Improvement Of Physical Ergonomics Using Material Handling Systems

Naveen Kumar

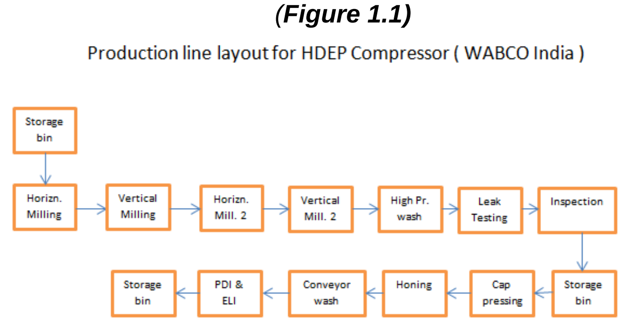
Abstract: This research paper is an investigation of the physical ergonomics of the work place in an automotive parts manufacturing company . Material transfer from one station to another station was done by hand, including a walk of a few steps to the next station. The unmachined components that has a quite heavy raw weight, also they are being loaded and unloaded by hand .Due to this continuous practice, some workers began complaining physical pain in their backs and muscular related pains. The work conditions of the workers were assessed using the REBA (Rapid Entire Body Assessment) test to understand the stress and the impact the work environment they are exposed to. Few material handling concepts have been suggested and explained to improve the quality of the work conditions for the workers and the REBA test tends to show some significant improvement when these improvements are implemented into the production line.

Index Terms: Material Handling system, REBA test, Physical and Muscular pain

1 INTRODUCTION

First Visual inspection indicates the lack of a material handling system in the production line of the shop floor. The entire material handling is dependent on the worker and this in turn falls under the category of Non-ergonomic conditions. Let's consider one worker for each machining process except the storage bin phase. The machining process starts from the horizontal milling stage using a CNC lathe. The worker lifts the heavy compressor casing by hand from the storage bin and loads it onto the CNC lathe. Each unmachined compressor casing from the first storage bin weighs about 35 lbs. Complaints have been reported by the workers telling that they get physically drained and hurt lifting these heavy casings from the storage bin and loading it into the CNC machine. After the horizontal milling is done, the component is to be moved over to the next process station i.e Vertical Milling. For this the worker has to again unload the machined casing by hand from the Horizontal milling machine and walk a few steps to the next Vertical Milling station and place it on the waiting platform. The worker from the next station again follows the same physical activity as the previous worker by lifting the compressor casing from the waiting station and loading it onto the CNC machine. Again after the machining process, unload the component and carry it to place it to the next process station. This same physical activity happens at each station till the end of line inspection process. Fig 1.1 below shows the layout.

(Figure 1.1)



- *Naveen Kumar is currently pursuing masters degree program in Manufacturing &Mechanical Systems Engineering in Rochester Institute of Technology, Rochester, NY,USA,E-mail: naveendg6@gmail.com*

2 STUDY AND BACKGROUND

The laws and policies in the United States control the proper ergonomic work conditions for the workers in industries. Where as in India, a country with a dense population, which lacks proper labor law control bodies for strict looking into these problems. One cannot imagine the fatigue and stress the worker feels lifting these heavy casings each day. This decreases the product output per hour time from each station because the worker will not be able to function efficiently. When the product output per hour is decreased, this means that it is due to the increase in waiting time for the component at each station. Kroemer (1989, Pg.279) recommends that if one needs to avoid certain trauma disorders, he/she should not maintain a certain prolonged body posture. If a body is maintained at a particular position for a long time, it causes discomfort and also even if a body is strained to work by lifting weights from a bad posture can lead to cause musculoskeletal disorders. According to Straker L (1997), he has determined the detrimental effects on performance and user's health when under prolonged or small change in posture. He states that the problem that the user faces due to this prolonged exposure is risky when repeated again and is more likely to get hurt. Each work station in the production line consists of elevated platforms for workers to work on, at the operating height level of the CNC machines. The storage bin at the first process station and the waiting area of each station are not at the height of the elevated platform. So due to this the worker needs to bend down to about 90 degree level to lift the heavy component from the storage bin or waiting area. Frequent posture of this lifting and loading the component to the machine causes musculoskeletal problems and also the same amount of stain is undergone when unloading the component after the machining process. This handling of the components can be called as manual handling since the workers use their hand for lifting, lowering, emptying. These work conditions causes musculoskeletal problems as mentioned before like sprains to the shoulders, lower backs and limbs depending upon these conditions. The NIOSH (National Institute for Occupational Safety and Health) 1991 Revised Lifting Equation can be used to evaluate manual lifting tasks. Under ideal circumstances, the maximum recommended weight for manual lifting to avoid back injuries is 51 lbs (23.13 kg). Using the exact conditions of the lift (height, distance lifted, weight, position of weight relative to body, asymmetrical lifts, and objects that are difficult to grasp), six multipliers are used to reduce the maximum recommended weight for less than ideal lifting tasks. (Source: Wikipedia). Being the 21st Century, where technology has improved drastically, this traditional manual handling must be replaced by automated handling systems, improving the working conditions of the worker.

3 Component

(Figure 1.2)

The above Fig.(1.2) shows the compressor that is being manufactured at the production line. The black part of the product is called the compressor outer casing, whose unmachined raw form weights about 35 lbs as mentioned which the workers lift by hand. The material being used for the outer casing is cast iron which has a high thermal resistance, and the reason for also the component being heavy.

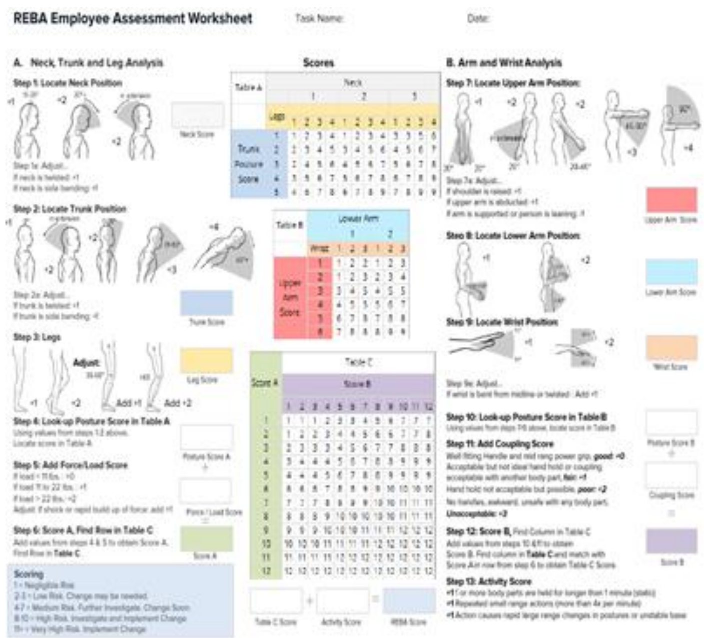
4 REBA Assessment

The **Rapid Entire Body Assessment worksheet (REBA)** is designed for easy use without need for an advanced degree in ergonomics or expensive equipment. Using the REBA worksheet, the evaluator will assign a score for each of the following body regions: wrists, forearms, elbows, shoulders, neck, trunk, back, legs and knees. After the data for each region is collected and scored, tables on the form is used to compile the risk factor variables, generating a single score that represents the level of MSD risk (Musculoskeletal Disorders). (*Taken from ergoplus.com*). Fig. (1.3) shows a table which lists the levels of MSD risk based on the score obtained from the REBA test. Decisions for improvement are taken based on the scores from this test which assesses the level of risk.

Score	Level of MSD Risk
1	negligible risk, no action required
2-3	low risk, change may be needed
4-7	medium risk, further investigation, change soon
8-10	high risk, investigate and implement change
11+	very high risk, implement change

(Figure 1.3)

A sample REBA sheet is shown below

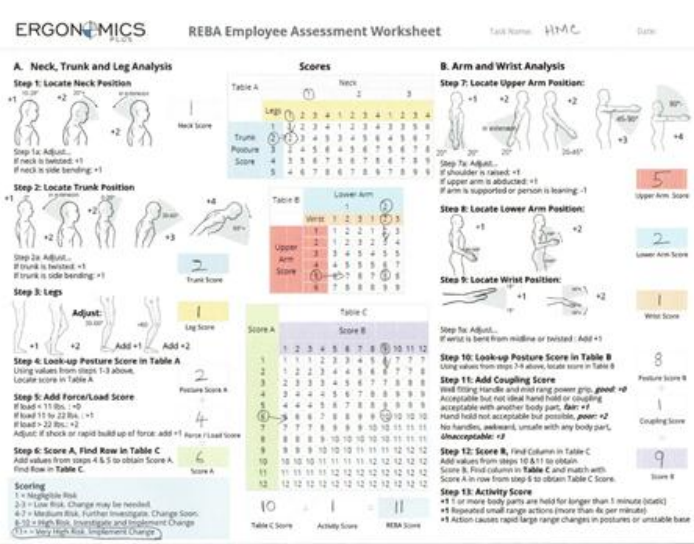


(Figure 1.4)

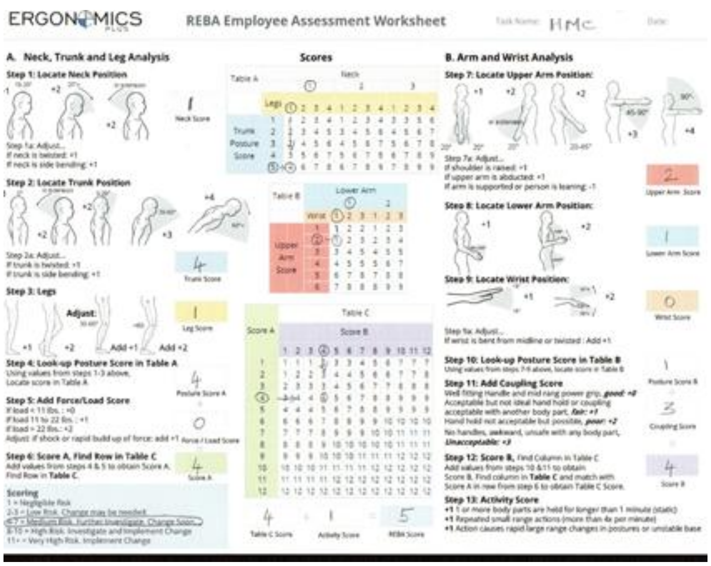
The given sheet in Fig. (1.4) is used for determining the body movement of the worker during the process at their station. Based on the Body assessment analysis done for the Horizontal Milling station (1st station) found on the layout chart Fig. (1.1), the readings have been graded in form of scores on the worksheet. There is a defined number of 4 movements (repeated twice according to REBA assessment) and is defined in 4 steps as follows:

1) Lifting the component from storage bin.
2) Loading component to CNC machine.
3) Unloading component from CNC machine.
4) Placing component on to next station waiting area.

The steps 1,4 and 2,3 have similar subjective movements and hence are assessed as one together in two REBA worksheets.



(Figure 1.5)



(Figure 1.6)

For the 1st step of the movement, the body gives a REBA score of **5** which is a **medium risk.** The 2nd step movement shows a REBA score of about **11** which fall into the **high risk factor.** The 3rd step movement is same as that of the 2nd step and the same risk factor. The 4th step is the same assessed move as that of the 1st step. From all these 4 steps, we get an average REBA score of 8 which falls under the high risk factor and in need for immediate change. These similar movements apply to the other processes as per the layout diagram given. The score report shows the extreme effort the worker takes in his routine and the amount of fatigue it causes him during work. These conditions are too uncomfortable for the worker to work peaceful and to show interest in the work he/she performs.

5 Concept Definition

Material handling is the short-distance movement within the confines of a building or between a building and a transportation vehicle. It can be manual, semi-automated and automated depending upon the safety factor required by the necessity for distribution, consumption or disposal. Material handling is integral for the design of most production systems since the efficient flow of material between the activities of a production system is heavily dependent on the layout of the activities. If two activities are adjacent to each other, then material might easily be handed from one activity to another. If activities are in sequence, a conveyor can move the material at low cost. If activities are separated, more expensive industrial trucks or overhead conveyors are required for transport. Chang, Sullivanj & Wilson (1984, Pg.15-26) state that material handling system of a Flexible Manufacturing System (FMS) consists of load and unload mechanisms, transfer mechanisms, and internal storage facilities, each of which may be configured in many different ways. In addition, many options are available for dispatching work-parts between work-stations. The inherent flexibility of an FMS affords the opportunity for enhanced system efficiency, yet it also makes the analysis and design of the system extraordinarily complex and difficult. Based on the work place ergonomic conditions and the body movement analysis of the worker, it is found that two types of material handling systems needs to be introduced into this production line to rectify the non-ergonomic conditions as per derived from the REBA worksheet. The two types of material handling systems are:

1) Base mounted Jib crane
2) Conveyor belt transfer

5.1 Base Mounted Jib Crane

This is the standard jib crane which is base mounted near the CNC machine. It consists of a sturdy support pole to which a maneuverable beam is attached on it which is capable of rotary motion along its own axis. Jib cranes are generally used for pick and place operations of components or objects. Depending on the need, steel or aluminum cables with its respective hooks are used. Jib cranes vary in size accordingly and are usually custom made based on its requirement as mentioned by the customer.

Usage for the issue:

Considering the usage of this jib crane in above ergonomic problem here, the standard jib crane with a wire type adjustable cable having a C-hook is used. It lifts the compressor casing from the storage bin and loads it onto the CNC machine, similarly also used to unload the machined component from the CNC after the operation. The C-hooks and wire cables are customized adjusted as per the requirement for each process operation machine and the position the component is needed to be loaded onto the machine. The crane's lifting mechanism will be automated and it is initiated by the buttons placed near the hook for going up and down. The worker uses this to pick and place the components depending upon the length needed for the hook to tag the component.

5.2 Conveyor Belt Transfer

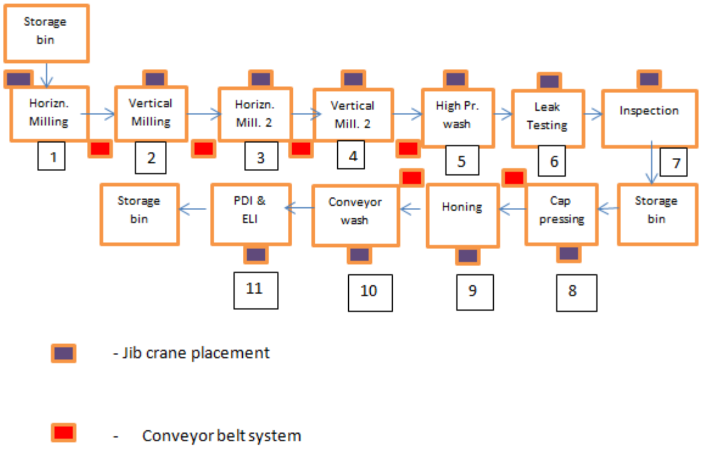
A conveyor belt system consists of two or more shaft pulleys which rotates a belt in an endless loop carrying medium and for transfer of material on it. In this system one or both the pulleys may be powered for the forward motion of the belt. These belt conveyors are found in abundance since they are less expensive and versatile. They are useful for retail, wholesale and specially manufacturing distribution. The common material used for the conveyor belt is rubber, plastic and nylon.

Usage for the issue:

This conveyor belt system is needed at the production line for component transfer from one process station to another. An additional object sensor is attached to each end of the conveyor. When the machined component from the HMC station (Station 1) is placed on to the conveyor belt, the sensor picks up the interference and starts the movement of the belt. When the component reaches the other end of the conveyor, another sensor there senses the object and stops the movement of the belt. This similar setup is to be implemented between each process stations except the station where the component next goes to the storage bin.

6 AFTER IMPLEMENTATION

In the given layout as shown in Fig.1.9 the placement of the material handling system as needed for each process station by means of color codes. The purple color code indicated the place where the job crane is required for lifting the heavy components loading and unloading use. The red color code indicates the places where the conveyor belt system is needed between the stations for component transfer from one station to the next station.



(Figure 1.9)

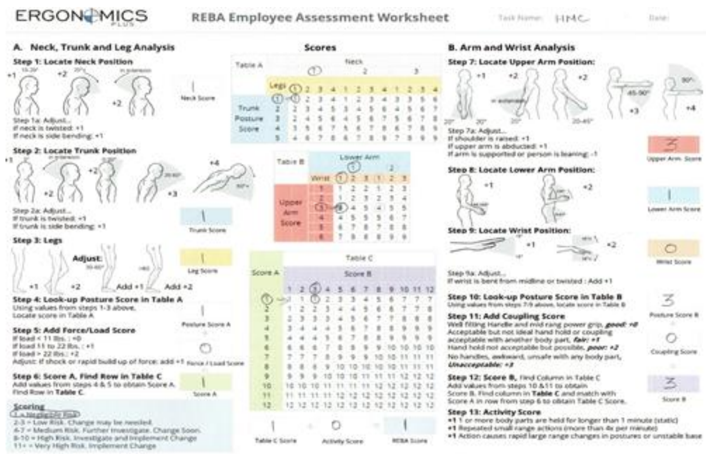
7 OUTCOMES AND RESULT

Based on the details provided previously for the implementation of a material handling system inside the production line of the company, the differences are shown if these changes get implemented. We get a clear picture regarding how the handling of things used to work before the material handling equipments were added and how the things are handled now after these equipments were added to the shop floor line. The tabular column Table (1.10) illustrates the differences that were told about previously in this paragraph. Taking **station 1** (HMC) into consideration,

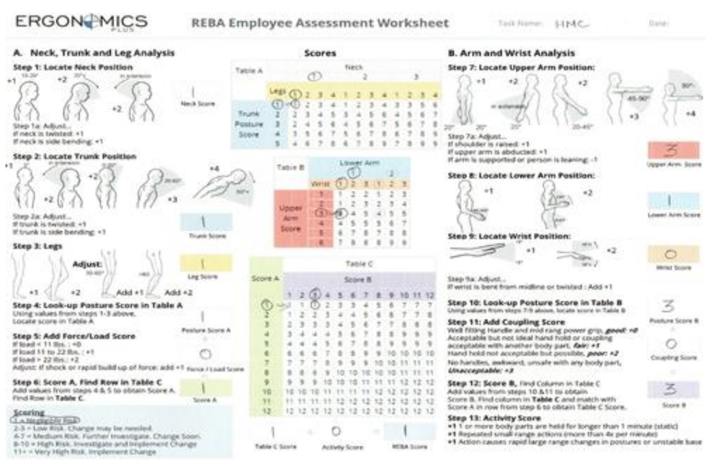
Before implementation	After implementation
1. Heavy Component lifted manually by hand from storage bin for loading.	1. Component is lifted using the operated Jib crane for loading reducing the carrying load for the worker.
2. After machining, the component is again unloaded from the machine by hand.	2. The automated jib crane is again used to unload the component from the machine, giving no stress to the worker.
3. Worker had to transfer the component to the next station by walking a few steps carrying the heavy component.	3. The sensor automated conveyor belt transfers the component to the next station after it is placed on it using the jib crane.

(Table 1.10)

When the REBA test was conducted previously before, it gave an average High risk value of 8. And if this setup were to keep continuing, the worker at one point was prone to get injured either by means of an accident of dropping the heavy component on a body part or by injuring a muscle due to constant lifting of the heavy component. When the REBA test is again taken after the implementation of these material handling system ideas, the values would be different and also tells the implementation as useful and worker suffers not much stress at all. The worksheet for the REBA test after implementation of material handling system is shown in Fig. (1.11) and Fig. (1.12). The study thus shows that physical ergonomics in this production line can be improved using the ideas as mentioned in this paper for the employee betterment. This would give satisfaction to the workers on the job and the productivity increases as the satisfaction increases. The production output now can possibly increase since the implementation of these material handling equipments makes work easier for the workers and the processes done at each station are performed at better efficiency. When better efficiency is put into work in the production line, it reduces the waiting time at each station and there is a smooth flow of the materials throughout the line.



(Figure 1.11)



(Figure 1.12)

8 CONCLUSION

This study has given us information regarding the physical difficulties faced by the workers in the industrial sectors where the material handling systems have not been established properly. Further analysis was done to find out the level of physical strain the worker feels when the components are being handled by hand instead of automated machines. The analysis is called a Rapid Entire Body Assessment test where the postures are scored based on an established ergonomic rating. Ergonomics is a factor where the people's efficiency in the working environment must be improved. It is also to improve the Man-Machine relationship factor. The problem here at this industry was that workers had given a constant complaint of musculoskeletal problems like pain in the lower back and limbs which was reportedly due to the material handling of the heavy compressor components. The problem also included the transfer of the component to the next station walking by foot. These problems were addressed by considering the required use of technology for the material handling equipments to make the working conditions of the worker easier. A study of the production line layout figured out that two types of material handling equipments would be suitable.

1) A mounted jib crane with a hook on a cable type lift
2) A standard conveyor belt system

When analyzed using the REBA test after implementation of this system shows significant improvement in posture and less strain for the worker. This ergonomic improvement factor has an indirect advantage in the improvement of the production output.

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