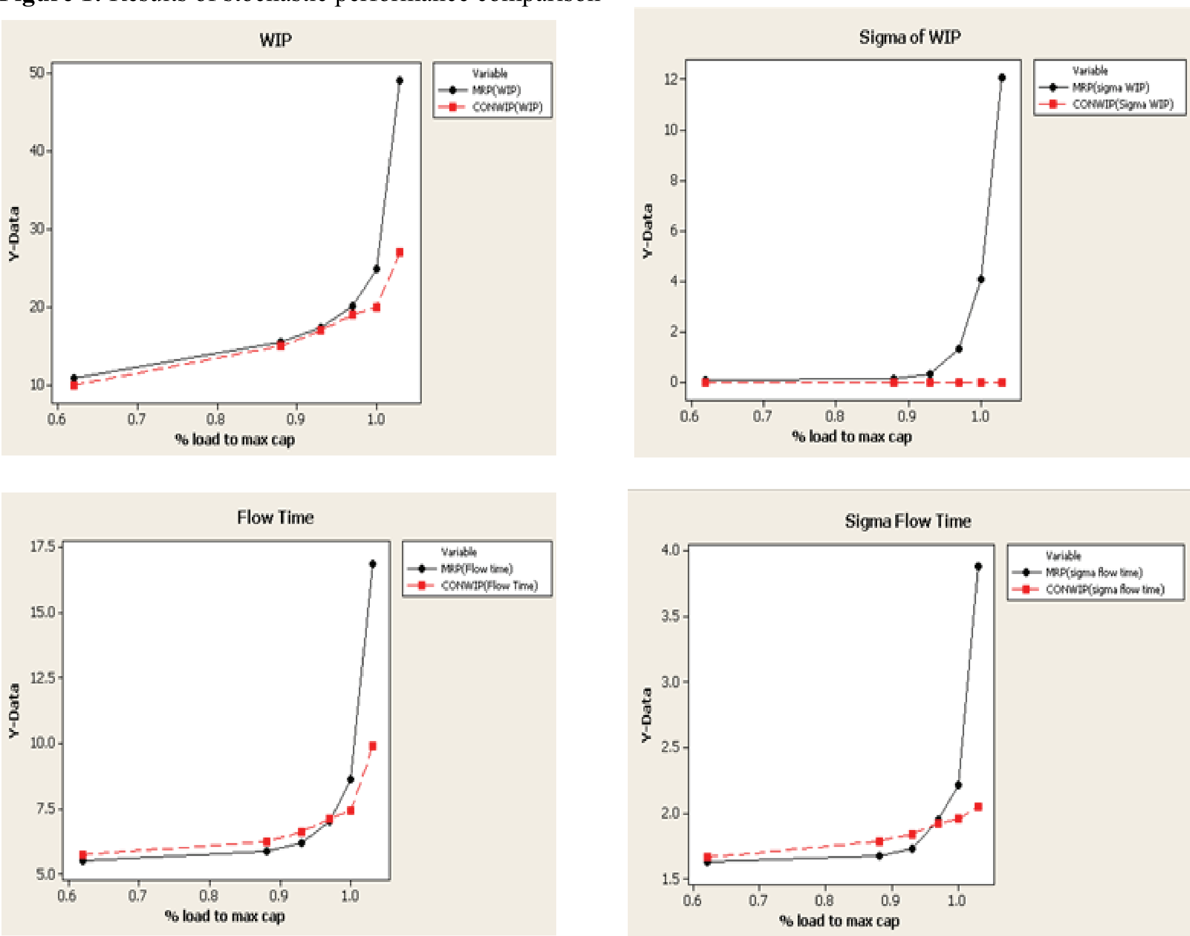
In this research, one product has been used as a case study. It normally is produced 1600 units per month. However, later it needs to be increased to 1900 units a month. With the higher production rate, the additional bottleneck equipments have been ordered by customer and delivered to Thailand for installation. Besides the additional bottleneck equipment is required, the WIP tray which is special design container, this product contained during its traveling throughout the production process, is also one of major investment customer need to be considered to support this capacity ramp up. There were also intense discussions between case company and its customer to identify the right order quantity of these trays. Because the production process potentially incurs the high failure rate from multiple test operations and stochastic cycle time, which make the WIP amount highly fluctuated in consequence, the tray order quantity calculation seems to be inaccurate so the customer is not convinced by the order quantity case company had been proposed. With the result the tray procurement budget was not approved. In order to resolve the problem for future capacity growth, the company needs to implement a pull based planning approach, CONWIP and identify a way to specify control parameters

3. EXPERIMENTS AND RESULTS

3.1 MRP – CONWIP performance comparison in stochastic environment

Assume stochastic environment, normal distribution of the standard time with standard deviation 50% of mean of standard time in every operation. Run the simulation model by changing % capacity utilization. To assess the both system performance responding to stochastic effect, firstly we set the degree stochastic at standard deviation equal to 50% to its mean value. Next step let have the % load to maximum capacity varied from 0% up until exceeding the bottleneck rate at 103% the investigate the change behavior of both system's KPIs. Observe 4 KPIs: 1) WIP 2) Standard deviation of WIP 3) Flow time and 4) Standard deviation of Flow time. These behaviors then define break-even point which CONWIP gain an advantage over MRP.

Figure 1: Results of stochastic performance comparison

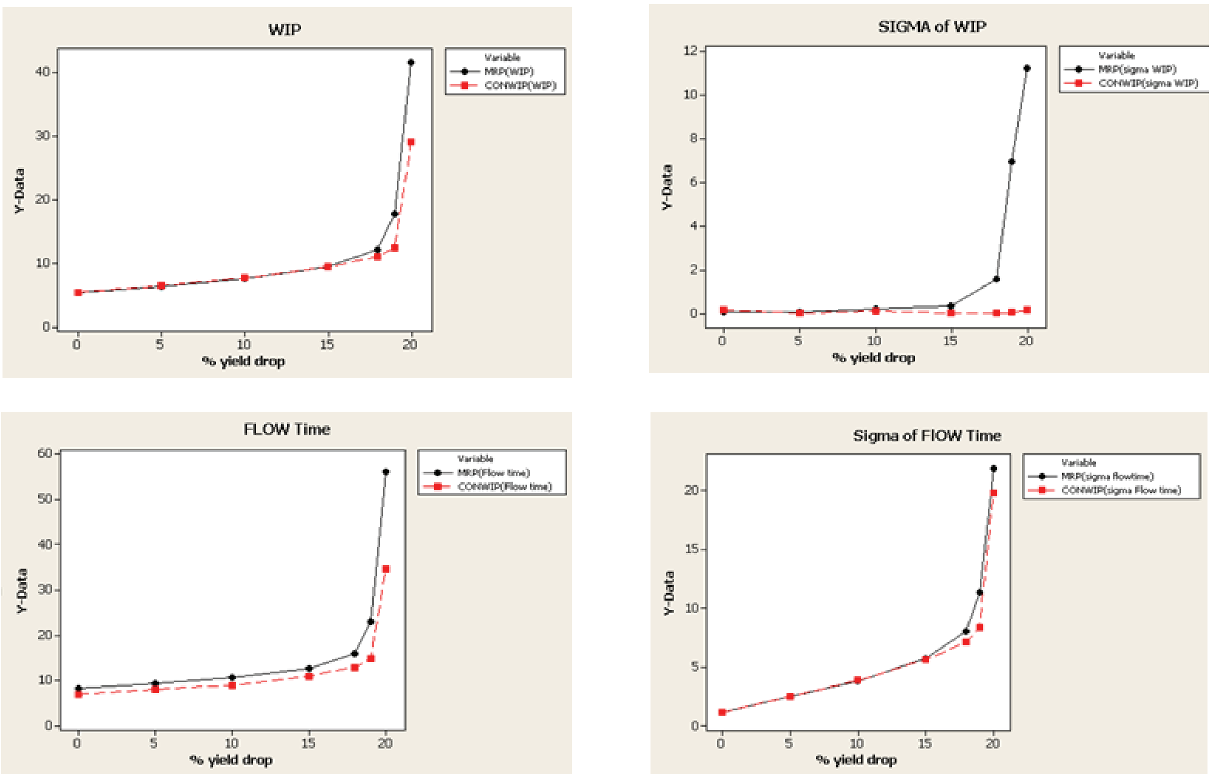


As a result from Figure 1, the higher degree of yield drop situation will produce more and more system turbulence especially for pushed MRP environment. With stochastic environment, MRP flow time's standard deviation start increase drastically when the job is released to system with the rate 97% of bottleneck and standard deviation become growing faster and faster especially when the system was overloaded while CONWIP flow time deviation still remain robust.All 4 KPIs analysis are emphasizing that stochastic effect could deteriorate the performance of both MRP and CONWIP system but MRP seems to be much more sensitive than CONWIP. The result of this test step concludes that CONWIP will be even more beneficial especially employing it in high degree of stochastic effect.

3.2 Investigate the effect of variation in production yield to the MRP and CONWIP performance

Re-run the simulation model with reduction of all test yields from every test operation by 5%, 10%, 15%, 18%, 19% and 20% respectively. fix the job release rate at the certain level at 840 units per month then measure all 4 KPIs investigating for the break-even point the CONWIP start gaining the improvement over the MRP performance.

Figure 2: Example of MRP-CONWIP performance comparison under yield variation scenario

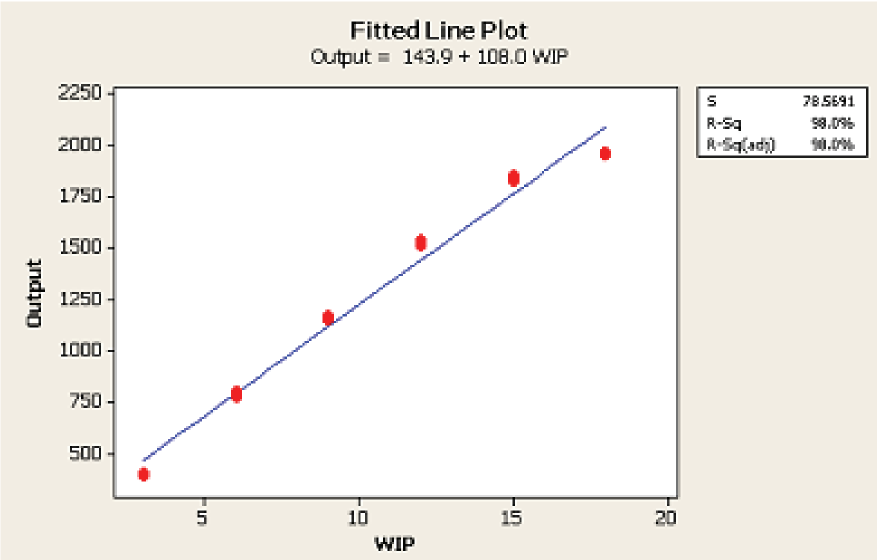


As a result from Figure 2, The higher degree of yield drop situation will produce more and more system turbulence especially for pushed MRP environment. Figure 2 clearly indicated that at some points of yield reduction in order to maintain constant output level ,CONWIP approach could be more robust in 4 KPIs characteristic than pushed MRP system .

3.3 Construct the CONWIP - WIP CAP identification model

From the result obtained from all 30 replications of simulation run, by using the regression analysis as WIP CAP (Level of Controlled Work-in-process) is an independent variable and output rate is a dependent variable. This regression model can be applied as useful tools for the production planner to set up their WIP CAP of CONWIP system in order to make the system capable to produce any output level the customer is calling for. This experiment is designed to investigate how strong the relationship between CONWIP output rate with its set level of WIP CAP is. If the strong enough relationship is found then the WIP CAP could be applied as the good predictor variable of CONWIP output rate.

Figure 3: CONWIP output prediction model



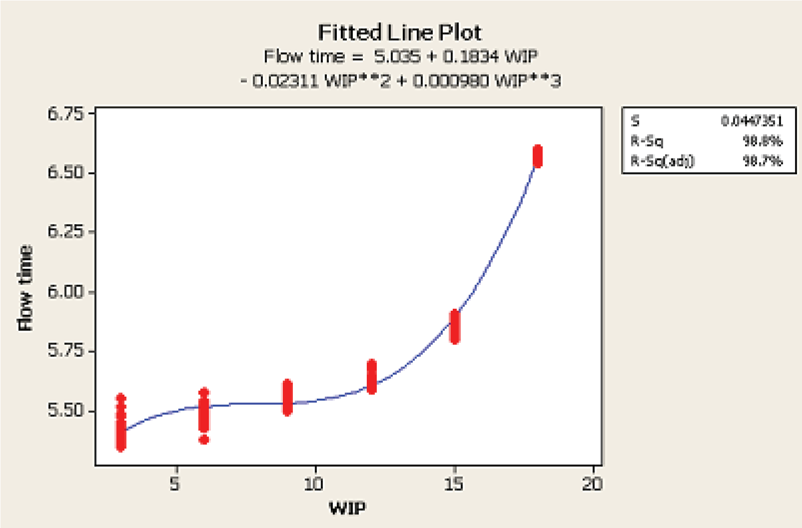
The acquired regression equation , Output = 143.9 + 108 WIP , shows very high fitting quality which reflects on its high value of R^2,98% . The result imply the strong relationship between those thwo variables which make this regression equation become an effective WIP CAP setting tool allowing the production planner capable to accurately determine the proper level of WIP CAP set to acquire his/her desirable output rate.

3.4 Construct the CONWIP- Job release rate identification model

The experiment which is conducted to examine the degree of relationship between CONWIP-WIP CAP level and its average Flow Time corresponding to provide better suitable due-date estimation given to customer. Because the Flow Time is the average duration each jobs spent traveling throughout the production system, so it definitely represents the manufacturing lead time, the duration since the factory taking the customer's order until the finished product can be delivered.

As the result of previous experiments, approaching with CONWIP strategy the less fluctuation of Flow Time can expectedly be acquired comparing to MRP. Taking this CONWIP advantage, the flow time prediction model can be constructed employing the WIP CAP as a predictor variable. The experiment control settings are: setting the WIP CAP at multiple levels starting from 3 jobs in the system increase the WIP CAP by increment of 3 up to 24 jobs and measuring flow time of each WIP CAP level for 30 replications

Figure 4: CONWIP Flow Time prediction model



Apply the cubic form polynomial regression model to construct the Flow Time prediction model using the WIP CAP as a single predictor variable. The acquired Flow time – WIP CAP model indicates their strong relationship through the high R2 value , 98.8% , with cubic polynomial regression equation , Flow time = 5.035 + 0.1834 WIP - 0.02311 WIP2 + 0.000980 WIP3 . This result imply that with CONWIP strategy the WIP CAP is a good predictor variable capable to accurately predict the Flow Time of each individual job.

Knowing the appropriate WIP CAP level set from the regression model giving from Figure 3 can dictate the CONWIP output rate only when the system is running in the steady state condition. However in order to make the system steady, planner also need to set much enough job releasing rate to ensure that the system will always get the new job when there is one job is exiting the system. Higher job release rate will always ensure that the system will not lose the WIP over the time but have too high rate will incur too much cost relate to material procurement and their storage cost. So the planner could just need the release rate at some proper level which is not too high but still maintaining the WIP constantly over the time.

4. CONCLUSIONS

WIP control and manufacturing lead time estimation are nowadays a substantial topics being focused by management because both elements directly relate to company product cost and customer satisfaction level which are the key factors making the organization survived in today crucial competitive situation. It is a management duty to seek for the alternated approach to improve those two factors.

This research has introduced the CONWIP control, one of the Pull based material control protocol to one of the production line of the case company which involves with high defective rate and stochastic cycle time. This study also demonstrates the advantage of CONWIP over current approach MRP system with getting help from ARENA simulation. Benefit of using CONWIP is now revealed however the planner who implement this system have to have well understand of how to control to CONWIP driving the system to provide the desirable output rate.

This study also establish the planning framework with getting help from the regression model providing the planner help to easily set his/her appropriate level of 2 CONWIP key input factors, WIP CAP and job releasing rate. Finally after have the WIP CAP and release rate set, taking the benefit of CONWIP less standard deviation of flow time, planner could also be able to predict the job's time to delivery more accurate with the proposed Flow time V.S. WIP CAP regression model.

Although CONWIP has shown its superior over MRP through the perspective of 4 KPI.s, WIP, sigma of WIP, Flow time and its sigma however the study also indicated that there is only one parameter CONWIP never show the advantage of the MRP no matter what scenario has been studied. It is the "Standard deviation of output". CONWIP can not make its output constant as good as MRP can do because of the natural of CONWIP mechanism which will allow new job introduce into the system only one depart so it is rarely possible that the CONWIP system could make its bottleneck operation run with constant utilization so the output become greater fluctuating. However variation of output is not much significant in term of cost perspective. High output variation also does not effect to the product delivery especially when the planner making a long-term production plan.

Further study can be performed in more technical level. In this study CONWIP are not yet unable to adapt itself to the change of customer's order. When there is the new demand rate updated from customer, planner will always response to this change modifying the set WIP CAP and release rate according to the predetermine regression model back and forth. This model could possibly upgrade to make the system automatically adapt itself to change.

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