IOP Conf. Series: Journal of Physics: Conf. Series **885** (2017) 012015 doi:10.1088/1742-6596/885/1/012015

Synchronization of workshops, using facilities planning

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Abstract. In this paper, we will present a methodology used for the synchronization of two workshops of a sheet metal department. These two workshops have a supplier-customer relationship. The aim of the study is to synchronise the two workshops as a step towards creating a better material flow, reduced inventory and achieving Just in time and lean production. To achieve this, we used a different set of techniques: SMED, Facilities planning...

1. Introduction

In the automotive industry, achieving a one piece flow and producing in just in time is essential for lean production. Ever since its origin in Japan at Toyota in the early 1970s, JIT has become a “comprehensive management philosophy” [1]. The benefits of adopting just in time in manufacturing have been acknowledged by many industrial firms, as stated by Monden:”If JIT is realized in the entire firm, then unnecessary inventories in the factory will be completely eliminated, making stores or warehouses unnecessary. The inventory carrying costs will be diminished and the ratio of capital turnover will be increased” [2].

Functioning in Pull systems and Just in time manufacturing is indeed known for eliminating waste and improving productivity, however their down side according to Teruyuki Minoura, former President of Toyota Motor Manufacturing in North America: “ If some problem occurs in one-piece flow manufacturing then the whole production line stops. In this sense it is a very bad system of manufacturing. But when production stops everyone is forced to solve the problem immediately.” [3] Therefore, investing in one piece flow processes is a good start towards lean production that leads to improvement overtime. From this perspective, we conducted a study about the synchronization of two workshops of a sheet metal department: The assembly workshop with the metal fitting and finishing workshop at an automotive assembly firm. These two workshops have a supplier-customer relationship. The aim of the study is to synchronize the two workshops as a step towards creating a better material flow, reduced inventory and achieving Just in time and lean production.

2. Methodology

2.1. Production plan analysis

To achieve the synchronization of the two workshops, we first analyzed the production plan, that is considered as an unchangeable constraint due to the fact that it is based on all the processes constraints, moreover there are other processes for which a change in the production plan would prove to be costly (expensive changeover of tools and wasting of residual raw materials…). Since the two workshops

Work in a push fashion, we need to know for each finished product of the customer workshop, what pieces the supplier workshop needs to provide and how many tool changes to operate if we want to respect the production plan in a one piece flow model. This analysis helped better understand the production needs in terms of products specificities and tool changes.
Besides, the supplier workshop suffers from an important storage activity that leads to traffic congestion within the plant and a complicated physical flow of materials (transport and material handling between the workshops and the storage area, overcrowding of semi-finished products…), hence the will of the company to reduce it through the synchronization project. The main cause behind this over-stocking issue is due to the "over-production" of 450 s (7.5 hours) in advance by the supplier workshop. The production plan is daily transformed into lots instead of one piece at a time to minimize the number of tool changes. Not only does the current work in process stock contributes to minimizing changeovers of tools but it also serves as a buffer stock and thus preventing chain stops. Nevertheless, as a form of "Muda", inventory needs to be reduced if not eliminated.

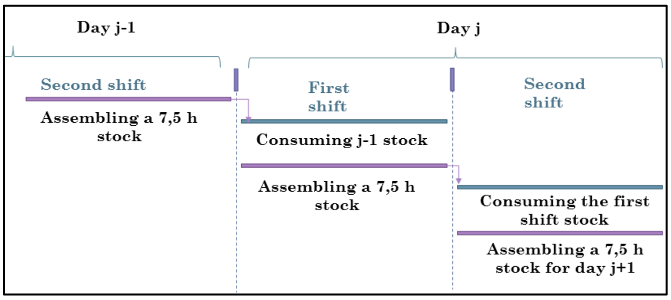

Figure 1. The Initial stock replenishment mode

During this study, we realized that the main constraint in the synchronization of the workshops was due to the important number of specificities in the finished goods produced, leading to an important number of changeovers (of tools, machinery and raw materials), that is avoided by the work-in-process inventory produced by the first workshop. However, in the synchronization context, all tool changes imposed by the production plan shall be taken into account. Consequently, we tried to simulate a single piece flow on an excel sheet using the current tool changing time that varies between 420s to 600s (7 to 10 minutes), according to the type of tools or machinery used for each change. We realized afterwards that given the actual tool changing time, it won't be possible to produce the minimum required quantity of finished goods per day, hence the need to reduce the time of tool changes.

2.2. A SMED Approach

The changeover of tools only happens for the first workshop, for the second one, only the raw materials are changed. In order to reduce the changeover time, we relied upon a SMED approach (Single Minute Exchange of Die). Following a detailed analysis of the different types of changeovers that occur for the first workshop (route sheets, flow and process analysis, operations analysis, Gantt diagrams…), it became clear that the transportation and storage of the tools and machines are the primary consuming time activities and thus we decided to see if we could remove those activities.
The table below sums up the main problems encountered and the proposed solutions:
Many of the proposed solutions following the SMED analysis have in common the change of the current disposition of the first production workshop as a mean to reduce changeover times. The idea here is to group all of the production means (tools and machinery) that are usually stored in another storage area in the same work cell where they are needed. A suitable facilities disposition would allow us to : avoid flow crossing, avoid congestion inside the workstation, store the tools and machinery on the ground and avoid their transportation, bring the storage area closer to the station or put all the tools inside the station. The storage problem (for tools and machinery) would be solved and our gains would be in terms of time and space. Consequently, the next issue to address is how can we organize those

production means in the space-limited work cell, without disrupting the flows, encumbering the cell and inconveniencing the operators?

Table 1. Summary of the SMED analysis findings

Operation	Responsible causes for increasing time	Parameters to study	Proposed solutions
Operation 2	Difficulty of access and clutter for the stacker	-WorkStation intern disposition -Difficult access to the station.	-Proposing a new implantation for the workstation -Standardization of changeover paths
Operations 3, 9	Heavy load to transport	Heavy load	-Consider alternative handling means -Avoid moving tools and machinery
Operation 4	Maneuvering a heavy load to an elevated position.	Storage in high places	Storage of tools and machinery on the ground
Operation 6	Recurring position error	Positioning errors	Using POKA YOKE
Operation 7	Free transport (transporting nothing)	Distance between the storage area and the workstation	-Moving the storage area closer to the workstation. -Putting all the tools and machinery inside the workstation.
Operation 8	The shape of the tool involved makes its grip more difficult	Shape and volume of the tools	Taking it into consideration

2.3. Facilities planning

We started by calculating our space needs and comparing them to the surfaces available in the work cells which makes our solution feasible in terms of space. Since we do not have an initial facility plan for the desired solution, we started by the study of the initial implementation through a flow diagram, it is usually done on a real map of the plant, and it shows the path taken by each piece and represents the total plant flow. This approach is useful for detecting flow crossing and backtracking, and gives an idea of the covered distances. Flow crossing can be responsible for congestion and security issues, whereas Backtracking refers to “material moving backward in the plant… Backtracking costs three times as much as flowing correctly” [4]; indeed parts should be routed to the "customer" service and not in the direction of the "supplier", hence the need to eliminate it.

In our quest to a better flow, we used different flow analysis techniques: String diagrams and multi-column process charts. These two methods rely upon the creation of “route sheets” according to the route sheet data requirements specifies in the work of [5] “Facilities planning”.

- String diagrams: a representation where circles refer to equipment and lines to the flow, in case of backtracking the line goes beneath the circles. [4]
- Multi-column process chart: It is based on the calculation of the number of steps travelled. A step refers to the distance between the centres of two consecutive circles, meaning if we jump a circle we will have two steps. [4]

Using these techniques, we evaluated the efficiency of each proposed plan for a new and improved layout. Here below is an example of a multi-column process chart with the efficiency calculus.

MULTI-COLUMN PROCESS CHART				
	Part Numbers			
Tools	N 1	N2	N3	
R				
M1				
M2				
M3				
M4				
M5				
M6				
M7				
M8				
M9				
S				Total
Number of steps	18	18	18	54
Least steps	10	10	10	30

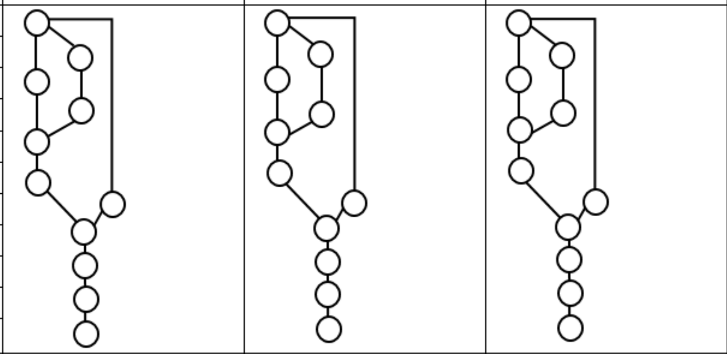

Figure 2. Example of a multi-column process chart

$$\text{Efficiency} = \text{Least steps} / \text{Number of steps} \quad (1)$$

For the first proposition, we found: Efficiency=30/54=55,55%. We repeated this steps for different layout proposals, and thus moving from an improved efficiency to another, until we reached the chosen layout; The improvements adopted consisted in avoiding loops between workstations (getting two machines 1 and 2 out of the workstation but still very near) and the installation of rails on which the machines will slide during tool changes. The efficiency shifted from the initial 55,55% to 58.82%. Here below are the initial and the final layout; X, Y and Z refer to the empty place where the machine/tool will be slided to on the rails.

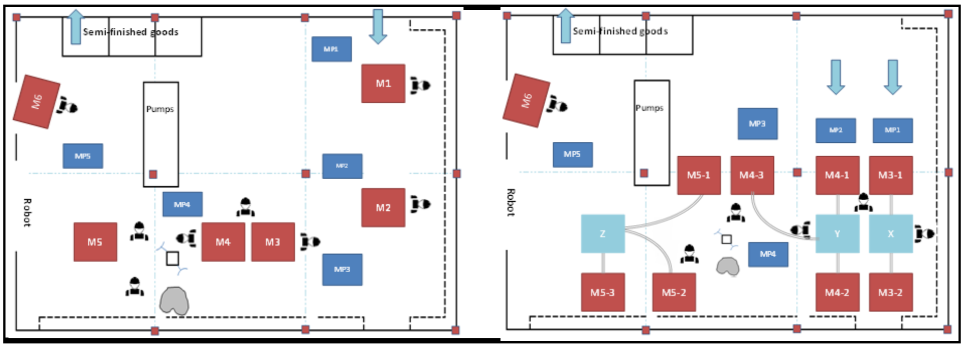

Figure 3. Initial layout at the left and final layout at the right

We used a time standard analysis MTM1 (Method Time Measurement 1) in our case, to estimate the new tool changing time that has become 4 minutes when using the improved facility design instead of (7 to 10 min before). It is mainly due to the possibility of changing all of tools/machines simultaneously instead of one by one as it used to be done before.

2.4. Synchronization scenarios

To make the synchronization of the two workshops possible, we studied four scenarios. Each scenario presents an idea for synchronizing through a special procedure. All these procedures come together in the act of delivering the right piece to the right place in the right sequence at the right time from the first workshop to the second. However some scenarios have drawbacks that cannot be overlooked. The main differences between the four scenarios are either to produce per batches or not, and how many batches per time slot should we consider. We used Gantt diagrams on Excel (that represents activities

in scales of hours, minutes and seconds unlike their classical use in project management where they rely on day scales) to simulate the production on a day where we have the highest amount of tool changes (for the last three years), we could access this data from the company history and applied our scenarios for that specific day.
The chosen scenario consists, for each time slot (of one hour), in producing pieces in batches according to their specificities. Thus, minimizing the number of tool changes per hour, while achieving the workshops synchronization; for each time slot, we deliver the right piece in the right amount with the right specificities and at the right workshop. We also noticed that this scenario allows us to produce more parts (at least 5 more per day) which is a good starting step if the plant ever wants to rise its current production capacity.
The remaining problem appears to be in the sequencing of pieces, because even though we produce the right products for each time slot they are not produced nor delivered in the right order and this is why we proposed to develop a VB.Net application that helps the operators in placing the right product in the right place of the metal containers that are transported through forklifts between the two workshops. The metal containers used have metal separators for each product to be placed which makes our VB.Net application very useful, the last operator to receive the piece assembled has simply to put it in its right place of the metal container as shown in the computer application in front of him.

2.5. *Further considerations*
With the transition to synchronisation, producing or assembling defective parts and rebus require retouching or outright remake, which consumes time and can lead to accumulating delays or chain stops, hence the idea of having a safety stock next to the assembly stations and in case of a defect we replace it right away. Thus, we calculated the quantity of pieces to keep as our safety stock to replace any defective product, we relied on the defects history to determine which and how many pieces to store to avoid delays in current timeslots. In addition, we will just have to make sure to renew our safety stock every week to avoid oxidation issues.
We also decided to reorganize the workload among operators, and to assess the synchronisation influence on logistics activities according to the assumption of the new operating mode, starting with forklift drivers that transport the metal containers back and forth between the two workshops, we used the MTM3 (Method Time Measurement 3) method to evaluate their workload before and after the synchronisation of the workshops, and reorganize their activities to avoid imbalances.
Finally we studied the project profitability, and the risks of operational failures through a failure mode effects analysis (FMEA). It is essential, when dealing with similar projects to summarize the results in a clear and concise procedure and to communicate it with all those affected by the changes undertaken. A communication-based approach involving all employees can help overcome problems of resistance to change that may result from the synchronization project.

3. Conclusion
In this study, we explored the synchronisation of two workshops in an industrial context. We started with an analysis of the production needs for a synchronized process between the two workshops with an emphasis on the frequency of tool changes. Especially since the synchronization requires to perform all of the tool changes imposed by the plant production plan. Hence the need to reduce their time. The idea that we came up with is considering a new flexible workstation design that will enable the achievement of tool changes in less time. We also proposed several synchronization scenarios and carried a careful study to choose the most advantageous one. Finally, we calculated the safety stock to use and focused on the problems that may arise with the synchronization through a risk study. In conclusion, all of the steps mentioned represent a step by step guide to exploit this factory's experience in the synchronisation of workshops. This experience can benefit other companies and can even be applied in other industries.

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