Article

Screw Conveyor Design to Reduce Musculoskeletal Disorders (MSDs) Risk in Coconut Shell Handling

Fajar Hadi Crisnamurti [1,*], Agus Edy Pramono [1]

[1] Magister Program in Applied Manufacturing Technology Engineering, Politeknik Negeri Jakarta, Jl. Prof. Dr. G.A. Siwabessy, Kampus UI, Depok 16425, Jawa Barat, Indonesia

[*] Correspondence: fajar.crisnahadi@gmail.com

Abstract: This study aims to analyze the working posture of operators involved in feeding coconut shells into a processing machine, using the Rapid Entire Body Assessment (REBA) method. Data were collected through direct observation and video analysis of workers performing the task over a full work shift, ensuring diverse movement patterns and postures were captured. The assessment yielded a total REBA score of 9, which indicates a high level of ergonomic risk requiring immediate corrective action. This elevated score is attributed to repetitive movements during the material handling process. To mitigate the risk of Musculoskeletal Disorders (MSDs), a specially designed portable screw conveyor is proposed as an assistive tool. The proposed conveyor is expected to significantly reduce physical strain and improve the overall ergonomics of the task by minimizing repetitive lifting and awkward postures. Visual illustrations of the design and technical drawing are provided to support the implementation concept. This study highlights the importance of ergonomic interventions in industrial settings to promote worker health and operational efficiency.

Keywords: Material Handling; Ergonomic worker; Rapid Entire Body Assesment (REBA); Coconut Shell

1. Introduction

The manual process of feeding chopped coconut shells into a shredding machine often leads to physical fatigue among workers. This task requires continuous lifting and inserting of coconut shells over extended periods, resulting in muscle strain and increasing the risk of work-related injuries. Repetitive movements and awkward postures contribute significantly to ergonomic hazards like Musculoskeletal Disorders (MSDs), which are among the most common occupational injuries in labor-intensive environments[1]. The entire handling process including transferring coconut shells from storage, placing them into backets, transporting them to the shredder machine, and subsequently tidying up the area is carried out manually. Due to production targets, little attention is paid to workers' posture during these repetitive tasks, further elevating ergonomic risks[2].

Despite the widespread use of coconut shells in biomass energy and other industrial applications, the broader significance of improving this processing step, particularly in terms of worker safety and productivity, remains underreported. According to a study by the International Labor Organization (ILO), ergonomic risk account for over 30% of all workplace-related injuries in manual material handling operations[3]. However, localized data and case studies

on the ergonomic impacts of coconut shell processing in Indonesia or similar contexts remain limited.

To address these issues, this study proposes the design and development of a portable conveyor system as an ergonomic intervention aimed at reducing physical workload. The conveyor system is designed for mobility and flexibility, allowing the equipment to be relocated as needed depending on the workflow layout. The proposed conveyor is constructed using mild steel for the frame, a wear-resistant rubber belt for material transport, and castor wheels to enhance portability. The drive system employs a low-power electric motor to ensure energy efficiency and operational sustainability.[4]

The manufacturing process involves cutting, welding, and modular assembly of components, which simplifies maintenance and enhances the system's adaptability in various work settings. This proposed design is expected to improve productivity, minimize injury risks, and provide flexible application across multiple workplace environments. The following figures illustrate the three-dimensional design concept, the coconut shell handling process, and the associated worker postures[5].

2. Materials and Experiment Methods

The design process began with problem identification through direct observation at the PT GKI Cibinong Bogor Plant, specifically in the coconut shell processing area at the Production Department section. A field study was conducted using interviews and on-site observations. A detailed case analysis was carried out using the Rapid Entire Body Assessment (REBA) method. Supporting tools used in this research included a weighing scale, ruler, and measuring tape. In addition, AutoCAD software was utilized to evaluate the operator's working posture[6].

The REBA method is an ergonomic assessment tool designed to evaluate the overall posture of the human body, covering the neck, back, arms, wrists, and legs [7]. This method is particularly relevant for addressing common ergonomic issues faced by workers in small and medium-sized enterprises. The REBA score is influenced by external forces acting on the object being handled and the nature of the work activity itself [8]. This method enables a relatively quick evaluation and provides a general overview of the activities that require immediate intervention to reduce the risk associated with operator work behavior.[9]

Figure 1. Worksheet REBA [10]

Data collection involved documenting one of the operators while performing the task. The results were then analyzed and compiled into a table format based on the REBA Employee Assessment Worksheet, as shown in Appendix Figure 1. The first step in the Rapid Entire Body Assessment (REBA) method involves the evaluation of working posture, which is categorized into two groups. Group A includes the trunk, legs, and neck, while Group B consists of the upper arm (shoulder), lower arm (elbow), and wrist [11]. During the process of lifting coconut shells into the machine, each of these body components is assessed and assigned a score based on the observed working posture[12].
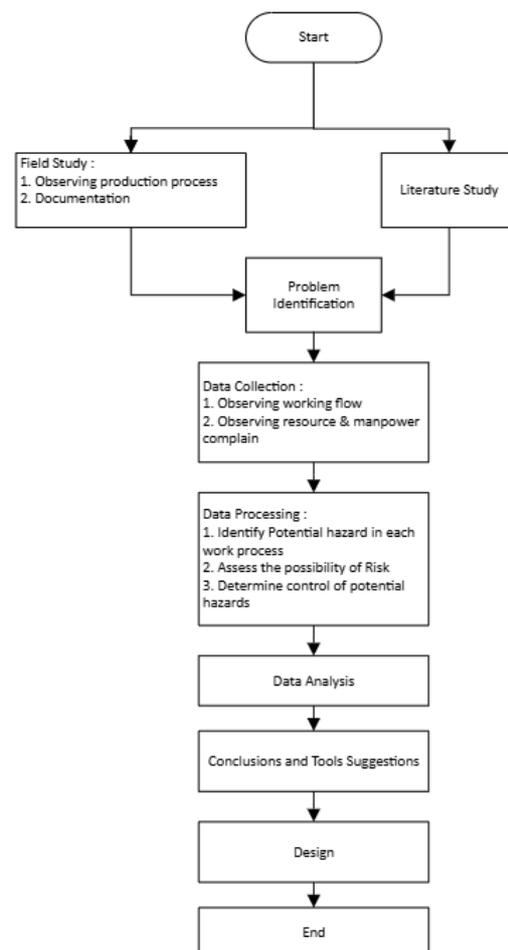

Figure 2. Flow Diagram

The workflow diagram in Figure 2. Illustrates the systematic approach used in this study to identify hazards and propose appropriate design interventions in the coconut shell feeding process. The process begins with a field study consisting of direct observation of production activities and documentation of worker routines, this also supported by a Literature Study. These two initial inputs lead to Problem Identification, where specific issues related to manual handling and worker posture are defined[13].

Following problem identification, Data Collection is conducted, focusing on two key activities: observing the workflow and documenting feedback or complaints from the workforce.[14] These observations serve as the foundation for Data Processing, which involvherehree critical steps: identifying potential hazards in each task, assessing the associated

risks, and determining possible control measures to minimize those hazards. The evaluation results are then referenced against the REBA action level chart [15], as presented in Table 1.

Table 1. REBA Action Level.

Total Score	Risk Level	Corrective Action
1	Neglected	Not Necessary
2-3	Low	Might Be Necessary
4-7	Medium	Needed
8-10	High	Needed As Soon As Possibly
11-15	Very High	Required Now

Subsequently, the study proceeds to Data Analysis, where the collected information is evaluated to understand the relationship between manual handling activities and ergonomic risk. Based on the analysis, the next stage involves drawing Conclusions and Suggesting Tools, including potential ergonomic interventions such as the use of a portable conveyor system. The final stage is the Design phase, where proposed solutions are translated into technical specifications, followed by implementation planning[16].

This structured methodology ensures that the solution is grounded in empirical observations and aligned with ergonomic safety standards, ultimately aiming to improve worker well-being and operational efficiency.

3. Results and Discussion

The posture assessment process begins with capturing photographs using a camera. The resulting images are utilized to determine the angular measurements of each body segment. The body parts evaluated include the neck, back, legs, upper arms, lower arms, and wrists. These angles are analyzed to assess the posture of the worker during the activity. The angle assessment of the worker's posture is illustrated in Figure 3 below.

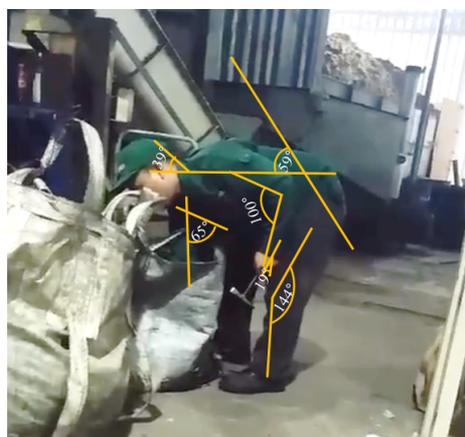*3.1. Assesment of Worker Body Posture Angles*

Figure 3 Worker Body Posture Angles

Figure 3 Illustrates the ergonomic assessment of a worker's body posture during the coconut shell feeding process using the the REBA (Rapid Entire Body Assesment) method. The

image captures a real-time scenario where the worker is manually transferring chopped coconut shells from a storage bag into a container. The body angles measured included the neck (39° flexion), trunk (59° bending), upper arm (65° elevation), fore arm (100°), and feet (144° flexion), all of which indicate awkward and strained postures.

This static posture involves significant bending of the back and knees while simultaneously elevating the arms, contributing to a high ergonomic risk score. Such posture, if repeated frequently without proper intervention, can lead to musculoskeletal disorders, particularly in the lower back, shoulders, and feet or knees. The REBA analysis based on these angles suggests that the task falls within a high-risk category, requiring immediate ergonomic improvement or redesign of the work method.

Table 2. Worker Body Postures Angles

Number	Body Part											
	Neck		Back		Feet		Upper Arm		Fore arm		Wrist	
Fig.3	A	39°	A	59°	A	144°	A	65°	A	100°	A	19°
Score	3		3		2		3		2		2	

3.1.1. Score A

Figure 4 Score A in REBA Worksheet

Figure 4 presents the calculation of Score A in the REBA worksheet, which focuses on the postures of the neck, trunk, and legs during the task. Based on the postures angles observed in the previous figure (Figure 3), the scoring results are as follows: a score of 3 for the trunk posture due to a significant forward bend, 3 for the neck due to moderate flexion, and 2 for the leg position based on the semi-squat stance.

These scores are cross-referenced in the REBA Table A matrix, resulting in a combined posture score of 6. Since the load handled by the worker is under 4.9kg (11lbs), no additional load or force score is added at this stage. This Score A indicates a moderate risk level and serves as an early warning that ergonomic improvements-such as workstation redesign or mechanical aids should be considered to prevent long-term musculoskeletal disorders.

3.1.2. Score B

Figure 5 Score B in REBA Worksheet

Figure 5 illustrates the calculation of Score B in the REBA Worksheet, which evaluates the posture of the upper limb segments namely the upper arm, lower arm, and wrist. In this assessment, the upper arm scores a 3 due to shoulder elevation and forward reach, the lower arm receives a 2 based on its angle, and the wrist also scores 2 due to a slight bend and deviation from neutral postures.

When these values are referenced in Table B, the combination results in a posture score of 5. This score reflects a moderate level of ergonomic risk for the upper extremities during the task. As the object being handled is not considered heavy, no additional force or coupling points are added. This indicates a need for improvement in arm posture possibly by redesigning the workstation layout or using supportive equipment to reduce strain on the shoulders and wrists during prolonged tasks.

3.1.3. Total Score A + B

Figure 6 Total Score

Figure 6 displays the final calculation based on the Rapid Entire Body Assessment (REBA) worksheet score by combining Score A and Score B using Table C. In this assessment, Score A is 6, derived from trunk, neck, and leg posture analysis, while Score B is 5, based on the upper limb positioning (as detailed in Figure 5). When these two values intersect in Table C, the result is a combined score of 8.

However, considering that the task being evaluated is performed repetitively, an additional point is added, resulting in a final Group C score of 9. This score falls into the category of high

risk, signaling that immediate ergonomic intervention is required to prevent musculoskeletal disorders and improve workplace safety.

The high REBA score justifies the need for design modifications or assistive tools. In this context, the article proposes the implementation of a portable conveyor system to handle coconut shell materials more efficiently and ergonomically. This solution is intended to reduce strain on the worker's posture and improve productivity, as illustrated in Figres 7 and 8.

Figure 7 Design Conveyor Portable

Figure 7 shows the 3D Design of the proposed portable conveyor that serves as an ergonomic intervention tool in the coconut shell handling process. This conveyor is specifically designed to reduce manual lifting and bending activities, which contribute significantly to musculoskeletal risk as identified in the REBA assessment. The structure is constructed from lightweight yet durable materials to ensure portability and ease of relocation in a workshop or factory setting. The slanted configuration enables the material to move upward efficiently, thereby minimizing physical strain on workers during material transfer.
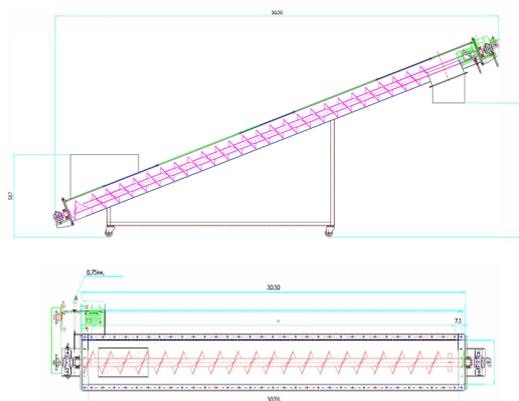

Figure 8 Drawing Conveyor Portable

Figure 8 presents the technical draing of the conveyor design, showcasing its dimensional specifications and mechanical configuration. The conveyor has a total length of 3076mm with a transport inclination angle that optimizes material movement while maintaining stability. The side view illustrates the internal screw mechanism that aids in transporting the coconut shells, while the top view reveals the spatial layout of the motor, screw shaft, and casing. These detailed engineering visuals serve as a blueprint for fabrication and emphasize the importance

of ergonomic design in equipment manufacturing, ensuring both worker safety and operation efficiency.

4. Conclusions

Several conclusions can be drawn from the study on operator posture analysis, which reveals a high potential for triggering symptoms of Musculoskeletal Disorders (MSDs). Using the Rapid Entire Body Assessment (REBA) method, the assessment of worker posture during the process of inserting coconut shells into the machine resulted in a REBA score of 9. This score indicates that immediate corrective action is necessary to reduce the risk of worker injury.

To address this ergonomic issue, the implementation of an assistive tool specifically a Portable Screw Conveyor is proposed. This tool significantly mitigates the risk of MSDs by eliminating repetitive lifting, bending, and twisting motions, which are common when feeding coconut shells manually. The conveyor system allows for continuous, controlled material flow, thereby maintaining a neutral posture for operators, minimizing spinal stress, and reducing static load on the upper limbs and back. Such mechanical intervention reduces physical strain and improves overall occupational health during the coconut shell feeding process.

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