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Ergonomic Improvement at an Indian Heavy Equipment Manufacturing Industry

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***Abstract*— This project focused on applying ergonomic principles in heavy equipment manufacturing industry to improve worker safety and productivity. The literature review revealed that ergonomic interventions can have a significant impact on worker safety, productivity, and overall job satisfaction. Two commonly used ergonomic analysis methods, REBA and RULA, were explained in detail, along with other ergonomic interventions such as job rotation, redesigning workspaces, and the use of external fixtures and automation. The project specifically focused on the use of external fixtures to eliminate the need for workers to perform certain tasks manually. This solution not only ensured worker safety but also increased productivity and efficiency. It is recommended that ergonomic principles be integrated into the overall design and production process of heavy equipment manufacturing industries to ensure worker safety and productivity. This could involve training programs for workers and management to increase awareness and understanding of ergonomic principles, as well as the ongoing evaluation and improvement of working conditions based on feedback from workers and analysis of work processes.**

***Index Terms*— Ergonomics, purging operation, REBA, RULA, sheet rolling, and tube expansion.**

I. INTRODUCTION

HEM was formed in 1983. The company went public in 1994 and is listed on the Bombay Stock Exchange and National Stock Exchange of India. HEM received its first Venture Capital from ICICI Bank in 1987. Today it has investors like venture capitalist Vinod Khosla who has a 10% stake and Marubeni Corporation. HEM Foundation was established in 2005 as the CSR wing which is managed by Parimal Chaudhari. In 2021, the company and Indian Oil Corporation signed a memorandum of understanding to explore opportunities in the production of alcohol-to-jet (ATJ) fuels, 1G & 2G ethanol, compressed biogas, and other related opportunities in the biofuels sector.

HEM Industries Limited is an Indian multinational process and project engineering company, headquartered in Pune, Maharashtra. The company also has offices in South Africa, North America, Latin America, the Caribbean, Thailand, and Philippines. Its manufacturing facilities are at 4 locations – in Sanaswadi, near Pune, Kandla, Port in Gujarat and Wada, Thane District. HME is a recipient of the DSIR National Award in 2005 for outstanding In-House R&D Achievements.

What started off as an entrepreneurial venture three decades ago, is today India's most successful company in the field of bio-based technologies and engineering with presence all over the world. The zeal of working toward making the world a better place has stayed with us till today and will continue to do so.

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With a humble beginning as a supplier of ethanol plants, today Heavy Equipment Manufacturer (HEM) is a globally leading company with a bouquet of sustainable solutions for bioenergy, high purity water, critical process equipment, breweries, and industrial wastewater treatment. Headquartered in Pune, India, HEM has spread its presence across the globe with 1000+ References in 100+ countries across all 5 continents.

II. Literature Review

Ergonomics in heavy equipment manufacturing industries has been a topic of interest among researchers for several years. Previous studies have highlighted the importance of ergonomics in reducing work-related musculoskeletal disorders (WMSDs) and improving overall worker safety and productivity.

One such study by Elcigil and Hatipoglu (2016) focused on the ergonomics of a manufacturing plant that produced automotive components, such as shock absorbers and struts. The study utilized RULA and REBA analysis to evaluate the ergonomic risk factors associated with various tasks involved in the manufacturing process. The results showed that workers involved in tasks such as welding, painting, and assembly were at a high risk of developing WMSDs. The study recommended the implementation of ergonomic interventions to mitigate these risks.

Another study by Yang et al. (2017) investigated the ergonomic risk factors associated with workers involved in the assembly of a heavy-duty truck cabin. The study utilized RULA analysis to identify the ergonomic risk factors associated with the assembly tasks. The results showed that workers involved in tasks such as seat assembly and dashboard installation were at a high risk of developing WMSDs. The study recommended the implementation of ergonomic interventions, such as the use of adjustable workstations and ergonomic tools, to reduce the risk of WMSDs among workers.

Similarly, a study by ShenS et al. (2020) evaluated the ergonomic risk factors associated with workers involved in the assembly of an aircraft engine. The study utilized REBA analysis to identify the ergonomic risk factors associated with various assembly tasks. The results showed that workers involved in tasks such as component installation and engine assembly were at a high risk of developing WMSDs. The study recommended the implementation of ergonomic interventions, such as the use of ergonomic tools and proper work posture education, to mitigate these risks.

Overall, the literature review suggests that ergonomic analysis is crucial in heavy equipment manufacturing industries to identify and mitigate ergonomic risk factors associated with various tasks involved in the manufacturing process. The studies have utilized various ergonomic analysis methods, including RULA and REBA, to evaluate the ergonomic risk factors associated with different tasks. Based on the findings of these studies, ergonomic interventions, such as the use of ergonomic tools, adjustable workstations, and proper work posture education, can be effective in reducing the risk of WMSDs among workers in heavy equipment manufacturing industries.

III. Data Collection

The data presented was collected from the shop floor through observation, videos, and images.

A. REBA analysis for sheet rolling operation.

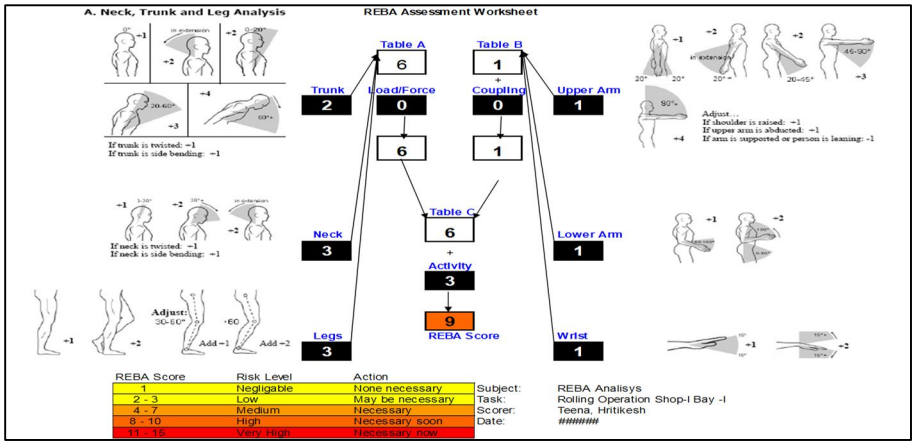

Figure 1. REBA analysis for sheet rolling (Current)

Figure 2. Rolling Operation

Fig. 1 shows the REBA analysis for current scenario of sheet rolling operation and REBA score is 9, analysis is done based on the body postures in Fig. 2.

B. REBA analysis for PAW welding operation

Figure 3. Purging Operation

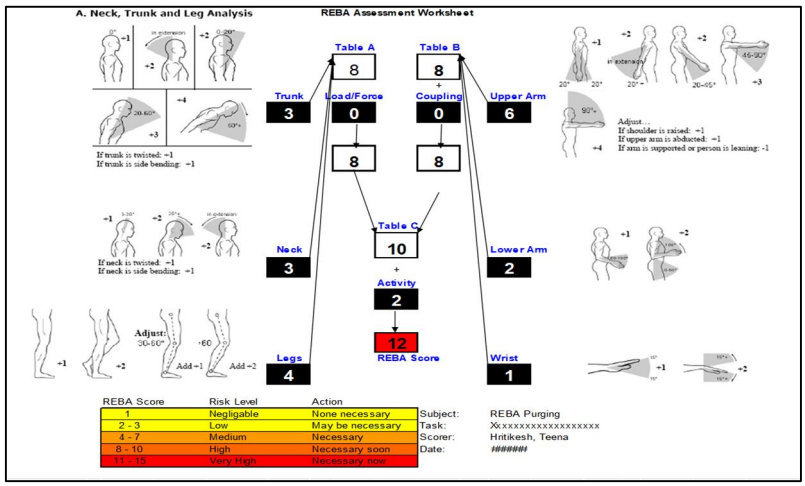

Figure 4. REBA analysis for purging operation (current)

Fig. 3 shows the body posture of workers in purging operation, Fig. 4 shows the REBA analysis for current scenario of purging operation and REBA score is 12.

C. REBA analysis for tube expansion

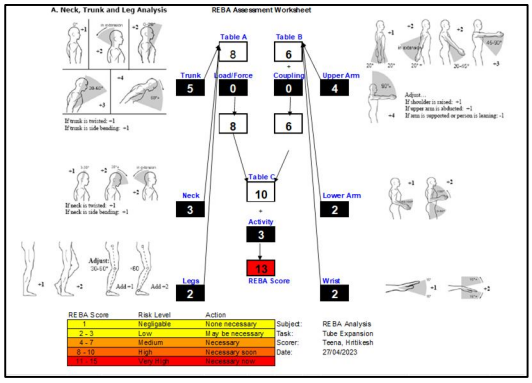

Figure 5. REBA analysis for tube expansion (current)

Figure 6. Tube expansion operation

Fig. 5 shows the REBA analysis for current scenario of tube expansion operation and REBA score is 13, analysis is done based on the body postures in Fig. 6.

D. Ergonomic improvement for sitting workstations.

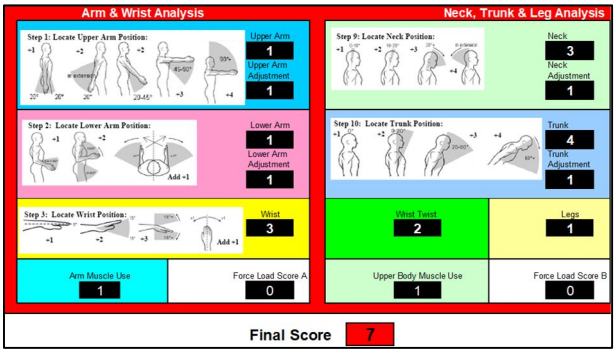

Figure 7. RULA analysis for sitting workstation

Figure 8. Improper sitting posture for work

Fig. 7 shows the RULA analysis for current scenario of sitting workstations and RULA score is 7, analysis is done based on the body postures in Fig. 8.

IV. Solution

A. Rolling Operation

Feasible solutions to address the current problem are - Visibility improvement, Better sitting arrangement, and Mobility Arrangement.
Mobility arrangement was opted in-order to achieve multiple objectives in one solution, it not only improvised the visibility to the operator but also provided a platform/workstation to work seamlessly without hampering natural body postures.

B. Purging Operation

Feasible solutions to address the current problem are - External Fixture, Internal Fixture, and Process Alteration.
It was observed that the process was having very risk factor towards operator's health and life, as the process was continuously carried out while the operator is inside the job doing purging operation. To eliminate risk and make the process easier external fixture was designed to have an implementable and meaningful solution.

C. Tube Expansion

Feasible solutions to address the current problem are - Adjustable Height Arrangement, Mobile Equipment, and Rock & Roll Model.
Compact Scissor lifts were proposed to address the developed problem keeping safety at priority. It will not only be helpful in adjusting height of the platform but also make the workplace more secure for the operator.

D. Ergonomic Improvements

Feasible solutions to address the current problem are - Provide stools and platforms.
Provision of proper tools and equipment is important to get a good output, but also maintaining operator's posture will lead to long term same quality products. To do so stools, platforms, etc., are needed to be installed at various workplaces in the industries to improve the overall productivity and reduce the fatigue.

V. Result And Discussion

A. Sheet Rolling Operation

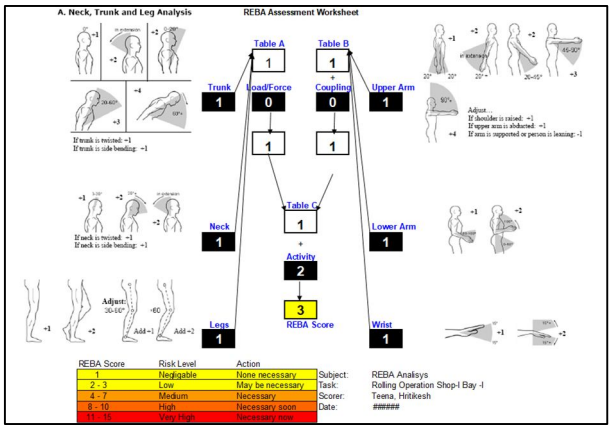

Figure 9. REBA analysis for sheet rolling (proposed)

The REBA score which was once 9 and is now decreased to 3, is shown in Fig. 9 and is based on the solutions adopted.

B. Purging Operation

The use of external fixtures in place of workers is an example of how ergonomic principles can be applied to improve safety and productivity in the workplace. By designing a solution that eliminates the need for workers to perform certain tasks manually, companies can reduce the risk of workplace injuries and illnesses, as well as increase productivity and efficiency.

In the case of the task described, the earlier practice of workers being present inside the shells posed a significant risk to their safety. The use of an external fixture eliminates this risk entirely by removing the need for workers to be near the shells during the task. This not only ensures worker safety but also allows for the task to be performed more efficiently and with greater consistency.

The elimination of unsafe manual tasks using external fixtures or automation is becoming increasingly common in many industries, including manufacturing, construction, and logistics. This approach not only reduces the risk of workplace injuries and illnesses but also improves productivity and efficiency by freeing up workers to focus on more complex and higher-value tasks.

Overall, the use of ergonomic principles in the design of work environments and tasks can have a significant impact on both worker safety and productivity. By taking steps to eliminate unsafe manual tasks and reduce physical strain on workers, companies can create a healthier and more efficient workplace that benefits both workers and the bottom line.

Tube Expansion

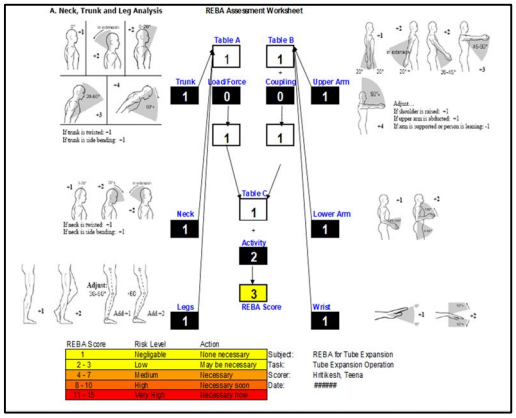

Figure 10. REBA analysis for tube expansion (proposed)

The REBA score which was once 13 and is now decreased to 3, is shown in Fig. 10 and is based on the solutions adopted.

C. Ergonomic Improvements

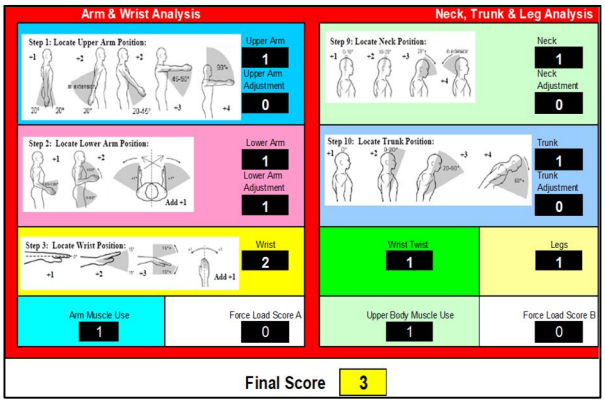

Figure 11. RULA analysis for sitting workstations (proposed)

The RULA score which was once 7 and is now decreased to 3, is shown in Fig. 11 and is based on the solutions adopted.

VI. Conclusions

The project on ergonomics in heavy equipment manufacturing aimed to enhance worker safety and productivity. By analysing working conditions and applying ergonomic principles, unsafe manual tasks were eliminated, physical strain was reduced, and external fixtures were used to increase efficiency. The project highlighted the

importance of integrating ergonomic principles into the design and production process of heavy equipment manufacturing to ensure worker safety and productivity.

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