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Optimal design of the braking system of industrial cutting machines with the approach of increasing speed, safety and preventing amputation

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ABSTRACT

Life-saving and amputation prevention systems in traditional cutting machines are designed to prevent serious accidents such as amputations and severe injuries. These systems usually include a set of sensors, emergency stop mechanisms, and specialized brakes that work together to stop the operation of the device quickly in case of dangerous conditions, but the stopping speed is sometimes not enough or the safety factor of the brake used in the device's engine. The mentioned is not enough and it leads to an error that leads to serious harm to the user. In this research, an advanced system to save life and prevent amputation has been designed. This safety system is designed for industrial cutting devices whose purpose is to prevent serious accidents such as amputations and severe injuries. The research method includes the design and evaluation of these systems using different sensors and emergency stop mechanisms. The results show that these systems can effectively prevent accidents and increase productivity.

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Introduction

In today’s modern life, human dependence on electrical systems, particularly squirrel cage induction motors, has significantly increased [1]. Moreover, a substantial portion of electrical power consumption in power systems is attributed to electric motors. Induction motors, as one of the most widely used dynamic loads, play a crucial role in various industrial applications [2]. Almost all industrial cutting machines are equipped with squirrel cage induction motors. Life-saving and amputation prevention systems in industrial cutting machines are designed to prevent severe accidents such as amputations and serious injuries. These systems typically consist of a combination of sensors, emergency stop mechanisms, and specialized brakes that work together to rapidly stop the rotation of the electric machine, which is mainly an induction motor, in hazardous situations. However, the stopping speed is sometimes insufficient, or the reliability of the braking system used in these machines is not high enough, leading to potential failures that can cause serious harm to the operator [3].

The design and optimization of modern industrial cutting systems equipped with emergency braking mechanisms are crucial in environments where industrial cutting tools are used. The primary goal of this research is to develop innovative cutting systems that enhance worker safety by reducing the risk of accidents and physical injuries. A review of previous studies indicates that cutting operations, particularly in industrial settings, have always been associated with significant hazards, leading to numerous injuries in workshops and factories [4].

For instance, Kerlik (2024) examined squirrel cage induction motors and emphasized the importance of implementing effective detection and monitoring methods to reduce risks associated with sudden stoppages [5]. In another study, Sharda (2023) focused on optimizing the design of squirrel cage induction motors using genetic algorithms, which can help reduce energy consumption and improve safety in industrial equipment [6]. Additionally, Broze (2006) explored new methods for detecting rotor bar failures in squirrel cage induction motors, which can enhance safety and reliability in industrial applications [7].

All studies related to electric machine learning require an initial training phase with a comprehensive and reliable dataset for accurate decision-making. Most high-accuracy studies rely on experimental laboratory datasets [8]. This research has also been conducted with precise experimental and practical results.

Problem Statement

Recent studies emphasize the integration of technologies such as machine vision and sensor-based systems for real-time monitoring and risk reduction [9]. This research will examine the structure of these systems, different types of braking mechanisms used in them, and the most effective braking method to significantly enhance the reliability of industrial cutting machines.

Despite technological advancements, the existing safety systems in industrial cutting machines are often not sufficiently efficient. These systems include sensors and emergency stop mechanisms, but in many cases, the stopping speed and braking reliability are inadequate, which can lead to serious accidents [10].

Life-Saving and Amputation Prevention System Structure Safety systems in industrial cutting machines typically include the following components: Presence and Motion Detection Sensors These sensors are responsible for detecting the presence of the user's hand or other body parts near hazardous areas of the machine. Some of the most common types include optical, infrared, and ultrasonic sensors. These sensors can instantly detect foreign objects and transmit the information to the central control system [11].

Touch Sensors These sensors consist of electronic boards that are electrically connected to the cutting blade and operate based on contact between the user's skin and the blade surface. Central Control System The central control system processes the data received from the sensors and makes necessary decisions to stop the machine's operation. It is typically programmed with safety algorithms and, upon detecting a hazard, sends an immediate stop command to the braking and emergency stop mechanisms [12].

Emergency Stop Mechanisms These mechanisms are responsible for immediately stopping the machine in the event of a danger. They can be activated manually (by pressing an emergency button) or automatically (based on sensor detection). Emergency stop mechanisms should be designed to bring the machine to a safe state in the shortest possible time [13].

To design and implement a safety system for industrial cutting machines, a comprehensive review of similar research and existing braking systems was conducted. This review included an analysis of the mechanical, pneumatic, hydraulic, and electronic braking technologies currently used in industrial machinery, with particular attention to their response times, reliability, and ease of integration. Since braking speed in life-saving systems for industrial cutting machines is absolutely critical—where even a millisecond delay can lead to irreversible injuries such as amputation—our design approach focused on minimizing stopping time to the utmost extent. To achieve this, the safety system was designed by combining multiple braking mechanisms, including mechanical brakes for immediate physical locking, pneumatic brakes to provide rapid force application, and electronic sensors for real-time emergency detection and system activation.

The design phase involved detailed modeling and simulation of the braking process to predict stopping times and forces under various operating conditions. Materials and components were selected based on their durability, response speed, and compatibility with the machine's existing structure. In the implementation phase, the braking system was integrated into the industrial cutting machine, ensuring minimal interference with normal operations while maximizing emergency response. The mechanical components were custom-fabricated to fit the specific motor and blade assembly, and pneumatic lines were routed to provide swift actuation. Testing was carried out in a controlled environment using high-speed cameras and sensors to measure the exact time elapsed from emergency trigger to full stop of the rotating blade motor. Various emergency scenarios were simulated to validate the system's reliability and consistency, including power failures and sensor malfunctions. Finally, practical experiments were conducted to evaluate the effectiveness of the combined braking system. Key performance indicators such as braking time, repeatability, system robustness, and operator safety feedback were recorded and analyzed. These evaluations confirmed a significant improvement in stopping speed compared to traditional single-mechanism brakes, demonstrating the system's potential to prevent severe injuries.

Types of Brakes Used in Industrial Cutting Machines

Brakes play a crucial role in quickly and safely stopping industrial cutting machines. The following are different types of brakes used in these machines:

Mechanical Brakes

Mechanical brakes are the simplest type of brakes, utilizing mechanical force to create friction and stop the machine. These brakes are commonly used in smaller and less powerful cutting machines. Examples include disc brakes and drum brakes. This type of brake is one of the most widely used braking systems in induction motors and is typically installed by the motor manufacturer [14].

This type of brake consists of two circular discs at the end of the motor, one connected to the rotor shaft and the other attached to the stator via a coil (magnet) and multiple springs. The coil is powered by direct current (DC).

- In the normal state, when no voltage is applied to the motor, the springs press the discs together, preventing rotor movement—this is known as the braking state [15].

- When DC voltage is applied to the coil, the magnetic field pulls the stator-connected disc away, separating the two discs and allowing the rotor shaft to rotate freely. Once power is supplied to the stator, the motor can drive its load (Figure 1).

- A small diode bridge is typically placed in the motor terminal box, converting the motor's supply voltage into DC voltage for the brake coil. This ensures that when power is supplied to the motor, the brake is released, and when power is cut off, the brake is engaged, stopping the motor immediately [16].

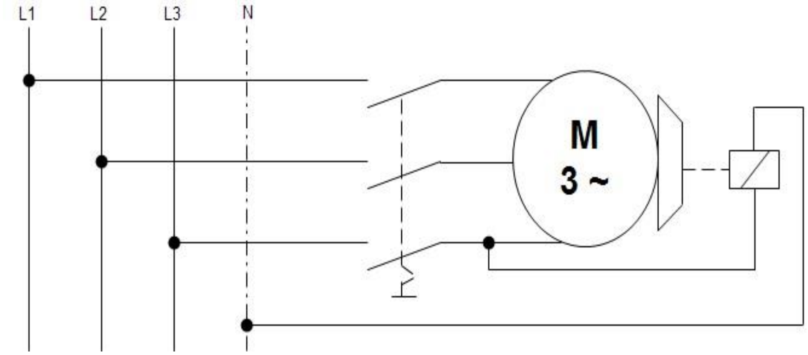

Figure 1. Technical Diagram of a Mechanical Brake for an Induction Motor

Figure 2 shows examples of this type of brake motors:

Figure 2. An image of a simple motorcycle and a gearbox with a mechanical brak

Plugging Brake (Reverse Current Braking) In this method, braking force is generated within the motor itself by reversing the connection of two phases, which in turn reverses the direction of the rotating magnetic field. As a result, the motor’s direction of rotation is also reversed (Figure 3). Once the machine reaches a standstill, the circuit must be immediately disconnected; otherwise, the motor will start rotating in the opposite direction. This braking method is widely used in band saws, elevators, and hoists [17].

However, the energy dissipation in plugging brakes is very high because the motor slip suddenly reaches approximately 200%, causing a sharp reversal in motor direction.

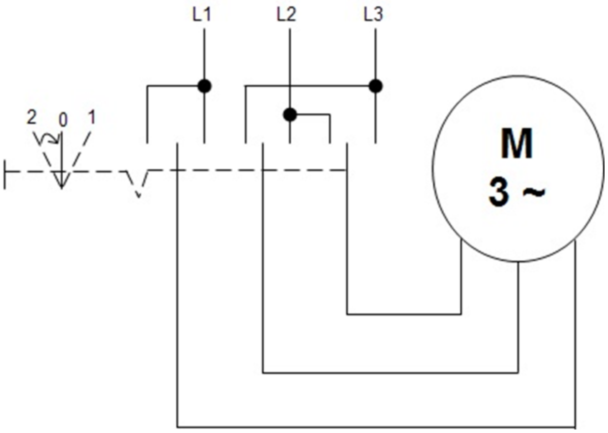

Figure 3. Countercurrent braking

Synchronous Brake

In this type of brake, the motor is released from operation and, due to acceleration, turns into an induction generator. Its application is in motors with variable poles, such as in elevators. In the use of synchronous brakes, the machine operates in the generating zone, and the rotor's kinetic energy is converted into electrical energy and returned to the grid. This type of brake can only prevent an increase in load speed and cannot bring the shaft to a complete stop [18].

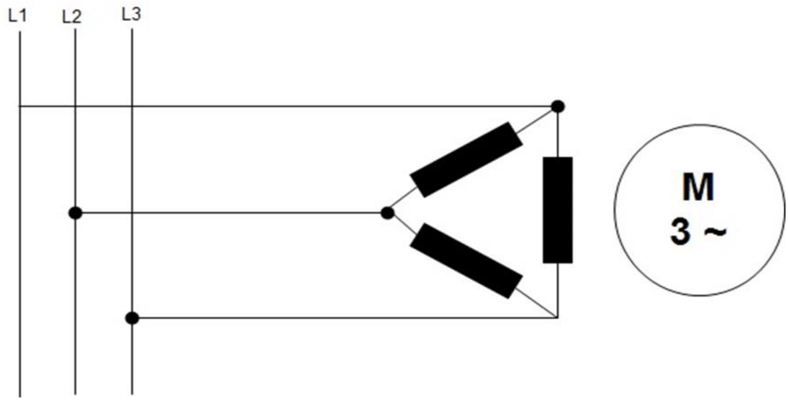

Figure 4. Synchronous Brake

Sub-Synchronous Brake In a sub-synchronous brake, the goal is to reduce the motor speed below synchronous speed. This is typically achieved through one of two methods: a. Frequency Change Using an inverter or variable frequency drive (VFD), the input frequency to the motor is reduced. This change in frequency causes the magnetic field speed to decrease, and the motor then operates in the sub-synchronous region. b. Resistive Load In some cases, by adding a resistive load to the system, a negative torque can be generated. This load can be mechanical or electrical and will reduce the motor's speed (Figure 5). Induction motors with wound rotors are connected to the grid in a single-phase configuration, and a braking torque appears, which disappears once the motor comes to a stop [19].

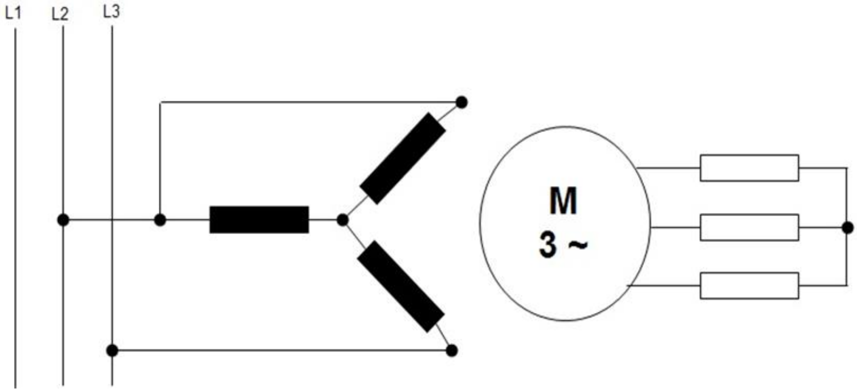

Figure 5. Sub-Synchronous Brake

Moreover, this indicates the elimination or weakening of many non-primary harmonic components in local grids connected to motors with wound rotors because, in this state, the motor turns into a generator [20].

DC Braking

Since mechanical and pneumatic brakes are more commonly known, let's discuss DC braking, which is of the controlled type used in the mentioned system: In this type of brake, after cutting off the alternating current from the motor's windings, a direct current is applied to the windings. Its circuit diagram is shown in Figure 6 [21].

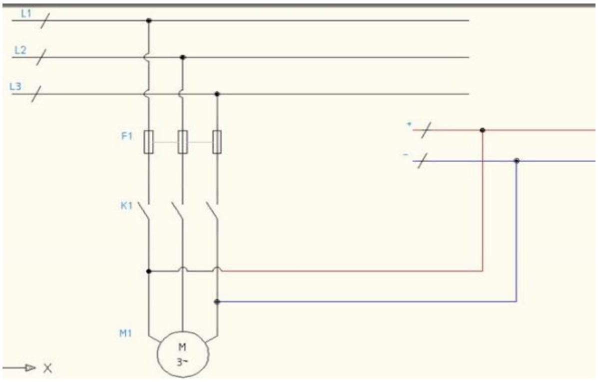

Figure 6. DC Braking Circuit

The stator windings are connected to a low-voltage DC source, and as the rotor continues to move, the braking current is induced in the windings. Its application is in machine tools and vehicles. Various configurations of the stator windings in DC braking systems for asynchronous motors are shown in Figure 7.

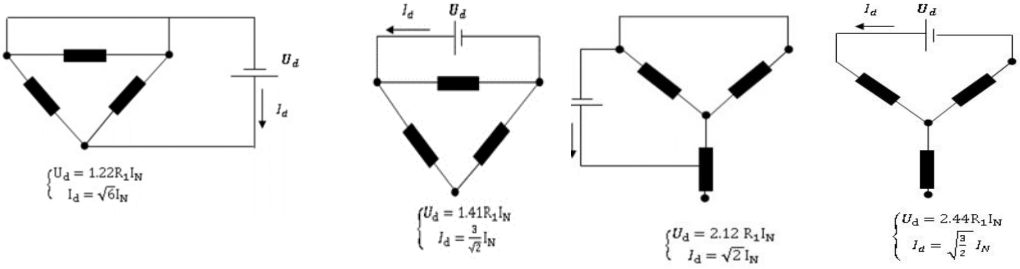

Figure 7. Different Models of Braking Connections DC

braking in induction motors generates a constant magnetic field. When the power supply is cut off, it produces a reverse torque, rapidly stopping the motor. This method is widely used in industrial applications for its efficiency and high-speed braking capabilities.

Hydraulic Brakes Hydraulic brakes use fluid pressure (hydraulic oil) to generate braking force. These brakes have precise adjustability and can provide the required braking force under various conditions. Hydraulic brakes are typically used in large industrial cutting machines that require gradual and controlled stops. Pneumatic Brakes Pneumatic brakes use compressed air to generate braking force.

These brakes offer fast and reliable performance and are widely used in various industries. Pneumatic brakes, especially in devices that require frequent and quick stops, are highly applicable.

Key components of this system include pneumatic pumps, air tanks, compressors, pipes, check valves, relief valves, actuators, and brake pads. Pneumatic brakes come in two types: disc and drum. However, it’s important to note that disc pneumatic brakes have a higher power capacity than drum ones [22].

Pneumatic Brake Operation

Under the brake pedal, there is a valve (spring-loaded) that maintains the pneumatic force before the pedal is pressed (Figure 8). When the brake pedal is pressed, the pneumatic force quickly moves from the air tank through the pipes to the actuators, changing the direction of the brake pads. When the pads’ direction changes, significant friction occurs between the rotating disc and the stationary part. It’s also important to note that the compressor is responsible for filling the air tank in pneumatic brakes [23].

Figure 8. Pneumatic Brakes in Vehicles and Rotating Industrial Machines

Applications of Pneumatic Brakes One of the primary applications of pneumatic brakes are to maintain and reduce the speed of vehicles. In the past, older vehicles used pneumatic braking systems, but today, only heavy-duty trucks and passenger transport vehicles, such as buses, trucks, vans, and trailers, are equipped with pneumatic brakes. Some construction and industrial vehicles also use pneumatic brakes. Many heavy industrial machines also use pneumatic brakes. Due to the large weight and high speed of certain devices, they require powerful braking systems to slow down. As a result, pneumatic brakes are often used to reduce speed and stop heavy industrial machines [2].

Main Components of Pneumatic Brakes Air Supply System: This system includes an air compressor, an air tank, and pipes to transfer compressed air to the braking components. Pneumatic Cylinder:

This is a key component of the brake system that generates mechanical force using compressed air.

When air enters the cylinder, the piston inside moves, and this movement is transferred to the brake calipers or discs. Brake Calipers:

These components come into contact with the brake disc and, by applying pressure to the disc, reduce speed and eventually stop the rotation. Brake Disc:

A disc attached to a rotating shaft that stops when force is applied by the brake calipers. Pneumatic brakes are widely used in industries such as machinery, power transmission systems, and heavy equipment due to their fast response and precise control [19].

Dynamic Brakes Using resistors to dissipate heat can help slow down a mechanical system. This process is called dynamic braking, and such resistors are known as dynamic braking resistors (or simply braking resistors). To reduce the speed of an electric motor, kinetic energy is converted back into electrical energy, which is then dissipated as heat through resistors (Figure 9). Braking resistors are used in motion control systems (small-scale) as well as large structures such as trains or trams. One major advantage of this type of braking over friction-based systems is reduced wear and greater braking efficiency [20].

These brakes offer high performance and can be used for the rapid and safe stopping of cutting machines. When the motor begins to stop and its kinetic energy is converted into electrical energy, the motor transitions from being a power consumer to a power generator. As a result, to bring the electric motor to a halt, the generated energy needs to be dissipated effectively. In this case, an inverter braking resistor is used. The resistor converts the generated energy into heat, allowing for a quick stop. Additionally, the presence of a braking resistor ensures inverter safety by preventing damage caused by excessive voltage on the DC bus [19].

Figure 9. Example of a Dynamic Braking Resistor

Advantages of Dynamic Braking Resistors Compared to Friction Brakes

- Less wear on components
- Voltage control within safe levels
- Faster braking of AC and DC motors

- Lower maintenance requirements and higher reliability Braking Resistor Technology Braking resistors have relatively low resistance values and high power ratings. Therefore, wire-wound resistors are a popular solution. These resistors often have a ceramic core and are fully welded. They are usually placed in a frame to ensure a safe distance from other components.

To improve energy dissipation, frames often include cooling fins, fans, or even water cooling systems [21].

Considering the reviewed factors, there is a clear need for an advanced and integrated system that effectively prevents accidents while improving the efficiency of industrial cutting machines. The theoretical framework of this research is based on behavioral sciences and engineering principles, focusing on the interaction between human factors and machine design [22]. The main issue is the high incidence of injuries in cutting operations, which requires a comprehensive approach combining technology, optimized design, and safety training to create a safer work environment. This study evaluates existing systems and proposes a new solution in this field.

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Experimental method

In this practical study, three different braking models were individually coupled with the induction motor driving a profile-cutting blade. The response speed of each model was measured separately using a digital chronograph, and the detailed results were recorded in a table for comparison. The recorded time represents the duration between body contact with the cutting blade and the complete stop of the blade, which must be reduced to the shortest possible time, ideally close to zero, to prevent serious injury. The advantages and disadvantages of each braking system were assessed, and the best option—offering both high-speed performance and economic feasibility—was selected.

Then, all three braking systems were combined and tested again. The response speed of the integrated braking system and the time required to stop the cutting blade were measured and recorded.

Proposed System The proposed system, which was practically implemented by the researcher, is a hybrid braking system that integrates three different types of brakes and emergency stop mechanisms [25]. This hybrid system automatically activates all three braking types upon contact between the skin and the cutting blade, ensuring a faster stopping time, enhanced safety, and reduced risk of severe injuries during cutting operations. The researcher successfully implemented this system on a profile-cutting machine widely used in the industry, commonly known as the “Fire Saw”, for the first time in Iran. This innovation led to obtaining a patent certification with approval from the Iranian National Elites Foundation (Figure 10)

Figure 10. Fire saw industrial cutting machine equipped with intelligent system

Saving life and preventing user amputation

Result and discussion

According to statistics from the Standardization Organization, industrial cutting machines have a high rate of limb amputations among users. On average, three amputation incidents occur per month per 100 cutting machines in the industry. This translates to 36 cases per year for every 100 machines. As a result, many families endure severe emotional distress and irreversible financial losses. Considering the widespread use of these cutting machines across the country, the actual number of amputation incidents is significantly higher than the reported figures. Since the mentioned statistics only cover a small portion of industrial cutting machines, designing and developing an intelligent safety system—one that ensures both high operational speed and reliability while remaining economically viable for industrial use—is essential. This system must effectively protect machine users from severe and irreversible injuries, such as limb amputations. Intelligent Life-Saving System for Preventing Amputations in Industrial Cutting Machines This system is designed to immediately halt and lock the cutting blade as soon as it comes into contact with human skin. This prevents serious bodily harm and ensures 100% prevention of amputations. The system's mechanism consists of an electronic board that detects skin contact with the cutting blade. Upon detection, it instantly triggers a command to:

1. Shut down the motor at high speed
2. Activate the braking system These two actions occur simultaneously and instantaneously, ensuring rapid response and maximum protection.

Testing the System on the “Fire Saw” Cutting Machine To measure the braking performance speed in industrial cutting machines, specialized devices such as industrial chronographs or dynamic analyzers are used. These tools accurately measure the reaction time of the brake system. Common Measurement Tools

1. Digital Chronographs: Measure the reaction time from the activation of the brake until the machine comes to a complete stop.
2. Laser and Optical Sensors: Detect speed variations and precise stopping times in motion control systems.
3. Speed and Acceleration Analyzers: Evaluate deceleration and braking performance to determine efficiency. These measurement tools play a crucial role in optimizing braking systems for industrial machinery, enhancing both safety and precision in manufacturing processes. For this research, a digital chronograph was used to assess the following braking systems:

1. Electromagnetic (Electric) Brake

- Reaction Time: Less than 0.2 seconds (one of the fastest braking systems).
- Advantages:
- Immediate and precise response
- Minimal mechanical maintenance, reducing long-term operational costs
- Disadvantages:
- Requires specific power sources
- Higher initial costs

2. Mechanical Brake

- Reaction Time: Approximately 0.5 seconds
- Advantages:
- Simple design and lower cost
- High reliability

• Disadvantages:

• Requires frequent maintenance and replacement of worn-out components 3. Hydraulic Brake

• Reaction Time: Approximately 0.3 seconds (slightly faster than mechanical brakes)

• Best suited for: Heavy-duty machinery requiring high braking force • Advantages:

• Higher power output and precise control

• Lower initial cost compared to electromagnetic brakes

• Disadvantages:

• More complex design

• Requires special maintenance systems Integrated Safety Braking System The hybrid safety system developed in this study combines all three braking technologies—mechanical, electrical, and hydraulic—for maximum efficiency and safety. The electric brake in this system operates on direct current (DC), ensuring rapid stopping and enhanced protection. This intelligent braking system, when integrated into industrial cutting machines, provides:

Ultra-fast stopping times

High safety assurance

Reduced risk of severe injuries and amputations Cost-effectiveness for industrial application This innovation was successfully implemented on the "Fire Saw" industrial cutting machine and has received patent certification with approval from the Iranian.

Table 1. Blade Stopping Time for Different Brake Types

Brake Type	Minimum Stopping Time (seconds)	Maximum Stopping Time (seconds)
Electromagnetic (Electric)	0/2	0/5
Mechanical	0/5	1/2
Hydraulic	0/3	0/8
Combined (Electric, Mechanical, Hydraulic)	0/1	0/2

Analysis of Stopping Time for Different Brake Systems Table 1 presents the stopping time of the cutting blade for four different brake types. The results indicate that electromagnetic brakes provide the fastest response (maximum 0.2 seconds and minimum 0.1 seconds), while mechanical brakes have the slowest reaction time (maximum 1.2 seconds and minimum 0.5 seconds). The implementation of a combined braking system has reduced the stopping time to 0.1 seconds, significantly enhancing safety. The presence of these three brake types on the cutting machine not only increases system reliability and prevents limb amputations but also achieves a stopping time of 0.1 seconds. If measured using a more precise chronograph, this time would likely be even shorter. This high stopping speed, combined with the increased reliability from three different braking technologies, greatly improves the performance of the cutting machine, preventing irreversible injuries to operators.

Table 2. ANOVA Test for Stopping Time Comparison Across Different Brakes

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F-Statistic	p-value
Between Groups	2/75	3	0/9167	6/15	0/000
Within Groups	0/89	12	-	-	-
Total	3/64	15	-	-	-

The p-value (0.000) indicates a statistically significant difference between the groups. The combined brake system had the lowest stopping time (median = 0.15 seconds), outperforming the electromagnetic, mechanical, and hydraulic brakes. To further validate these findings, post-hoc tests were conducted to compare pairwise differences between braking systems.

Table 3. Post-Hoc Pairwise Comparison of Brake Stopping Times Comparison

Comparison	Stopping Time (seconds)	P
Combined vs. Electromagnetic	0/15	0/01
Combined vs. Mechanical	0/15	0/01
Combined vs. Hydraulic	0/15	0/01
Electromagnetic vs. Mechanical	0/35	0/04
Electromagnetic vs. Hydraulic	0/5	0/08
Mechanical vs. Hydraulic	0/2	0/01

The results indicate that the combined brake system is significantly faster than all other brake types ($p < 0.01$). Electromagnetic vs. mechanical and electromagnetic vs. hydraulic comparisons also showed significant differences, but mechanical vs. hydraulic brakes did not show a statistically significant difference.

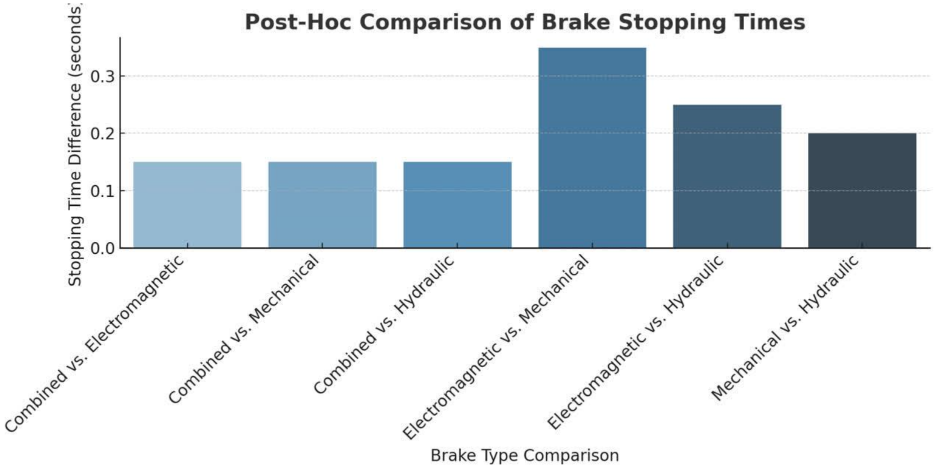

Figure 11. post-hoc comparison of brake stopping times

Post-Hoc Statistical Interpretation To further analyze the significant results obtained from the ANOVA test (Figure 11), two post-hoc visualizations were generated: one showing the pair wise differences in stopping times between braking systems, and the other showing the corresponding p-values for these comparisons. The first chart revealed that the combined braking system significantly outperformed all other individual systems in terms of stopping time. The average difference in stopping time between the combined system and each of the electromagnetic, mechanical, and hydraulic systems was 0.15 seconds. Additionally, a notable difference of 0.35 seconds was observed between the electromagnetic and mechanical systems. This clearly highlights the superior response speed of the combined system.

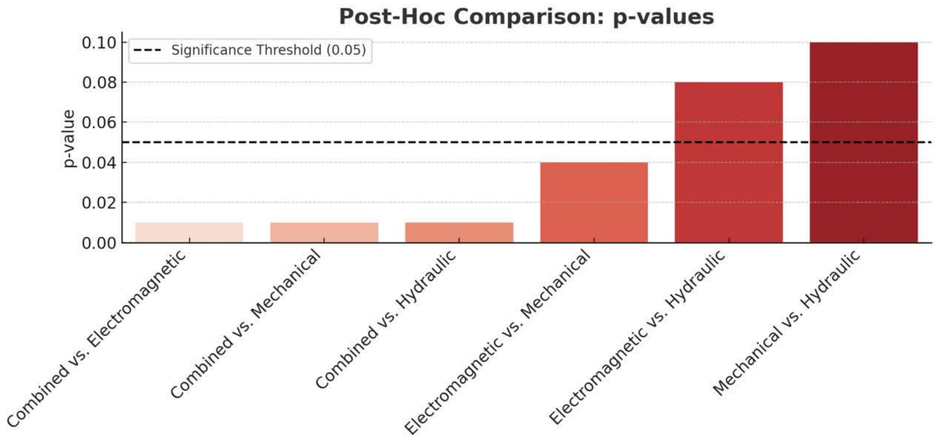

Figure 12. post-hot comparison: p-values

In the second chart, which plotted p-values of the pairwise comparisons, a dashed line at the threshold of p = 0.05 was used to indicate statistical significance. Comparisons between the combined system and all other individual braking systems showed p-values of 0.01, confirming highly significant differences. The electromagnetic vs. mechanical comparison was also statistically significant (p= 0.04). However, comparisons between electromagnetic vs. hydraulic (p = 0.08) and mechanical vs. hydraulic (p= 0.10) were not statistically significant, suggesting that their differences in stopping performance may be due to random variation rather than a true performance gap (Figure 12).

These findings validate the high efficacy and rapid responsiveness of the hybrid (combined) braking system and reinforce its potential for widespread industrial application.

Conclusion

Safety systems for industrial cutting machines play a critical role in protecting workers. By integrating advanced braking technologies, such as mechanical, electromagnetic, hydraulic, pneumatic, and dynamic brakes, the safety and response time of these systems can be significantly improved, preventing severe injuries and creating a safer work environment. These findings align with Kerlik (2024), who reported that electromagnetic brakes perform better than mechanical ones. Additionally, Shrada (2023) emphasized the importance of optimizing braking systems for enhanced safety. For individuals prioritizing high-speed response and minimal maintenance, electromagnetic and mechanical brakes are the best options, despite their higher initial cost. However, for those seeking a cost-effective solution with a reasonable stopping time, hydraulic brakes are a suitable alternative. When selecting a brake system for industrial cutting machines, a combination of electromagnetic, hydraulic, and mechanical brakes offers the best balance between speed, safety, and affordability. However, the final choice depends on specific operational needs and desired safety levels. Implementing proper safety protocols and correct usage of these systems should be a top priority in various industries.

Recommendations

Evaluate the performance of this system in other similar industrial machines

Assess the impact of environmental conditions on the efficiency of the combined system

Explore cost reduction strategies for wider industrial adoption.

Limitations of the Study

1.Single Machine Type Evaluation:

The experimental system was implemented and tested only on one type of industrial cutting machine (Fire Saw). Thus, the findings may not generalize to all other cutting machines with different mechanical structures or motor specifications.

2.Controlled Laboratory Conditions:

All tests were conducted under controlled laboratory conditions. Environmental factors such as dust accumulation, humidity, and long-term wear—common in real industrial settings—were not simulated, which may affect real-world performance.

3.Limited Long-Term Durability Assessment:

The long-term durability, maintenance needs, and potential degradation of the hybrid braking system components (particularly in harsh industrial environments) were not assessed due to time constraints.

4.Economic Feasibility Not Fully Explored:

While the system demonstrated high performance, a detailed cost-benefit analysis was not conducted to evaluate its economic viability for large-scale industrial adoption.

5.Limited Sample Size for Statistical Testing:

Although multiple trials were conducted per braking configuration, the number of unique machines and operational scenarios tested was relatively limited. This may affect the statistical generalizability of the results.

Disclosure statement and funding

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