International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 09 | Sept - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Ergonomic Hazard Evaluation Tool for Foundry Workplaces

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Abstract :- This research paper presents a detailed analysis of ergonomic risk factors among foundry workers using the Rapid Upper Limb Assessment (RULA) method. Foundry operations typically involve repetitive motions, awkward postures, and heavy lifting, all of which increase the likelihood of musculoskeletal disorders (MSDs). The RULA method, a widely recognized ergonomic assessment tool, was applied to evaluate risks associated with various tasks and workstations. Data were collected through direct observation and video analysis, and RULA scores were calculated to determine ergonomic risk levels. The results identify specific high-risk tasks and workstations, offering valuable insights for targeted ergonomic interventions aimed at improving workplace conditions and reducing the risk of MSDs among foundry workers.

Keywords: Ergonomic risk assessment, Musculoskeletal disorders (MSDs), Workplace ergonomics

I. Introduction

The foundry industry, a cornerstone of the manufacturing sector, relies extensively on sand casting—an age-old method valued for its versatility and cost-effectiveness. Despite its advantages, this traditional process often presents substantial ergonomic challenges and hazards for workers. Manual operations such as mold preparation, molten metal pouring, and finishing require awkward postures, heavy lifting, and repetitive motions, thereby increasing the risk of musculoskeletal disorders (MSDs) and other occupational health issues. Historically, production efficiency has taken precedence over ergonomic considerations in many foundries, leading to work practices that heighten ergonomic risks and compromise worker well-being.

This research addresses these concerns by assessing ergonomic risk factors among foundry workers engaged in sand casting processes. The Rapid Upper Limb Assessment (RULA), a widely recognized ergonomic evaluation tool, was employed to systematically analyze and quantify risks associated with different job tasks in the foundry environment. By applying RULA, the study identifies tasks and workstations with elevated ergonomic risks, providing critical insights into areas requiring intervention and redesign.

II. Research Objectives

1. To utilize the Rapid Upper Limb Assessment (RULA) method to identify and characterize ergonomic risk factors, particularly work-related musculoskeletal disorders (WMSDs), associated with various tasks in the foundry environment, with emphasis on sand casting processes.
2. To employ RULA as a proactive tool for improving worker safety, health, and overall well-being by systematically addressing ergonomic concerns and fostering a safer work environment.
3. To propose workplace modifications and interventions aimed at reducing worker discomfort and minimizing ergonomic risks.

III. METHODOLOGY

1. Awkward working postures were observed among workers in the foundry environment. This study employs the Rapid Upper Limb Assessment (RULA) method to evaluate the risk of work-related musculoskeletal disorders (WMSDs) in small- and medium-scale foundries. Data were collected from four major departments: fettling, melting and pouring, molding, and pattern making. RULA analysis was conducted both manually, through direct observation of workers' movements, and using CATIA-V5 software.
2. To further assess risk levels and compare the effectiveness of ergonomic assessment tools, statistical analysis was performed using Minitab-16 software to evaluate the agreement between RULA and the Rapid Entire Body Assessment (REBA) methods. Based on the identified risk levels, tasks most prone to WMSDs were highlighted, and ergonomic interventions were suggested. RULA assessments, carried out both manually and with software, were performed before and after implementing the recommended interventions to evaluate their effectiveness.

RULA Analysis Using CATIA V5

RULA Worksheet

The RULA assessment in CATIA V5 was performed using the *Human Builder* tool to create a digital representation of a worker within the workspace. The worker model was positioned to replicate the real-world posture adopted during specific foundry tasks, ensuring accuracy in reflecting actual working conditions.

Subsequently, task-specific loads were applied to the worker's arms and hands using CATIA V5's simulation capabilities to represent the weight-bearing requirements. The simulation was paused at key points to analyze worker posture, joint angles, and movement patterns. CATIA V5's measurement tools were employed to quantify joint angles and distances, with particular attention to the upper limbs and trunk posture.

The RULA scoring system was then applied to evaluate the posture, movements, and force exertions. The analysis resulted in a RULA score of **7**, indicating a high ergonomic risk level and classifying the task as hazardous for workers in such an environment. The combined scores provided the overall ergonomic risk level associated with the task, highlighting the urgent need for intervention.

RULA Analysis (Manual)

Manual RULA analysis was conducted on workers' movements within the foundry environment, resulting in a score of **7**, which indicates a high level of ergonomic risk. The assessment focused on various job tasks commonly performed in sand casting processes to evaluate the ergonomic stressors affecting workers.

The findings revealed frequent occurrences of awkward postures, repetitive movements, forceful exertions, and limited rest opportunities. These factors collectively pose significant risks to worker health and safety, increasing the likelihood of musculoskeletal disorders (MSDs) such as back pain, shoulder injuries, and repetitive strain injuries.

If left unaddressed, these ergonomic hazards may result in reduced worker morale and job satisfaction, along with potential legal and financial implications for the organization. Furthermore, productivity may be adversely affected. To mitigate these risks, it is imperative to implement targeted ergonomic interventions aimed at reducing worker discomfort, improving workplace design, and safeguarding the health and well-being of foundry workers.

Analysis Following Suggestions (Manual Assessment)

After the integration of multi-head centrifugal die casting machines, CNC machines, lathes, and shot blasting equipment to streamline production processes in the foundry, a significant improvement in manual RULA

scores was observed. The score decreased from **7 to 4**, reflecting a marked reduction in ergonomic risks associated with manual labor tasks. This outcome demonstrates the effectiveness of technological interventions in improving workplace ergonomics and safeguarding worker health.

The introduction of automated machinery substantially reduced the need for manual handling of heavy materials and repetitive motions, thereby minimizing musculoskeletal strain and fatigue among workers. Furthermore, the precision and efficiency provided by these machines contributed to more streamlined production workflows, further reducing the physical demands placed on workers.

By addressing key ergonomic concerns and optimizing task performance through automation, the foundry has successfully established a safer and more supportive working environment. These improvements not only enhance worker well-being but also promote long-term productivity and operational efficiency.

Results and Discussion

[1] Prior to the intervention, the Rapid Upper Limb Assessment (RULA) score was **7**, both in CATIA-based analysis and in manual assessment, indicating high ergonomic risks for workers. After implementing the suggested improvements, the RULA score was successfully reduced to **4**, reflecting an approximate **42.9% reduction** in ergonomic risk levels.

[2] This reduction demonstrates a substantial improvement in workplace ergonomics, contributing directly to enhanced worker well-being, comfort, and safety.

[3] The findings highlight that technological interventions—such as the integration of automated machinery and process improvements—are effective in mitigating ergonomic hazards associated with manual labor tasks. The decrease in risk levels underscores the value of proactive ergonomic interventions in not only safeguarding worker health but also in fostering a safer, more productive, and sustainable working environment within the foundry.

Conclusion

Research on the risk of work-related musculoskeletal disorders (WMSDs) using postural analysis methods in the foundry sector remains limited. This study demonstrates that workers in small- and medium-scale foundry units are exposed to high ergonomic risks, particularly in the melting, pouring, casting, and fettling departments, where the likelihood of WMSDs is greatest. The findings emphasize the urgent need for ergonomic interventions in these work areas.

The integration of automated machinery significantly reduced the need for manual handling of heavy materials and repetitive motions, thereby lowering musculoskeletal strain and fatigue among workers. This improvement highlights the effectiveness of technological solutions in enhancing workplace ergonomics and worker health.

The outcomes of this study can serve as a foundation for developing participative programs that actively involve workers in the design of ergonomic solutions. Furthermore, training initiatives should be implemented to ensure adherence to safety and ergonomic principles in daily operations. By adopting such measures, foundries can foster safer work environments, safeguard worker well-being, and enhance overall productivity.

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