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Assembly Line Optimization Using 'Lean' Principles

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Abstract - *This work was under taken in a one of the leading electronics company. The company is a well-known organization which works in manufacturing of electric component. In view of fierce competition, they are planning for new products and their assembly lines at the current facility. Also, for the sake of avoiding electric components from dust and rust they are running a climate control project at the shop floor. In order to accommodate new product assembly lines company is shifting the current assembly lines to new locations to avail more space. Thus these assembly lines are redesigned and optimized. The assembly lines are optimized in view of time, space, material replenishment, material flow, etc. Also there is a plan for central warehouse for all assembly lines. Thus all assembly lines needed to be converted to assembly line with a whole new concept.*

Key Words: **Value Stream Mapping(VSM), Kaizen Bursts, First in First out (FIFO), Two-bin system, Space optimization, Central Warehouse, Spider Concept, etc.**

1. INTRODUCTION

The company where this study was undertaken, was about to introduce couple of new product assembly lines for which they needed additional space. The assembly lines were long conventional assembly lines containing large conveyors amongst workstations. The raw material was stacked behind the workstations itself. Thus, the idea was to redesign the assembly lines in order to optimize the available space, time, material flow and material replenishment. Because of stacking of materials required for the assembly of product behind the assembly lines, there was huge amount of space which was being wasted. In addition to this, there were large conveyors between the workstations for the movement of subassemblies in between workstations. As a result of this, the space was not utilized properly. This also resulted in increase in work in process (WIP) inventory. First In First Out (FIFO) system for material especially in electronic products plays a vital role in functioning of the product. This was ensured with barcode based two bin system. Thus these assembly lines are redesigned and optimized.

2. LITERATRE REVIEW

As a part of the way of implementing lean manufacturing philosophy, the work and time measurement techniques help manufacturer to increase the productivity by defining proper working method and standard time, the way of maximizing the resource utilization and helping to distribute work load among other workstations. Concept of MOST (Maynard Operation Sequence Technique) is proposed for the same in the literature. In addition to standard time, there is a need of takt time calculation, which will improve the overall WIP efficiency to a good value. It helps decreasing the WIP between stages and the finished goods inventory. In manufacturing plants, the assembly lines usually maintain a store of components to be assembled in the finished parts. The main problem associated with the supply of these components is the limited space of the workstation, optimizing the overall production shop layout. However, the improvement process of synchronous production processes is creating problems with internal transportation of materials.

Another aspect to think while implementing two-bin system. A two-bin system is typically adopted for C class items. This simple system has two bins which an empty an empty bin signals the need of replenishment order and other bin is used to satisfy the demand. Two-bin system is often used in lean concept. In addition to two-bin system, Information Technology assists in replenishing signal with barcode scanner.

3. INTRODUCTION TO PRODUCT FAMILY

New in the Environmental Portfolio of company are parts of the industrial control technology component family. These controls are designed to ensure minimal power loss, and help both passively and actively to make systems and applications efficient. The components exhibit extremely low specific power loss. The new generation achieves an even more significant reduction. So not only can energy costs be saved but the waste heat in control cabinets can also be lowered. This means that more can be packed into a control cabinet and that less cooling is needed. Company focuses on different customer value and environment value through these products and contributes in global goal of having healthy environment. Main values are listed below:

1. Customer Value
   - Cost savings from significant energy saving
   - Optimal integration in energy management systems
   - From an energy standpoint, the best drive solution for fixed-speed applications
2. Environmental Value
   - Significant energy savings compared to conventional systems
   - Reduction of carbon dioxide emissions
   - Environmentally friendly disposal at end of life cycle

3.1 Introduction to XYZ Assembly lines

X, Y and Z products basically belong to family mentioned above. The operations in assembly of these assembly lines are quite similar; except some additional operation for Z product assembly. Thus, improvement approach for these lines is identical. These assembly lines are conventional long straight lines. The testing and packing workstations are common workstations for these three assembly lines. The assembly lines are connected to testing and packing workstations by long conveyors. Huge amount of raw materials were stacked behind the workstations.

Initially two components required for assembly of these lines were imported. Thus, workstations required for X, Y and Z were 4, 4 and 5 respectively. But, later these two components were made localized which added 2 workstations for each assembly line. One of these workstations is placed at the beginning of each line as it was required at start of the line. But, the workstation for other component which was required after two operations was a problem. So, these workstations were placed with 180^{o} opposite orientation to that of current orientation of the assembly line. The output of this workstation was fed from rear side of third workstation. Thus, operator has to start with subassembly of second localized part and then had to go the first workstation and complete the assembly subsequently in linear pattern. We would tackle many such problems in subsequent steps. The layout is sown below:

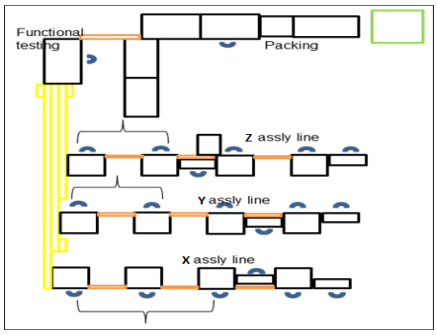

Fig -1: Current layout

4. INTRODUCTION TO VSM

A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product: (1) the production flow from raw material into the arms of the customer, and (2) the design flow from concept to launch.

For mapping the current state X assembly line is chosen as demand for this product among XYZ product family is highest. Also growth of this product in future is expected to be on peak. Prior to collecting data for mapping of the current state, we formed a Cross-Functional Team (CFT) which helped us a lot in improving those lines. We involved people from metal shop, plastic shop, winding section, production department, logistics people, union people in this team so that we should get maximum of inputs in order to make this process more and more informative. Even workers were involved in order to get inputs about actual working conditions so that these assembly lines will be full proof.

4.1 Current State Map

Then our team collected data about the modes of information flow amongst various departments in factory as well as information flow between customer and factory and information flow between factory and supplier departments. Supplier departments for these lines are metal shop, winding and raw material store for secondary parts, etc. Lead times and modes of transportation were noted for the supply of material at assembly lines.

After plotting information about customer and supplier, information about the workstations were collected. Data boxes were prepared for each of the workstation consisting information about cycle time, setup time, uptime, rejection, shifts, working time. Rejection data was collected by quality department in order to find mudas relating to the quality of the raw material. Inventory was calculated among the workstations. This helped us to know about the process time for a component. If at a particular noted time we mark a component with some identification then it will be seen as a part of the final product after a period equal to the process time.

After having this all primary and important data collected we did a lot of brainstorming to arrive at the criticisms of the layouts. These are called as 'Kaizen Bursts' in VSM terminology. These Kaizen Bursts are explained in further sections.

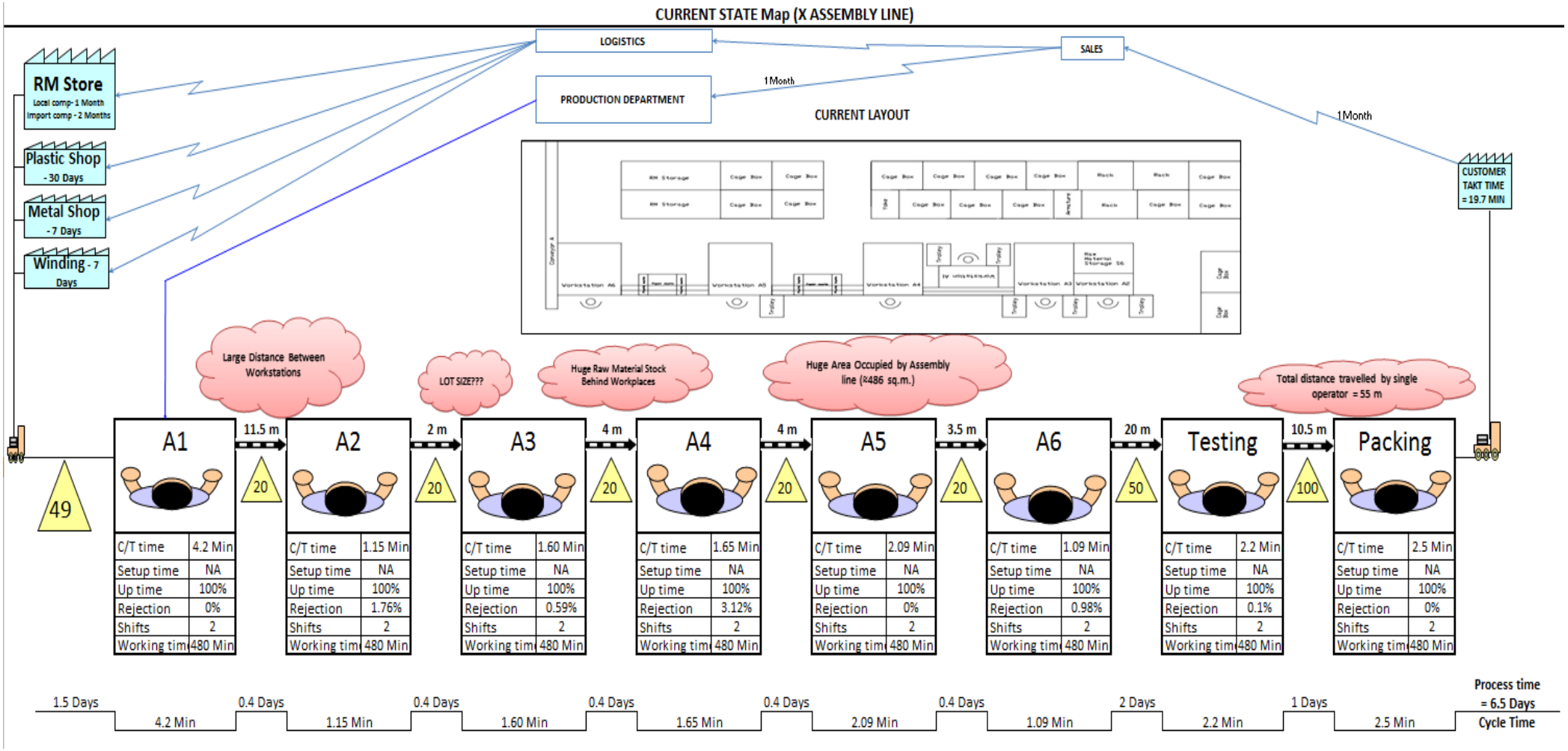

Fig -2: Current State Map

4.2 Kaizen Bursts

4.2.1 Large distances between workstations

There are huge conveyors amongst workstations as a result of which there are large distances between the workstations. So, workmen has to travel a lot distances. Also inventory on roller track gets piled up at the roller track conveyor which is a type of waste as per lean principles.

So, we brought the workstations near to each other such that there will be some space to place the subassemblies and provided roller track conveyors in some innovative way such that space will not be wasted for the sake of conveyors. For example we provided a two-fold roller track conveyor in order to place same number of subassemblies in half space.

4.2.2 Lot Size

Another aspect of concern is to decide upon the lot size or batch size for the operation. Currently a batch of 30 is being run which piles up huge work in process inventory. This is not acceptable form the viewpoint of Lean principles. But, achieving single work piece flow was not possible as workmen have to travel a lot resulting fatigue. Thus, to overcome this, we reduced batch to 10.

For implementing this particular idea we involved workers union. Upon discussions we reached a both side agreement on batch of 10 work piece. Here team work and shop floor involvement were our key take away points.

4.2.3 Huge raw material stock behind assembly lines

Huge amount of raw material stocks were stored behind the assembly lines which occupied a lot of the area. Also inventory of 1.5 days was maintained at assembly lines which oppose the implementation of Lean principles. This was reduced to 1 day's stock.

This particular problem will be overcome by implementation of the **central warehouse** where vertical utilization of space will be done effectively for the purpose of storage of the material. These material will be replenished by a **Spider** upon receiving a Kanban signal.

4.2.4 Huge area occupied

Because of long conveyors, huge raw material stocks behind assembly lines, huge amount of area had been occupied by XYZ assembly lines. In addition to this, the width of the workstations is too long needlessly.

To overcome this, we decided to cut the workstation from rear side so that we could maintain the standard workstation width as 1.6 meters as we maintained in other assembly line workstations. Also we focused upon making U-shape layout instead of the conventional straight long assembly lines. This was achieved after a lot of brainstorming. We tried permutation and combinations with help of 'Post-It' to arrive at feasible and improved layout for XYZ assembly lines.

4.2.5 Human Efforts

The distance that a worker has to travel plays a vital role in his efficiency. In this case the workmen had to travel about 55 meters from first assembly workplace to packing workplace and about 30 meters from the first assembly workplace to the last assembly workplace. Most of the times the testing and the packing operations are done by separate workmen than the one who does the assembly work. Still, 30 meters is a huge distance to travel. Also because of the newly added localized workstation with 180^0 opposite orientation to rest of the assembly, operator had to travel a lot.

The first problem is overcome by arranging the workstations in vicinity of each other which reduced the travelling distance to about 4.5 meters which is huge saving from the perspective of human efforts.

This was supported with arranging the localized workstation in line with the other workstations. Let us explain example of the X assembly line. Last three workstations are combined into single workstations (let us say it as last workstation). Second workstation is original one. Now, first and third workstations are localized; out of which first is placed at the beginning of the assembly line. The other one (third workstation) was originally placed at opposite orientation. Output of third workstation is required at the last workstation. Also, output of the second workstation is directly required at the last workstation. So, we put a roller track conveyor over fixture on third workstation connecting second and the last workstation. Proper care was taken so that operation of fixture on third workstation will not cause any difficulties.

This reduced travelling distance to a great extent. Also due to combined workstation i.e. the last workstation area occupied by three workstations reduced to single workstation. New layout is as follows:

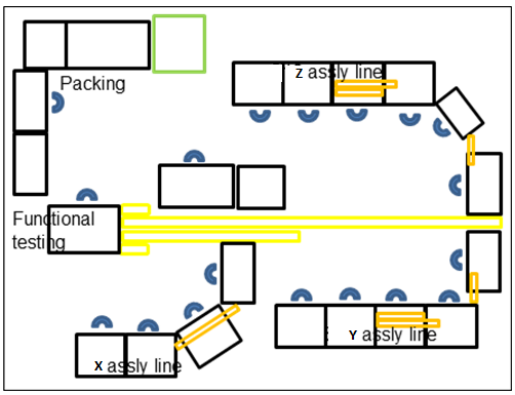

Fig -3: Proposed layout

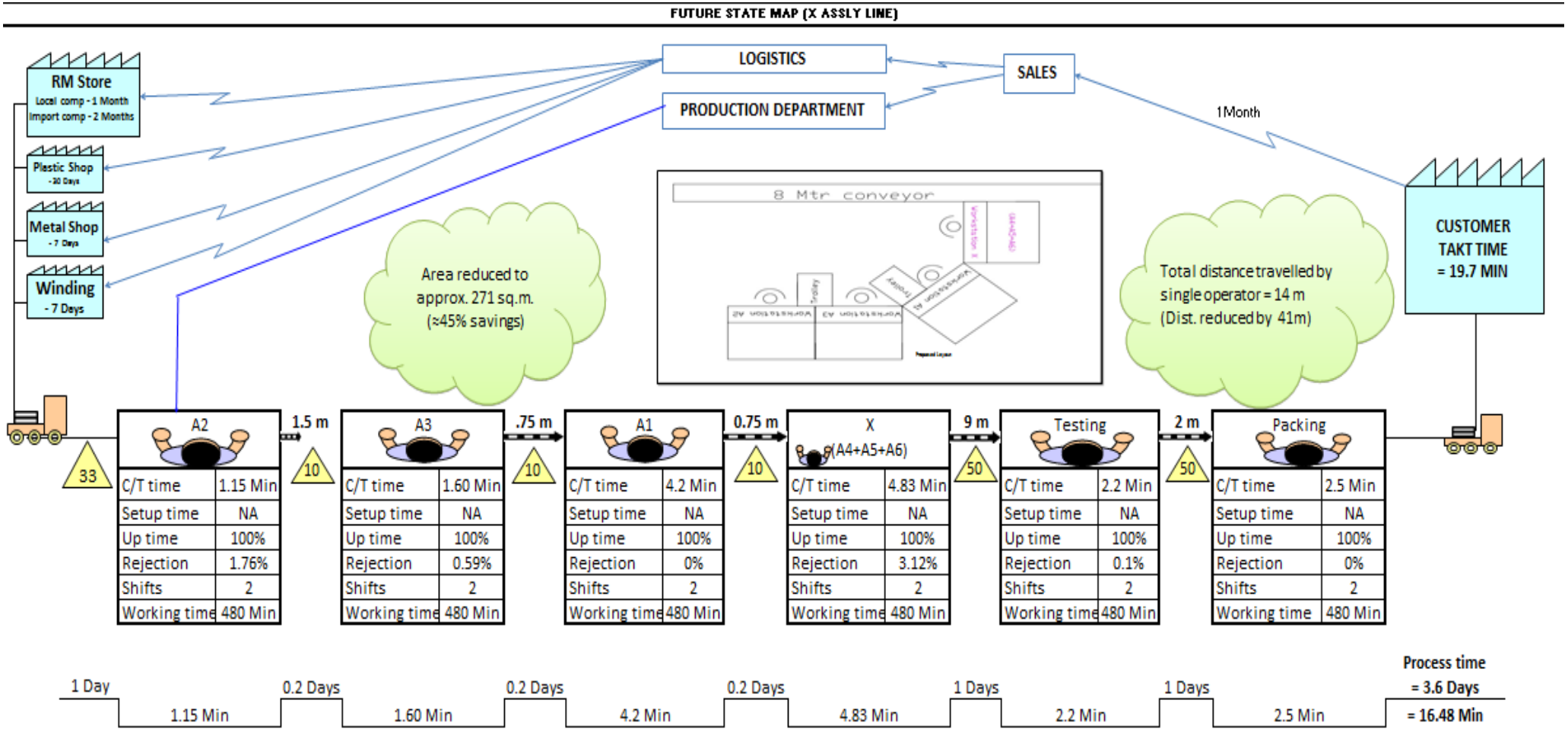

Fig -4: Future State Map

5. RESULTS

5.1 Space Optimization

We saved a lot of space from XYZ assembly lines. We almost reduced area by 50% (i.e. from 2 bays to one bay). Earlier area occupied by these lines was about 486 sq. m. Now we have set up these very assembly lines within 271 sq. m. area. These lines are audited by authorities and accepted the new assembly lines with good compliments.

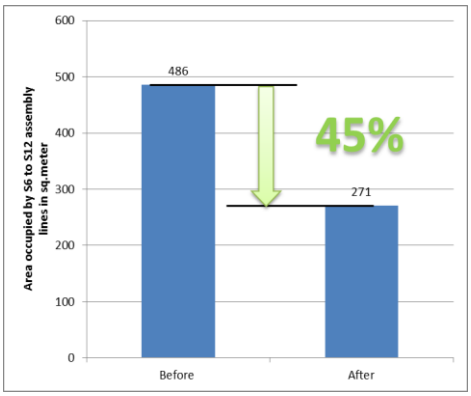

Chart -1: Space Optimization

5.2 Other results

- Process time reduced to 3.6 days from 6.5 days
- Reduced Human efforts
- Involvement of workers
- Team coordination
- Team work

6. CONCLUDING REMARK

After implementing the future state map successfully, we can see there exists further scope of improvement in reducing the raw material stock at the assembly lines. This stock can well be reduced in order to move towards single piece flow of work piece on an assembly line.

Thus, by considering the future state map now as current state map, we derive another future state map. This future state map consists of raw material stock of one shift i.e. half day. Round of the spider from central warehouse is scheduled after every two hours to the assembly lines. Thus raw material stock at assembly lines can be reduced to two hours. But, the central warehouse system is not working at full-fledged condition right now. Thus, raw material stock of one shift is taken under consideration. Further revisions may include raw material stock of two hours considering the spider concept.

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