Ergonomics Study for Injection Moulding Section using RULA and REBA Techniques

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Abstract *— Ergonomics enhances human performance including the health, safety and productivity of workers. This project is carried out at the one of the reputed plastic industry. The main aim of the project is to identify the work-related musculoskeletal disorders (WMSDs) by using Rapid upper limb assessment (RULA) and rapid entire body assessment (REBA) techniques and design the new working area, which reduces the WMSDs, two work stations are conceded based on manual assessment and Egronomical study is concerned about various work related disorders and their reduction using ergonomically designed work station.*

Keywords — WMSDs, RULA and REBA techniques.

I. INTRODUCTION

Ergonomics enhances human performance including the health, safety and productivity of workers. This work is carried out one of the plastic industry to study and analyse the ergonomic issues in operating of CNC injection moulding machines and working area of operator. Relocation of the work stations, RULA and REBA score calculation by using work pro software and designing of working table and stool to reduce the RULA and REBA score to operator to work in ergonomically safe zone.

A. Problem statement

- Study existing working method of injection molding machine w.r.t workers, analyze the existing method with help of RULA & REBA Techniques, and propose new method to reduce human stress.

B. Objectives of Study

- To reduce unwanted motions involved in the operating of injection molding machine by ergonomics study with help of RULA & REBA technique.
- Suggest new working area of operating of injection molding machine, which reduce workers stress.

II. LITERATURE REVIEW

The International Ergonomics Association (IEA) defines ergonomics as; the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. In the current market scenario, cost fall technique is on stage significant role to meet the competition in the market. The Ergonomics thought required to be governed, in the small-scale industries (SSIs), a precise case of Cultivators and Harvester manufacturing unit is considered which is different from all these aspects. mainly, an important & large component 'turn table' is consider for analysing the ergonomic manufacturing methods [1].

Ergonomics study was conducted in assembly workstation of a furniture manufacturer with three alternative layout designs. The result shows that the best layout for assembly is where the worker feels comfortable in completing the task [2].

A fully adjustable ergonomically designed assembly workstation (smart workstation) was used for the experiment. Ten college students (five boys group and five girls group) randomly assigned into three experimental conditions (table adjustable, chair adjustable, and gender) performed the assembly task [3].

Ergonomics Study was conducted on 102 workers of a forging industry using the posture analysis tool REBA Method. A video showing the different action and activities of the workers was shot and the snapshots were taken from it for the analysis. The results of REBA showed that about 7.63% of the workers were under very high-risk levels and required immediate change. About 44.6% of the workers were at high-risk levels, which required changes soon, and 45.03% of the workers were at medium risk levels. About 2.67% of the workers were at lower risk levels. The present Study recommended the awareness and proper ergonomics training to the workers [4].

The advantage of productivity improvement using work-study techniques at assembly workstations is achieved by reducing cycle time by providing smooth flow of components for assembly. This helps in reducing the worker fatigue and suggesting new methods for smoother work flow [5].

Work-study is a systematic investigation of processes involved in operations it involves study of different workstations and suggesting improvements for the same. Work-study techniques are directly

related to the reduction of non-productive time and increasing the efficiency of production [6].

III. ERGONOMICS

Ergonomics composed of two Greek words i.e. ergo (work) and nomos (law) given a group of scientists in 1949. It also known as "human engineering". It is commonly defined as the scientific study of relationship b/w man, machine (with which he works) and environment (in which he works). Today, however, the word is used to describe the science of "designing the job to fit the worker, not forcing the worker to fit the job." Ergonomics covers all aspects of a job, from the physical stresses it places on joints, muscles, nerves, tendons, bones and the like, to environmental factors, which can affect hearing, vision, and general comfort and health[5]. It evaluates the combined effect of all these interacting factors on productivity. Successful application of such tools and techniques of the domain of ergonomics may lead to the development of the most comfortable working conditions in terms of illumination, climatic condition, noise level which ensures the minimization of physical work load, to improve work posture as well to reduce the effort of certain movements [7].

Work-related musculoskeletal disorders are:

- the leading cause of disability for people in their working years
- caused by chronic exposure to these physical stresses
- forceful gripping - kneeling
- lifting - squatting
- bending - vibrating equipment
- twisting

A. Work pro software

Work pro is software for doing improvement in organization through video work-study (VWS). Video work-study is the most economical, effective and a fast way to improvement your operations and profitability the main objective of software is to make improvement simple and natural way of life for all in organizations.

B. Work pro ergo module

Work Pro Ergo module is intended to help the Work Study Professionals to find out the health hazards of the work doing a particular work so that the work method can be re-designed to eliminate the health risks.

In Work Pro, the following Ergo assessments are included at present:

1. RULA – Rapid Upper Limb Assessment
2. REBA – Rapid Entire Body Assessment
3. MFA – Muscle Fatigue Analysis as given by Susan Rodgers Methodology
4. STINDEX – Strain Index assessment as given by Garg-Moore tables
5. NIOSH (Revised) Lifting tables – for assessing the Lifting loads of operators

C. Rapid upper limb assessment (RULA)

The RULA tool where the assessor assigns score to postures and body alignment based on body part diagram. Load, Force and coupling scores are added to calculation for the body and then final score for both groups are summated to form the final action score.

Table – I
RULA action levels

Score	Requirements for action
1 or 2	Indicates that posture is acceptable if is not maintained or repeated for long periods.
3 or 4	Indicates that further investigation is needed and changes may be required.
5 or 6	Indicates investigation and changes required soon.
7	Indicates investigation and change are required immediately.

As shown in table I RULA action taken based on the RULA score level MSD risk will be decided.

D. Rapid entire body assessment (REBA)

REBA (Rapid Entire Body Assessment) was developed by Hignett S and McAtamney, REBA is a quick and easy to use observational postural analysis tool for whole body activities and giving a musculoskeletal risk action level.

Table - II
REBA action level

Score	Requirements for action
1	Negligible risk, no action required
2-3	Change may be needed
4-7	Medium risk, further investigation
8-10	Highly risk, investigate, implement change
11 +	Very high risk, implement change

As shown in table II REBA action taken based on the REBA score and based on this score level MSD risk will be decided.

IV. DATA COLLECTION BASED ON MANUAL WORKER ASSESSMENT AND RATING METHOD

TABLE – III

MACHINES AND PRODUCT LIST

Machines and products	Cycle time/ piece	Total number of products /day (10hr)	Finishing operation time for 1 product
IMC01 (Windsor)	60-65 sec	2000 pieces	20 sec
IMC02 (Mud flab)	69-75 sec	400 pieces	35 sec
IMC03 (Mud plug)	70-80 sec	500 pieces	45 sec
IMC04 (Core plug)	115-120 sec	400 pieces	50 sec
IMC05 (Radiator fan)	80-84 sec	550 pieces	40 sec

As shown in the table III machines used to produce the products and number of production /day and time taken for production is mentioned.

Note – IMC means injection-molding machine

A. **Musculoskeletal disorders (MSD) ratings**

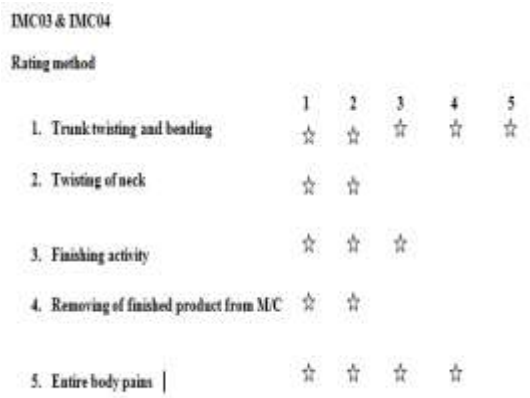

Figure: - 1 MSD Ratings

As shown in figure 1 MSD ratings based on the worker body pains and main MSD identified, is trunk twisting and bending due to this worker not able to work effectively.

B. **Case 1 (IMC03)**

As shown in below figure 2, 3 and 4 observed that in IMC03 trunk twisting, bending and wrist movement is more than safe working zone as per the ergonomic study and worker going face more WMSDs risk in future due to this some changes required in working area to reduce WMSDs risks.

Figure: - 2 Upper arm positions

Figure: - 3 Lower arm and wrist position

Figure: - 4 Trunk positions

C. **Present working area of IMC03**

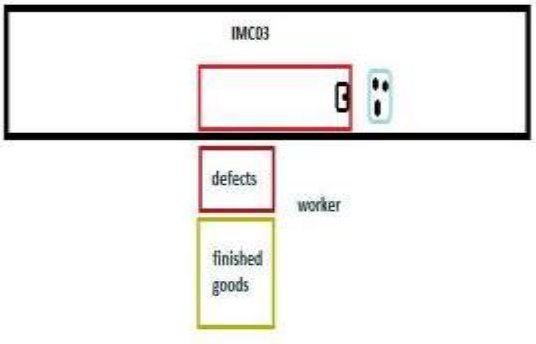

Figure: - 5 working area of IMC03

As shown in figure 5 IMC03 the worker arm position is 45^o to 90^o, trunk position is above 60^o, lower arm position is 60^o to 90^o, neck position is 10^o to 20^o and wrist rotating movement is there and the worker has to work daily for 10 hours the movements and bending actions of body is more in this operation the worker going to produce 400 to 550 products per day and in the production process Twisting of trunk and neck and Bending of trunk of worker is more than 450 times per day due to this the worker are facing Work-related musculoskeletal disorders (WMSDs) like neck pain, back pain, shoulder pain and wrist pain.

D. **Case 2 (IMC04)**

Figure: - 6 Trunk position

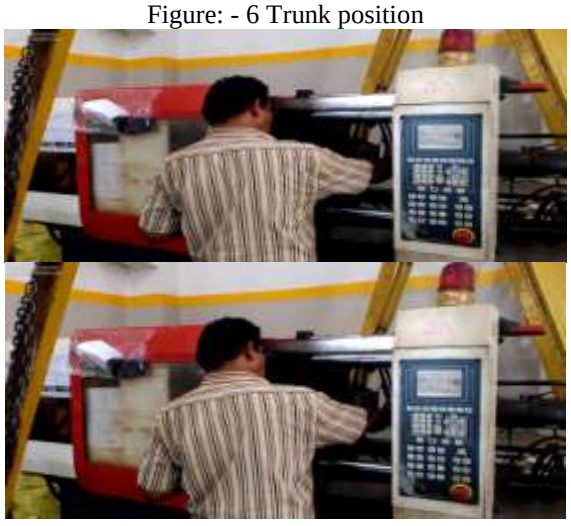

Figure: - 7 Upper arm positions

Figure – 8 Lower arm and wrist position

As shown in the figure 6, 7 and 8 observed that in IMC04 trunk twisting, bending and wrist movement is more than safe working zone as per the ergonomic study and worker going face more WMSDs risk in future due to this some changes required in working area to reduce WMSDs risks.

E. **Present working area of IMC04**

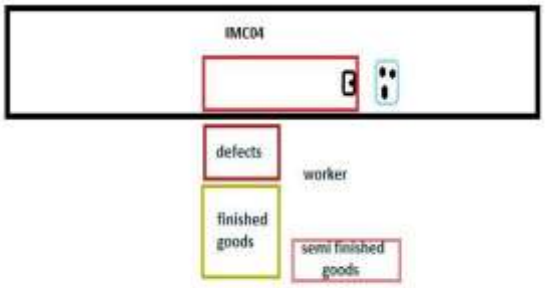

Fig: - 9 working area of IMC04

As shown in the figure 9 IMC04 the worker arm position is 45^o to 90^o, trunk position is above 60^o, lower arm position is 60^o to 90^o , neck position is 10^o to 20^o and wrist rotating movement is there and the worker has to work daily for 10 hours the movements and bending actions of body is more in this operation the worker going to produce 400 to 500 products per day and in the production process Twisting of trunk and neck and Bending of trunk of worker is more than 400 times per day due to this the worker are facing Work-related musculoskeletal disorders (WMSDs) like neck pain, back pain, shoulder pain and wrist pain.

V. ANALYSIS

RULA and REBA analysis of case 1 and case 2

1. **Case 1 IMC03 (Mud plug)**

RULA analysis

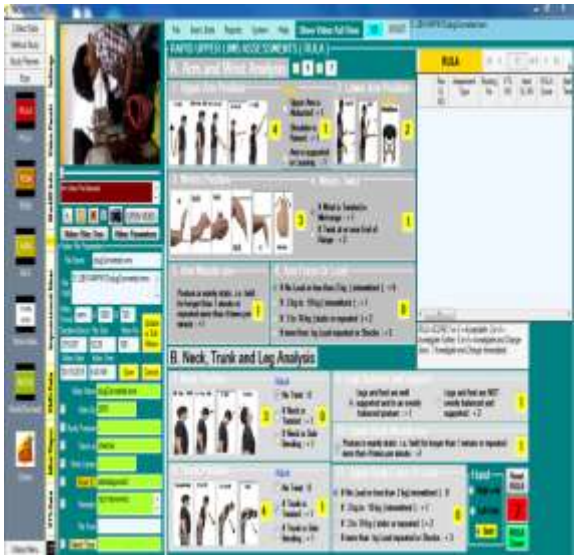

Fig – 10 RULA score for IMC03

As shown in the figure 10 the existing method the RULA score is 7 which indicates that change are required immediately to reduce the trunk and neck position.

REBA analysis

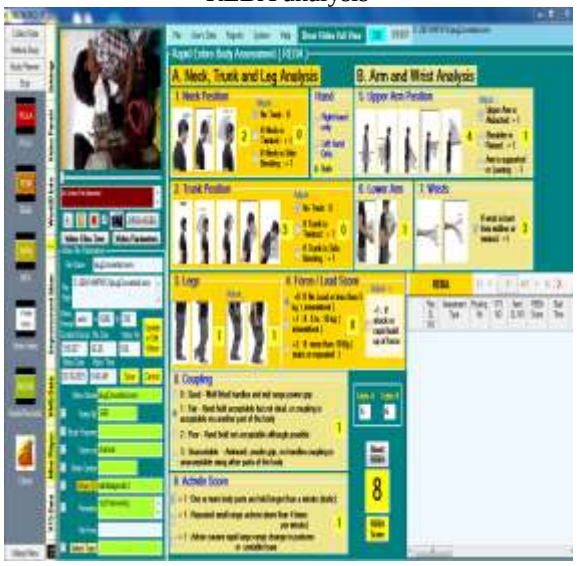

Fig -11 REBA score for IMC03

As shown in the figure 11 the existing method the REBA score was 8 which indicate that change are required soon to reduce the bending of trunk and neck position.

2. Case 2 IMC 4 (Core plug)

RULA analysis

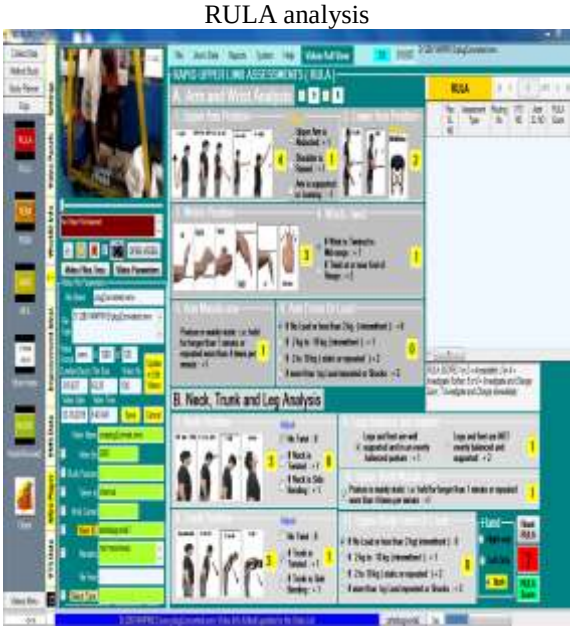

Fig – 12 RULA score for IMC04

As shown in the figure 12 the existing method the RULA score is 7 which indicates that change are required immediately to reduce the bending of trunk and neck position.

REBA analysis

As shown in the figure 13 the existing method the REBA score was 10, which indicate that change, are required soon to reduce the bending of trunk and neck position.

Fig -13 REBA score for IMC04

VI. PROPOSED METHOD

A. Design of tale and stool for IMC03

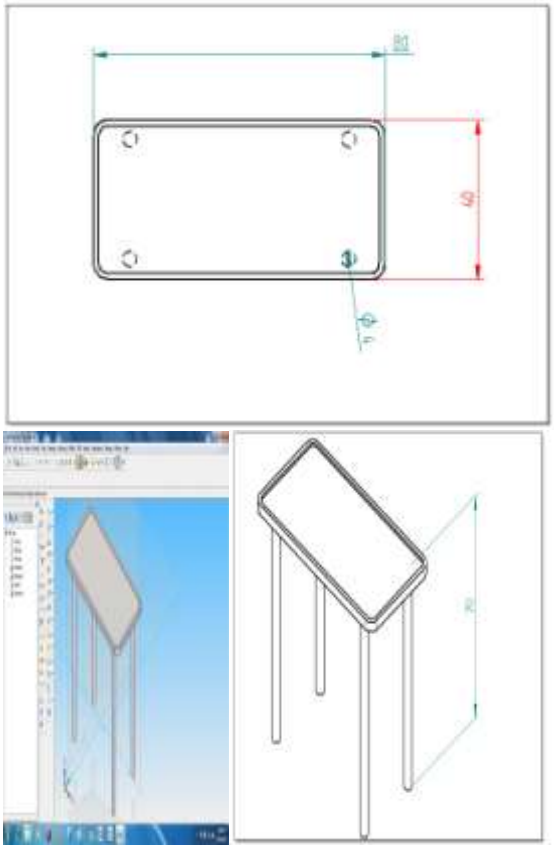

Figure: - 14 Concept design of table

As shown in figure ergonomically designed of table is made for ICM03 using solid edge software.

Design of Stool

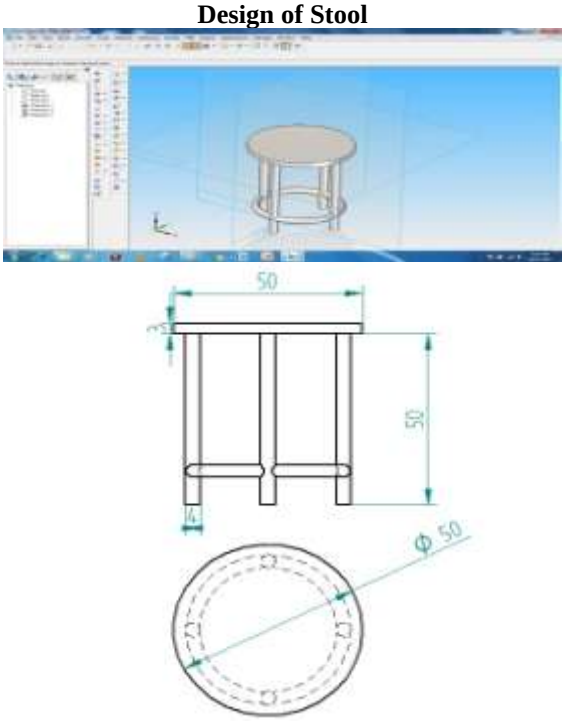

Figure: - 15 design of stool

As shown in figure ergonomically design of stool is made for ICM03 using solid edge software.

B. Proposed working area of IMC03

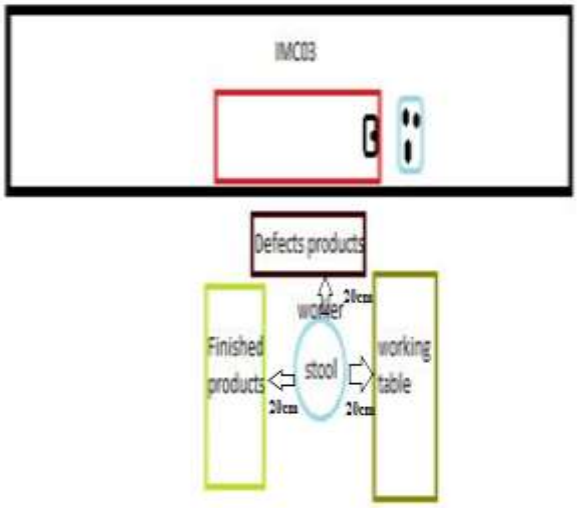

Fig: - 16 Proposed working area of IMC03

As shown in figure 14 working area of IMC03 which is redesigned to reduce the excess motions and bending of neck and trunk position here the working table is introduced to keep the semi-finished product which is hot at the beginning the worker has to wait for 30 to 40 sec to cool the product the he take the work piece and perform finishing activity according to ergonomics study the working table is designed with height of 70 cm and area of the table is 80×40 cm and stool is designed with height of 50 cm and seat with diameter 50 cm and which is placed at the right side of the worker and defects and waste parts of products are placed in front of the worker and the finished goods products box is kept left side of the worker from this working area twisting and bending of trunk and neck of the workers can be reduced.

C. Design of table and stool for IMC04

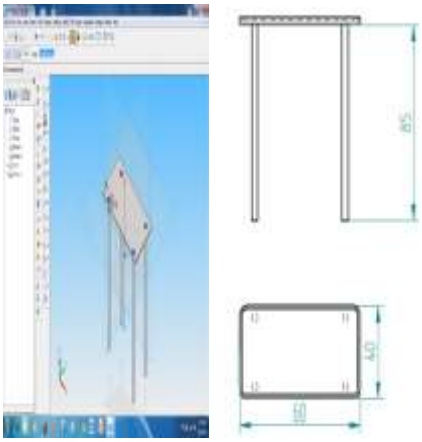

Figure: - 17 Concept design of table

As shown in figure ergonomically designed of table is made for ICM03 using solid edge software.

Design of stool

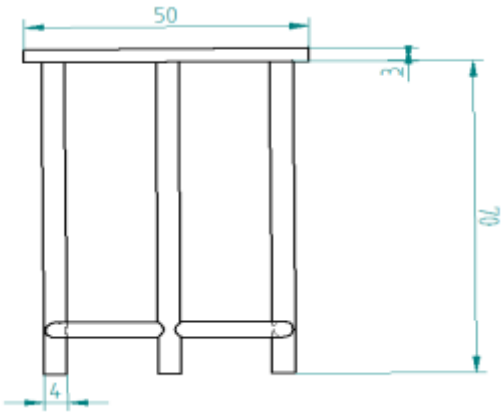

Figure:-18 design of stool

As shown in figure ergonomically designed of stool is made for ICM03 using solid edge software.

D. **Proposed working area of IMC04**

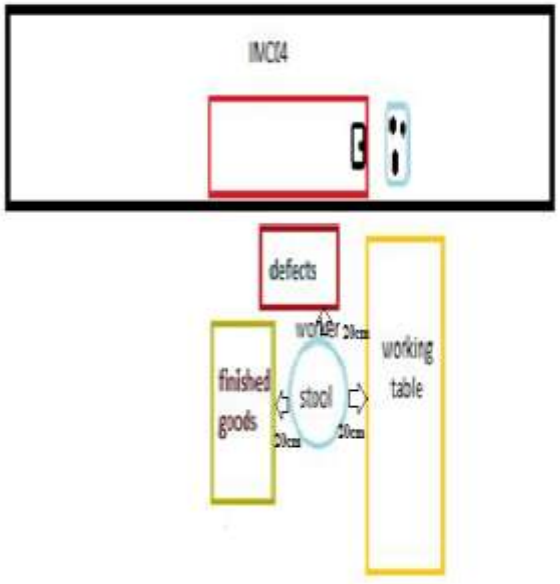

Fig: - 19 Proposed working area of IMC04

As shown in figure 15 working area of IMC04 which is redesigned to reduce the excess motions and bending of neck and trunk position here the working table is introduced to keep the semi-finished product which is hot at the beginning the worker has to wait for 30 to 40 sec to cool the product the he take the work piece and perform finishing activity according to ergonomics study the working table is designed with height of 85 cm and area of the table is 60×40 cm and stool is designed with height of 70 cm and seat with diameter 50 cm and which is placed at the right side of the worker and defects and waste parts of products are placed in front of the worker and the finished goods products box is kept left side of the worker from this working area twisting and bending of trunk and neck of the workers can be reduced.

E. **Proposed RULA for IMC03**

Below shown RULA and REBA, scores are for after changes made in work area of IMC03 and IMC04.

Fig – 20 Proposed RULA score for IMC03

As shown in figure 16 proposed working areas is reducing the RULA score from 7 to 3 which indicates that working area is safe and farther investigation may require.

F. **Proposed REBA score for IMC03**

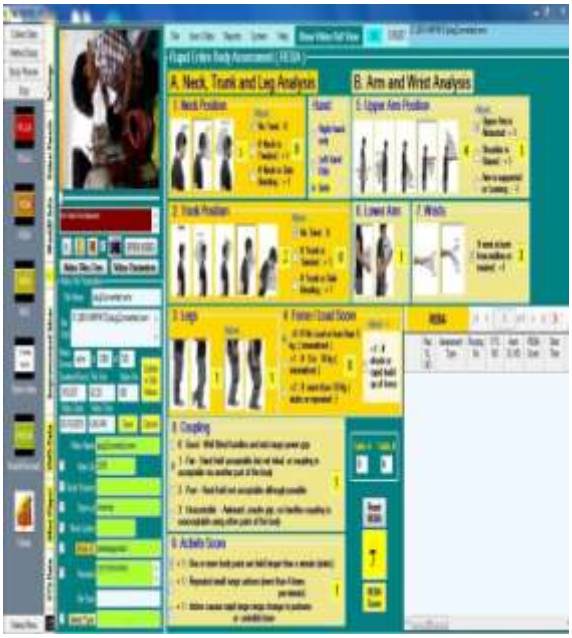

Fig – 21 Proposed REBA score for IMC03

As shown in figure 17 proposed working areas is reducing the REBA score from 8 to 7 which indicates that working area is safe and farther investigation required.

VII. Proposed RULA and REBA scores

A. Proposed RULA score for IMC04

Fig – 22 Proposed REBA score for IMC04

As shown in figure 17 proposed working areas is reducing the RULA score from 7 to 3 which indicates that working area is safe and farther investigation may require.

B. Proposed REBA score for IMC04

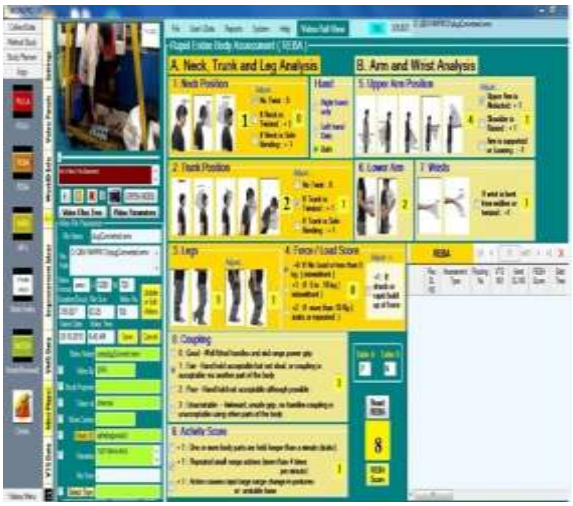

Fig – 19 Proposed REBA score for IMC03

As shown in figure 19 proposed working areas is reducing the REBA score from 8 to 7 which indicates that working area is safe and farther investigation required.

VII. CONCLUSION

- This case study based ergonomic study of IMC03 and IMC04 from a human factors and engineering point of view reduce musculoskeletal, physiological stresses of the workers and find the RULA and REBA score according to score and risk factor identified the workstation is redesigned to reduce the risk of WMSD.
- After implementation of the working area of IMC03 is implemented in plastic industry RULA sore is reduced from 7 to 3 and REBA score is reduced from 8 to 7.
- After implementation of the working area of IMC04 is implemented in plastic industry RULA sore is reduced from 7 to 3 and REBA score going to reduce from 10 to 8.

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