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Lean Concept in a High-Mix Production Environment

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Abstract: ***The lean manufacturing concept is well suited in the context of the traditional low-mix/ high-volume production environment. Nowadays, however, enterprises face the challenge ofa high variety of products along withdynamically changing demand. Lean tools and methods known from repetitive production do not always fit today's high-mix environment, which presents challengesin designing one-piece-flow production cells and material flow based on the pull system. There are numerous case studies proving outstanding benefits from the implementation oflean principlesinlow-mix / high-volume production environments. Lean tool application for high-mix production conditions require certain modifications. This article presents a case study of implementing lean concepts in an enterprise producing a highmix of products.***

Keywords: Lean Manufacturing, High Mix Production, Manufacturing Super Markets, Hybrid Replenishment

1. Introduction

The chosen enterprise for this case study is a leader in thegaming industry that is producing the most innovative and engaging cabinets. The production is configure to order, anddemand is irregular. Finished goods have more than 30percent uncommon parts. Thisarticle focuses on the assembly department reorganization based on thelean approach.

The value stream mapping tool was used to elaborate the current and future state value stream map, which estimated the potential influence of the planned assembly system reorganization on the rest of the production operations and identified the improvement areas. Based on the future state map, the goal for the assembly system reorganization was defined to increase productivity by 20 percent with the same resources.

Assembly operators' work content containeda significant amount of non-value-adding activities, such as waiting for parts, reaching for parts and tools, and moving within the workplace. Eliminatingnon-value-adding steps from work content was needed to achieve the goal of the project. To fulfill that,the following lean tools were applied:

- One-piece-flow to reduce the work in progress (WIP) level and shorten lead time. (see Figure-1)
- Standardized work to reduce the variability of assembly cycle time for a given product type.
- Proper material presentation at the workplace to reduce reaching for parts and unnecessary movement of operators.
- Milk run material delivery system to reduce the level of inventories at the workplaces and prevent operators from leaving workplaces to bring the parts.
- Hybrid replenishment system and manufacturing supermarkets to reduce shortages of parts for assembly.

Implementing One-Piece-Flow and Flexible Material Presentation

Figure 1: One-piece-flow reduces the work in progress (WIP) level and shortens lead time

A workplace in high-mix production has different component types stored around a workstation. Operators spend a significant amount of their time bringing parts from the store room to the workplaces, searching for materials, and reaching for parts and tools.

Organizing the assembly system in assembly cells reduced transport activity as well as any interruption of material continuous flow. Assembly equipment and personnel are arranged in a process sequence and includes all the operations and components necessary to complete a product or a major assembly sequence. Operators perform operations and transfer all parts associated with one-piece-flow to the next cell with improved safety and reduced effort. All components and materials are properly presented to assembly operators and delivered on time and directly to operators' fingertips. To do that, the containers with parts and assemblies are placed on flow racks in point of use within the assembly cell. All parts and assemblies are available for operators without any unnecessary movement and reaching. However, to reach this goal in ahigh-mix production performed on one versatile assembly cell was a real challenge. In our case study, special analyses were performed and a suitable flow rack was designed where all parts are in the best ergonomic location for operators. Because of many different product types produced on the workstation, it was necessary for partsto be delivered to the flow rack in kits prepared for one or two hours of production and placed in dedicated slides on the rack. The rack can hold the material for three hours of production. Color coded bins for parts facilitates the delivery process managed by material handlers.

Standardized Work

The standardized work instruction defines in detail all work elements performed by operator on assembly station and has usually a graphical, very visual form. (See Figure 2.) A challenge here was to prepare such an instruction for the high-mix production workstation despiteof all the different product types and assembly processes.

Figure 2: The standardized work instruction defines in detail all work elements performed by operator on assembly station

To create such a standardized work instruction, all types of assembly processes performed on assembly stations were caught on video tape and analyzed. The analysis showed that only 40 percent of all operations performed by assembly operators were value-adding operations. The goal here was to define a detailed assembly procedure including only the necessary steps to produce one selected product. The effect of those analyses were 25 standardized work instruction cards for 30 different product types assembled on the designed workcell. Their implementation produced a 10 percent improvement on product quality.

Milk-Run Deliveries

A material handler regularly moves along the standardized route (a milk-run route) and picks components from the supermarket required for one-piece production (See Figure 3.) The material handler thendelivers components from the supermarket to the rack at the first assembly cellon the production line. Operators perform the necessary operations and move in process assembly along with the rack to the next assembly cell. Component picks from supermarkets is streamlined with proper pick sequencing and single direction movement. Milk-run deliveries are an efficient method to keep inventories on the shop floor at a very low level and to increase material handler productivity.

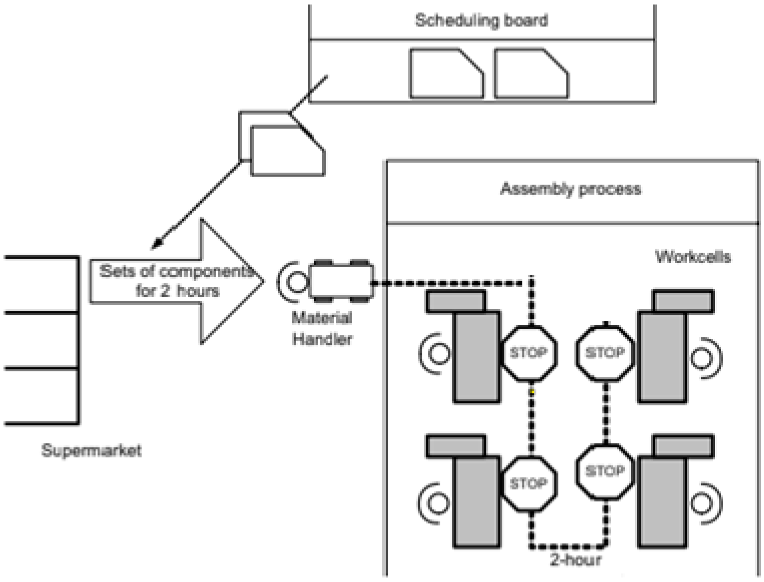

Figure 3: Milk-run deliveries keep inventories on the shop floor and increase material handler productivity

This scheme works perfectly for repetitive production, where the same types of components are used for longer periods. Forthe high-mix production environment,kanban cards cannot be used to provide material handlers with the information about what components need to be delivered to the workcells during the next milk-run. To resolve this problem, the final product kanban cards were implemented instead of components kanban cards.

During each milk-run, the material handler delivers components to the workcells for two hours of production and takes the final product kanban cards for the next two hours from the scheduling board. The material handler provides these cards to the component supermarket. The product kanban card holds information about the whole set of components required to assembly for the given final product. After implementing the milk-run delivery system, the level of inventories on the shopfloor was reduced to two hours and the space required for production was reduced by approximately 50% percent.

Replenishment System

The pull system was identified as a crucial tool to decrease the level of inventories and improve the availability of the components for assembly. (See Figure 4.) This is true for repeatable production with limited product variants. The pull system was inefficient for the high-ix environment as demand was not stable and the high variety of components was demanded by the assembly process. To find a proper solution, the components were divided into three categories:

- High runners: Components for products ordered by most of the customers in large volumes. The consumption by assembly department is repeatable.
- Medium runners: Components for products often ordered by the customers. The average daily consumption lower than for high-runners.
- Low runners: Components ordered rarely or in very low volumes as part of bigger orders for high- and medium-runners.

The pull system is used for highrunners. The supermarket holds these components in predefined quantities.

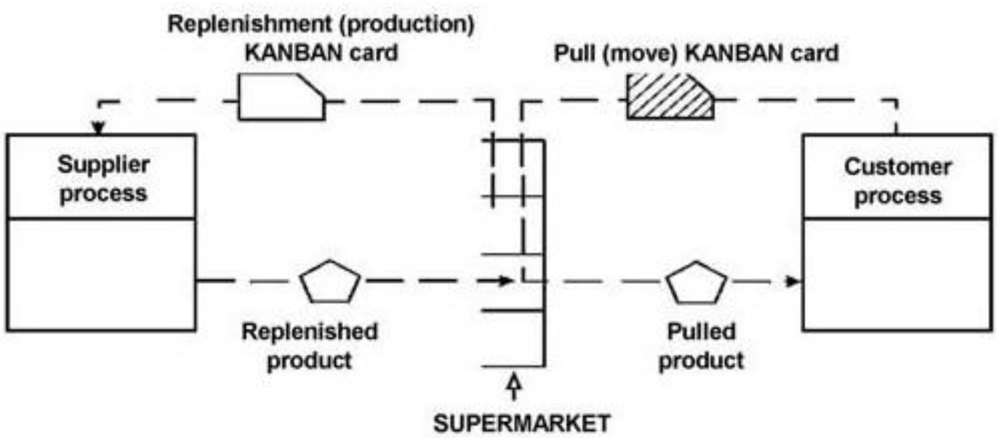

Figure 4: The pull system is a crucial tool to decrease the level of inventories and improve the availability of components for assembly

A hybrid supermarket replenishment model using the push system is ideal for holding components only for the current day's production for medium and low runners. A nightly replenishment job creates tasks to replenish thesupermarket from bulk inventory for medium and low runners. The push replenishment program replenishessupermarket based on the next day'sproduction schedule. The hybrid replenishment program is like the Oracle Push replenishment program for sales orders where you have tasks to pull material from bulk inventory.(See Figure 5.)

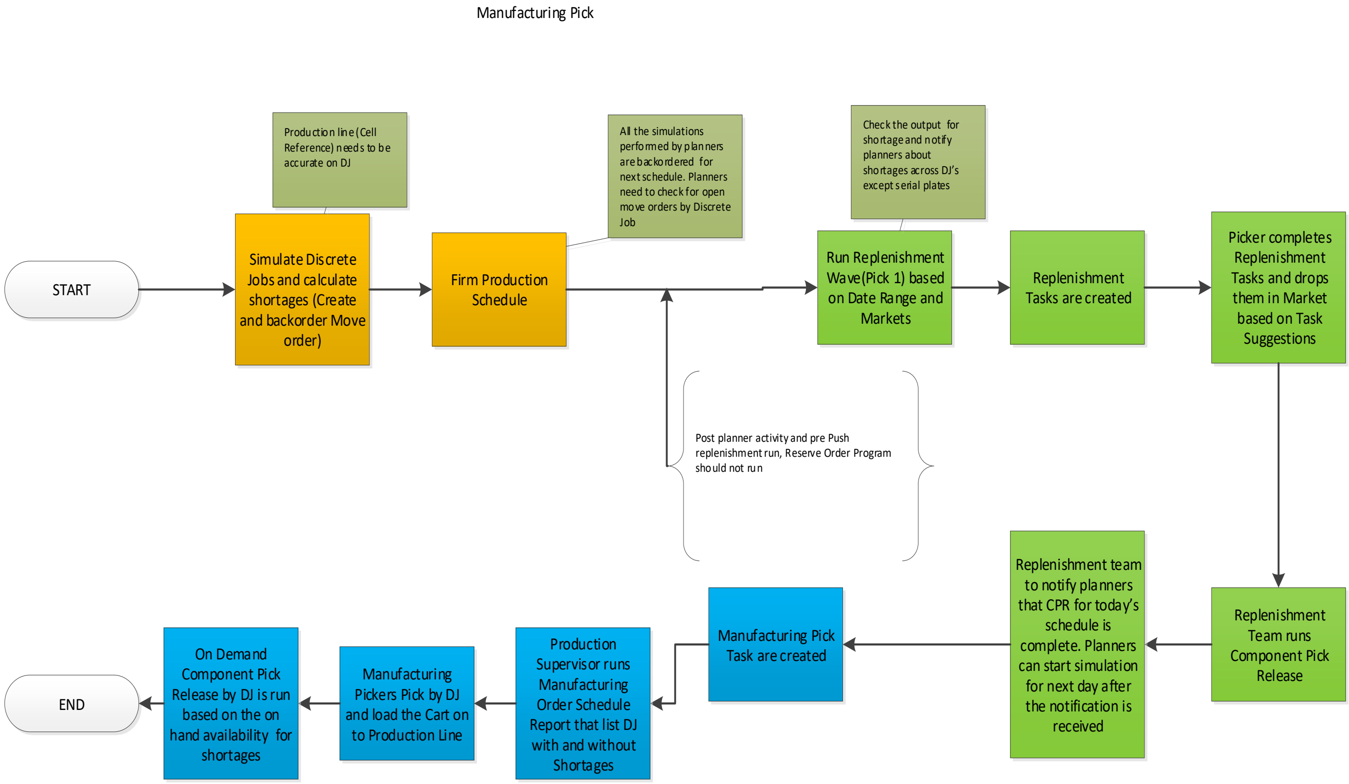

Figure 5: Push replenishment

Push Replenishment Process

1) Planners run the push replenishment program for next day production.
2) Push replenishment program creates consolidated demand for all the medium and low runners. It then creates supply from Bulk inventory to fulfill the demand. Consolidated Move Orders are created and an attempt is made to allocate all the move order lines.
3) Planner then logs into Custom production schedule page built on the results of move Order detailing. This page lists the shortages and associated Work order for each demand line. Planners reschedule few work orders to reduce shortages for next day production.
4) Planners re-run the push replenishment job to account for work order reschedules. Old Move orders are deleted and new move orders for replenishment are created. Planners look at the shortages and release tasks for replenishing the Super markets.
5) Material handlers perform the tasks and move the material from bulk to Super Market.
6) Replenishment team on day of production runs Component Pick release. This job creates tasks to pick material from super market and load on to flow racks.
7) All Work orders with any existing shortages are displayed on dashboards for Water Spider (specialized Material handler) to pick and load the flow rack.
8) Water spider logs into MSCA which is customized to allow scan of work order for component picks. Only tasks for a single work order to allow single piece flow are shown to the Water Spider. On the last pick associated to the work order, a custom message saying, "All tasks associated to the work order are picked" is displayed. On seeing the message, the picker loads the flow rack on to the conveyor belt and performs drop all LPN in MSCA application.
9) Cross docking allows any supply for shortages is directly sent to super markets to fulfill current production demand.
10) Operators at each assembly line pick material from flow rack and manually issue material to the work order. Items that are serial tagged require scanning of serial number at the time of WIP consumption.
11) Progress of Work order picks and production is frequently reported back to the dashboards

2. Conclusion

The lean concept can be applied successfully in high-mix production environments; however, the lean management tools must be modified on the level of technical solution for high-mix constraints. The proposed lean tools such as flexible parts presentation, milk-run deliveries, and the hybrid replenishment system allowsfor improvingthe productivity of the assembly department. This approach can be extended for multiple production lines with multiple supermarkets, all sourced from single or multiple bulk inventories. In our case study, the overall total savings were about $400K per quarter by resource /inventory stock.

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