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SOFTWARE QUALITY MANAGEMENT FRAMEWORK USING HACCP IN ENGINEERING

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Abstract. ***The paper aims to demonstrate the application of HACCP to software quality management framework in steel engineering. This paper begins with a quick discussion of the theoretical foundations of quality management including quality assurance, then moves on to a brief introduction to HACCP that emphasizes its possible applications in a variety of industries. The goals of interdisciplinarity include profit maximization, enhanced productivity, and customer pleasure.***

Keywords: HACCP, steel manufacturing, quality management, quality assurance, industrial processes

1. INTRODUCTION

In this article is emphasized the importance of continuous development for steel industry based on quality, customer satisfaction and profit. Due to the increased demand for premium steel, both new and established businesses must pay close attention to their equipment, and digitalization is becoming a crucial component of every step of the manufacturing process. Like it is mentioned in literature, a subfield of industry known as "metallurgy" deals with the extraction of metals from ores and other materials that contain metals [1-4].

Processes, procedures, and techniques used to guarantee that goods and services fulfill particular quality standards and requirements are referred to as quality management. It entails managing every task and activity required to uphold the intended standard of excellence. Quality management includes the following key components detailed presented in the following [5-6]:

The first key component is quality planning which is represented by establishing objectives and specifying the necessary operational processes and resources to fulfill quality requirements.

Another key component is quality control which is represented by monitoring and measuring outputs to identify any deviations from quality standards. This often involves inspections and testing.

Also, a very important component is quality assurance which is represented by systematic processes designed to ensure that quality requirements are met throughout the production or service delivery process.

Continuous Improvement is another key component of quality management and is represented by ongoing efforts to improve products, services, or processes by implementing incremental changes or breakthroughs.

Software quality standards are represented by compliance with established guidelines and benchmarks, which provide frameworks for quality management systems.

Software quality management is crucial in enhancing customer satisfaction, reducing costs associated with failures, and improving overall organizational efficiency. The key components of quality management are presented in the following figure [5-6]:

Figure 1. Software quality management key components

By embedding these quality management practices into their operations, steel manufacturers can enhance product reliability, ensure safety standards, and maintain competitiveness in the market. Also, incorporating these quality management practices can lead to improved product performance, customer satisfaction, and reduced waste, ultimately benefiting the overall efficiency and profitability of steel manufacturing operations.

Quality management in steel manufacturing involves a systematic approach to ensure that the steel produced meets specified quality standards and customer requirements [1-4].

2. SOFTWARE QUALITY ASSURANCE IN STEEL MANUFACTURING

Due to the fact that high-quality steel is in high demand, a special attention to equipment is required, despite the enterprises, digitalization becoming a crucial component of every step of the manufacturing process.

Like it is mentioned in literature, quality management in steel manufacturing is critical due to the specific requirements and standards expected in the industry. One significant component of quality management, quality assurance (QA) in steel manufacturing is essential for ensuring that the products meet specified standards and customer requirements.

It is worth mentioning that there is a difference between quality assurance and quality control, more precisely the first one focuses on preventing defects by establishing process controls and standards, meanwhile the second one involves the testing and inspection of materials, processes, and finished products to ensure they meet quality specifications.

Also, software quality assurance encompasses various processes and protocols designed to ensure features such as consistency, reliability, and safety throughout production. In the following figure are represented the key principles of software quality assurance [5-7]:

Figure 2. Software quality assurance principles

Steel producers may guarantee safety requirements, improve product reliability, and stay competitive in the market by integrating the quality management techniques into their operations.

In the following figure are represented the software quality management principles [5-7]:

Figure 3. Software quality management principles

Improving customer happiness, cutting down on failure-related expenses, and increasing overall organizational effectiveness all depend on quality management. A very important aspect is to ensure that raw materials meet specified standards is vital. This involves selecting high-quality ores, alloys, and additives. Regular testing of materials is essential before they enter the production process [6].

Also implementing strict monitoring and control of the manufacturing process, including melting, casting, rolling, and heat treatment are very important. Automation and real-time monitoring systems may improve optimal conditions. Adhering to industry quality standards ensures that products meet specifications. Certifications not only enhance credibility but also facilitate access to global markets [6].

In order to maintain quality, are mandatory routine inspections and testing of manufactured steel products for properties such as tensile strength, hardness, corrosion resistance, and dimensional tolerances. Non-destructive testing methods may also be used to assess material integrity. Implementing systems to trace raw materials and finished products through all stages of production helps in identifying and managing quality issues effectively [6].

Also, utilizing methodologies like Six Sigma or Lean Manufacturing to continuously analyze and improve processes, reduce waste, and ensure consistent quality. A very important aspect is to invest in workforce training to ensure that all employees understand quality management principles and practices. In order to maintain quality, clients are very important and actively seeking and analyzing customer feedback will improve product quality [6].

3. HACCP IN ENGINEERING QUALITY MANAGEMENT

It is well known from literature that HACCP stands for Hazard Analysis and Critical Control Points. HACCP, while traditionally associated with food safety, can be adapted to other industries, including steel manufacturing, to improve safety and quality control [7-11].

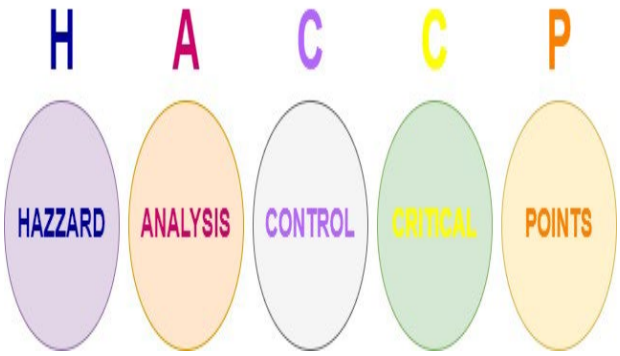

Figure 4. HACCP representation [10-11]

By integrating the following presented components, steel manufacturers can enhance their quality assurance processes, leading to improved product reliability, reduced defects, and greater customer satisfaction.

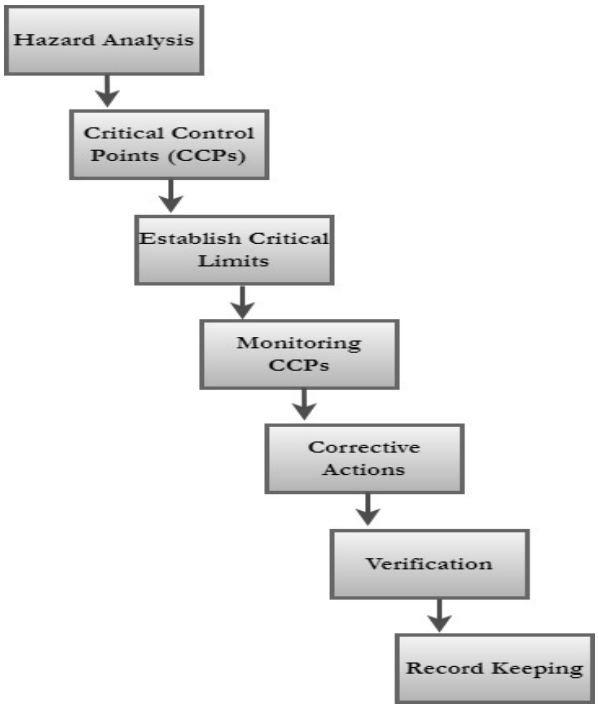

Figure 5. HACCP concepts [10-11]

The applicability of HACCP in the steel industry is presented in the following diagram:

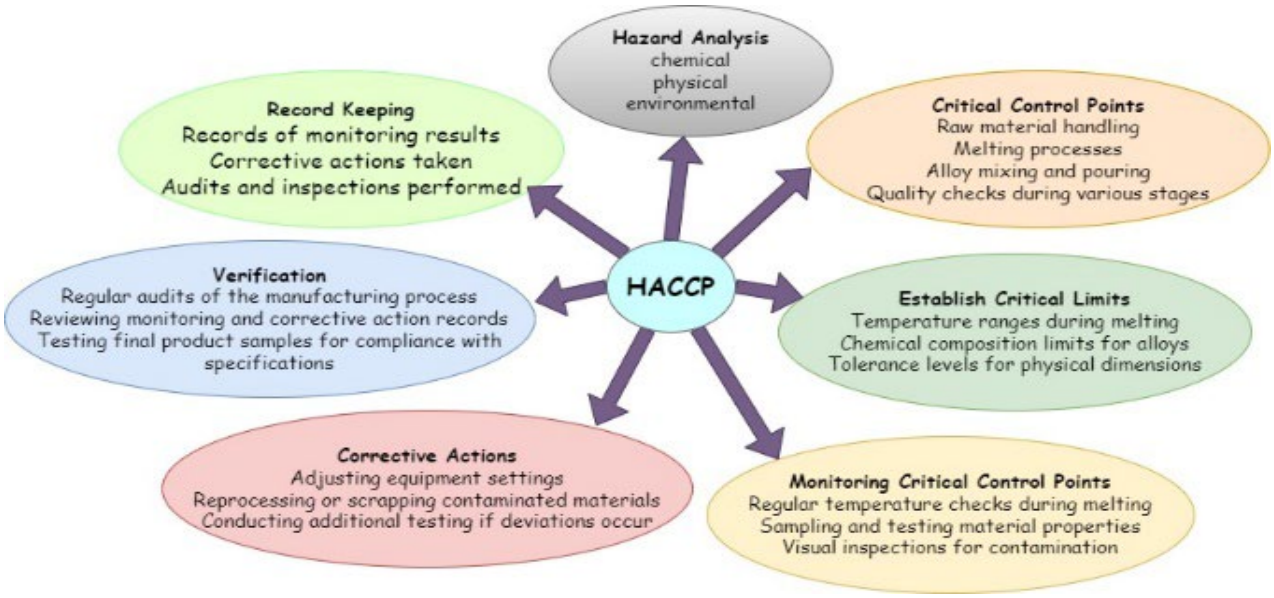

Figure 6. HACCP concepts [10-11]

Although HACCP has historically been linked to food safety, it can be applied to other sectors, such as steel production, to enhance quality assurance and safety. The HACCP concepts can be applied to the steel industry to detect, evaluate, and reduce production process hazards, guaranteeing worker safety and product quality [10-11].

The first HCCP concept, Hazard Analysis, can identify potential hazards in the steel manufacturing process, such as:

- Chemical hazards such as contaminants from raw materials
- Physical hazards such as foreign objects or metal shavings
- Environmental hazards such as dust, gases, or

temperature extremes

Another HCCP concept is represented by Critical Control Points. The role of this concept is to determine critical points in the manufacturing process where different hazards may occur. Suggestive examples of Critical Control Points are the following:

- Raw material handling.
- Melting processes.
- Alloy mixing and pouring.
- Quality checks during various stages.

Also, another important HACCP concept is Establish Critical Limits. The role of this concept is to define acceptable limits for each critical control point, such as:

- Temperature ranges during melting.
- Chemical composition limits for alloys.
- Tolerance levels for physical dimensions.

An important HCCP concept is represented by Monitoring Critical Control Points. The main objective of this concept is to implement monitoring processes at each Critical Control Point which may include:

- Regular temperature checks during melting.
- Sampling and testing material properties.
- Visual inspections for contamination.

An additional HCCP concept is represented by Corrective Actions. The purpose of this concept is to develop procedures for addressing deviations from critical limits:

- Adjusting equipment settings.
- Reprocessing or scrapping contaminated materials.
- Conducting additional testing if deviations occur.

Another HCCP concept is represented by Verification. The main scope of this concept is to ensure that the HACCP plan is effective through:

- Regular audits of the manufacturing process.
- Reviewing monitoring and corrective action records.
- Testing final product samples for compliance with specifications.

Another HCCP concept is represented by Record Keeping. The role of this concept is to maintain thorough documentation to support traceability and compliance, which includes:

- Records of monitoring results.
- Corrective actions taken.
- Audits and inspections performed.

An important aspect to mention is that integration of HACCP principles can enhance existing quality management systems, improving the consistency and reliability of steel products through rigorous monitoring and control.

Also, by demonstrating commitment to safety and quality through HACCP, steel manufacturing companies can enhance customer trust and satisfaction, leading to better business relationships.

4. CONCLUSIONS

Hazard Analysis Critical Control Point (HACCP) is primarily associated with food safety, but its principles can also be applied in steel manufacturing to enhance quality control and safety processes. HACCP is widely used in food manufacturing, processing, and handling industries, and it is often a requirement for businesses that export food or wish to obtain certifications like ISO 22000 or others. It helps organizations prevent foodborne illnesses and ensure the safety of their products.

Also, adopting HACCP principles in steel manufacturing can lead to improved safety, product quality, and operational efficiency. Although traditionally associated with food safety, the methodology's structured approach to identifying and managing risks can provide significant benefits in the industrial context.

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