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The Impact of Inventories on the Leanness of Job Shop Production System

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ABSTRACT

Lean is a powerful process improvement strategy that is widely used to improve different processes. In this Paper, lean manufacturing as process improvement strategy is employed throughout relative tools and techniques as VSM, 5S, and standard work. These tools and techniques are employed to identify measure and evaluate processes. Job shop production of General Company for hydraulic industries, with focus on Damper and Tasks Factory (DTF) is tested as a case study for the two most customer demanded rear dampers of Samaned and Nissan. Data analysis shows different issues Work-In-Process (WIP) issues causing under/ over and production discrepancy. Improvements are introduced throughout WIP developments and 5S techniques. Results show that these developments may result in reduction of 65% WIP waiting time for Nissan and 58% of Samaned rear dampers. An increase in Overall Work Efficiency (OWE) could result in by 10% for Nissan, and 2% for Samaned dampers While 5S may result in improvements by 50% production processes and 43% assembly processes for Set in order , and by 33% in both production and assembly processes for standardize. Data where analyzed and further results are generated using software's are; Minitab Version 17, Quality Companion Version 3, and Edraw-Max Version 7.

1. Introduction

There is a huge variation in the stockholdings of different industries and organizations. Despite these differences, inventories play an important – and even essential – role in every organization. Without these inventories most operations are simply impossible. At the very least, they allow operations to become more efficient and productive. inventories affect lead times and availability of materials – there by affecting customer service, satisfaction, and the perceived value of products. They affect operating costs – and hence profit, return on assets, return on investment and just about every other measure of financial performance. Inventories also affect broader operations, by determining the best size, location and type of facilities. Inventories may be risky, due to certain storage requirements, safety, health and environmental concerns also they can encourage growth of other organizations, such as suppliers and intermediaries offering specialized services [1]. The main purpose of inventories is to give a buffer between supply and demand. This safety cushion is essential to ensure the smooth running of operations. Inventories can be raw materials, work in progress, finished goods, spare parts or consumables. The amounts held have widespread effects on the performance of an organization. Organizations hold different types of stock. A useful classification of inventories is [2];

- Raw materials: which have arrived from suppliers and are kept until needed for operations;
- Work In Process (WIP): which are units currently being worked on. Work-in-process inventory are materials that have been partially converted through the production process. These items were typically located in the production area. It worth's mentioning that to calculate the amount of work-in-process inventory, determine the percentage of completion, and assign a cost to it is time-consuming process.
- Finished goods: which are waiting to be shipped to customers

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This is a fairly arbitrary classification, as one organization's finished goods are another organization's raw materials. Some organizations (notably retailers and wholesalers) have finished goods only, while others (manufacturers say) have all three types. Some inventory items do not fall easily into these categories, so it can define two additional types as [2]:

- Spare parts: for machinery, equipment, etc., and
- Consumables: such as oil, paper, cleaners, etc.

These are needed to support operations, but they do not form a part of the final product as shown in Fig. 1. This research highlighted the effect of different inventory issues as an important aspect of waste from lean manufacturing perspective in Job shop production system as a case study (DTF factory) that could reflect the impact of inventories. The next paragraph present theoretical background to lean manufacturing and some of its relative tools and techniques, followed by literature survey that reflect the international concern in both lean manufacturing tools ,techniques and inventories as a major source of waste. Data are collected and analyzed for the above mentioned production system. These data are analyzed, discussed, improvements are presented toward deceasing inventories and therefore waste, conclusions are deduced .Finally recommendations for future work are highlighted and presented.

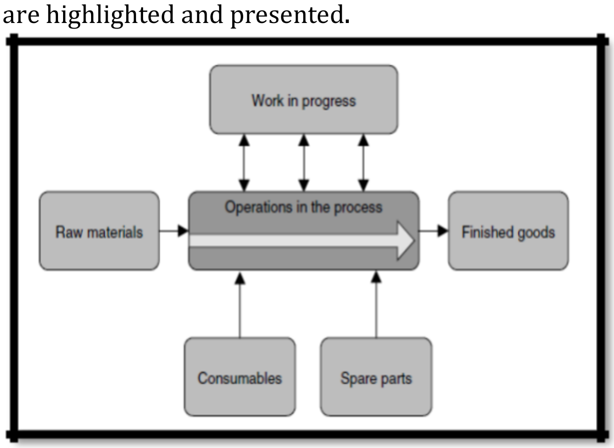

Figure 1. Different types of inventory [2]

2. Theoretical Background

The process of transforming raw material into finished goods is the objective of any manufacturing company. The processes that make that transformation possible are the result of two different activities: those that add value and those that do not. National Institution of Standards and Technology (NIST) define lean: "as a systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection" [3]. The main concern of Lean manufacturing (LM) is to eliminate waste. Lean also focus on retaining activities that add value and eliminating non-value adding activities. LM is normally driven by customer demand. This brings up the point about what the driver of a business process should be [4]. Value-added activities are considered the actions and the process elements that accomplish those transformations and add value to the product from the perspective of the customer. While non-value-added activities are the process elements that do not add value to the product from the perspective of the customer [5].

Lean handles every aspect of manufacturing process as a discipline that is designed to reduce waste and create evenly distributed processes. Lean methodologies have a potential to generate significant quantitative and qualitative benefits. The following Table 1 shows the Quantitative and Qualitative Advantages of Lean [6].

Table 1. Quantitative and Qualitative Advantages of Lean [6]

Quantitative advantages	Qualitative advantages
Reduction of Lead time and Throughput time substantially	Team spirit - Higher morale, motivation and participation, leading to higher innovation and excellence
Reduction of WIP and WIP related issues – almost completely	Pleasant Working conditions
Floor space savings	Longer Machine life
Increased Productivity as a result of highly responsive processes	Systematic approach to work
Substantial Improvement in quality	Improved flexibility
Overall cost reduction	Environmentally friendly

2.1 Eight Types of Waste

Lean targeted eight waste types which are [7];

i. Defects: Production off-specification products, components or services that resulted in scrap, rework, replacement production, inspection, and/or defective materials.
ii. Waiting: Delays associated with stock-outs, lot processing delays, equipment downtime, and capacity bottlenecks.
iii. Unnecessary Processing: Process steps that are not required to produce the product.
iv. Overproduction: Manufacturing items for which there are no orders.

v. Movement: Human motions that are unnecessary or straining, and Work-In-Process (WIP) transporting long distances.
vi. Inventory: Excess raw material, WIP, or finished goods.
vii. Complexity: More parts, process steps, or time than necessary to meet customer needs, and
viii. Unused Employee Creativity: Failure to tap employees for process improvement suggestions.

Inventory management is an important part in making all the decisions in handling the inventory in an organization such as activities to be carried out, policies of inventory management, and procedures in handling the inventory in order to ensure enough quantity of each item is kept in the warehouse at all times. Besides, the organization puts a lot of effort in controlling the inventory expenses through inventory management [8].

2.2 Lean Manufacturing Tools

There are many lean tools of improving performance and reducing time and cost by eliminating the eight forms of wastes, in order to bring the most value to the customer these are [8];

2.2.1 5S

5S is one of the most widely adopted techniques from the lean manufacturing tool. Along with standard work and total productive maintenance, 5S is considered a "foundational" lean concept being establishes the operational stability required for making and sustaining continuous improvements. 5S is one of the first tools that can be applied in a company that is starting down the path of the continuous improvement culture [9].

5S implementation helps to define the first rules to eliminate waste and maintain an efficient, safe, and clean work environment. The objective of this tool is to improve the work environment, quality, safety and effectiveness. Thus it is removing or reducing the waste and non-value adding activity. The primary objective of 5S is to create a clean, orderly environment (an environment where there is a place for everything and everything is in its place). Many companies begin their lean transformation with 5S because it exposes some of the most visible examples of waste it also helps establish the framework and discipline required to successfully pursue continuous improvement initiatives. It worth's mentioning that 5S is originated from five Japanese words that start with 'S' Seiri, Seiton, Seiso, Seiketsu and Shitsuke. These words translated into English are; Sort, Set, Shine, Standardize and Sustain [9, 10] as shown in Fig. 2 which illustrates 5S.

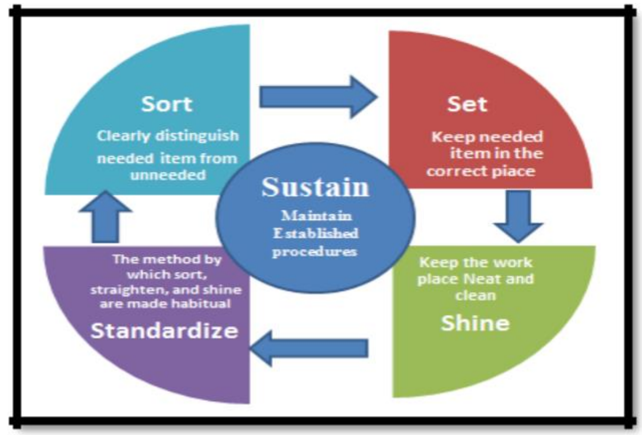

Figure 2. The 5S [10]

Benefits of 5S are [10]:-

i. Reduce non-value adding activity.
ii. Improve product quality.
iii. Reduce parts stored in inventory, and associated inventory carrying costs.
iv. Improve floor space utilization.
v. Reduce mistakes from employees and suppliers.
vi. Reduce time for employee orientation and training.
vii. Reduce search time in navigating the facility and locating tools, parts and supplies.
viii. Reduce unnecessary human motion and transportation of goods
ix. Extend equipment life through more frequent cleaning and inspection.
x. Improve employee safety and morale. Therefore:-

❖ Sort

Means to simply separate what is needed and necessary in the workplace or station from what is not. Sorting reduces problem and annoyances in the workflow, improves communication between workers, increases product quality and enhances productivity [9].

❖ Set in place

It is a storage principle in which everything in the work area has a place and is always stored there when not in use. This makes the tools easy to find and anyone should be able to find them and then replace them after use. Properly setting in order can eliminate variety of waste in the workplace including motion, searching, human energy, excess inventory, unsafe working conditions and using the wrong tools. In order to store items to eliminate waste according to 5s, items must be located according to their frequency of use in the workday and items used together should be stored together and in the sequence that they will be used. These items should also be located at the point of use. The storage places should be larger than the items being stored so that they are easily removed and replaced [10].

There are several different strategies used to set in place or order which can be used apart or together. The signboard is one strategy that identifies what, where and how many items should be stored. There are three main types [10]:

- location indicators which show where items go.
- Item indicators which show what specific items go in these places, and
- Amount indicators which show how many of these items, belong in those places.

Signboards can be used to identify: name of work areas, inventory locations, standard procedures, machine layouts and etc.

- The painting strategy is also used to identify locations on floors and walkways.
- While outlining strategy is where color-coding is used to show clearly which part and tools go in which place.

❖ Shine (Scrub)

To keep the work places clean by eliminating all forms of dirt, dust, grease and grime. This improves the work environment, provides safer workplace, and helps maintaining equipment value. Cleaning can also be used as a form of inspection (cleaning a piece of equipment, a problem can be noticed that would not have been seen in passing). In order for shine to be effective and 5s to be maintained, cleaning must become a standard part of the everyday routine [9].

❖ Standardize

Where working conditions are implemented to maintain sort, set in place, and shine. Standardization creates a consistent way that tasks and procedures are carried out so that absolutely anyone can understand the work [9].

❖ Sustain

Following the correct procedures and continuously repeating all the steps of the 5s process by sustaining all of the 5s steps, many problems in the work place can be avoided including [10]:

- Unneeded items piling up as soon as the sorting process is completed,
- Tools being put in the wrong place after use,
- No one ever cleaning equipment or picking up after themselves,
- Items being left in walkways,
- Dark, dirty work environments which lower morale of employees, and
- Dirty machines which start to malfunction and/or produce defects.

The commitment to sustain a particular course of action is made because the rewards for maintaining this course of action are greater for the individual or organization than the rewards of departing from the course of action [11].

2.2.2 Value Stream Mapping (VSM)

Value stream mapping is the set of processes including value-added and non-value-added activities, required to transform raw materials into finished goods that the customers value. The value stream can be defined by the customers but in some cases, companies must identify the entire value stream for each product or each product family by themselves [12].

Value stream mapping is a process that helps organization systematically to identify and eliminate the non-value-added activities and generates a design and a plan to implement lean manufacturing. It is a visual representation of all the specific activities including the flow of material and information which occurs along the value stream selected for a product or family [13].

There are four steps to value stream mapping [13]:

i. Preparation: Record as much information as possible and draw the current state map.
ii. Process design: In this step, all the possible information for each process of the value stream selected including cycle time, changeovers times, number of operators, inventory in process, available time and etc. must be collected.
iii. Product development: In this step, the company must identify customer requirements; quantity required daily, method of transportation, etc.
iv. Planning: Develop the future state map.

2.2.3 Standardized Work

Standardized work involves three elements which are the baseline against which any given process can be assessed: takt time, work sequence, and in-process stock. Standardized work is relayed to the operators through standard operations sheets and charts that define standard work [9].

Standardized work is the safest, easiest, and most effective way of doing the job that we currently know, but the purpose of standardized work is to provide a basis for improvement on that job. The goal is to optimize the utilization of people instead of machines because the flexibility of people provides more benefits than machine utilization. Standardized work provides many benefits such as process stability, clear stop and start points for each process, organizational learning, audit and problem solving, employee involvement, pokayoke, and kaizen (continuous improvement). It also provides a basis for training [14].

i. Takt Time and Cycle Time

Takt time refers to the frequency of a part or component that must be produced to meet customer demand. Takt time depends on monthly production demand. If the demand is increased, the takt time decreases and if the demand is decreased, the takt time increases and this means that the output interval is increased or decreased. Thus, takt time is the speed with which the product needs to be created in order to satisfy the customer needs. Takt time plays a leading role in manufacturing systems [15]. Takt time is calculated as follows [16]:

______________ .....(1)

While cycle time is defined as the period required to complete one of an operation, or to complete a function, job, or task from start to finish. Cycle time is used in differentiating total duration of a process from its running time. In manufacturing, cycle time is the total it takes to produce an order [17].

ii. Work Sequence

It is the standard operations routine or the order in which the work is done in a given process and represents the current best way known to accomplish the task [18].

iii. In-Process Stock

Or standard quantity of work in process is the minimum number of unfinished work pieces required for an operator to complete the process. Work cannot progress without this certain number of pieces on hand. The standard quantity held should be kept as small as possible because this will reduce holding costs as well as providing a visual control for checking product quality because defects are more evident [14].

3. Literature Review

Inventory management is an important part in making all the decisions in handling the inventory in an organization such as activities to be carried out, policies of inventory management, and procedures in handling the inventory in order to ensure enough quantity of each item is kept in the warehouse at all times. Besides, the organization puts a lot of effort in controlling the inventory expenses through inventory management [19].

Othman N. (2015). Has studied the issues arise as a result of poor inventory management faced by organization were underproduction, over production, stock out situation, delay in delivery of raw material and discrepancy of inventory. In his research, Kanban system was proposed where primary and secondary data of raw materials were used to analyze the data collected. The Kanban card was applied to schedule the flow of operation. The production people must follow the Kanban schedule and prepare to order raw materials, the stocks of raw material reduces. First-In-First-Out (FIFO) implemented to make sure the product movement becomes more smooth and efficient than before [20].

Mazanai M. (2012). Conducted a study to investigate the impact of Just-In-Time (JIT), inventory management system in South Africa. The objectives attempted were the application of JIT to investigate the effects the inventory management approach on cost, efficiency, quality, and flexibility of SMEs. The study employed questionnaires and the results of the reduced storage costs, low loss of products were due to obsolescence and lower inventory holding costs. Furthermore, results have found a statistically positive significant relation between the application of JIT, inventory management, improved quality, and flexibility [21].

Salleh N., et al. (2012). Finding from survey used in order to evaluate the integrated TQM and Lean Manufacturing (LM) in a Malaysian Automotive company, by a forming company. Their purpose is to achieve total to remove the eight wastes in any process in an organization, measure the consistency between simulation and actual result for other type of process. Delmia Quest Simulation has proven to be able to simulate the manufacturing process. It was also found out that in lean manufacturing system, takt time and Yamazumi chart are very powerful tools that can be used together with cycle time in mass production. Yamazumi chart used to relay out their production line from push production to pull production. Less work in process parts cause low inventory, thus, this helps the company to have more cash flow rather than having to keep stocks as more WIP parts will affect the total revenue of the company for the year. More space arranged in ways that avoid wastes of time, inventory, motion, over produce and over processed [22].

Rehab M. A. and Ahmed M. D. (2014). They presented a dynamic model to evaluate the degree of leanness in manufacturing firms. The model was based on system dynamic approach and presents a ''leanness score'' for the manufacturing system. The leanness score system was composed of three metrics which were Overall Equipment Effectiveness (OEE), Overall Work-in-process Efficiency (OWE), and Overall service level (OSL). In addition, it has examined the dynamics associated with the application of '' One-piece flow'' concept via ''Takt time''. Results showed that working on adjusting the system's cycle times to follow takt time will improve the overall performance. Improvement are reflected in the overall service level, overall WIP efficiency, and overall equipment effectiveness. The developed model with its performance metrics has helped the decision makers in adopting optimal parameters settings of the system [23].

Sain M. K., et al. (2015), objectives are reducing production lead time and WIP in order to increase the production rate in TEI Company, Jaipur, so that customer order demand can be fulfilled. Batch processing in full capacity and bottlenecks in the production process were key contributors to long production lead times. VSM lean tool is used in bearing manufacturing industry by focusing both on processes and their cycle times. Results of the research had direct impact on product production lead time and WIP which resulted in reducing cost and meeting customer demand. The total lead time was reduced from 7.3 days to 3.8 days, the WIP at each workstation has also been reduced and the production lead time was reduced from 409 seconds to 344 seconds [24].

4. Data Collection and analysis

In order to evaluate the lean aspects and relative waste general company for hydraulic industries with focus on Dampers and Tasks Factory (DTF) has been selected as a case study. This factory produce two types of dampers are front and rear for different cars brands as Hammer, Chevrolet, Samaned, Nissan pick-up, Ford, pride and ByD. Sample of dampers produced, which are shown in Fig 3.

The main parts involved in the manufacturing process are body, inner cylinder, bushing, pipes while other parts (standard) are exported from countries like Spain, or China. The current annual production plan is prepared in advance according to market need of certain products. Although DTF produces different car dampers however, the production processes are rather similar.

.

Figure 3. Different Types of Dampers

Damper also known as shock absorber, consists of 29 parts 26 parts are imported and three parts are manufactured in the factory (as maximum).

Nissan and Samand Rear Dampers are selected as the most customers demanded products. Where two parts of Samand rear damper are produced in the company are:-

- Body (manufactured parts for one damper is one piece for each rear damper).
- Inner cylinder (manufactured parts for one damper is one piece for each rear damper).

While three parts of Nissan Pickup rear damper produced in the company these are;

- Body (manufactured parts required for one damper is one piece for each rear damper).
- Inner cylinder (manufactured parts required for one damper is one piece for each rear damper).
- Bushing (manufactured parts required for each rear damper four piece should be produced.

Figs 4 and 5 show 2D detailed dimensions for the above mentioned rear dampers generated using AutoCAD (2010), all dimensions are in (mm).

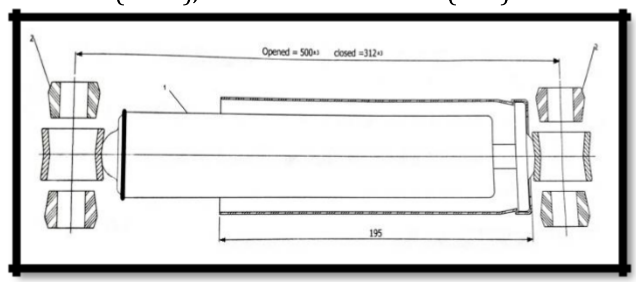

Figure 4. Nissan (Pick up Rear) Damper

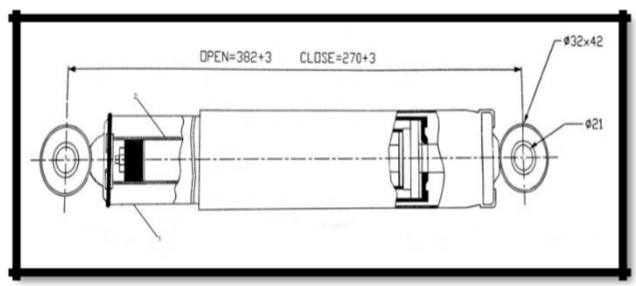

Figure 5. Samaned Rear Damper

5. Technological Path

- The factory consists of processing and assembly areas. Each damper is passing through 20 different processes to be a final product knowing that, the number of pieces produced of Nissan and Samaned rear dampers are 25 Pcs. / day.

  The production line consists of the following sequence of processes that are shown in Table 2 and the process flow diagram for this production line is shown in Fig 6.Knowing that:-

- Most of the inspections are visual or using manual inspection tool (Vernia) except the final test which is done using machine to measure the speed, extension force, and compression force for damper within the specified standards.
- All the transportation processes are manual by two operators in the processing and assembly areas using containers (van) between these processes.
- Inventories types in damper factory are raw materials inventory, WIP, and finished products inventory. All WIP inventories are kept in the containers.
- Raw materials inventories which are Semi-processed materials referred as standard parts.
- Standard Parts are referred to the parts / subassemblies imported i.e. not manufactured in DTF factory.

Table 2. Detailed Production Processes of the Dampers

	No.	Processes	Description of the Process/ Stage
PROCESSING	1.	Cutting	Raw material for body and inner cylinder and bushing are brought to cutting machine which single automated. Where the whole factory depends on it knowing that there is another manual machine not used.
	2.	Chamfering	Bushing and the body pass through this process to perform edge break.
	3.	Turning	Where the length and break edge of the inner cylinder at 45 angles is processed.
	4.	Chemical cleaning	Treatment of corrosion for body and bushing. By using 10% HCl at (at a room temperature which approximately from (25-35) °.
	5.	Point welding	The ring and the tip (Standard parts) are welded by point welding machine then welded together with the Shift (Standard part) and Bushings.
	6.	Arc welding	The body and reservoir head (standard part) are welded with ring (standard part) and Bushing in point welding process.
	7.	Cleaning	Inner cylinder, body, and shift are cleaned from the slag and impurities. Further clean is conducted manually by a piece of cloth.
ASSEMBLY	8.	Compression	Seven Standard parts are compressed together in compression machine and then assembled with the shift.
	9.	Extension	Eleven standard parts are assembled together to perform the extension set that will be assembled with the inner cylinder and shift.
	10.	Guiding set	Three standard parts are assemble with the inner cylinder.
	11.	Oil filling	The damper is filled with oil depending on the size, speed, weight, and type of car.
ASSEMBLY	12.	Bending over	The tip is bended over with the body using rotary turning machine.
	13.	Testing machine	The assembled dampers are tested (it a machine that used to measure the speed, extension force, and compression force for damper within the specified standards rate), if the tested part is not throughout this rate the part will be reworked.
	14.	Join operation	Joining the damper with the plastic cover (standard part).
	15.	Washing process	The parts are immersed in tanks to be washed by water.
	16.	Phosphate coating	Phosphate coating protect parts from rust, by spraying or immersion. Phosphating steps are; remove grease and fat, using three Chloride Ethylene or Sodium Chloride, Sodium Hydroxide, Sodium Triphosphate. This process is conducted at 90 ° for 10-15 minutes. Benefits are; limit the moisture access to the metal surface and prevent rust, and offer good base for the cohesion of the layers of paint.
	17.	Washing process	In cold water wash basin, the parts are immersed for 15 minutes.
	18.	Painting	The dampers are painted by electrostatic painting.
	19.	Drying	Dampers are dried for three hours (air drying).
	20.	Packaging	Packaging all the dampers, two pieces in each package.

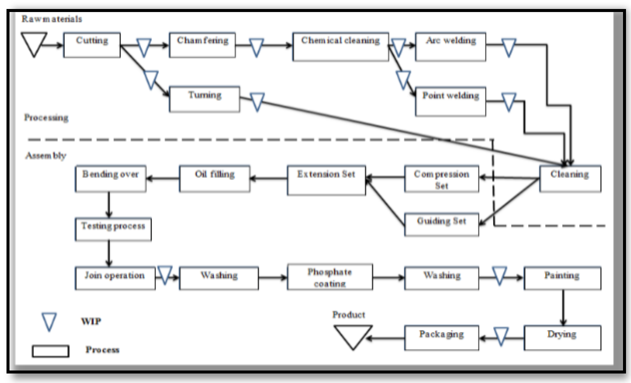

Figure 6. Flow Chart for Manufacturing Processes

6. DTF Inventory Data and Information

The factory uses push production system thus high inventory between processes is noticed, therefore according to lean concept it is waste. Table 3 shows the WIP for each process and the time loss due to waiting between processes for Nissan and Samaned dampers separately.

Table 3. Actual WIP and Time for Each Process for Nissan and Samaned rear Dampers

	No.	Processes	Nissan WIP (units)	Waiting Time (minutes)	Samaned WIP (units)	Waiting Time (minutes)
PROCESS	1.	Cutting	150	2	50	2
	2.	Chamfering	125	150	25	150
	3.	Chemical cleaning	50	75	25	75
	4.	Point welding	25	60	25	15
	5.	Arc welding	25	250	25	250
	6.	Turning	25	150	25	150
	7.	Cleaning	----	250	----	250
ASSEMBLY	8.	Compression set	25	----	25	----
	9.	Extension set	25	----	25	----
	10.	Guiding set	25	----	25	----
	11.	Oil filling	----	1.5	----	1.5
	12.	Bending over	----	2.5	----	2.5
	13.	Testing machine	----	----	----	----
	14.	Join operation	25	3	25	3
	15.	Washing process	----	125	----	125
	16.	Phosphate coating	----	----	----	----
	17.	Washing process	----	15	----	15
	18.	Painting	25	----	25	----
	19.	Drying	25	125	25	125
	20.	Packaging	25	180	25	180

From the Table 3, it can be noticed that;

- Waiting time is not depending on the damper neither on the type process.
- WIP for Arc welding, packaging, followed by chamfering, drying, and chemical cleaning were the highest waiting time due to type of process, and requirements.
- Waiting time before Arc welding and cleaning was 250 minutes in both products i.e. 4 hrs. out of 7 hrs. i.e is more than half working day.

7. Results and Discussion

It is important to investigate this production system, therefore evaluate the overall work efficiency for this production system is calculated using equation 2

Thus OWE for DTF is:-

For both dampers as shown in Table (4) below. It can be noticed from the above results of both assembly and production operation areas, OWE is less than rang the recommended which is 25%-30%.

Table 4. OWE for DTF Factory

OWE %	Nissan rear Damper and Samaned rear Damper
Production	9.7
Assembly	14.5
Whole DTF	24.2

7.1 Waiting Time for DTF Factory

Since calculation the amount WIP, to determine the percentage of completion, and assign a cost to is time consuming. it is standard practice in many companies to minimize the amount of WIP just prior to the end of a demand period.

Figs. (7 and 8) below show the WIP in the production processes area and assembly area for Nissan and Samaned rear dampers respectively.

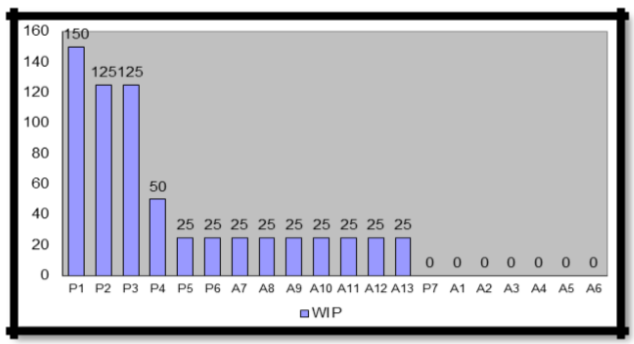

Figure 7. WIP for Nissan Rear Damper

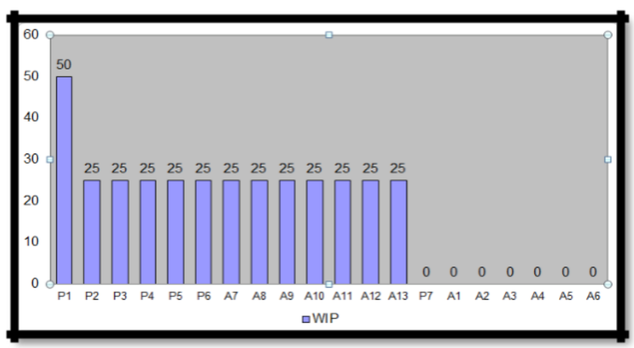

Figure 8. WIP for Samaned Rear Damper

Form these above figures, it could be noticed that:

- WIP between production possesses is larger as compared to the assembly area.

- WIP is too high for both dampers tested types before the cutting process (assigned as P1).Thus WIP should be decreased.

7.2 Inventory Issues for DTF Factory

The issues that faced inventory management in this company according to lean manufacturing waste taxonomy are; underproduction, overproduction, stock out situations, delays in the delivery of materials and discrepancy of inventory records. Fig 9 below illustrates for both Nissan and Samaned dampers.

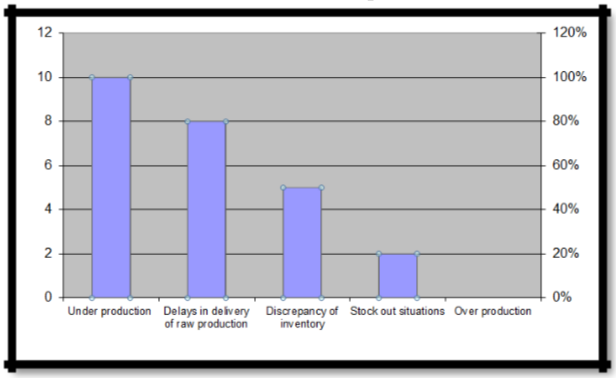

Figure 9. Inventory Management issues for Samand and Nissan rare dampers

From this fig. It could be noticed that;

- The highest value was for underproduction because the production rate is lower than customers' demand. If inventories are low or under production it will cause stock out situation(when the safety stocks of products are unable to meet market demands.

- Delay in delivery of raw materials (or standard part) from suppliers. The time needed form supplier to receipt and process the order, sometimes is long (ranging from 2 weeks- to one month).
- Discrepancy of inventory records always occur and the actual quantity of materials is not relevant to customers' order. loss of worker productivity due to error in material documentation, misplacement, and misappropriation of inventory in the factory. This issue should not occur since this company was accredited by ISO since 2008 and documentation should be proper since that time.

From the previous process and performance data analysis, it could be concluded the following:

- ❖ This factory suffers from many issues causing decrease in process performance regardless the type of damper or the no. of pieces produced in each rear damper which were three pieces for Nissan and two pieces for Samaned.
- ❖ The major issue in DTF factory was non adding value activities and time. These activities were depicted in WIP causing under / over and production discrepancy. While the NVA time was almost 90% of cycle time for both of the above selected dampers.

Therefore improvement should be introduced to decrease WIP either by using pull system since the system is job shop or by reducing the number of parts to be pushed, or by increase handling parts .

8. Developing production processes toward lean manufacturing.

It was mentioned earlier that the WIP is crucial in the aspects of quantity and waiting time throughout different processes regardless the type of rear damper produced causing an increase in the cycle time and waiting time. Therefore, two different improvements was introduced;

1. Since waiting time for the chemical cleaning process is 75 min. Therefore, instead of transporting parts after finishing all of them in 75 mins.(the current status). Transporting parts after finishing 25 parts at 15 min. Thus saving cycle time, reducing waiting time of WIP as the processing (chemical cleaning) requirements is 25 parts each batch.
2. Introducing 5S Approach

Many companies begin their lean transformation with 5S because they expose some of the most visible examples of waste and also helps establish the framework and discipline required to successfully pursue continuous improvement initiatives.

From Table 5, it can be showing that for production and assembly processes in the DTF factory.

- The min. 5S value for the production and assembly processes was 30% that because of the working conditions were not implemented to maintain Sort, Set in order, and Shine.
- The second min of 5S is for Set in order, 35% for production processes, and 45% for assembly processes and this means that the storages principles (location indicators, item indicators, quantity indicators, marking of walkways, and tools) were needed more improvement. By facilitating the working place by using the one or all of the following

strategies such as sign board strategy, painting strategy, and outlining strategy.

- There were less or no documentations even though the company had a certificate of ISO 9000/2008.

Table 5. Results of 5S of Damper Factory

5S	Production processes	Assembly processes
Sort	50%	50%
Set in order	35%	45%
Shine	50%	55%
Standardize	30%	30%
Sustain	60%	60%
Overall %	45%	48%

- Improvements throughout implementing of 5S (sorting, sign board strategy) for WIP by facilitating the working place by using the following strategy
    1. Sign board strategy which identifies what, where and how many items should be sorted. There are three main types;
        i. Location indicators, which show where items go.
        ii. Item indicators, which show what specific items go in those places, and
        iii. Amount indicators

Table 6 shows the results achieved of 5S of damper factory.

Table 6. Improvements in 5S for DTF Factory

5S	Production processes		Assembly processes	
	Current	Future	Current	Future
Sort	50	50	50	50
Set in order	35	70	45	80
Shine	50	50	55	50
Standardize	30	45	30	45
Sustain	60	60	60	60
Overall %	45	55	48	57

9. Conclusions and Recommendations

1. DTF factory suffers major inventory issues issue depicted in WIP, under/over and production discrepancy.
2. WIP between production possess area is larger as compared to the assembly area.
3. WIP is too high for both dampers tested types before the cutting process.
4. OWE is less than rang the recommended which is 25%-30%.
5. Waiting time is not depending on the damper neither on the type process. Where Arc welding and cleaning processes waiting time is 250 (4 hrs. out of 7 hrs minutes) in both tested products i.e. is more than half working day.

Therefore continuous improvements are essential for this manufacturing system. Since lean manufacturing offers fast out comes. Two improvements were presented those results in decrease in WIP waiting time for Nissan and for Samaned causing an increase in OWE that could be achieved was up to 10% for Nissan, and 2% for Samaned. Also Improvements in 5S of 50% production processes and 43% assembly processes for set in order, 33% in both production and assembly processes for standardize. It is recommended to introduce another process improvement strategy that could be concurrently affect positively as TQM, or Six Sigma.

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