Balancing of Takt Time in A Cellular Manufacturing Industry

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ABSTRACT:
In recent years, cellular manufacturing has emerged as a potent tool for enhancing productivity. However, realizing the full potential of cellular manufacturing hinges on two primary factors: the design of machine cells and part families, and the operational methods that leverage the inherent advantages of the cell structure. Even with an efficiently designed cell, inappropriate loading and scheduling methods can undermine the effectiveness of the cellular manufacturing system (CMS), potentially leading to failure.

This study was conducted at "TAFE INDIA PRIVATE LTD" in Madurai, focusing on optimizing production through Takt time analysis and bottleneck reduction. By employing these strategies, the production time was balanced effectively. A case study presented in this thesis identified bottlenecks within the assembly shop. Through Takt time analysis, these bottlenecks were addressed by reducing cycle times, consequently boosting productivity. Additionally, in cases where component models varied, alternating with other components facilitated successful Takt time optimization.

Maintaining Takt time was achieved through bottleneck reduction or elimination of delays. This method eliminates wasteful activities by synchronizing and balancing work steps, ensuring seamless progression of products from one step to the next, one piece at a time until completion. Bottleneck activities were identified, root cause analysis was conducted, and solutions were identified and implemented through an action plan. All actions were standardized to ensure consistency and efficiency.

Keywords: Takt time, Bottleneck and Cellular Manufacturing System (CMS).

1.0INTRODUCTION

1.1 TAKT TIME

Takt time, originating from the German word Taktzeit meaning "meter," represents the average unit production time required to fulfill customer demand. For instance, if a customer seeks to purchase 10 units per week, each unit should ideally take 4 hours or less to manufacture within a 40-hour work week. In industrial manufacturing, production cycle times must align with or be shorter than the Takt time to ensure production meets customer demand. Take, for example, automobile manufacturing, where cars move along an assembly line at a specified cycle time, ideally transitioning to the next station within the takt time to prevent over or underproduction. Typically, the cycle time for each station is shorter than the takt time, allowing for a buffer against uncertain demand and process disruptions like unplanned downtime. While the aim is to synchronize cycle time precisely with takt time to avoid inventory buildup and equipment over-sizing, the dynamic nature of demand and potential disruptions necessitates a slightly shorter cycle time in practice.

1.2 IMPLEMENTATION

Takt time is utilized across various tasks in business operations, including manufacturing processes like part casting, hole drilling, and workspace preparation, as well as control tasks such as part testing and machinery adjustment. It is particularly prevalent in production lines where products move through stations performing predefined tasks. Implementing a takt system offers several benefits:

The implementation of a takt system in manufacturing processes offers several advantages. Firstly, it facilitates the identification of bottlenecks and unreliable stations, as delays in product movement become immediately noticeable, allowing for timely intervention and optimization. Secondly, the limited time allotted by the takt serves as a motivational factor for eliminating non-value-added tasks such as machine setup and product transportation, thereby streamlining operations and enhancing efficiency. Thirdly, the specialization of workers and machines in specific tasks under the takt system contributes to increased productivity by reducing the need for daily adaptation to new processes, promoting consistency and proficiency. Finally, the takt system minimizes opportunities for product removal from the assembly line before completion, thereby reducing shrinkage and transit damage, ensuring the integrity of the final product and optimizing overall production output.

1.3 PRODUCTION METHODS IN TIME CYCLE

- Takt time
- Matching the rate of production to the rate of sales or consumption
- Cycle time
- Time required for the operator at one stage
- Throughput time

1.3.1 MATCHING THE RATE OF PRODUCTION TO THE RATE OF SALES OR CONSUMPTION

Similar parts of machining process containing the production to developed and produce the lot of machining. Some of the machined parts are stored through the allocated area, which the listed process to consume every machined parts through stores.

1.3.2 TIME REQUIRED FOR THE OPERATOR AT ONE STAGE

The manpower work conceding the factor of combination with the machines. The workers domain their respected work and desired works are alerted through the labour. The leading hours should be taken by the labor, and he done the several types of work involvement. But the value of product and the efficiency is less. The time concerned about the workman's rest hour. So the need of worker to fulfill the self-sources in various periods.

1.3.3 THROUGHPUT TIME

The amount of material or items passing through a system or process is known as throughput and much of the time to taken by the process is well known as Throughput Time. The system throughput or aggregate throughput is the sum of the data rates that are delivered to all terminals in a network. Throughput is essentially synonymous to digital bandwidth consumption; it can be analysed mathematically by applying the queuing theory, where the load in packets per time unit is denoted as the arrival rate (λ), and the throughput, in packets per time unit, is denoted as the departure rate (μ). The throughput of a communication system may be affected by various factors, including the limitations of underlying analogue physical medium, available processing power of the system components, and end-user behaviour. When various protocol overheads are taken into account, useful rate of the transferred data can be significantly lower than the maximum achievable throughput; the useful part is usually referred to as good put.

1.4 TIME STUDY TOOLS

The focused work was taken by the operators and to study their work and do their work for an alerted time were the work had finished their level. The systematic work flow has done by the workers on their period of working hours. Some of the people were take much of time to finish the work, in which the area of buffering and to handle the near one, who was finished his work before the takt time range. By the way to distribute the work through entire level of cell 5 unit and consume the break even analysis. Major bottleneck contributing factors has been identified by plotting graph between the Actual time and the designed Takt time.

Time Study measures how long it takes for an average worker to complete a task at a normal pace. It helps management determine how much is produced by workers in a specific period of time, therefore making it easier to predict work schedules and output. Motion and Time Study is a scientific method designed by two different people for the same purpose, to increase productivity and reduce unit cost. The two methods evaluate work and try to find ways to improve processes. Computers, barcodes and accustudy software are the main tool to be used today for time study.

2.0LITERATURE REVIEW:

In recent decades, various methods, such as agile, flexible, and intelligent approaches, have been extensively explored to enhance the productivity of manufacturing plants. Notably, Cellular Manufacturing Systems (CMS) have garnered significant attention from both researchers and industries. Johannes Hinckeldeyn et al. (2014) highlighted the detrimental impact of bottlenecks on company performance. While previous bottleneck management research primarily focused on manufacturing processes, their work introduced a novel bottleneck management concept tailored for product design and engineering processes, thereby broadening the scope of bottleneck management.

Similarly, Jin Zhang et al. (2013) emphasized the vulnerability of logistics networks in a global environment to unforeseen emergencies. They proposed a cellular stochastic diffusion search-based intelligent algorithm to address such challenges, underscoring the critical importance of research in emergency logistics system [1].AtulAgarwal et al. (2008) delved into performance and cost considerations during the transition from a functional layout to a cellular manufacturing (CM) layout. Their decision framework offered a systematic approach for practitioners undergoing such conversions, contributing valuable insights into integrated performance and cost issues [2]. Meanwhile, Koichi Nakade et al. (2008) tackled optimization problems in U-shaped production lines with multiple heterogeneous multi-function workers. Their study aimed to minimize cycle time while satisfying demand constraints, shedding light on workforce allocation strategies in manufacturing settings. Furthermore, O. Kulak et al. (2005) proposed a framework based on Axiomatic Design principles to guide the transformation of traditional production systems towards cellular orientation. Their feedback mechanism for continuous improvement provided a structured approach to evaluate and enhance cellular design against predefined performance criteria [3]. Bhaba R. Sarke et al. (2001) introduced the concept of grouping efficiency as a measure of machine-part group quality in cellular manufacturing systems. Their evaluation of different grouping measures, including the novel double-weighted grouping efficiency measure, offered insights into optimizing machine-part groupings for improved system performance [4].

Sobhanallahi et al. (1998) developed a comprehensive decision framework for the conversion of functional layouts to cellular manufacturing layouts, considering both performance and cost aspects. Their total cost model and examination of setup time reduction's impact on cell operations provided practical insights through a case study in a small manufacturing organization [5]. Lastly, Kanton T. et al. (1998) outlined a systematic process for developing cellular production systems, particularly for shock absorber manufacturing. Leveraging lean manufacturing techniques such as Just-In-Time and product-oriented layouts, their approach emphasized single-piece part flow aligned with takt time principles, highlighting the importance of efficient production system design [6].These studies collectively underscore the diverse strategies and methodologies employed to optimize manufacturing processes, from bottleneck management and logistics optimization to layout redesign and workforce allocation, ultimately contributing to enhanced productivity and performance in manufacturing industries [7].

3.0 IDENTIFICATION OF BOTTLENECK ACTIVITY

3.1 INTRODUCTION

This chapter was discussed about the manufacturing method, manufacturing time involved in the production and the various cycle of the machines for the identification of the bottlenecks.

3.2 BOTTLENECK

In production and project management, a bottleneck is one process in a chain of processes, such that its limited capacity reduces the capacity of the whole chain. An example is the lack of smelter and refinery supply which cause bottlenecks upstream. Another example is in a surface-mount technology board assembly line with several pieces of equipment aligned. Usually the common sense is driven to set up and shift the bottleneck element towards the end of the process, inducing the better and faster machines to always keep the PCB supply flowing up, never allowing the slower ones to fully stop, a fact that would be heeded as a deleterious and significant overall drawback on the process.

3.3 IMPROVING PRODUCTIVITY FROM ACTUAL CYCLE TIME BY THE SOURCE OF BOTTLENECK ACTIVITY

The stage wise activity details with the cycle time of each process and the total cycle time for each process was calculated.

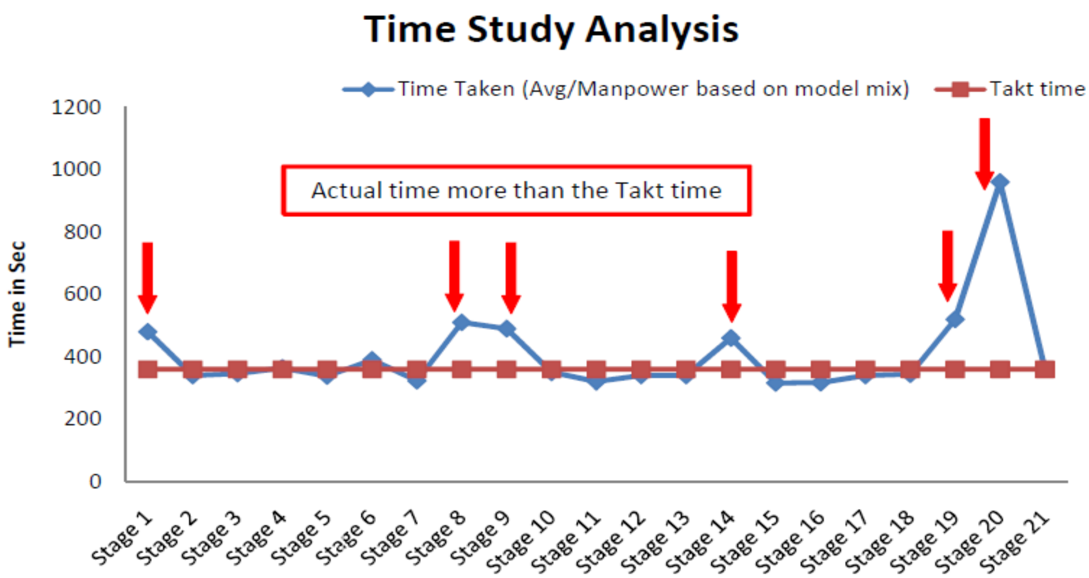

Figure 1 Time study Analysis in Takt Time Range

Total manpower employed in the respective stage and the available time was taken. Both the values are compared and the bottle neck activity (Time consuming process) was identified in the bottleneck stage. In production work, skill yields outputs. The same job function is executed by many workers in parallel according to the work process standardized by the backup function namely, production engineering staff. The workers, it is assumed, perform no knowledge work in performing their assignments. An example is the lack of smelter and refinery supply which cause bottlenecks upstream. Another example is in a surface-mount technology board assembly line with several pieces of equipment aligned. This cycle of variable time is shown as table 3.1. Usually the common sense is driven to set up and shift the bottleneck element towards the end of the process.

The numbers of an activity which consumes more time in the concerned stage and contribute for the bottleneck are as follows,

Table 1 The takt time for various activities

Activity Description	Stages	Takt time in H:MM:SS
Shuttle Lever, Ball Joint Connection	Stage 1	0:06:00
ROPS top frame manufacturing	Stage 8	0:03:00
Main harness routing and strapping process	Stage 8	0:03:00

Fender, extension plates & dummy plugs	Stage 9	0:02:00
Swinging drawbar fitment process	Stage 9	0:10:00
TC top cover	Stage 14	0:02:00
Propeller shaft manufacturing	Stage 14	0:06:00
Surround & Cluster fitment	Stage 20	0:08:00
Hood seating	Stage 20	0:12:00

The findings that cause bottleneck are:

The current assembly process faces several challenges. Firstly, the designed takt time is shorter than the actual assembly time, leading to potential delays and inefficiencies. Additionally, the process heavily relies on manual labor, making it susceptible to factors like operator fatigue and inconsistency. Manual handling of parts further exacerbates these issues, increasing the risk of errors and slowdowns. Moreover, the assembly line lacks proper balancing, resulting in uneven workloads and decreased throughput. Recognizing the need for productivity improvement, there's a clear imperative to address these shortcomings. The present assembly procedure is time-consuming and hindered by various factors, highlighting the urgency for optimization and streamlining measures to enhance efficiency and output.

Table 2 Opportunity for Productivity Improvement

Bottleneck Activity Description	Stage	Actual Cycle Time	No. of Persons	Designed Cycle Time	Scope for Productivity Improvement
Shuttle Lever, Ball Joint Connection, Main harness routing and strapping process	Stage 1	1444	3	360	364
ROPS top frame mounting	Stage 8	1013	2	360	393
Fender, Extension plates & dummy plugs	Stage 9	972	2	360	352
TC top cover and propeller shaft mounting	Stage 14	594	1	360	234
Swinging drawbar fitment Process	Stage 19	1315	3	360	235
Surround, Cluster fitment and Hood seating	Stage 20	2806	5	360	1006

3.4 RESOLVING OF BOTTLENECK REMEDIES

Based on the Cycle time analysis conducted on the bottleneck stages, it is evident that productivity improvements are necessary in Stage 1, Stage 8, Stage 9, Stage 14, Stage 19, and Stage 20, as indicated in Table 3.2. By enhancing productivity in these stages, the cycle time of bottleneck activities can be aligned with the actual takt time of the main line assembly. Analysis of takt time application sources reveals opportunities for improvement in the production area. Implementing such improvements, particularly in fertilizers, can enhance the quality of work in this tractor manufacturing industry and help mitigate bottleneck challenges. Applying takt time principles has proven beneficial in avoiding overload issues in Cell 5. By identifying the time taken by similar processes and implementing our new takt time methodology, we successfully reduced workload. The following activities contribute to achieving this objective and are listed below. In Cell 5, which consists of 20 stages, the existing setup and its improvement with cycle time savings are outlined in the following table.

Table 3 The Suggestions for Improvement

Stage	The existing setup	The improvement suggested	Time savings in seconds
Stage 1	The existing lever sub assembly has 2 racks and occupied more space in assemble line.	Special provisions made for sub assembly along with fixture and proper binning arranged for loose parts. Operator fatigue reduced and morale improved and repeated quality issues eliminated.	70
Stage 1	The existing oil draining process was done manually with the help of air purging for both engine and gearbox oil which was found during gearbox testing, Improper draining (Man dependant) and Time consuming.	Using sensor system, the air purging system was automated. Once the airline is picked, it will start to dispense air for 280 seconds for engine oil and then 2nd sensor will be actuated and start purging air for 280 seconds for gear oil.	240
Stage 1	The existing process of component binned in assembly point and milk	The procedure was executed the new system are developed by the	50

	run concept used for part replenishing. The operator movement high for picking each part and large inventory at assembly point.	work on kitting system introduced for line feeding component pick up time reduced and inventory reduced at assembly point.	
Stage 9	The existing fender handling, manually handled. The couple of workers supported to maintain a single unit of fender.	Fender Handling improved by clubbing the Fender alongwith the ROPS mounting.	252
Stage 19	In existing practice draw bar manually lifted from pallet to mounting trolley caused more operator fatigue and necessity of couple of workers. Both are engaged to lift the draw bar, safety related issues to the operator, more fatigue due to weight and more cycle time.	New lifting hoist facility provided for draw bar lifting which has reduced the operator fatigue and only one man power is enough to handle the process, one workman can do the complete work, operator fatigue reduced and safety ensured.	235
Stage 14	The existing method of manual selection of the oil for each tractor type of oil manually selected quantity of oil manually selected. Possibility of wrong selection no foolproof method involved man dependant& more time consuming.	The new barcode system was introduced for a selection of type of oil quantity. The oil selections are through one time scanning fool proof process.	240
Stage 15	The existing work containing the pneumatic gun used for initial tightening for both sides. When using the torque wrench 16 bolts are torqued through one manpower work. Torqueing process was more fatigue.	The torque controlled DC nut runner installed for tightening the 16 bolts on either side. There is a manpower eliminated and used in bonnet sub assembly process.	360
Stage 20	The usage of bonnet assembly has single fixture previously. The cycle time of each assembly is more than 16 minutes. The bonnet delivery is once in 16 minutes only and then bonnet & sub assembly part pickup time is more line stoppages & Short fitment due to	The system has implement of Bonnet manipulator introduced. One manpower can handle the bonnet and one out of the two manpower employed can be eliminated. The line stoppage and Short fitment avoided and part pickup time reduced.	485

	delivery of bonnet after 16 min, Line Stoppage and short fitment encountered.		
Stage 20	The existing system of Bonnet manually lifted and fitted in in the tractors. There is 2 Manpower employed for this event and due to delivery of bonnet after 16 minutes, line stoppage and short fitment encountered. Finally part pick up time is more.	The system of bonnet manipulator introduced. One manpower can handle the bonnet and one out of the two manpower employed can be eliminated. By the utilization of the new system the line stoppage and short fitment avoided.	485
Stage 20	In existing practice, binnacle, and cluster were assembled in mainline. So the assembly sections has taking more cycle time and much more difficulty in assembly in mainline.	An introducing sub assembly station was fitted a sub assembled component in mainline and the sub assembly station introduced. And also considering main line assembly cycle time was reduced.	100

4.0 CAUSE OF BOTTLENECKS IN PRODUCTION

4.1 Introduction

A technique for generating ideas on a given subject within a limited period of time. Typically conducted in a facilitated session or workshop environment, it aims to stimulate creative thinking and develop novel or innovative solutions to problems by introducing "controlled chaos" into the thought process. It is the most widely used technique for cultivating ideas, prioritizing quantity over quality based on the principle that "many brains are often better than one."

4.2 Brainstorming

A group or individual creativity technique whereby efforts are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by its members. The term was popularized by Alex Faickney Osborn in the 1953 book "Applied Imagination." Osborn claimed that brainstorming was more effective than individuals working alone in generating ideas, although more recent research has questioned this conclusion. Today, the term is used as a catch-all for all group ideation sessions.

In this project work, a brainstorming session was conducted to obtain various solutions for the incurred problems in the assembly area, which were listed in Chapter 3.3 and Table 3.3 as suggestions for improvement.

4.3 ADVANTAGES

Democratic participation by encouraging all participants to contribute ideas freely and without judgment. It is a fast-paced and energizing activity that stimulates creativity without evaluating the content or quality of ideas generated. This environment of non-evaluation allows for the free flow of thoughts and promotes the exploration of diverse perspectives. Additionally, brainstorming has the capacity to stimulate ideas rapidly, with one idea often sparking others in a collaborative and iterative process. Its ease of use makes it accessible to a wide range of participants, enabling effective idea generation across various contexts and settings.

4.4 DISADVANTAGES

Encourages the free flow of ideas, it lacks mechanisms for converging ideas, potentially leading to the dismissal of valuable contributions that are not immediately recognized as relevant. Moreover, its capacity to leverage individual participant expertise directly is limited, which may result in overlooking valuable insights or specialized knowledge. Without firm management, brainstorming sessions can introduce excessive chaos, hindering productivity and coherence. Consequently, the absence of structured convergence mechanisms and the potential chaos may prolong problem resolution, impeding the efficiency of the brainstorming process.

While promoting idea generation, lacks mechanisms for converging ideas, potentially leading to the dismissal of valuable contributions that are not immediately recognized as relevant. Additionally, its reliance on group dynamics may limit the direct utilization of individual participant expertise, overlooking specialized knowledge. Without effective management, brainstorming sessions can introduce excessive chaos, hindering productivity and coherence. Consequently, the absence of structured convergence mechanisms and the potential chaos may prolong problem resolution, resulting in longer turnaround times for reaching solutions.

4.5 SUGGESTED MODIFICATIONS

Some of the figures to identify the bottleneck areas which is the process to containing for more work and the delay how to resolve by the new methodologies are followed here,

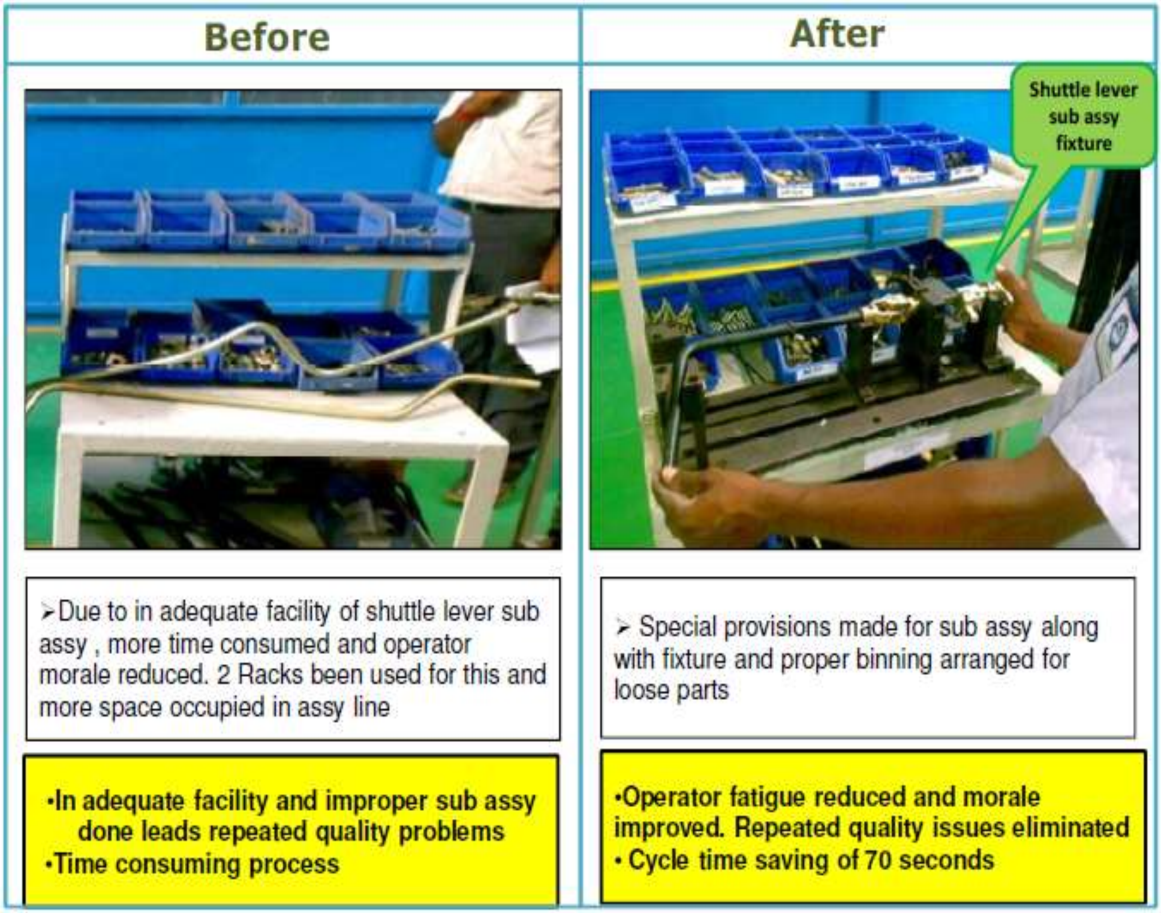

Figure 2 Cell 5- Stage 1 – Shuttle lever Sub Assembly Fixture

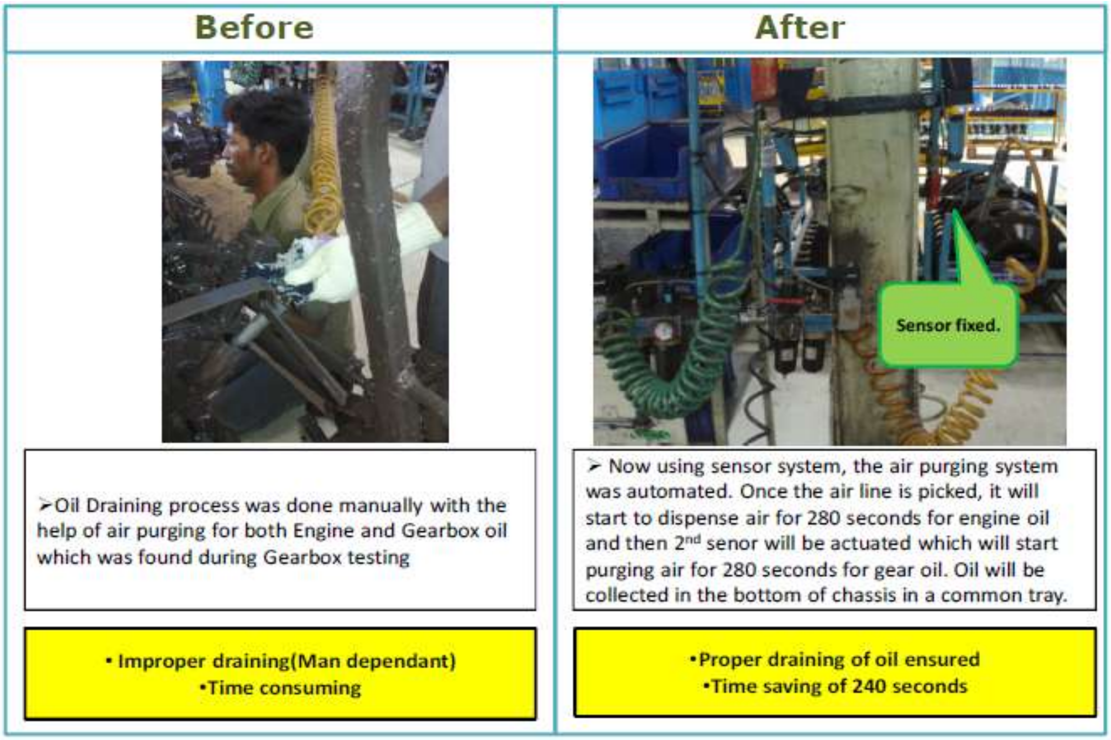

Figure 3Cell 5- Stage 1 – Engine Oil & Gear Oil Automation

Figure 4 Cell 5 – Stage 1 – Part Kitting System

Figure5 Cell 5- Stage 8 – ROPS & Fender Manipulator Introduction

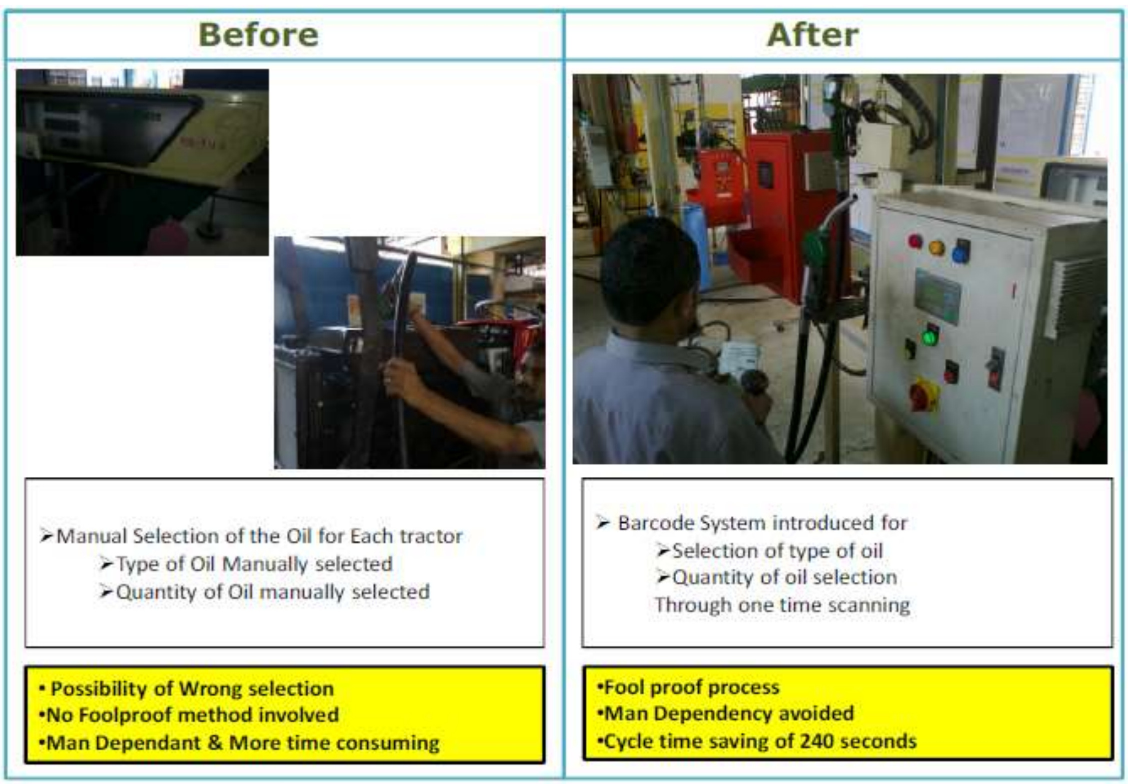

Figure 6 Cell 5- Stage 19 – Draw bar lifting new Hoist

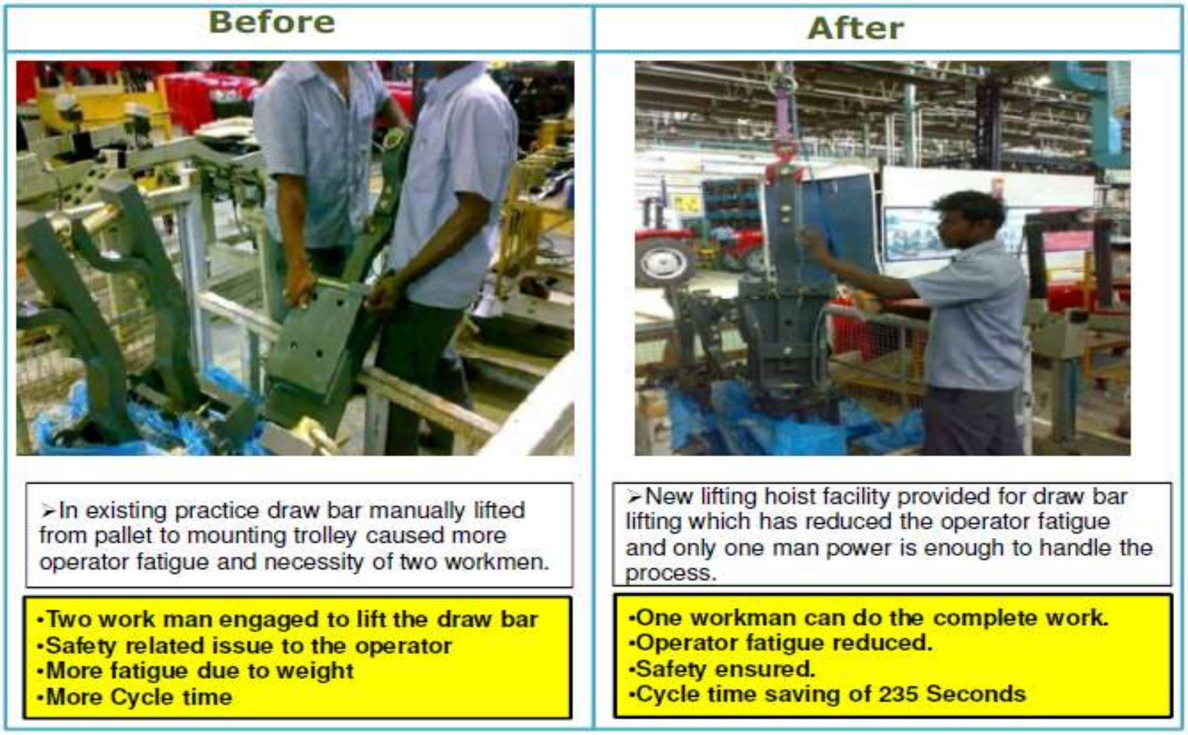

Figure 7 Cell 5- Stage 20 – Bonnet Sub Assembly Layout Change

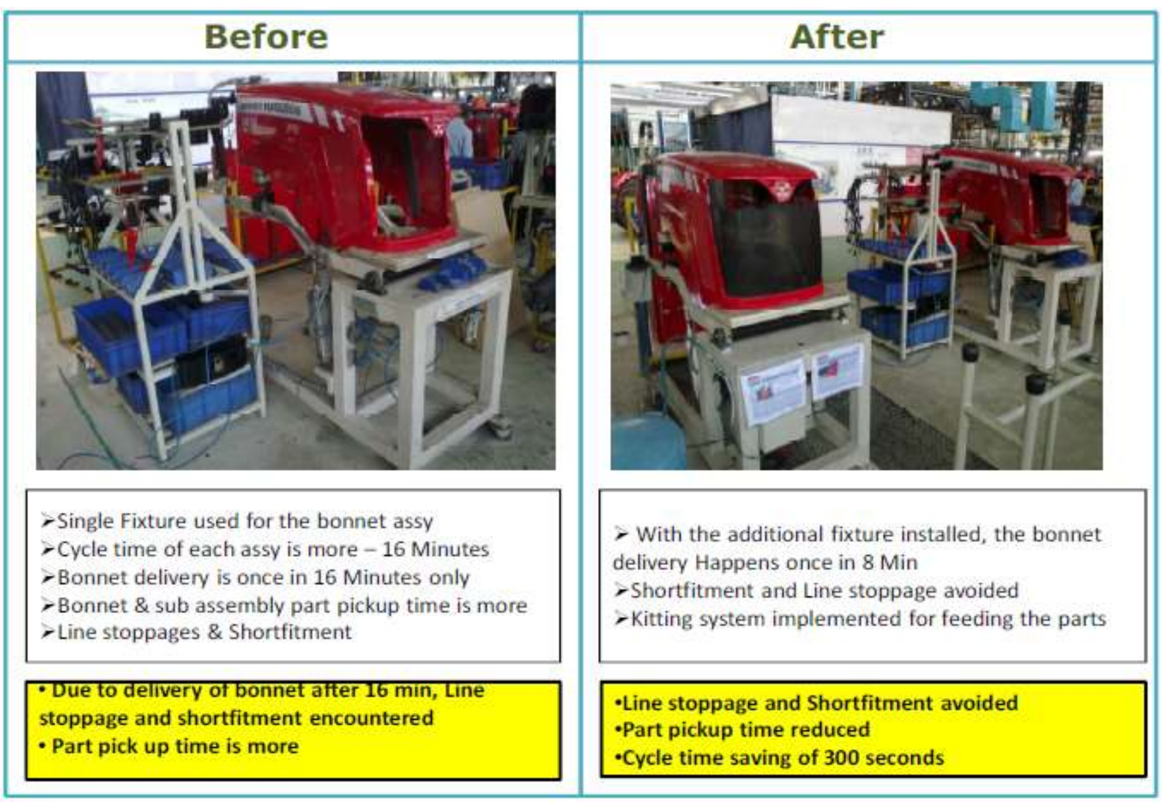

Figure 8 Cell 5- Stage 20 – Bonnet Sub Assembly Layout Change

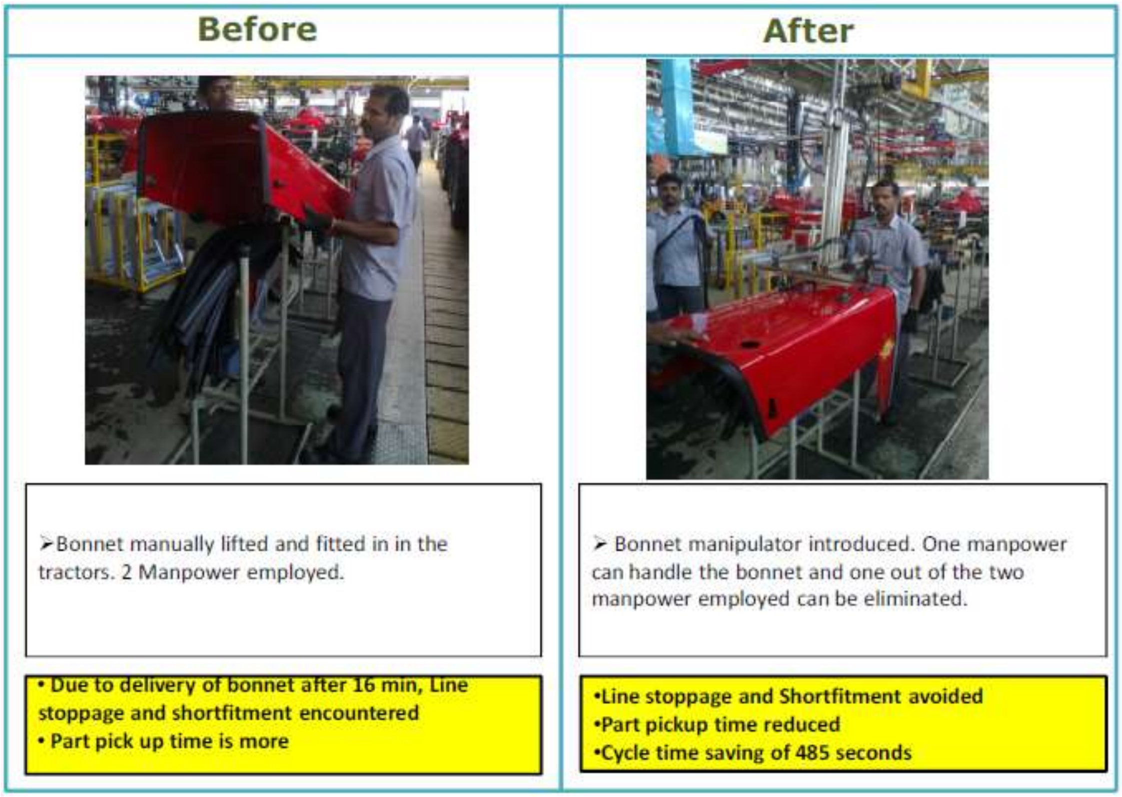

Figure 9 Cell 5- Stage 20 – Bonnet Sub Assembly Layout Change

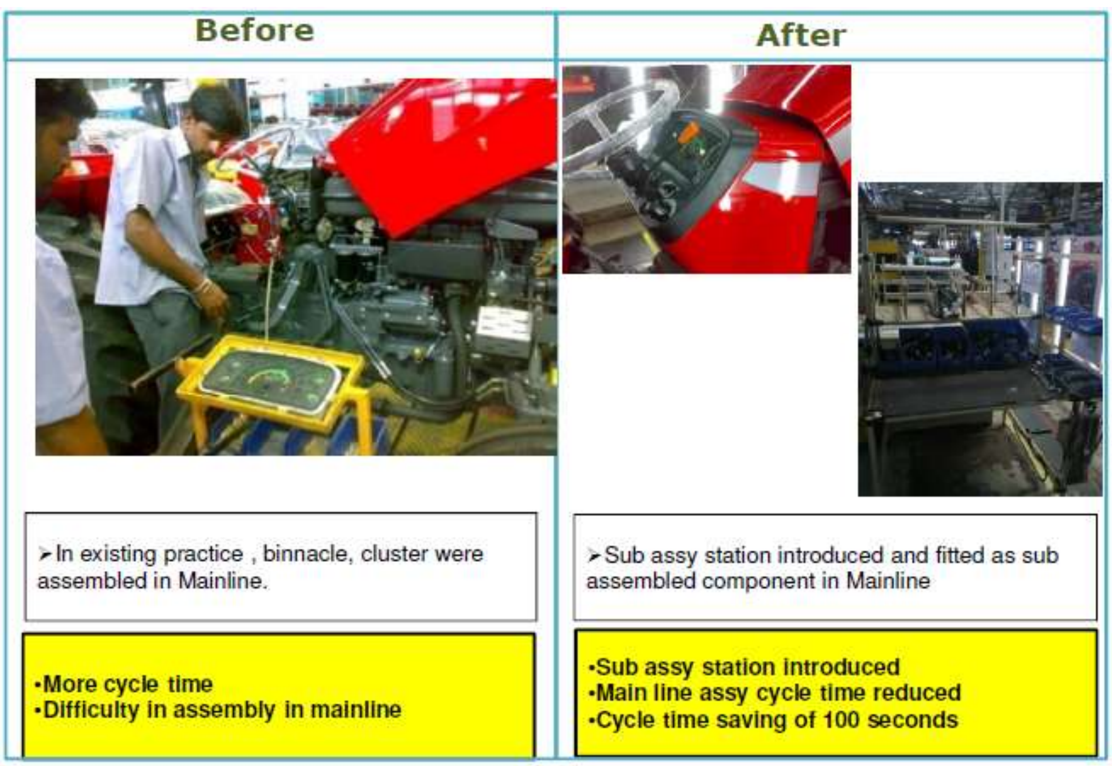

Figure 10 Cell 5 – Stage 20 – Surround Sub assembly station

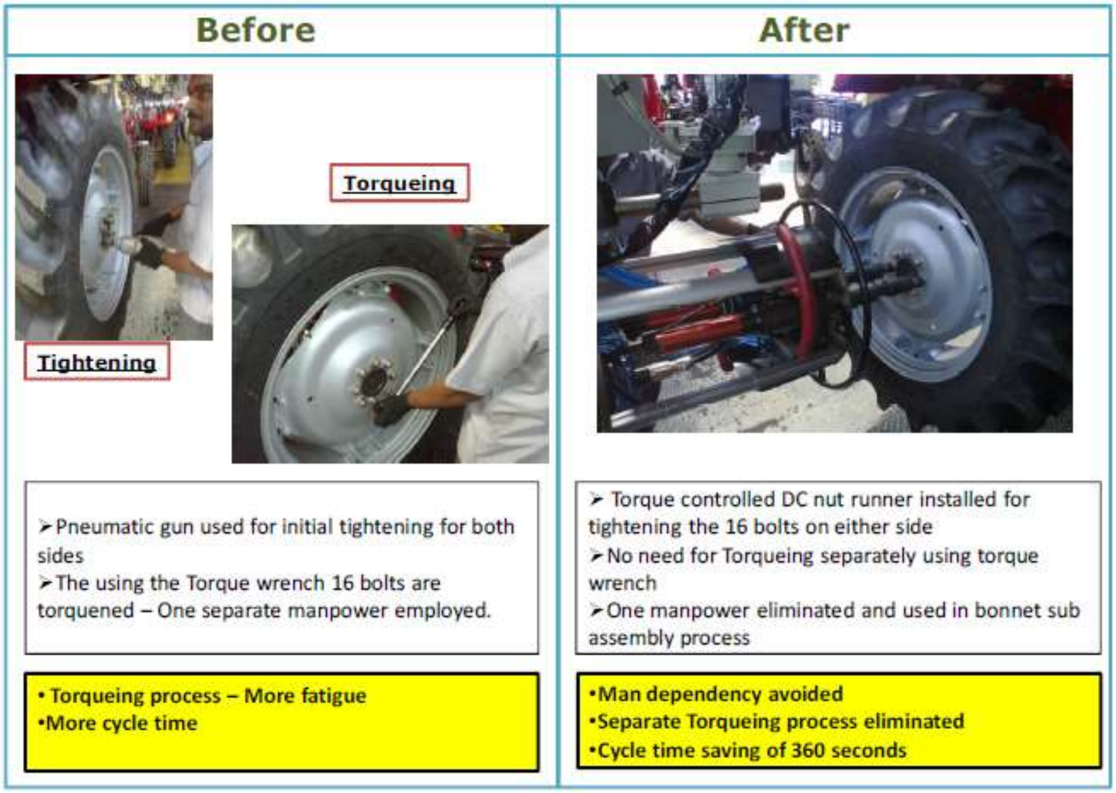

Figure 11 Cell 5 – Stage 15 – DCNutRunnerforRear Tyre Manufacturing

4.6 STANDARDIZATION

The productivity improvement in each stage has been standardized through layout updating, machine drawing release and hand over the same to maintenance department for preventive and breakdown maintenance reference. The followings are the standardization done in the respective stages.

- Engine and Gear oil draining process
- Shuttle lever sub assembly process
- Layout updated for the Kitting trolley feeding mechanism
- Assembly process using ROPS manipulator
- Oil filling & diesel filling
- Swinging drawbar handling using manipulator
- Bonnet handling using manipulator

5.0 CELLULAR MANUFACTURING SYSTEM

5.1 INTRODUCTION

This chapter was discussed about the formation of cells, find the problemand necessity of productivity in tractor industry by using alignment of cells in Cellular Manufacturing System (CMS).

5.2 MANUAL ERROR WHILE FEEDING THE GATE NUMBER

The following procedure is applicable to hopper scale installations commonly known as bulk-weighers with a capacity of 15 tonnes (15 000 kilograms) or less, used to weigh granular product such as those typically found in grain elevators, feed mills or grain cleaning facilities.

5.3 TRANSPORTER RESPONSE TIME ARE MORE

These results suggest that genetic variation in the serotonin transporter gene effects the response time to sertraline and provides complementing evidence to previous reports that this polymorphism affects response time

5.4 SEASONAL DEMAND

There are certain goods, which are demanded seasonally, like woolen garments in winters or umbrellas in the rainy season. The production of these goods takes place throughout the year to meet the seasonal demand. So there is a need to store these goods in a warehouse to make them available at the time of need.

5.5 LARGE-SCALE PRODUCTION

In case of manufactured goods, now-a-days production takes place to meet the existing as well as future demand of the products. Manufacturers also produce goods in huge quantity to enjoy the benefits of large-scale production, which is more economical. So the finished products, which are produced on a large scale, need to be stored properly till they are cleared by sales.

5.6 QUICK SUPPLY

Both industrial as well as agricultural goods are produced at some specific places but consumed throughout the country. Therefore, it is essential to stock these goods near the place of consumption, so that without making any delay these goods are made available to the consumers at the time of their need.

5.7 CONTINUOUS PRODUCTION

Continuous production of goods in factories requires adequate supply of raw materials. So there is a need to keep sufficient quantity of stock of raw material in the warehouse to ensure continuous production.

5.8 PRICE STABILIZATION

To maintain a reasonable level of the price of the goods in the market there is a need to keep sufficient stock in the warehouses. Scarcity in supply of goods may increase their price in the market. Again, excess production and supply may also lead to fall in prices of the product by maintaining a balance of supply of goods, warehousing leads to price stabilization.

5.9 WAREHOUSING & INVENTORY MANAGEMENT

Market and product base stability Long –term market potential for growth and for how the product range may expand will influence decisions on the size and location of a warehouse facility, including space for prospective expansion. These considerations will also impact on the perceived need for potential flexibility, which in turn can influence decisions on the type of warehouse and the level of technology to be used. Type of materials to be handled: Materials handled can include raw materials, WIP, OEM Auto spare parts, packaging materials and finished goods in a span of material types, sizes, weights, products lives and other characteristics.

5.10 WAREHOUSE FACILITY

Type, size and location. The type of operation, the design capacity and size of a warehouse and its location will all be influenced if not directly determined by its exact role and position in the supply chain network, and the role, capacity and location of any other facilities in the supply chain. The customer base, level of inventory, the need for optimization of inventory, time compression in the supply chain and the overall customer service levels should also be considered when deciding on type, size and location. A further consideration here is whether the warehouse facility should be an own-account operation run by the company.

5.11 PROBLEMS AND REMEDIES

- In TAFE, for every 4.5 minutes one tractor has produced and came out
- If the timing will change the production rate will be reduced
- To eliminate this problem ,Bottle necks in production area are identified
- Minimize cycle timing and increase production rate

5.12 NECESSARYPRODUCTIVITY CONDITIONS

The necessary conditions for 100% productivity are:

Operators area their working positions and they know what (expressed in financial and non-financial formulations), when (or by what time or period), where, and how many pieces of products they need to produce. Omitting any of the five conditions means complete loss of productivity and incomplete fulfillment of these conditions means decreased productivity.

The consequences can be for example these:

- 4.5 minutes of looking for information each shift means 1% loss of the production time, but not necessarily productivity. However, it can cause productivity decrease, if the loss is not caught up later with the increased speed. If the operators do not have full information, they lose 100% of the production time.
- Each4.5 minutes thrown out production time are 1% loss of operator’s productivity. Also each 4.5 minutes spent on repair is the 1% loss. 100% speed will not catch up with the lost production time. This loss can be caught up only with the higher speed than 100%.

5.13 DESCRIPTION OF CELLS IN TAFE

TAFE looks at the world as its market place. Its acquired knowledge base of diverse agro climatic zones, crops and cropping practices of over forty years has empowered it to design and develop tractors and aggregates to suit any climatic zone or application in the world. Its product development and styling strengths have been validated by worldwide acceptance of its products and styling. TAFE currently exports to over 80 countries worldwide in markets such as US, Eastern Europe, Africa and South Asia.

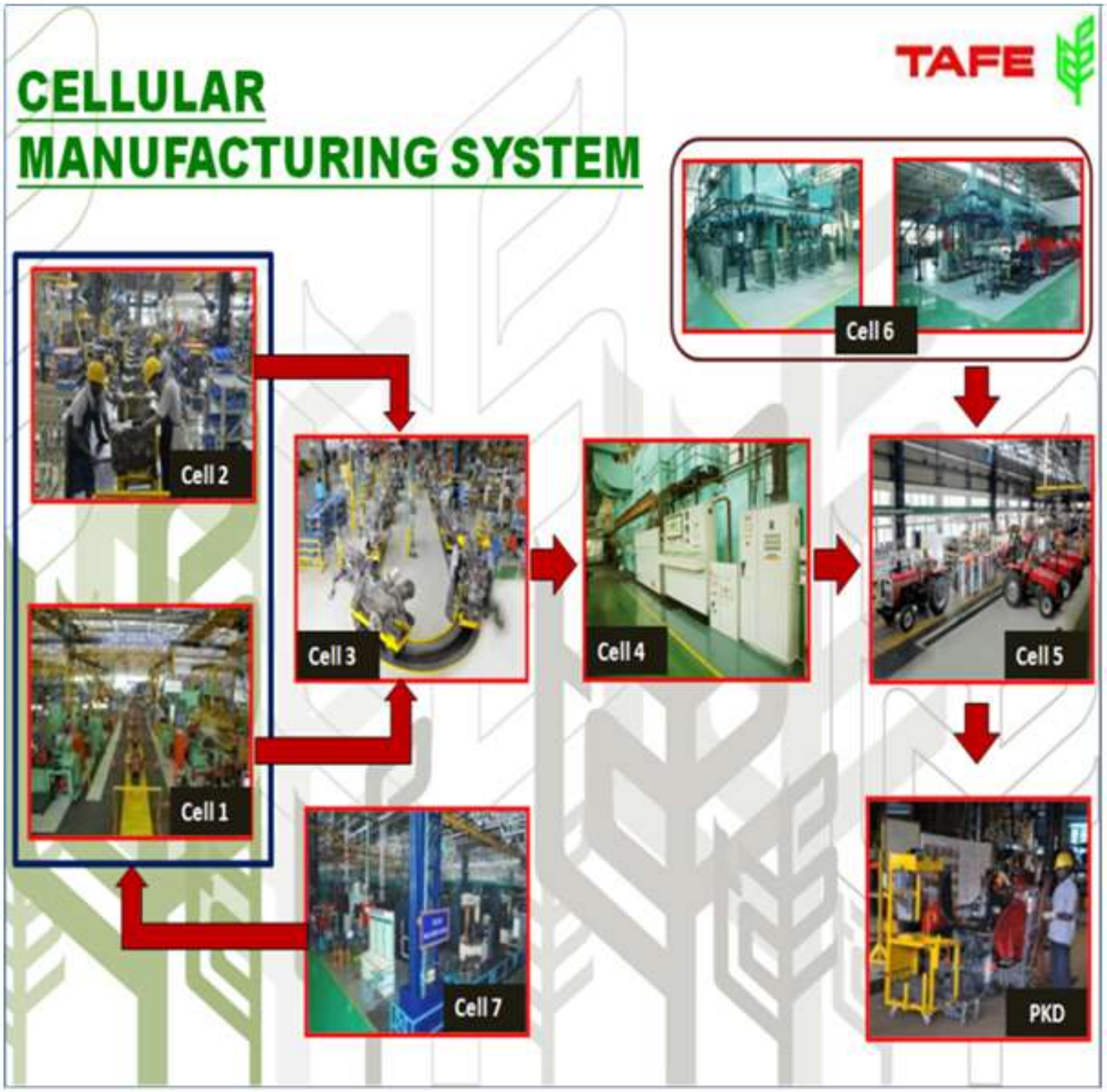

Figure 12 Autonomy of CMS in TAFE

5.13.1 CELL 1-Rear Transmission Build Stages

- Cleaning central housing unit
- Pump assembly
- Rear axle assembly
- Differential assembly

- HLC cover assembly
- Assembling all the parts in rear transmission
- Hydraulic testing

5.13.2 CELL 2-Main Transmission

- Cleaning gear box housing
- Assemble counter shaft
- Assemble main shaft
- Assemble gears
- Assemble steering
- Dispatch to assembly line
- Sliding mesh gear, synchromesh gear, constant mesh gear are the variants

5.13.3 CELL 3-Chassis Assembly

- Engine clutch assembly
- Four wheel drive assembly
- Assemble rear transmission, gear box, engine, front axle, four wheel drive and other accessories together.

5.13.4 CELL 4-Stores and Paint Shop

- Storage of Bonnet
- Bumper
- Mud guard
- Grill
- Side roofs etc., are painted and dispatched

5.13.5 CELL 5-Post Painting

- Bonnets ,bumper ,bumper ,mud guard, grills ,side roofs are fitted
- Assembling other accessories
- Battery, dashboard, steering and tyres

5.13.6 CELL 6-Approval

- Checking batteries

- Checking for leakages and spills
- Checking for speedometer ,odometer, rpm meter, neutral indicator, side indicators , starter motor, engine, etc.,

5.13.7 CELL7-PKD, SKD, CKD

- After testing the tractors are knocked down ,packed and exported
- Tractors are packed according to PKD- Partially knock down
  Tyres, silencer, free cleaner, top link, lower ink, steering are dismantled individually and packed.

6.0CONCLUSION:

This thesis were enabled a reduction of bottleneck rejections in tractors by implementing the actions to overcome the potential root cause. The corrective actions has been effectively implemented and adhered and the results are consistent and reliable. Further improvement was achieved by increasing in on time delivery of tractors. Absorption and balancing of takt time has done the work of good range productivity from the time study analysis. By the utilization of balancing takt time has improving productivity and equalizes the employment. It has also reduces the cost of the rework by doing First Time Right. From the regular visit to the Tractors and Farm Equipment (TAFE) the major problems which affect the processes in production area was found out. The main problems that identified were production stoppage due to incorrect material handling, delivery time and unloading of casting materials time is more. The Balancing of Takt time reduced the production stoppage by the identification and elimination of bottlenecks in the assembly line which increases the cost efficiency, productivity, quality, health, safety and morale of the workers.

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