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Improved Cell Design using Digital Ergonomic Tools

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Abstract. Work related Musculoskeletal Disorder (MSD) such as back pain, erroneous body postures, osteoarthritis, fibromyalgia, carpal tunnel syndrome, eye strain are exacerbated mainly due to the intensity of work and working environment. These Musculoskeletal Disorders (MSD) are cumulatively called monotonous injury or overuse injury. These injuries arise due to various reasons such as lifting of bulk load, vibrations, surrounding noise, bending, stretching, awkward posture in the workplace. This results in discomfort among the workers and decreases the productivity rate. Poor ergonomics disrupts the working environment of the employee and may cause partial paralysis. Hence application of ergonomic solutions is necessary to overcome difficulties including muscle exhaustion, tiredness, boredom among the workers because of tedious processes for a long time. This journal is concerned with the improvement of assembly cell design using digital ergonomic tools. This study was based on the workers and working environment of the manufacturing industries. The objective of the work is to analyse and simulate the discomforts faced by the workers in the assembly cell using a software named DELMIA. The purpose of this ergonomic program is to eradicate work related Musculoskeletal Disorder and to reduce stress level, so that employee performance is enhanced. This improves the production efficiency in an assembly cell.
Key Words: Musculoskeletal Disorder (MSD), Assembly cell, Digital ergonomic tools, DELMIA, simulate

1. Introduction

Ergonomics is the science of interaction between human beings and artificial products that are designed in such a way, so that it reduces stress and improves employee's performance. The term ergonomics is extracted from a Greek word, where 'Ergon' refers to 'tasks or 'work' and 'Nomos' refers to 'laws or 'regulations. In simple terms ergonomics can be coined as a task which deals with interaction between human beings and their limitations which predominantly focuses on irreconcilability between the task and worker to create indefensible work environment. Proper execution of ergonomic plans improves productivity rate around 10-15%. This improves wellness of employees and reduces stress by improving their work postures. If an employee feels comfortable with his workplace, then they can perform their work more efficiently without having complications in their work and working environment[6]. The main purpose of ergonomics is to eradicate discomfort and work-related Musculoskeletal Disorder (MSD). This can also reduce the cost of compensation that is given to the injured worker[3]. This further uplift the morale and make employees feel safe about their workplace. This also reduces absenteeism[4,6,7] as the workers feel convenient with their wellbeing and the working environment[6]. Some of the basic fundamental principles that are to be followed in work places for the wellness of workers are as follows:

Work At Proper Height: Working at improper posture for a long time can cause strain[6]. Ideal desk and chair height, helps to maintain the posture and prevents the worker from muscular stress especially fatigue. The ideal working height varies from person to person, depending on the industries that the worker works. Consider the desk and chair as a single component. Alter the desk and chair height accordingly by adding extensions or neglecting extensions[3]. Supporting the height of a chair, using a Hassock will be an ideal solution. Performing tasks at ideal height makes the task more flexible and convenient.

Maintain Neutral Posture: Neutral posture refers to the reclining position of joints such as sinew, commiserate, nerves etc... In this position, the joints experience less pressure. This consents the workers to work with their full potential and govern over their work. Awkward postures exert additional pressures on joints[6]. These types the workers excruciating. Improper postures denote to the 'C' curve or transpose 'V' curve. In these posture's joints tend to experience more stress, eventually causing back pain. So, it is necessary to maintain neutral posture in order to elude discomforts and Musculoskeletal Disorder (MSD).

Work At Comfort Zone: Working zones can be classified into two types. They are a comfort zone and risk zone. Comfort zone generally lies between the chest and thigh. This is the zone where the work can be done more efficiently with less power input. The zone that lies above and below the comfort zone is called the risk zone. Performing the task at comfort zone, helps in reducing the risk of shoulder, neck and back strain [3]. Here the working environment refers to the assembly cell of a manufacturing industry. The purpose of this journal is to provide a solution for the discrepancies faced by the worker specifically in an assembly cell [3]. Assembly cell is a group of workstations arranged in a sequential approach in which the parts of the products are assembled from one workstation to another station. There are various types of assembly cell in a manufacturing industry. Each assembly cell is designated to perform the assigned task. The primary purpose of the assembly line is to elevate productivity and efficiency.

Bench Assembly: The bench assembly cell has advanced out of progressive ability to perform assembly of compact parts with easy reach of workers. In a bench type assembly cell, assembly of portable parts is done either in sitting or standing position. This type of assembly process requires high precision, carefulness, and exactness [7]. In order to attain these qualities, the workers need to stretch either in forward or backward direction for accurate visualisation. This leads to improper posture and may cause lower back injuries, eye strain, epicondylitis, rotator cuff injuries etc [7].

Multistation Assembly: Inline assembly cells are a string workstation of in which the components are assembled in a chronological order. Inline assembly may be either manual or automated. This assembly cell is more well organized and efficient. In a multi station assembly line the employee has to work at a fixed workstation with a regular interval of time. This reduces the stress and strain on a solitary employee as the work gets distributed among other workers. This increases the attentiveness of the workers and increases the productivity [4, 5]. Nevertheless, it has its own demerit. Any fault in a particular workstation may disrupt the entire assembly line.

Modular Assembly: Unlike other assembly cells, the modular assembly cell emphasizes on pre-assembled components to fabricate the end product. Modular assembly cell proceeds to improve in an efficient system. The term modular refers to 'Ductile or 'flexible'. This assembly cell predominantly focuses on how an employee can work with ease without facing any discrepancies as faced in traditional assembly lines. Additionally, the modular assembly cell can be redesigned for multiple purposes as per the flexibility and convenience required by the employee. But in a modular assembly cell the employees are present in a confined area. This makes the employee harder to move freely and stretch out. Lack of reclamation eventually causes soft tissue shortening, weakening of tendons, fatigue and discomforts.

Flexible Assembly: Flexible assembly cell (FAS) is a consolidated system that the assembly line is driven by Computer Numerical Control (CNC) under a domiciled system. This assembly cell comprises a number of workstations that are interlinked to each other through a belt conveyor. A number of tasks can be performed in a single workstation. This primarily emphasizes on the principle of ductile or flexibility. As this assembly cell Is utmost automated, employees have a lesser role to supply. Stress, fatigue and other discomforts due to work are not concerned here as in conventional assembly cells, thus making the employee tranquil and free from work related disorders.

2. Objective

Based on the complications addressed in the mentioned assembly cells from the above studies, the purpose of this studies is:
1. To reduce the discomforts and work-related disorders.
2. To improve the productivity rate and efficiency of the task.
3. To modify the work or work station using DELMIA to suit the workers**.**

3. Initial Work State

The prerequisite for any manufacturing or processing plant would be time management and lesser product cycle time. In some cases, the worker might travel a lot in the workplace to complete the assembly of the product which takes ample time thus increasing the time taken to complete a product. The rationale of the proposal named assembly cell design leads to the chief problem happening to be time. Ergonomically, the worker may develop musculoskeletal disorders [2]. The consequences of a poor assembly cell design might have chances of snowballing the time required to develop or assemble the product and push the worker under stress and might lead those developing musculoskeletal disorders. This research adds in ways to extinguish the MSD's and improve the cycle time reducing it for a particular assembly.

4. Methodology

For this research, a standard two-wheeler engine assembly cell with appropriate data collected is considered for development with ergonomic assessment. The layout is measured to have two manikins employed at the workstation, both in standing posture and creating ample displacement of their hand. The layout is then virtualized by CAD modeling, thus implementing a methodology name virtual manufacturing for this ergonomics assessment [2] The station is provided with conveyors, one for the unassembled materials and the other for the assembled product. The process of ergonomic assessment and evaluation receipts place with the aid of a computer software named DELMIA. The manikin or human model used in the assessment is of measurement and standards an average Indian man [9]. For each assembly the employee translates the product a minimal distance of 0.5m and the period for the accomplishment of a single assembly spreads to 7.5 minutes.

5. Delmia

DELMIA is standalone software from Desalt systems providing platform for ergonomic assessments and simulations along with robotic simulations and plant layout optimization. Standards for working and measurements can be assigned, imported or selected from library. The ergonomic assessment tools used for this would be RULA and REBA. For accessing the RULA assessment for the manikin, the layout is designed with CAD and then the manikin is positioned accordingly and afforded constraints on load and activity based on the standards.

6. Rula and Reba

RULA abbreviates Rapid Upper Limb Assessment and REBA to Rapid Entire Body Assessment. The assessment takes place in consideration with a score sheet for REBA and RULA assessing tools would be readily available within the software. The results and observations are calculated in means of score with whole number less than 10. Nevertheless, the safety limit stays within 3 to 5, and the posture would need enhancement when the score scopes overhead 5. RULA and REBA are risk measuring techniques that can be performed on any misconfigured human. The RULA and REBA both are for rapid assessing of the body and the RULA assesses the neck, arm and the spline as it stands for the upper body, while REBA assesses the whole of the body. Table (1) and (2) shows the safety limits for REBA and RULA assessments.

Score	Level of MSD Risk
1	Negligible Risk
2-3	Low Risk, Change may be needed
4-7	Medium Risk, Change soon
8-10	High Risk, Implement Change now
11 +	Very High Risk, Implement Change now

TABLE 1. REBA Safety limits [9]

Score	Level of MSD Risk
1-2	Negligible Risk
3-4	Low Risk, Change may be needed
5-6	Medium Risk, Change soon
6+	Very High Risk, Implement Change now

TABLE 2. RULASafety Limits [8]

7. Assembly Cell Design T Site

The standard engine assembly is considered for enhancement. The machine or finished parts translates to the assembly through conveyors. Manpowered assembly of the parts with the help of a press takes place. The task bestowed to the man would be acceptance of the part, insertion at the fixture and utilizing the press for the insert. The weightiness of the part might be contemplated to be elevated. Once the insert is completed, essential measurements is taken for quality assurance at the next step. In content with the initial assembly cell design, the appointed labourer must walk some distance with the heavy weight on hand, thus increasing the cycle time and wasting energy. The assembled and quality assured product translates from the assembly cell by the aid of a conveyor and goes out for fine inspection. Figure (1) provides a standard assembly cell design for engines.

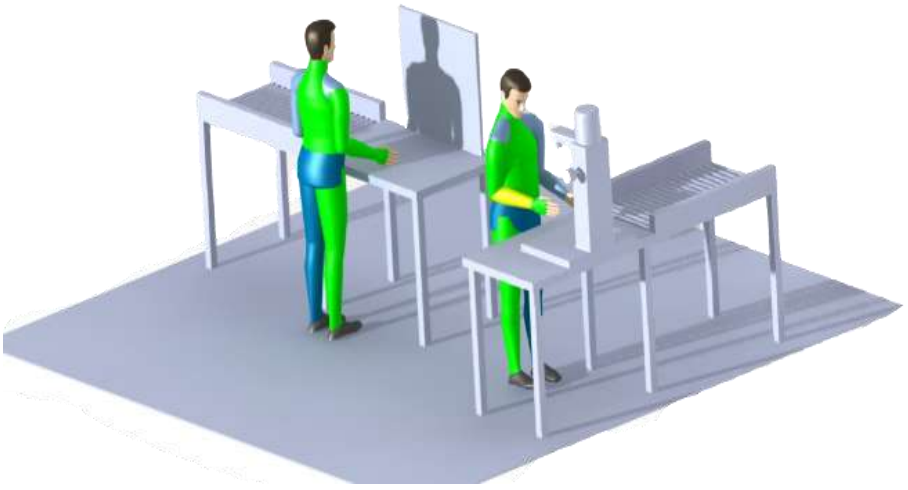

FIGURE 1. Layout design of the standard assembly cell.

8. Improved Assembly Cell Design

The proposal consists of switching place of the press nearby the quality and the entrance. The quality assurance section is translated more near to the assembled product receiving conveyor. Apart of switching places, a stool with rotary motion restrained with 90degrees and with a height in accordance with the press is introduced. The conveyors are brought nearer to the table and is modified in such a way that a single worker can work at the station with comfort. Figure (2) provides the pictorial representation of the design of the improved layout.

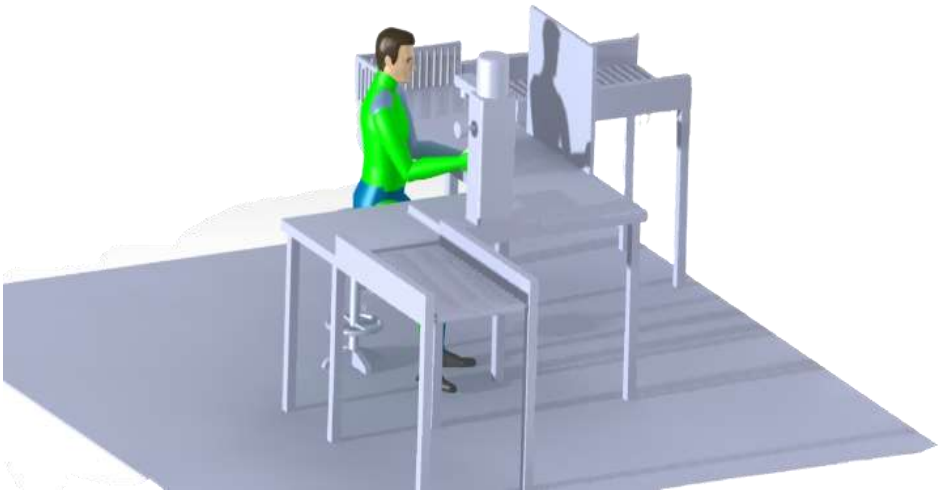

FIGURE 2. Layout design of the improved or proposed assembly cell.

9. Results and Discussion

Improvement in Cycle Time: From the observations of the improved assembly cell design it is notable that the cycle time of the product is improved. Cycle time is the time period between the times started to manufacture or assemble the product till the time at which the product is completed. Prevention of MSD's: From the inference of the improved assembly cell design, it is evident that the labourer's thoracic and clavicular loads are reduced and the intense load on thigh muscles are also prevented by the introduction of rotatable stool at an optimum height with the work. RULA and REBA Assessment of the Standard Design**:** The RULA and REBA assessment scores when assessed for the standard design, appear elevated with the reference of the tables (1)(2). The RULA and REBA assessment score along with titles are provided below in figures (3)(4). The RULA score scopes to a whole number value of 6 which when referred with the table (2) elucidate medium risk and requires change shortly. The REBA scores range to a whole number value of 4 which when referred with table (1) elucidates medium risk with a change to perform shortly.

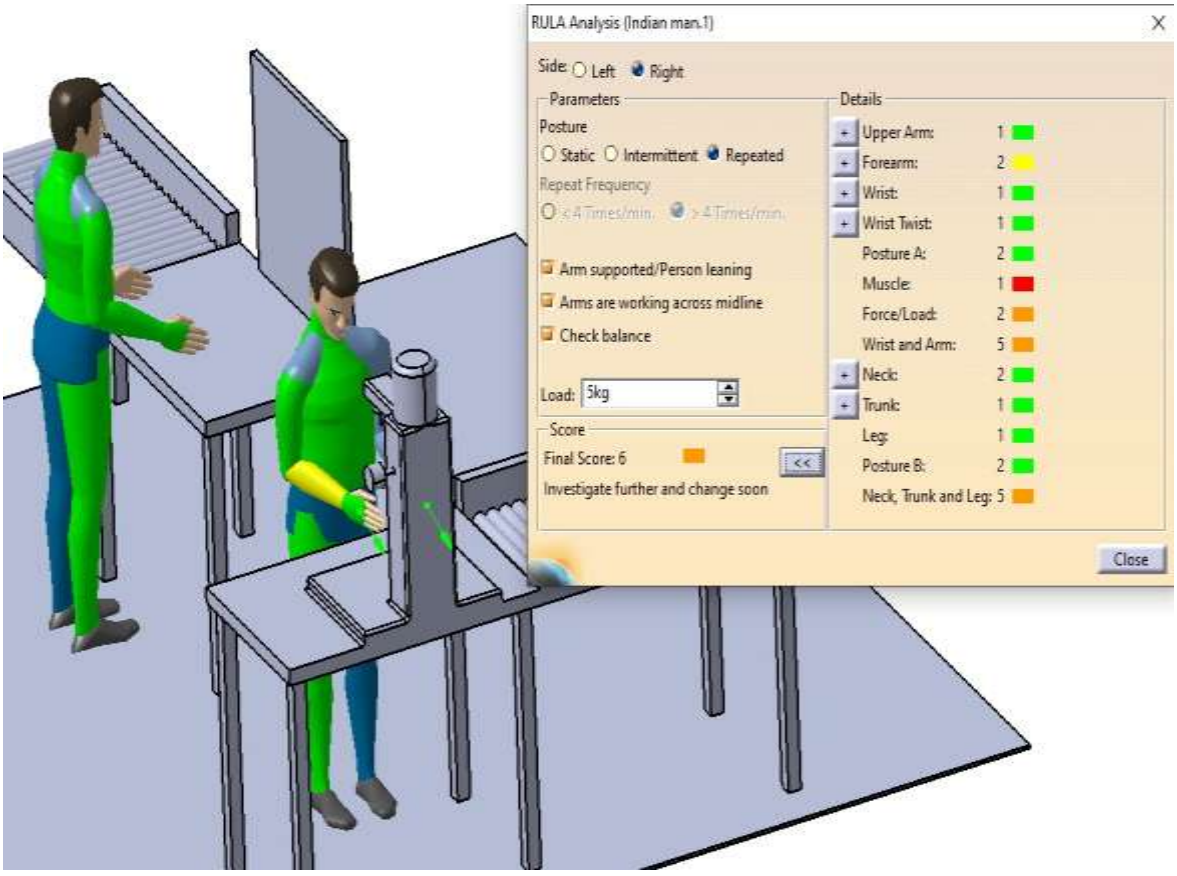

FIGURE 3. RULA assessment of the standard assembly cell design assessed using DELMIA.

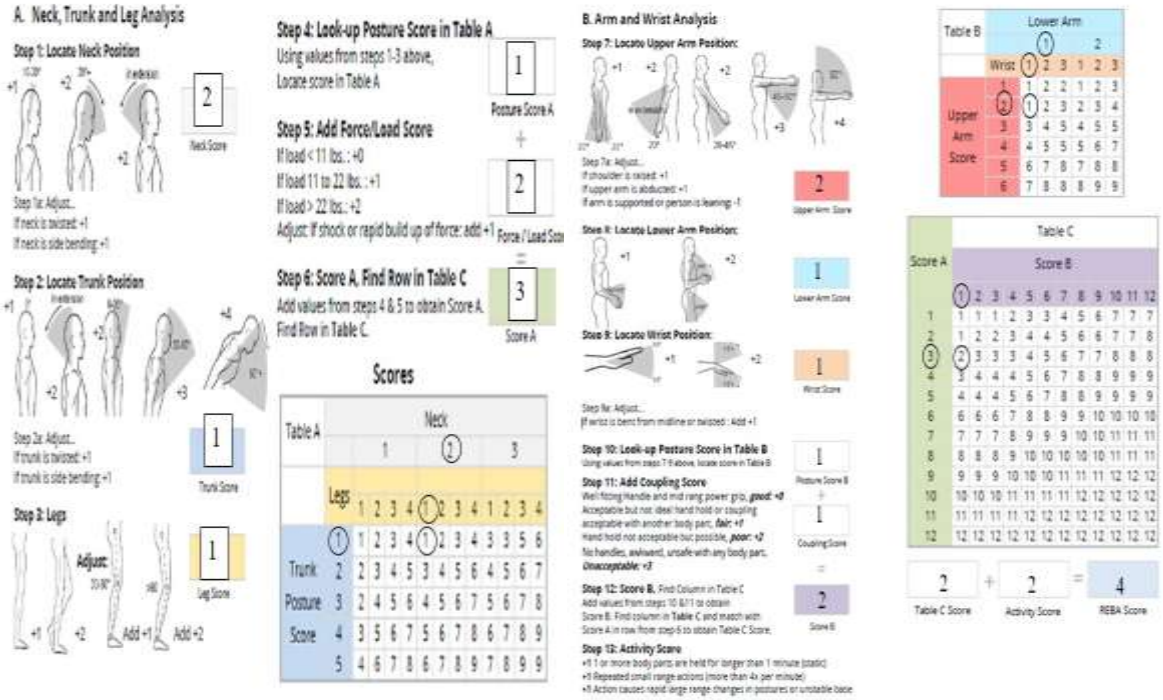

FIGURE 4. REBA assessment of the standard assembly cell design assessed using REBA score sheets [1].

RULA and REBA Assessment of the proposed cell design: The RULA and REBA assessment of the proposed and improved assembly cell design is shown in figure (5)(6). When the RULA scores are accessed with the computer software DELMIA the scores scopes to 3 which is an improvement when compared with the standard assembly cell design. The REBA scores when accessed with the score sheet [1] appear to 4 with fewer values in the trunk and neck locations.

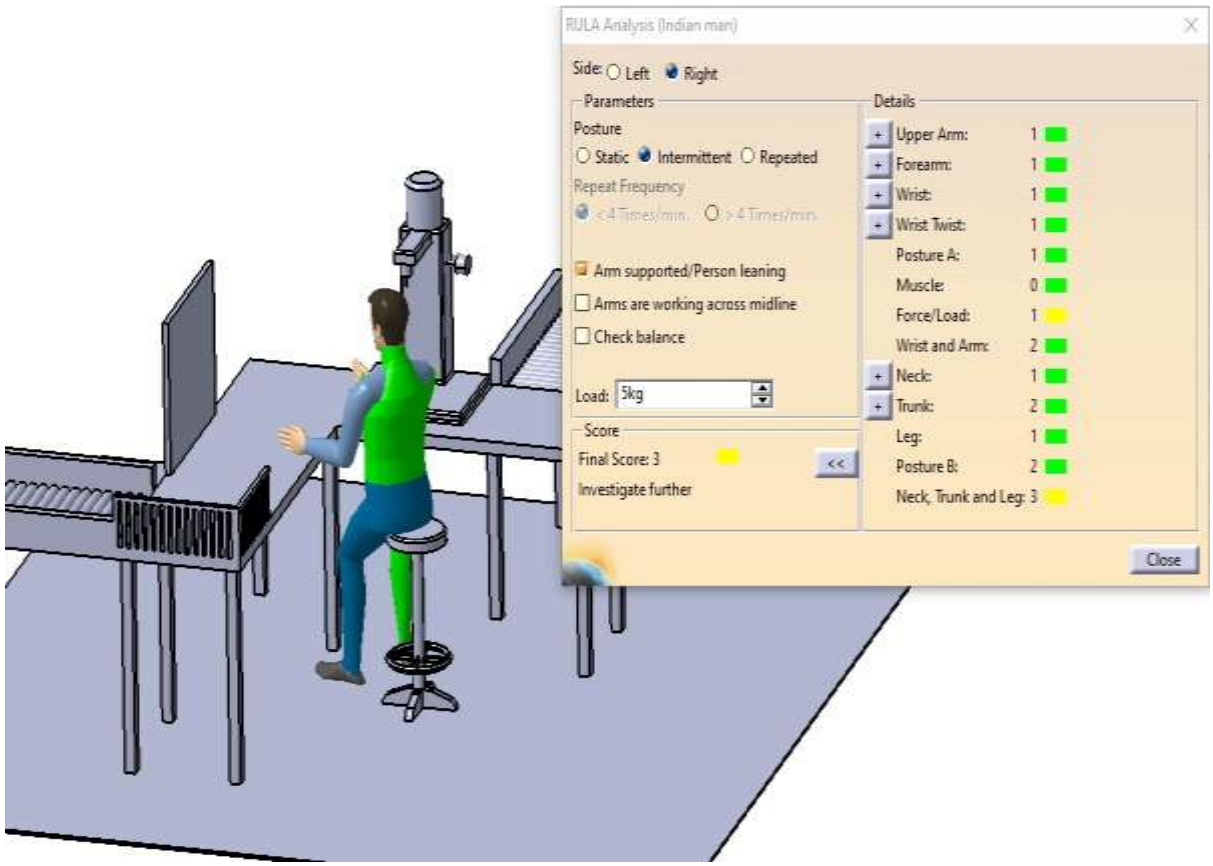

FIGURE 5. RULA assessment of the improved or the proposed assembly cell design.

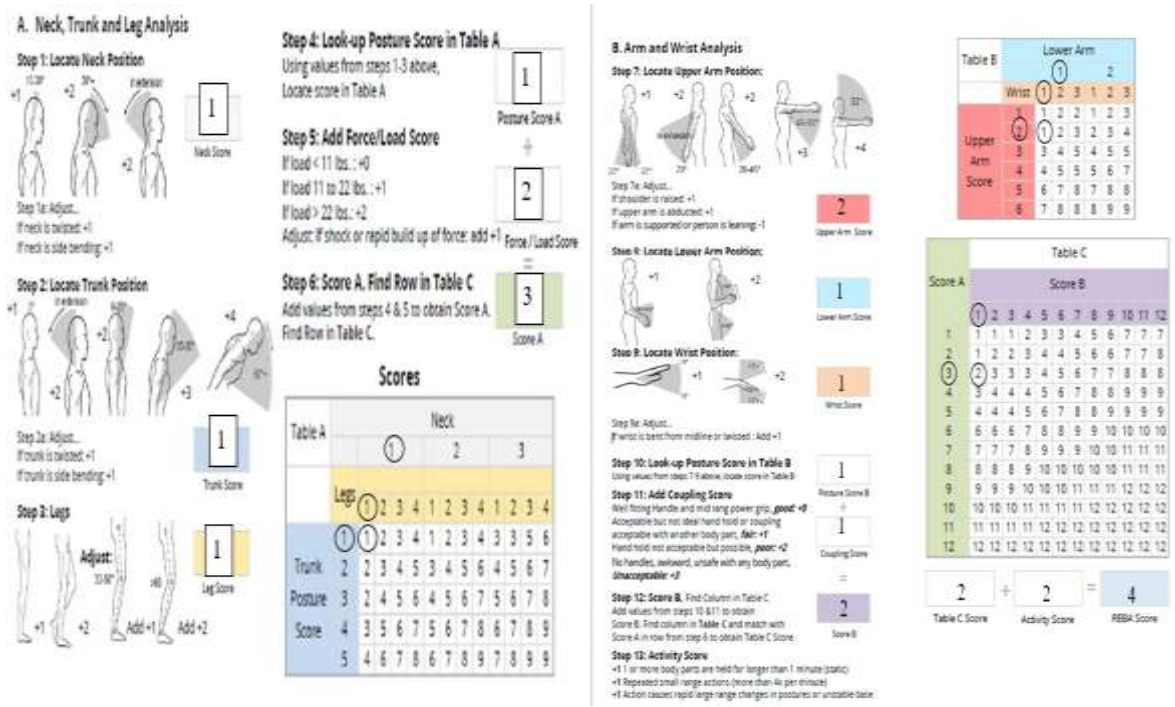

FIGURE 6. REBA assessment for the improved or the proposed assembly cell design [1].

10. Conclusion

Most of the products in the world are completed in a single process. The product not endures way lot of processes along with assembly before it grasps the customer's hand. Application of digital ergonomic tools will eradicate the discrepancies faced by the employees in different industries, thus improving the productivity along with eradication of musculoskeletal disorders among the workers. This research includes improving the designing of the assembly cell in automobile engine assembling industries and affords a rudimentary awareness for the layout optimization in accordance with ergonomic principles.

References

[1]. N. A. Ansari, Dr. M. J. Sheikh, "Evaluation of work Posture by RULA and REBA: A Case Study", IOSR Journal of Mechanical and Civil Engineering, Volume 11, Issue 4, 18-23 , Aug. 2014

[2]. Di Pardo, M., Riccio, A., Sessa, F., Naddeo, A. et al., "Methodology Development for Ergonomic Analysis of Work-Cells in Virtual Environment," SAE Technical Paper 2008-01-1481, 2008

[3]. Deros, B. M., Khamis, N. K., Ismail, A. R., Jamaluddin, H., Adam, A. M. &Rosli, S. (2011). An Ergonomics Study on Assembly Line Workstation Design. American Journal of Applied Sciences, 8(11), 1195-1201.

[4]. Caputo, F., Di Gironimo, G., & Marzano, A. (2006). Ergonomic optimization of a manufacturing system work cell in a virtual environment. ActaPolytechnica - Journal of Advanced Engineering, 46(5), 21-27

[5]. S S, Gnanavel&Balasubramanian, Venkatesh&Narendran, T.. (2015). Suzhal – An Alternative Layout to Improve Productivity and Worker Well-being in Labor Demanded Lean Environment. Procedia Manufacturing. 3. 574-580. 10.1016/j.promfg.2015.07.268.

[6]. Colim, Ana &Faria, Carlos & Braga, Ana Cristina & Sousa, Nuno & Rocha, Luis & Carneiro, Paula & Costa, Nelson &Arezes, Pedro. (2020). Towards an Ergonomic Assessment Framework for Industrial Assembly Workstations—A Case Study. Applied Sciences. 10. 3048. 10.3390/app10093048.

[7]. Aghilinejad M, Azar NS, Ghasemi MS, Dehghan N, Mokamelkhah EK. An ergonomic intervention to reduce musculoskeletal discomfort among semiconductor assembly workers.Work. 2016 Jun 14;54(2):445-50.

[8]. McAtamney L, Nigel Corlett E. RULA: a survey method for the investigation of work-related upper limb disorders. Appl Ergon. 1993 Apr;24(2):91-9.

[9]. Hignett, Sue &Mcatamney, Lynn. (2000). Rapid entire body assessment (REBA).Applied ergonomics. 31. 201-5. 10.1016/S0003-6870(99)00039-3.