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# A review on injury prevention using sensor-based safety system for thresher

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**Abstract**

Threshers play a vital role in efficient grain processing, but their intricate mechanisms and high-speed operations introduce significant safety risks. To mitigate these risks and enhance safety, a sensor-based safety system is proposed. This advanced system leverages cutting-edge sensors to monitor, detect, and address potential hazards, thereby aiming to reduce accidents and improve overall safety in agricultural settings. Threshers, essential for harvesting grain, are prone to accidents such as mechanical failures, operator injuries, and entanglements. These incidents often result from inadequate maintenance, operator errors, and insufficient safety measures. Traditional safety practices may not fully address these high-risk factors. The proposed sensor-based system offers a proactive solution by incorporating real-time monitoring and automated safety features. The system integrates various sensors, including proximity sensors to alert operators of nearby objects or people near critical machine parts, and temperature sensors to detect overheating that could lead to fires or mechanical breakdowns. Sophisticated algorithms analyze real-time data from these sensors to predict and manage safety risks. The system can automatically reverse or stop the conveyor belt or feeding chute, activate warnings, or notify operators and maintenance staff when hazards are detected. This proactive approach aims to prevent accidents before they occur, significantly reducing the risk of injury and damage. Implementing this technology involves integrating sensors into existing threshers, developing data processing algorithms, and conducting field tests. Collaboration with equipment manufacturers and safety experts is crucial to ensure the system meets industry standards and effectively addresses the specific challenges of thresher operations. Field trials and user feedback are essential for refining the system and confirming its effectiveness. Beyond individual safety improvements, this sensor-based system enhances thresher reliability and efficiency, minimizes downtime, and supports compliance with safety regulations, thus fostering a safer working environment. Representing a significant advancement in thresher safety technology, the system's real-time monitoring and automated hazard detection capabilities reduce accident risks and improve operational safety. Ongoing research and industry collaboration will be vital in further enhancing this technology and ensuring its widespread adoption in agriculture.

**Keywords:** Thresher, feeding chute, conveyor belt, sensor, safety lever

## 1. Introduction

Agricultural operation is universally acknowledged as one of the most dangerous industries worldwide, with agricultural activities presenting considerable risks to workers [1]. The sector consistently ranks among the most hazardous, subjecting farmers to a high incidence of both fatal and non-fatal injuries. In India, agriculture plays a vital role in the economy, employing 40 to 50 percent of the workforce and contributing approximately 15 to 16 percent to the nation's Gross Domestic Product (GDP) [2]. Despite its importance, the sector faces significant occupational hazards, with an estimated 120 million accidents occurring annually, 12 to 15 percent of which lead to permanent disabilities, highlighting the inherent dangers of the profession (ILO).

Hand injuries are among the most frequent in agricultural accidents, comprising 20.5 percent of all reported cases, often linked to machinery use [3]. Equipment such as threshers, hay balers, and chaff cutters are common culprits in these incidents. For example, threshers, which separate stalks and husks from seeds, can be operated manually or mechanically, with the latter posing a higher risk of injury. The threshing process, which separates the edible part of grain from the outer chaff, is physically demanding and prone to accidents [4].

Manually feeding crops into a thresher is particularly labor-intensive, causing fatigue and increasing the likelihood of injury, especially in traditional farming settings [5]. Similarly, while older, manually-operated chaff cutters were relatively safer, modern power-driven chaff cutters present a greater danger [3, 6]. The prevalence of hand injuries, particularly in the upper body, varies by age and gender, with adult males being disproportionately affected by these accidents [1, 3, 7, 8].

These statistics underscore the urgent need for enhanced safety measures and ergonomic improvements in

agricultural practices to safeguard the health and well-being of workers. Updating machinery, offering comprehensive training, and raising awareness of safety protocols can significantly reduce these risks, ensuring that while agriculture remains essential, it is not life-threatening.

## 2. Threshing

There are different factors that affect the thresher's performance. These are: crop type, service utilized, and various threshing techniques. For small scale crop production, the stationary thresher is highly suggested and the performance is affected by crop moisture content, operational speed, the mechanism of feeding and the designed target [9].

### 2.1 Conventional threshing

In Ethiopia, traditional threshing methods, which demand significant energy and labor inputs, remain the predominant practice in agriculture. However, this manual process is not only labor-intensive but also highly time-consuming, often contributing to considerable post-harvest losses [10]. Despite its widespread use, the inefficiencies of conventional threshing highlight the need for modernization. Mechanical threshing has been introduced as a more efficient alternative, designed to reduce post-harvest losses and improve the overall quality of grain. By using machinery, farmers can preserve more of their harvest, boosting both productivity and sustainability.

The primary aim of mechanical threshing is to decrease the labor required during this crucial stage of harvesting. Mechanization not only saves time but also significantly reduces the physical energy traditionally needed for manual threshing [11]. This transition is viewed as a key strategy to alleviate the physical strain-commonly referred to as "drudgery"-experienced by laborers in post-harvest operations. Mechanical threshing, therefore, represents a vital advancement in reducing the physical burden on agricultural workers while addressing the inefficiencies of manual techniques.

Beyond labor and energy savings, mechanical threshing delivers more consistent results, enhancing grain quality through efficient and controlled processing. The adoption of this technology can also bring broader economic benefits, enabling farmers to maximize yields, reduce waste, and increase profitability. By addressing traditional challenges such as labor demands, energy consumption, and post-harvest losses, mechanical threshing is emerging as a critical tool for modernizing agriculture, particularly in countries like Ethiopia where traditional methods still dominate. Embracing this technology can have wide-ranging implications for food security, rural development, and the overall efficiency of the agricultural sector. 2.2 mechanical threshing

### 2.2 Mechanical threshing

Mechanical threshing relies on a combination of physical actions-such as beating, rubbing, combing, and crushing-to efficiently separate grains from their stalks [12]. However, challenges arise when using machines like the Melkassa multi-crop thresher, especially for cereal crops. One significant issue is the manual feeding process, which is both labor-intensive and time-consuming. This not only reduces the overall efficiency of the thresher but can also lead to mechanical failures. Improper handling or overfeeding during the manual feeding can cause the thresher drum to stop or, in some cases, result in component breakage. Furthermore, the dust produced during threshing poses health risks to operators, complicating its use [5].

The poorly designed feeding mechanisms, along with inadequate safety measures, heighten the risk of accidents and injuries. Operators are susceptible to physical harm when interacting with the machine without proper safety precautions. In environments lacking safety measures, incidents such as cuts, bruises, or more severe injuries can occur during feeding, highlighting the urgent need for improved ergonomic designs and safety protocols in threshing operations.

The performance of a thresher is quantified by its output capacity, known as threshing capacity, which refers to the amount of grain the machine can process in a specific timeframe, typically measured in kilograms per hour (kg/hr). This capacity is calculated by dividing the total weight of threshed grain by the time taken for the process [13]. Achieving a high threshing capacity is vital for maximizing efficiency, particularly in large-scale farming operations where saving time and labor is essential.

To evaluate grain damage during mechanical threshing, it was recommended that collecting two 100-gram samples of the threshed grain for assessment. These samples were examined for grains that were broken, cracked, smashed, bruised, or split. A visual inspection of these damaged grains provided a more accurate evaluation of the thresher's effectiveness and its impact on grain quality [14]. Minimizing grain damage is crucial, as it directly influences both the market value and usability of the final product. Consequently, ongoing improvements to threshing machines are necessary to balance maximizing output with preserving grain quality.

### 2.3 Feeding chute of thresher

To boost the safety and efficiency of stationary threshers, equipping them with a feed conveyor system featuring an elevated chute and extended chute cover is crucial. These enhancements reduce injury risks and improve operational safety [15]. Proper feeding mechanisms lower injury chances, and optimizing chute height enhances threshing performance [16]. A robust safety system on the feed conveyor not only prevents operator injuries but also increases overall capacity and efficiency.

The performance of a feed conveyor is significantly influenced by its slope. A 30-degree slope is ideal for transferring harvested crops from a height of 1.77 meters. At 37 degrees, wheat begins to slip, requiring additional equipment. Mechanized conveyors, compared to manual feeding, are safer and more efficient [16]. The slopes up to 35 degrees are effective, with a minimum of 20 degrees for appropriate height [17].

Selecting a suitable feed conveyor involves considering the hopper arrangement, crop flow patterns, material characteristics, and the geometry of both the hopper and feeders [18] emphasized uniform feeding and integrated feeder designs to enhance efficiency [19] also highlighted the importance of an integrated feeder and mass flow hopper. Key factors include the load path direction, process type,

material flow rate, and environmental conditions. In traditional threshers, the feeding chute slope ranges from 10 to 35 degrees. A study in Punjab, India, found that human factors caused 73% of thresher-related injuries [20]. Implementing feed conveyor systems reduces these risks by automating the feeding process and minimizing human interaction with hazardous machinery.

For designing feed conveyors, an average inclination angle of 15 to 30 degrees was used, with the threshing drum speed set between 600 and 1200 rpm and conveyor speed at 1.5 meters per second. Ergonomics and economic feasibility are key considerations for user-friendly and cost-effective machinery [5]. Incorporating these design principles enhances safety, productivity, and efficiency in threshing operations.

### 2.4 Conveyor belt feeding chute of thresher

The feed conveyor consists of a supporting frame, bearings, rotating belts, pulleys, a side cover, a lower hopper, and V-belts. Split plot design with main plot, conveyor slope, and subplot is the conveyor speed is used to examine the influence of conveyor [5]. Using a feed conveyor can increase threshing capacity, reduce drudgery, save time and energy, reduce risk, and is the best way to feed the harvested crop.

Proper selection of suitable belt conveyor types can guarantee high operational safety, high productivity of labour, simple operation and maintenance, as well as a minimum environmental impact [21, 22]. In addition to determining the resistance, it is possible to calculate the required drive power, the belt tensile forces distribution and the needed (not overestimated) belt strength on the conveyor. Therefore it is possible not only to calculate, but also to optimize the operation of the conveyor [23].

Several authors have reviewed modifications to conveyor belt feeding chutes of threshers and chaff cutters, focusing on safety, efficiency, and operational performance. The key findings from these reviews highlight different aspects of design improvements and safety features. Safety in the operation of threshers and chaff cutters can be enhanced by modifying the feeding chute. For safer feeding operations, the height of the chute increased and covered [15]. These changes reduce the risk of hand injuries by keeping the operator's hands away from dangerous moving parts. Benefits of adding protective covers and barriers to the conveyor belt feeding systems. They noted that power-driven chaff cutters pose a higher risk than manual ones, especially if there is no proper protection. Modifications such as extended chute covers and feed conveyor guards can significantly reduce injury rates by keeping the operator's limbs away from fast-moving blades and rollers [3].

The importance of using conveyor belts for automated feeding in threshers and chaff cutters. They reviewed modifications to the feeding chute design, highlighting that the conveyor's slope and height directly affect threshing performance. Conveyor belts with adjustable slopes and optimized feeding heights (ranging from 30° to 35° inclination) help in achieving better grain separation and reduce blockages, improving overall productivity [16]. Automated feeding systems, which they found to be safer and more efficient than manual ones [8].

The study noted that setting the conveyor at an ideal slope of 30° improves the feeding process while preventing grains from slipping. Conveyor speeds of around 1.5 m/s were recommended for safe and efficient operation [5]. A well-designed conveyor belt, with adjustable angles and speeds, prevents jamming and increases the machine's throughput, improving safety and overall efficiency.

#### 2.4.1 Reduction of Manual Labor and Enhanced Safety Features

Modifications that reduce manual labor during feeding operations in threshers and chaff cutters. They suggested using sensors integrated with the conveyor system to detect the presence of crops and automatically adjust feeding rates. This minimizes the need for human intervention and significantly lowers the risk of injury during operation. Further noted that conveyor belts with automated stop functions provide additional safety by halting the machine if an obstruction, such as a human hand, is detected near the danger zone [6].

Traditional chaff cutters to include motorized feed systems with conveyor belts. These systems have enhanced safety features, including automatic shutdown mechanisms when abnormal loads or obstructions are detected [7].

#### 2.4.2 Prevention of Hand Injuries and Improved Control Systems

Thresher injuries are linked to human factors like carelessness or inappropriate handling. To reduce these risks, they recommended modifying the feed chute to include conveyor belts equipped with sensors that detect when an operator's hand enters a danger zone. This safety measure prevents hand and finger injuries by stopping the machine automatically before contact with hazardous parts [20]. By controlling the rate of feed, the likelihood of jams and sudden stops, which can cause the operator to inadvertently come into contact with dangerous moving parts, is reduced [14]. By designing conveyor systems that align with ergonomic principles, such as adjustable heights and controlled feed rates, the physical demands on workers can be minimized, leading to fewer accidents and injuries [13].

## 3. Risk associated with the operation

Assessing risks related to identified hazards involves evaluating both the severity of potential consequences and the likelihood of exposure occurring. This process requires a thorough understanding of the risks to gauge the criticality of each hazard. Sensor-based systems are increasingly enhancing this risk assessment process by providing objective data that minimizes the subjectivity inherent in traditional manual evaluations. These systems enable more accurate, data-driven assessments, helping to reduce human error and bias [24].

Construction safety planning can be viewed as a two-phase process. The first phase involves identifying potential hazards in the work environment, while the second phase focuses on implementing effective safety measures to mitigate these risks before construction activities begin. This systematic approach ensures preventive actions are in place to protect workers and minimize the risk of on-site accidents [24, 25].

Despite technological advances, many current safety

planning practices in construction rely on outdated methods. Safety managers often depend on 2D drawings, fragmented safety regulation documents, and past experiences to develop safety plans. While practical in some contexts, this manual approach has limitations, including communication gaps, misinterpretations of safety guidelines, and potential oversights, especially when safety regulations are disjointed and lack integration into a cohesive system. Such practices can lead to incomplete hazard understanding and inadequate preparation [26].

Traditional methods also struggle to fully capture the complexities of construction sites, as 2D drawings may not accurately represent dynamic work environments. This reliance on manual planning not only increases the risk of human error but also stifles innovation in safety management. As construction projects become more complex, there is a growing need for advanced, technology-driven solutions in safety planning.

Integrating sensor-based systems, 3D modeling, and real-time data collection can revolutionize safety management on construction sites. These technologies offer a more comprehensive view of the work environment, allowing safety managers to simulate potential hazards and evaluate various safety strategies before commencing work. Transitioning from manual methods to automated, data-driven processes enables construction teams to create safer and more efficient workspaces, ultimately reducing the risk of accidents and injuries. while traditional safety planning methods rely heavily on manual input and fragmented information, modern technology provides more reliable and objective tools for assessing and managing risks. Embracing these advancements is crucial for improving the effectiveness of safety measures and enhancing overall worker safety on construction sites

## 4. Safety measures to be taken

The safe environment for operating such hazardous machinery required measures to ponder upon the need for proper shielding of moving parts like the threshing drum and feeding mechanism, as exposed components in older models are major causes of hand injuries. Guarding these areas prevents accidental contact with fast-moving parts [3]. The safety guards around cutting edges and rollers in chaff cutters are critical to reducing injuries [8].

The benefits of automatic feed conveyors in stationary threshers, which reduce direct operator interaction and minimize injury risks [16]. The designing of longer feeding chutes and conveyor systems to keep operators at a safer distance from dangerous areas [15].

The integrating sensor-based safety systems that detect human proximity and automatically shut off machines, offering added protection, especially for high-speed operations [6]. The use of sensors to detect feeding irregularities or obstructions, which would automatically stop the machinery to prevent accidents [20].

The importance of operator training in ensuring safety when using threshers and chaff cutters [1, 7]. Untrained operators, as [14] pointed out, often lack awareness of machine hazards, leading to avoidable accidents.

The ergonomically designed feeding systems in newer threshers help reduce operator fatigue and the likelihood of injuries [5]. Mainly an improved ergonomic designs in threshing drums and chaff cutters reduce fatigue-related accidents [13].

## 5. Sensor based safety system

The effectiveness of obstacle detection systems can be significantly enhanced by the choice of algorithms used. The robust and efficient computational methods are vital for detecting image features through image processing or integrating sensor data fusion, both of which provide essential information for the autonomous guidance systems of agricultural vehicles [27]. Consequently, selecting the appropriate methods and signal-processing algorithms plays a critical role in the performance of these systems. Numerous algorithms have been proposed in the literature for detecting foreign objects or obstacles in the operation of autonomous vehicles.

The performance of various feature recognition algorithms, including average height, density, connectivity, and discontinuity methods, for obstacle detection using a specific LiDAR sensor was assessed [28]. In the same year, a 3D camera was mounted on a field robot to detect obstructions in an agricultural setting. To distinguish obstacles from background noise, noise reduction and background subtraction techniques were employed, enabling the system to gather clear data. Once the system segmented and extracted relevant information about potential obstacles, a clustering algorithm was applied to determine when the field robot should slow down or stop during its autonomous operation in the field.

Recently, an advanced information-processing architecture designed for multimodal obstacle detection and environmental recognition in agricultural areas was developed by the authors of another study. This architecture comprises four key components: A sensor platform, an inverse sensor model, fusion and mapping processes, and a process evaluation system. The combination of these elements provides a comprehensive framework for detecting and interpreting environmental data in real time.

Moreover, in agricultural automated machinery, especially those operating at relatively high speeds, the ability to quickly detect and respond to obstacles is crucial for ensuring operational safety. In response to this need, a fast obstacle detection technique introduced for use in complex agricultural environments, known as the multiple-expert color feature extreme learning machine (MEC-ELM) [29]. The MEC-ELM is capable of locating and classifying objects rapidly, achieving 84 percent accuracy and 91 percent recall in detecting weeds, with a processing speed of 0.5 seconds per frame. This high level of performance is attributed to the system's color-based implementation, using the SAT (Successive Approximation Thresholding) method to enhance detection speed and precision.

## 6. Conclusion

Agricultural operation through machinery is widely regarded as one of the most hazardous industries globally, posing serious risks, especially in countries like India, where it plays a crucial role in the economy. The prevalence of injuries, particularly hand-related ones, underscores the dangers associated with machinery such as threshers and chaff cutters. Manual feeding, still common in traditional farming practices, is labor-intensive and leads to fatigue,

further elevating the risk of accidents. While the advent of mechanical threshing has improved efficiency and reduced physical strain, issues like manual feeding, safety concerns, and grain damage remain.

Improving the design of agricultural machinery, especially by integrating ergonomic features and enhanced safety mechanisms like automated feed conveyors and sensor-based systems, can significantly reduce these risks. Features such as automation of manually operated partsin thresher and chaff cutter and protective guards around moving parts help prevent accidents, while streamlined feeding processes enhance both safety and productivity.

Modernizing agricultural practices through the implementation of advanced machinery and rigorous safety measures is critical for reducing injuries and safeguarding the health of agricultural workers. By addressing the traditional limitations in equipment design and operational processes, the agricultural sector can become safer, more efficient, and more productive, benefiting both workers and the broader economy

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