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Studying the effect of Re-layout considering Lean manufacturing, Availability, and Ergonomics: with case study

Hossam G.Hassanien, Ahmed M.El-Assal and Sameh S.Naeem
Mechanical Engineering Department, Benha University, EL ARABY GROUP
E-mail: hossamgmd@gmail.com

Abstract
Most companies in the world work to enhance material gains, satisfy their employees, and pay attention to the work environment and the extent to which production processes are running in a way that may be closer to ideal. One of the most important scientific methods taken to study cost reduction and work to improve the work environment is lean manufacturing and relying on its tools to improve circulation and process times [1], and also one of the most important Measures taken by institutions to improve the work environment are re-planning the factory. To enhance these results, the lean manufacturing process is combined with factory re-planning to obtain results in saving labor costs, saving the cost of transportation and internal circulation, providing storage spaces, working to reduce movement risks for workers, and providing availability to increase productivity [2].

Keywords: *re-layout*, ergonomic, lean, six sigma, risk, REBA

1. Introduction

In the context of global competition and the spread of global markets that do not recognize the borders of countries. Major global companies are always kept to maintain their position among competitors. For this reason, these companies always strive to use and apply the best scientific technology. Chief among these technologies are lean manufacturing and lean six sigma. Each of these technologies enables factories to increase production, availability, and reduce waste, losses and eliminate potential risks to worker safety and the risks of ergonomics. By removing unnecessary manufacturing processes, handling problems, overstocking, work in process, etc. Factories may depend on applying each technology for a specific goal, or more than one technology is used to promote a single goal such as the concepts of Lean or Six Sigma Washing machines are important category of domestic machines used for automating manual tasks and therefore helping humans over a number of Lean manufacturing is a model that eliminating wastes (non-value added) as well as improving working conditions. the lean manufacturing is to optimize production processes from raw material supplier to the final production of products [3]. in this application will discuss the effect of re-layout, lean manufacturing and cellular manufacturing system (CMS) on productivity, defects and Ergonomics. The Lean Manufacturing tools that aid, such as: (Kaizen, Poka-Yoke, Takt-Time, 5S, Balancing stations, Flow Mapping Value, Ergonomics, etc. and it will be applied in industrial company at Egypt (Elaraby group) for home appliances.

2. Literature review

Due to the importance of the subject many researchers attempt to provide How
can re-layout, lean manufacturing and cellular manufacturing system (CMS) affected on productivity, defects and Ergonomics:

Krajcovic et al. (2019), Suhardini, Septiani, and Fauziah (2017), or Kovács and Kot (2017) suggest that the most useful solution is the re-layout of the workplace. Workplace improvement by re-layout.

Senderská, Mareš, and Václav (2017) conducted a study on employees, focusing on efforts to reduce movements.

Koukoulaki (March 2014) explains that the basic idea of cellular manufacturing is to arrange equipment and workstations in specific geometric patterns to improve the production process by studying the times of manufacturing or assembly operations and the reliability of the arrangement of operations according to the investigation times.

V. Balasubramanian, T.T. Narendran, and V. Sai Praveen (2011) explain that REBA is designed for ease of use in assessing ergonomics and equipment use. Using the REBA worksheet, the auditor assigns a score to each of the following body areas: upper arm, lower arm, wrist, neck, trunk, and legs. After collecting and recording data for each area, the tables in the model are used to group all influences on the worker in terms of severity, creating a single score that represents the degree of risk of contracting MSD.

Heizer and Render (2003) explain that cellular manufacturing is the integration of people, equipment, and organized workstations to manufacture each unit of production. It helps in reducing work-in-process inventory in planning by creating a balanced flow of materials from one machine to another, improving scheduling and material flow, enhancing machine

utilization, and providing better visualization of problems with less WIP in planning.

Zhang, M., Batta, R., and Nagi, R. (2017) explain that improving factory planning operations involves improving operation times, re-planning the factory, and integrating these elements. (Bai et al., 2019) Among the strategies to reach customers' expectations and to increase competitiveness in the modern market, Lean Manufacturing (LM) stands out as it provides greater flexibility, quality, and responsiveness to a production system.

Liu and Liu (2019) explain that determining the layout of a manufacturing system can be challenging, as the most efficient shop floor arrangement depends on the unequal requirements of different natures and departments within the facility.

3. Methodology

Facility layout is considered an effective tool in studying all the influences, such as the interface spaces between production machines, the extent of the manufacturing departments' connection to each other, and their proximity and distance from the main production line and sub assembly warehouses, on the production process to reduce costs by enhancing productivity [8].

Re-layout design

After the facility has been in operation for a period of time, production plans change, workers' efficiency changes, some new components are introduced, and problems arise with parts handling and storage locations. Hence, management must intervene to solve these problems by redesigning the design. To improve the productivity of machines and the flow of materials and workers [6], [10].

The steps of layout redesign is the following:

1. define the problem (e.g. bottlenecks, lack of space, etc.),
2. analyzed the problem.
3. alternative solutions (re-layout alternatives),
4. evaluated alternatives based on key performance indicators,
5. select the most suitable re- layout design,
6. finally implement the preferred re- layout design solution.

Lean manufacturing tools

5S: Sort, Systemize, Sanitize, Standardize and Sustain

Bottleneck: Identify the part of manufacturing/process that break down the output of the process.

Continuous Flow: Eliminate of waste by ensuring WIP smoothly flow through production

Just-In-Time: Fulfilling the request within the specified time for the process.

Line Balancing: Line Balancing is a lean tool that defines the right amount of people to make the right amount of product within Takt Time.

Value Stream Mapping: Tools used to visually map the production flow to identify waste [7].

Takt Time: The time required to achieve the convergence of production operations at the specified times without disrupting the final assembly operations

VSM consists of five core process [5], [11] which are:

(1) selection of product family,
(2) draw current state mapping,
(3) draw future state mapping,
(4) define working plan,
(5) achieving working plan

Cellular manufacturing layouts

The basic idea of cellular manufacturing is to arrange equipment and workstations in specific geometric patterns in order to improve the production process by studying the times of manufacturing or assembly operations and the reliability of the arrangement of operations according to the investigation times [9].

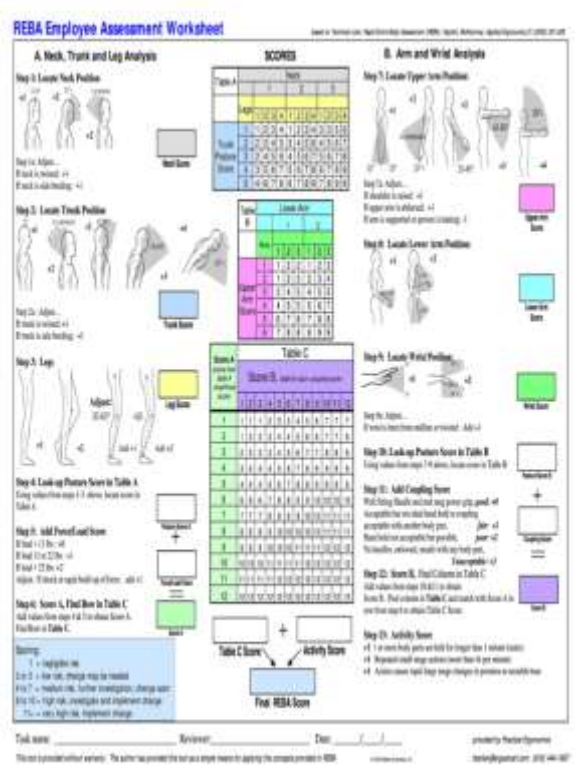
Cell manufacturing layouts [13].

I-shaped cell
U-shaped cell
O-shaped cell
T-shaped cell
S-shaped cell.

Rapid Entire Body Assessment (REBA)

REBA: A Step-by-Step Guide

REBA is designed for ease of use in judging ergonomics and equipment use. using the REBA worksheet [4], the auditor will assign a score to each of the following body areas: upper arm, lower arm, wrist, neck, trunk, and legs. After collecting and recording data for each area, the tables in the model are then used to group all influences on the worker in terms of severity [12], creating a single score that represents the degree of risk of contracting MSD, as shown below:



Score	Level of MSD Risk
1-2	negligible risk, no action required
3-4	low risk, change may be needed
5-6	medium risk, further investigation, change soon
6+	very high risk, implement change now

4. Case Study

In this paper, we will explain a case study of the spin basket assembly section in the vertical washing machine product. The washing machine consists of a group of sub-assemblies that are assembled together in the main production line, each according to its role in the assembly. Among these sub-assemblies is the assembled spin basket, which in turn consists of a group of parts. Manufacturing includes plastic parts and metal parts Fig. (4-2); the production process is described in steps. Spin basket sheet is the raw material for the spin basket production. The first processing phase is "rolling", in which spin basket stainless steel sheet is rolled in circular shape in a particular machine called, rolling machine. Next, with the "welding" phase, the stainless-steel sheet is welded in circular shape. This operation creates by tig welding machine, Erickson is carefully checked for any welding defect. After the Erickson inspection. The next phase is "forming", following which the welded sheet is forming further until it reaches the desired shape in trunk machine. The basket holder assembly with basket bottom in basket holder machine then entered into trunk machine to assembly with formed stainless-steel sheet, which gives the right shape and size required by bending stainless steel sheet on edge of basket bottom. The next step is installing rail cover by handily process then install the three filters by screwing bolts handily then install balance ring which filled by salt water. The final stage is tightening bolts to tight basket bottom spin basket sheet in basket bottom machine activities. Which are followed by operations and assembly as in Fig. (4-1). By studying the times for each process and studying the line balance of the operations, it was revealed that there are bottle neck processes for the department's production. It was necessary to carry out improvement actions to eliminate delays and disrupt the production process, which is the process of assembling the base of the basket, as it has the greatest time in the process. Final assembly process for the spin basket.

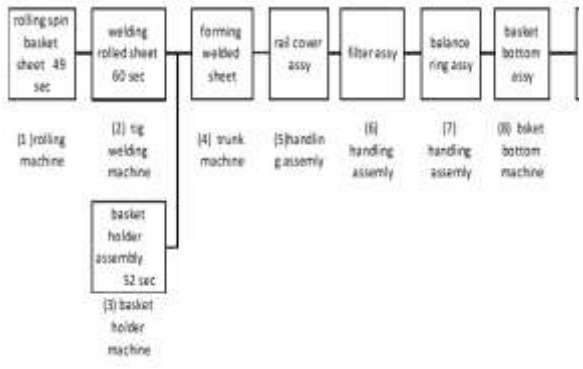


Fig. (4-1) spin basket body line balance

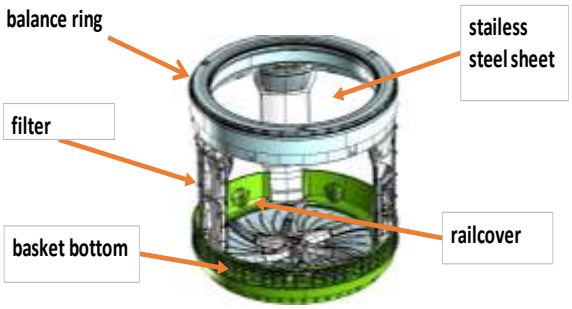


Fig. (4-2) spin basket body

4. 1. The case study phases

1- line balance (spin basket assembly)

2- relay out manufacturing processes in spin basket shop

3 - cellular group (manual assembly)

4 – relay out of cellular group on assembly line

٤.١.١. line balance (spin basket assembly)

By studying the times for each operation and studying the linear balance of the operations Fig. (4-3), it was found that there is a convergence in the times of the operations performed by machines and a large discrepancy in the time between them and the operations performed manually Fig. (4-4). However, the manual operations are followed by the basket bottom assembly process, which is done automatically by the basket bottom assembly machine. Through studying the linking and ordering of operations, it was found that the manual operations preceding the process of assembling the bottom of the basket are approximately equal in time, and it is not required that they precede the process of assembling the base of the basket. Therefore, it was necessary to implement improvement measures to control the synchronization of operations, as the basket base assembly machine disrupts the production process in the department, as manual operations wait for the machine for more than twenty seconds to feed it again.

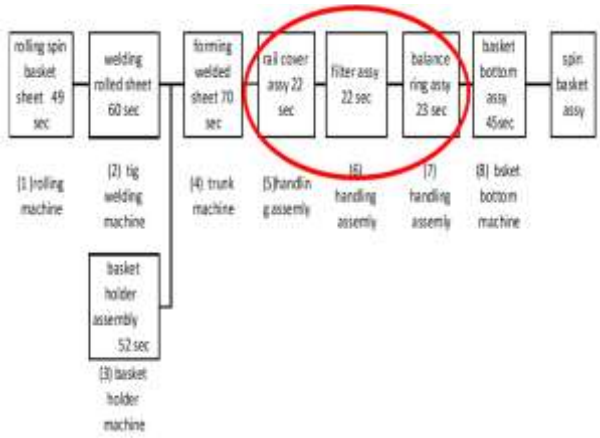


Fig. (4-3) Line balance spin basket body Before

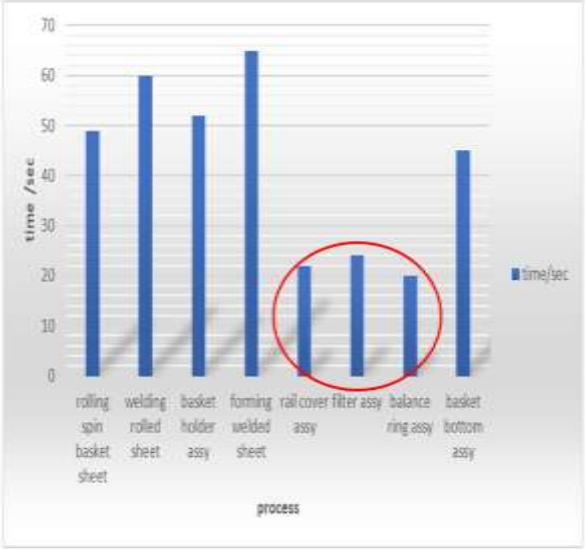


Fig. (4-4) Graph Line balance spin basket body

4.1.2 Relay out manufacturing processes in spin basket shop

moving the line of final sub assembly of spin basket (cover 1& 2 assembly -filters - balance ring assembly) to a new place (nearby spin basket feeding on main line assembly) By:

- Change spin basket assembly sequences of basket bottom assembly to be after trunk m/c instead of assembly after balance ring assy Fig. (4-5).
- The saved area by relay out = 6*8.5 =51m2 Fig. (4-6)

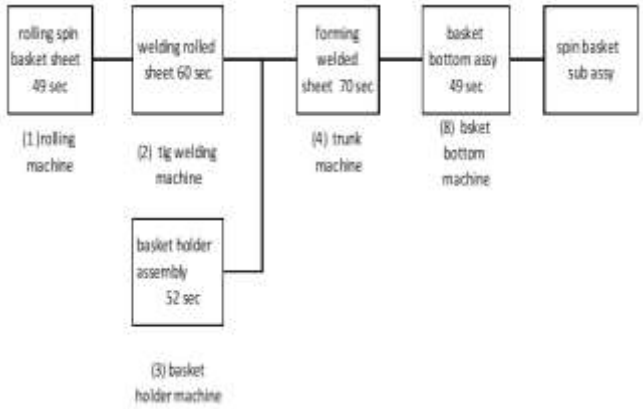


Fig. (4-5) Line balance spin basket body After

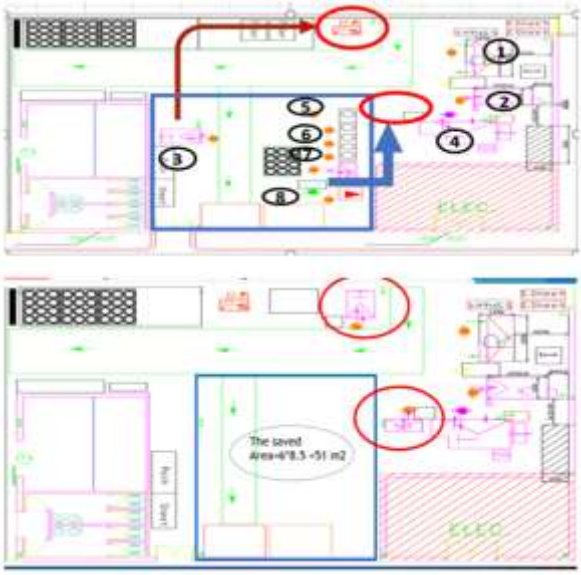


Fig. (4-6) The saved area by relay out

4.1.3 - cellular group (manual assembly)

moving the line of final sub assembly of spin basket (cover 1& 2 assembly -filters - balance ring assembly) Fig. (4-٧) to a new place (nearby spin basket feeding on main line assembly) Fig. (4-8).

Fig (4.7) Balance Ring assembly in a new place

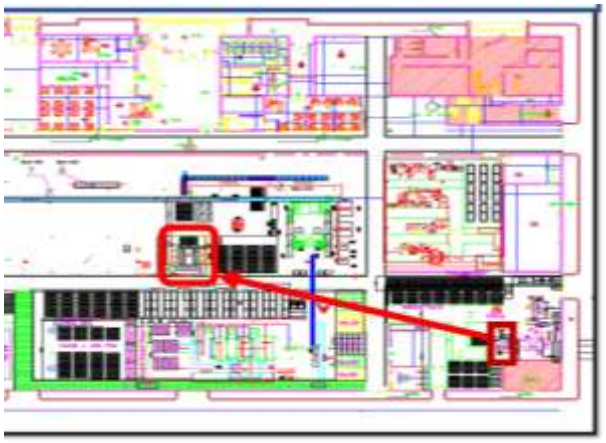


Fig (4.8) Spin Basket body assy cell (cellular region)

In the old design Fig. (4-9), the basket section is being worked on in three shifts to achieve the production plan, and the total manufacturing and assembly operations, as we mentioned before, are eight operations, including three manual operations, and three technicians are required for each shift, with a total of nine technicians, and there is a difference in the time of these manual operations and manufacturing operations using machines. In the department, it was necessary to withdraw these operations and form an assembly cell in it close to the final assembly line for washing machines, as the assembly line works in two shifts and produces a washing machine every twenty-five seconds (takt time), meaning that the manual basket assembly operations achieve the time required to feed the production line with the assembled basket, and this cell is operated in two shifts as a line. Production requires three technicians per shift, meaning a total of six technicians per two shifts, which provided
us with three technicians from the department's strength after moving the assembly cell

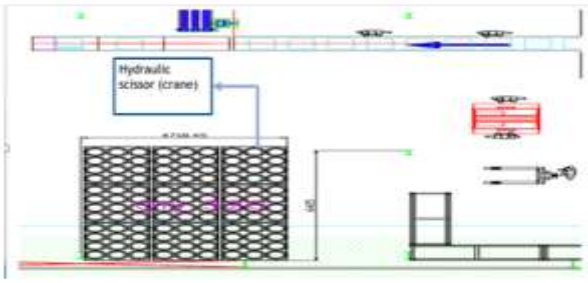


Fig. (4-9) cellular region before

4 .1.4 Relay out of cellular group on assembly line

After moving the final sub-assembly line of the rotating basket (cover 1& 2 assembly -3 filters - balance ring assembly) to its new location to feed the main washing machine production line with the assembled spinning basket). It was necessary to reconfigure the place to change the method of feeding the production line with the basket via a conveyor belt instead of a hydraulic elevator. The new belt transports the basket to a higher level than when it was lowered to the washing machine body to be assembled with its Fig. (4-10-a), Fig. (4-10-b) Fig. (4-10-c), which made the process much simpler than before, as the technician was placing the assembled basket cart on the hydraulic crane lifts it manually, then attaches it to a crane, then lowers it again to place it in the body of the washing machine. You can imagine the extent of the suffering. While loading each basket inside the washing machine cabinet, due to the difficulty of body movements affecting the technicians, which requires rotating the workers in this area every hour to reduce the harm to them, and measuring the movements of the technicians according to the REBA scale, it was found that they are of the highest degree of danger Fig. (4-11) , but after modifying the area and changing the working mechanism in it to the new position of the conveyor belt. The risk decreased to an acceptable level due to the lack of labor turnover in the region and Main Line assy. Feeding by a new design as shown a Figure. (4-12).

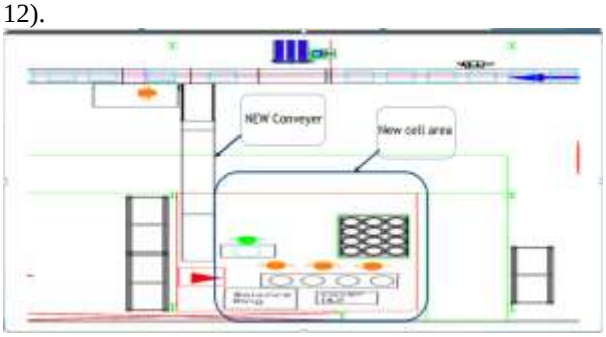


Fig. (4-10-a) cellular region after

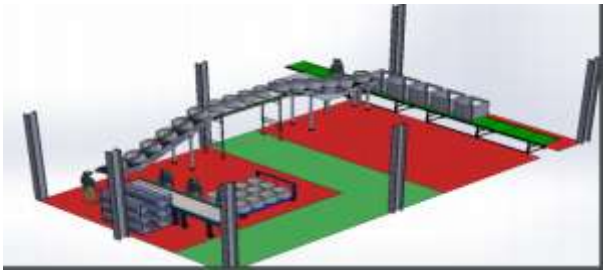


Fig. (4-10-b) cellular region after 3d

Fig. (4-10-c) cellular region after

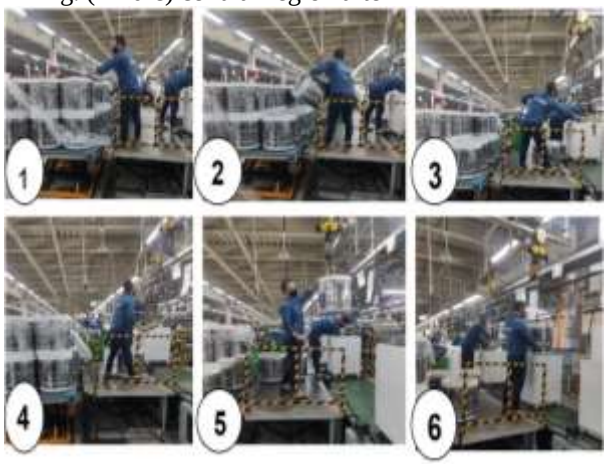


Fig. (4-11) stages of feeding

Fig. (4-12) Main Line assy. Feeding by a new design

4. Results

The results resulting from the application of lean manufacturing and the relay out of the spin basket department seem clear and have already affected the availability, productivity, defects and ergonomics of the technicians.

1-Availability

The final spin basket assembly is not dependent on balance ring buffer the main assembly line has increased its production availability, as the process of

producing the basket no longer depends on the presence of the basket parts (cover 1& 2 assembly -3 filters - balance ring assembly) at least two shifts before it in order to produce an assembled basket. Rather, it is now produced immediately after the presence of these parts, without waiting for them to be assembled in the basket manufacturing department, as it was before the modification, as it is required that these parts be available. To make a sufficient balance before operating the production line, at least two shifts, to provide the required number of assembled baskets.

2- **productivity**

The productivity of technicians increased to achieve time based on the production line and the provision of three technicians. It was also explained how to provide them before and they were employed in other places.

3- **Defects**

The impact of lean manufacturing and redesigning (Relay out) the department's location is evident in the lack of confusion, as the project reduced the processes of handling, stacking the collected basket, and reloading it onto the trading carts, and feeding became direct through the conveyor of the assembled basket next to the production line as shown defect ppm decreasing in Fig. (4-13).

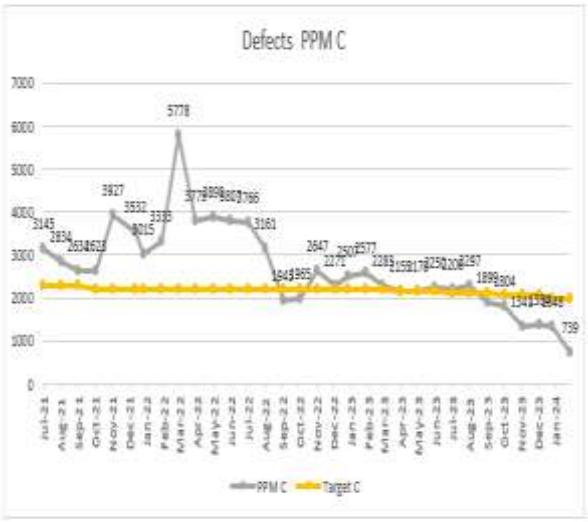


Fig. (4-13) defect ppm

4- Ergonomics

The impact of lean manufacturing, redesigning the location of the cell, and setting up a belt to transport the assembled basket in the Ergonomics of the technicians is evident, as the project reduced the number of movements and their hazardous conditions to the health of the workers, including loading the assembled basket, re-raising it, carrying it on the production line hoist, and re-lowering it into the body of the washing machine.

The REBA score before project

The REBA score after

REBA Score = 8

REBA Score = 1

5. Conclusion

The effect of re-relay out the factory and lean manufacturing is clearly evident in this research, as the results and indicators showed a clear effect in providing storage space after implementing the cellular group system and providing a number of workers in each shift of the spin basket department. Re-layout the factory and moving the new cellular group next to the production line led to reducing the damage of the assembled basket and using tools. Lean manufacturing. The takt time required to feed the production line with the assembled basket was achieved by modifying the production line feeding mechanism via an overhead belt instead of using a lifting platform. This led to reducing the degree of risk to the ergonomics of workers on the assembly line. The production assembly line availability was increased by relay out to cellular group because the final assembly of spin basket had not depended on balance ring production lead time which must product before that modification was found by two shifts early

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