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# Impact of 6S (5S+Safety) Implementation in Machine Workshops on Occupational Safety

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**Abstract:** In this current study, the impact of implementing 6S (5S+Safety) in the machining industry on occupational safety was investigated by selecting the chip machining section of a factory producing flywheels. To facilitate the comparison of risk levels before and after the implementation of 6S, a Fine-Kinney risk evaluation was conducted in the sawdust department before the application of 6S. The 6S implementation process took 28 days, and subsequently, a Fine-Kinney risk evaluation was performed in the sawdust department, revealing a 77.4% reduction in risks. As a result, the 77.4% reduction in accident risks indicates that the implementation of 6S, which emphasizes safety within the framework of the 5S principles, leads to a more organized, cleaner, and safer machine workshop environment. We can indicate that this approach not only reduces the risk of accidents but also enhances work efficiency, preventing time loss and material waste.

## Makine Atölyelerinde 6S (5S+Safety) Uygulamasının İş Güvenliği Üzerindeki Etkisi



**Anahtar Kelimeler**
Yalın üretim,
Makina imalatı,
İş güvenliği,
Fine Kinney.

**Öz:** Bu çalışmada,6S (5S+Güvenlik)'in makine imalat sanayisinde uygulanmasının iş güvenliği üzerine etkisini belirlemek için volant dişlileri üreten bir fabrikanın talaşlı imalat bölümü seçilerek araştırma kapsamında incelenmiştir. 6S uygulaması öncesi ve sonrası risk derecelerinin karşılaştırmalarının yapılabilmesi için, talaşlı imalat bölümünde 6S uygulanmadan önce Fine-kinney risk değerlendirmesi yapılmıştır. 6S uygulama eyleminin tamamlanması 28 gün sürmüş ve akabinde talaşlı imalat bölümünde yapılan Fine-kinney risk değerlendirmesi ile risklerin %77.4 oranında azaldığı görülmüştür. Sonuç olarak, kaza risklerinin %77.4 oranında azalması,5S ilkeleri kapsamında güvenliğe vurgu yapan 6S'nin uygulanması daha organize, daha temiz ve daha güvenli bir makine atölyesi ortamına yol açtığı görülmektedir. Bu yaklaşımın yalnızca kaza riskini azaltmadığını aynı zamanda iş verimini artırdığını, zaman kaybının ve malzeme israfının da önüne geçtiğini söyleyebiliriz.

## 1. INTRODUCTION

Effective occupational safety practices, especially in industrial enterprises and machine workshops, play a critical role in enhancing both the health of workers and the efficiency of workplaces. The 5S system has been implemented in the industry for years. Its use not only improves the quality of a workplace but also contributes to the enhancement of occupational safety, ergonomics, elevated job standards, and increased job satisfaction and productivity [1,2,3,4]. Due to the prioritization of occupational safety in the manufacturing industry, the term '6S system' has been used for some time. Oppenheim and Felbur [4] emphasize that the 6S system, which places greater emphasis on occupational safety than the 5S system, naturally replaces the latter. Harris and Harris [5] assert that the 6S system operates more comprehensively than the 5S system because it highlights the necessity of ensuring occupational safety, without which optimal job efficiency becomes challenging to achieve. Similarly, Badiru [6] indicates that the 6S system not only enhances quality and efficiency but also improves occupational safety. In this context, understanding and evaluating the impact of the 6S system on occupational safety represent a crucial research area to enhance health and safety standards in modern production environments.

### What is 6S?

In 6S, Safety focuses on preventive measures to protect employees from hazardous conditions and provide them with a safe environment. Research emphasizes the significant role of safety plays in maintaining a stress-free, secure workplace environment, thereby enhancing the overall work environment [7]. 6S is a system that includes the Safety principle as an addition to the fundamental principles of the 5S application. This principle is added with the aim of increasing safety in workplaces and minimizing potential hazards. 6S encompasses six basic principles: Seiri, Seiton, Seiso, Seiketsu, Shitsuke, and Safety [8]. As the 6S System is applied either on a process or departmental basis, the Safety step aims to protect employees from occupational diseases and workplace accidents by implementing health and safety measures [9].

**Importance in Machine Workshops**

Machine workshops are typically places where complex machinery and equipment are intensively used. Operations such as welding, gas cutting, and casting require additional precautionary measures to reduce the number of potential incidents [10]. The 6S method is integral to industries, manufacturing, or construction activities. The implementation of the 5S+1 tools creates safer working conditions [11,12]. Implementing 6S enables operators to use personal protective equipment (PPE) and gear to prevent accidents [13].

Therefore, maintaining high safety standards in such establishments is critical for protecting the health and safety of employees. The addition of Safety in 6S implies risk identification, aiming to enhance productivity, job quality, improve occupational safety, and optimize discipline [14]. This approach, as a result of proper 6S implementation, may improve the safety of industrial units and overall conditions [15].

6S implementations not only establish physical order but also provide a strategy to strengthen the safety culture in workplaces, thereby reducing workplace accidents and hazards [6]. This article aims to thoroughly examine the impact of 6S implementation on occupational safety in a machine workshop, seeking to understand how this system can contribute to enhancing workplace safety. We believe our study could significantly contribute to elevating occupational safety standards in machine workshops.

## 2. MATERIAL AND METHOD

### 2.1. Implementation of 6S Methodology:

A risk evaluation was initially conducted in the machine workshop. This risk evaluation was carried out directly through field observation to track workers' daily work habits and verify their interactions with the surrounding environment.

According to the image of the factory which can be seen in Figure 1, to evaluate the impact of the 6S methodology on safety levels, 6S was applied in an area where risks were high due to the arrangement of finished flywheels at elevated heights, the scattered presence of raw materials, products, and waste materials in the environment, and close contact between workers and forklifts. The use of motorized industrial vehicles can contribute to increased productivity and efficiency but also poses a significant threat [16].

In the first stage, a Fine-Kinney risk evaluation was conducted to quantify the level of safety in the work area. Risk Evaluation Values were obtained by multiplying scores related to Frequency, Severity, and Probability. Once this step was completed, the 6S application was implemented, and a comparison was made between the risk evaluation conducted after the 6S implementation and the initial risk evaluation.

Although some hazards (such as manual use, ergonomics, etc.) were present during the workshop evaluation through direct observation by the assessor these hazards were not taken into account.

The completion of the 6S implementation action took approximately 28 days. To enable before-and-after comparisons, the initial state of the workshop environment was documented with photographs.

### 2.1.1 Seiri

The aim of Seiri is to eliminate unnecessary items and systematically organize the remaining elements for an efficient and effective workflow [17]. Therefore, a list of all materials in the workshop was compiled. Materials and equipment were categorized as essential and safe for the CNC machining process and those posing safety risks to create a clean, organized, and reliable environment. Damaged or faulty tools, unused equipment, and unnecessary materials were sent back to the factory stock for removal. The layout of CNC machines, workbenches, and other equipment was considered, integrating safety-focused elements into the Seiri process to establish a foundation for a safer and healthier working environment in the machine workshop.



### 2.1.2. Seiton

The Seiton stage in the 5S Lean Production system focuses on organizing and arranging items to enhance efficiency and safety [18]. In the CNC workshop, clear and unobstructed pathways were organized to facilitate the movement of workers and the transportation of materials. Easily accessible spaces were designated for frequently used tools. A systematic storage system was established to prevent tripping hazards for raw materials, ongoing projects, and finished products. A working system for the proper disposal of waste materials, such as metal shavings and scrap, was implemented to ensure a clean and safe working environment. Clear and visible safety signs indicating areas with potential hazards, emergency exits, and locations of safety equipment (fire extinguishers, first aid kits, etc.) were placed.

**Figure 1.** Picture depicting the workshop condition before the implementation of 6S.

### 2.1.3. Seiso

In the context of Lean production and the 5S methodology, "Seiso" represents the third S, meaning "Shine" or "Sweep." The purpose of Seiso is to keep the workplace clean and free from dirt, debris, and other contaminants [19]. In a machine workshop producing flywheels with CNC machines, Seiso involves creating cleaning practices that contribute not only to a clean workspace but also to an environment promoting safety and health. A routine plan was established to clean machine surfaces and floors to remove any oil, grease, or residues that could pose slipping hazards. Care was taken to keep storage areas clean and orderly to prevent the accumulation of dust and other pollutants on raw materials and finished products. Shelves were regularly checked and cleaned to maintain balance and prevent items from falling. These measures aimed to create a cleaner and safer machine workshop environment, reducing the risk of accidents, and enhancing overall production efficiency.

### 2.1.4. Seiketsu

The purpose of Seiketsu is to create and sustain standardized work practices to ensure the continued improvement achieved through Seiri, Seiton, and Seiso [20]. Detailed working procedures were prepared for each task and machine operation in the Computer Numeric Control (CNC) machine workshop. These procedures clearly defined the correct and safe way to perform tasks and use materials. Visual cues and signs were used to emphasize safety information and procedures. A checklist was created to evaluate the condition of machines, the organization of work areas, and the use of safety measures.

### 2.1.5. Shitsuke

Shitsuke, or self-discipline, is undoubtedly one of the most critical stages for the successful adoption of 5S. While implementing 5S is relatively simple, the challenge lies in maintaining this principle and preventing the return of old habits. Self-discipline involves employees performing their responsibilities without the need for reminders [21]. Continuous observations were made to ensure that good practices remained in the field and that all achieved results were not temporary. Regular observations were made to remind employees of the importance of sustaining these changes. Evaluations began to take place weekly after operators developed the habit of keeping their work areas clean and organized.



### 2.1.6. Safety

In addition to the steps of Seiri, Seiton, Seiso, Seiketsu, and Shitsuke within the 5S System, the 6S System includes the Safety step [8]. Since the 6S System can be applied at the process or department level, Safety focuses on implementing health and safety measures to protect employees from occupational diseases and workplace accidents [9]. An effort was made to create a safety culture by involving employees in the process of improving and enhancing safety measures. Visual cues, such as safety posters, signs, and bulletin boards, were used to remind employees of safety rules. Safety practices were regularly reviewed to address the evolving needs and challenges in the workshop environment.

## 2.2. Risk Assessment Method

In this current study, the Fine-Kinney risk analysis method was employed for risk evaluation. The Fine-Kinney Risk Evaluation Method is calculated as R = O x F x Ş, where O = Probability, F = Frequency, Ş = Severity, and R = Risk Score.

In their study conducted in 1976, Kinney and Wiruth defined 'very strong probability', which they set as a reference point with a 10-point scale, as an event that has occurred before, is possible to repeat and will occur in the future and assigned 10 to this value. They assigned another reference point, 'Low Probability', to the value 1. They gave the value of 'Almost Impossible' probability, which forms the base of the probability scale, to 0.1, and the intermediate values created the scale as decreasing values depending on experience [22].

**Table 1**. Probability Score Ranking.

| Category | Value |
|---|---|
| Almost impossible | 0.1 |
| Impossible | 0.2 |
| Weak possibility | 0.5 |
| Low probability | 1 |
| Rare but possible | 3 |
| Highly probable | 6 |
| Very strong possibility | 10 |

Kinney and Wiruth also created a scale table for frequency values in the same study. In the frequency table, risks are classified according to their frequency of occurrence on a time basis, such as hourly, daily, or annual. As can be seen in Table 2, if the frequency of the determined risk is 'hourly', it is accepted that the risk occurs 'continuously' and the frequency value used in creating the risk value is determined as 10, which is the highest value in the table, 0.5 as the lowest value, and 3 as the middle value [22].

**Table 2**. Frequency (Exposure Frequency) Score Ranking.

| Category | Value |
|---|---|
| Very rare (once a year or every few years) | 0.5 |
| Quite rare (once or a few times a year) | 1 |
| Rare (once or a few times a month) | 2 |
| Occasional (once or a few times a week) | 3 |
| Frequent (once or a few times a day) | 6 |
| Continuous (once or multiple times within an hour) | 10 |

In calculating the risk score, the amount of damage resulting from the risk is taken into account in the scale table prepared for the third multiplier, severity. The severity scale table obtained as a result of this calculation is given in Table 3. In the scale created here, scoring was made by taking into account the death rate caused by violence [22].

**Table 3.** Damage/Consequence (Severity) Score Ranking.

| Category | Value |
|---|---|
| Multiple fatalities | 100 |
| Fatal accident | 40 |
| Permanent injury | 15 |
| Significant damage | 7 |
| Minor damage | 3 |
| Near miss | 1 |

Depending on the determined risk, probability, frequency and severity values are obtained from the relevant tables and the risk score is determined by multiplying the three parameters. Obtained risk scores are classified according to Table 4 [22].

**Table 4.** Risk Skor Evaluation Result.

| Risk Skor | Category | Things to do |
|---|---|---|
| $R \geq 400$ | Very high risk | Tolerance for risk is unacceptable. Immediate measures should be taken. |
| $200 \leq R < 400$ | High risk | Should be improved within a few months. |
| $70 \leq R < 200$ | Significant risk | Should be carefully monitored. Improvement should be made within one year. |
| $20 \leq R < 70$ | Possible risk | Should be kept under observation. Control methods should be developed. |
| $R < 20$ | Insignificant risk | No probability of causing harm. Not a priority |

**Table 5.** Risk Evaluation Table.

| Hazard Risk Level Identification Table | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Before 6S | | | | | | After 6S | | | | |
| Danger | P | S | F | Score | Possible risk | P | S | F | Score | Result |
| Knocking over of stacked gears | 3 | 15 | 2 | 90 | Significant risk | 0.5 | 15 | 2 | 15 | Insignificant risk |
| Forklift hitting gears | 3 | 15 | 1 | 45 | Significant risk | 1 | 15 | 1 | 15 | Insignificant risk |
| Forklift hitting workers | 1 | 40 | 2 | 80 | Significant risk | 0.5 | 40 | 1 | 20 | Possible risk |
| Storage stacking | 3 | 15 | 2 | 90 | Significant risk | 0.5 | 15 | 2 | 15 | Insignificant risk |
| Tripping over parts and falling | 6 | 7 | 3 | 126 | Significant risk | 2 | 7 | 2 | 28 | Possible risk |
| Objects falling | 3 | 15 | 3 | 135 | Significant risk | 1 | 15 | 2 | 30 | Possible risk |

## 3. RESULTS AND DISCUSSION

As a result of creating a systematic storage area for raw materials and completed spur gears, wider safe passageways were established between forklifts and workers, eliminating the possibility of the forklift colliding with the products and minimizing the risk of accidents. The elimination of metal chips and unused scrap materials resulted in removing tripping and falling hazards. Regularly checking and organizing shelves to maintain balance and prevent objects from falling reduced the risk of objects falling from the shelves.

In the initial phase of this study, a risk evaluation was conducted in the workshop environment. To compare the scenario before and after the implementation of 5S and to understand whether there was any impact of 6S application on workshop safety after the implementation of 5S, a new risk evaluation was conducted.

The results, as seen in Figure 2, indicate that by applying 6S to the identified location and utilizing risk evaluation, it is possible to reduce the total risk by 77.4%."

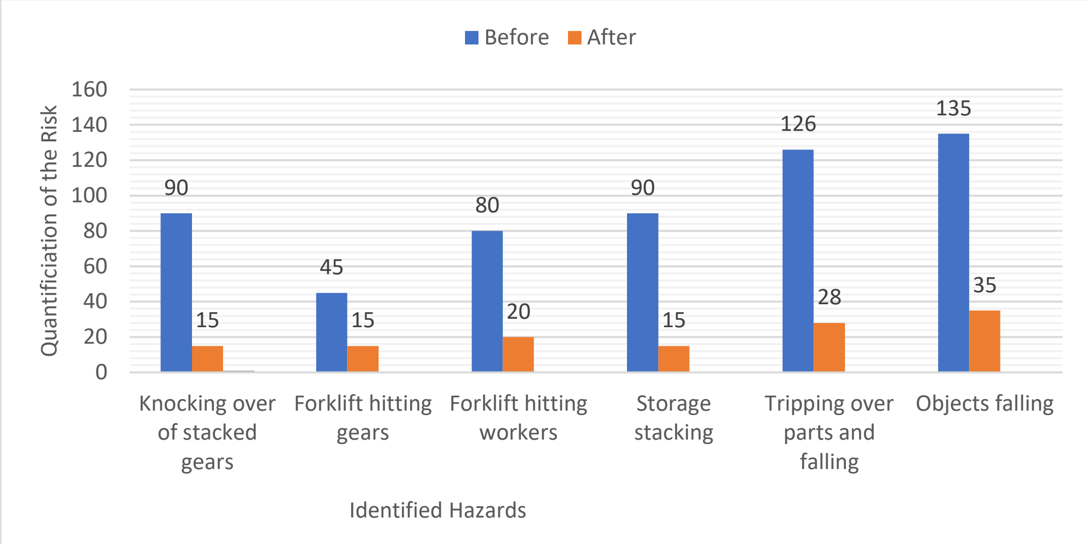


**Figure 2**. Risk assessment before and after 6S.

## 4. CONCLUSIONS

This current study investigated the application of 6S (5S+Safety) in the machine workshop of a factory producing flywheels in Konya, exploring its potential contributions to production efficiency and workplace safety conditions. The following results were obtained from the study:

The research highlighted that, in addition to being a powerful tool for organizing and optimizing the workplace environment, ensuring workplace safety is crucial. The results demonstrated that by applying 5S+1S, or 6S, in the identified location and utilizing the risk evaluation tool, it is possible to reduce the total risk by up to 77.4%. The time saved in finding tools, the reduction in wasted materials, and improvements in overall workspace efficiency were observed as benefits.

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