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ANALYTICAL AND CONTROL METHODS FOR ASSESSING QUALITY AND NON-QUALITY PARAMETERS. A CASE STUDY PART I

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Abstract: *In this study, a case analysis was conducted to evaluate the application of graphical and tabular methods in monitoring and controlling both quality and non-quality parameters of webbings manufactured using a webbing loom. The analysis and control of product and process quality can be achieved through various methods, including graphical, tabular, and matrix-based approaches. To address most quality-related issues, graphical methods known as the Seven Basic Quality Tools can be employed. These include the cause-and-effect diagram (also known as the fishbone diagram or Ishikawa diagram), the histogram, the Pareto chart, the scatter diagram, the stratification diagram (also referred to as the process diagram or data sequence diagram), the check sheet, the control chart and tabular methods. Information presented through charts and tables is structured in a way that enhances clarity, making it easier to comprehend and retain.*
Charts are two-dimensional visual representations that facilitate easy and quick understanding of the situation and the analyzed data, allowing for the rapid identification of trends, relationships, and variations in the characteristics being examined. They can be used to highlight patterns within a dataset, compare information, and support decision-making. Tables are structured in a matrix format and are used to present data in a clear and systematic manner. Unlike charts, which provide a quick visualization of trends, tables allow for a detailed and precise presentation of information. They are particularly useful when accurate comparison of values is required or when access to specific individual data points is necessary.

Key words: *Graphical methods, tabular methods, webbing, defects, quality*

1. INTRODUCTION

In a globalized and competitive economy, quality is a key determinant of an organization's success. The concept of quality not only refers to compliance with standards but also to customer satisfaction, process efficiency, and cost optimization. On the other hand, non-quality results in significant losses, including scrap, repairs, complaints, and the loss of customer trust. [1], [2]. This paper aims to analyze several methods through which quality can be ensured and the impact of non-quality. In the webbing industry, where safety and reliability are critical, a rigorous approach to quality is essential to avoid significant risks, such as structural defects or accidents. [3].This paper aims to demonstrate the importance of the systematic analysis of defects and the factors that generate them, thereby contributing to process optimization and the improvement of product or service quality [4], [5].

2. GENERAL INFORMATION

In quality control practice, [6], [7], [8] there are different types of cause-and-effect diagrams (Ishikawa) that vary in terms of structure, the way causes are organized and systematized, and the purpose for which the diagrams are used, such as:

a) Diagrams for analyzing the variation of quality characteristics
b) Diagrams structured by process stages
c) Diagrams for listing causes

The cause-and-effect diagram is used for the following purposes:

- ✓ To identify potential causes of a known effect
- ✓ When working in a team, to foster a common understanding of the problem's causes and their interrelationship
- ✓ To highlight other causes of the desired effects
- ✓ It is preferably used when a problem exists and the causes are primarily hierarchical

The Pareto chart is a graphical method that highlights the relative frequency of various issues or characteristics (scrap, defects, complaints, errors, etc.) and presents the information in descending order, from the most frequent to the least frequent. The column chart is accompanied by a concave curve, plotted on the same graph, representing the cumulative percentages of the columns

3. RESULTS AND DISCUSSIONS

The defects in the fabric are determined by factors such as the technical condition of the weaving machines, the quality of the warp and weft threads, the operation of the weaving machines, the quality management system, a.s.o. By recording the defects occurring per 1000 meters of webbing produced on the webbing loom, the following defects were identified, as shown in Table 1

Table 1: *Types of Defects*

No.	Defect	Defect Image	No.	Defect	Defect Image
1.	Yarn Binding Errors		5	Frayed/ Destroyed Webbing (nests)	
2.	Weft Yarn Omission		6.	Warp Yarn Omission	

3.	Warp Float with Varying Lengths	 	7.	Knots	
4.	Over-Tensioned Warp Yarn				

3.1. The **C Method (Causes)** is a quality analysis technique with a preventive character, focused on identifying the root causes that lead to defects. It emphasizes the investigation of the underlying causes of a problem, rather than merely addressing symptoms. [9]. This method enables the logical categorization of contributing factors, facilitating a more structured and efficient analysis. One of the variations of this method is the cause-and-effect diagram, also known as the fishbone diagram or Ishikawa diagram. This tool allows for the identification of potential quality issues and the development of optimal solutions within a sufficiently short timeframe, ensuring that delays in the production flow are avoided. [10],[11],[12] The Ishikawa diagram is a fundamental tool in quality analysis, primarily used for product design and defect prevention. For practical analysis, developing a cause-and-effect diagram involves applying the brainstorming technique to identify the potential causes of a problem, which are then progressively detailed into primary, secondary, and tertiary categories, along with specific contributing factors. [13],[14],[15] When analyzing the causes of variation in a quality characteristic — regarded as the effect — the six categories of influencing factors, known as the 6Ms, are: Man (human resources and workforce), Machine (equipment and technological systems), Material (raw materials and components), Method (operational and organizational procedures), Measurement (inspection and control methods), and Environment (ambient conditions affecting the process). [9].

When analyzing the quality of a product during both the manufacturing phases and its usage, it may be observed that in some cases, incompatibilities arise between these two types of quality. To manage such incompatibilities, the Ishikawa method can be applied, [16] which classifies quality and non-quality characteristics into primary (those that directly influence the end user's experience) and secondary categories.

For some of the defects presented in Table 1, the primary and secondary factors are identified. For the defect “knots” it is considered that two primary factors interact, namely: the raw material and the weaving machine, as presented in Table 2. Other factors exert an indirect influence.

Table 2: *The factors influencing the formation of knots*

Raw material	**The direction of influence**	**Weaving machine**	**The efect**	**The knot type**
Over-twisted weft or warp	→	High tensions in the yarn	Yarn breakage caused by the working components in contact with the yarn	Improper knots caused by yarn over-tensioning
Yarn with excessively large knots	→	Improper functioning of the yarn monitoring devices	Weaving yarns with excessively large knots	Knots from previous stages of weaving
Yarn damage	←	Working components in contact with the yarns	Yarn breakage	Improper knots caused by yarn over-tension
High-tensioned yarn	→	Mismatch of the technological parameters of the weaving machine	Frequent yarn breakage	Improper knots caused by excessive yarn tension

The Ishikawa diagram applied in the analysis of the knots in the fabric is presented in Figure 1.

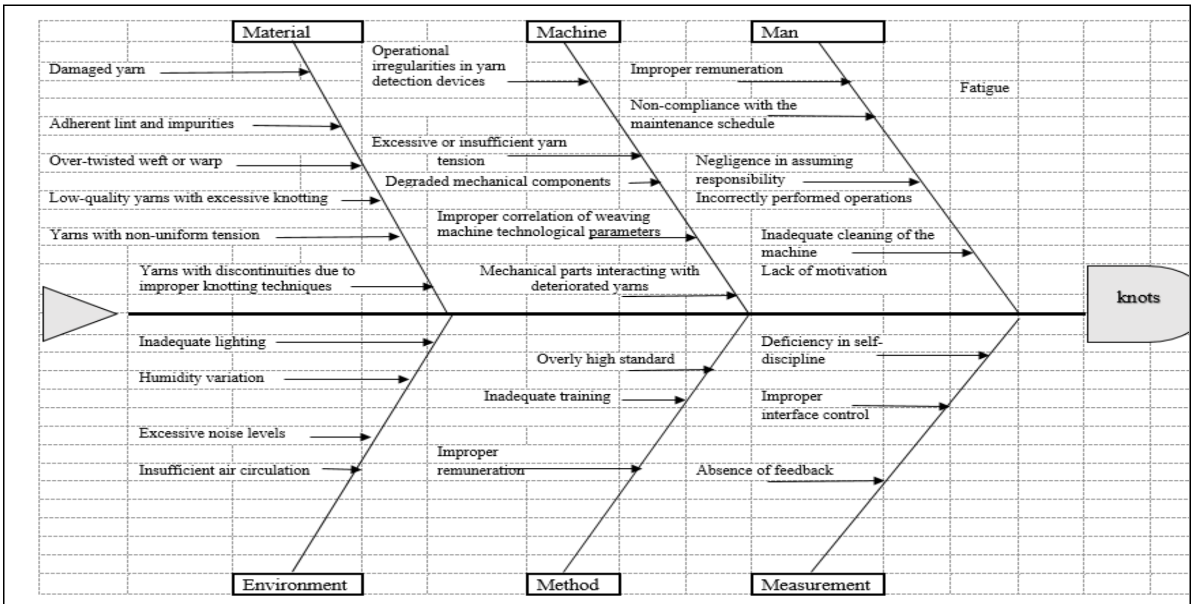

Fig. 1*: Ishikawa diagram applied in the analysis of the knots*

For the 'missing weft yarn' defect, it is considered that two primary factors interact, namely: the raw material and the weaving machine, as presented in Table 3. Other factors exert an indirect influence.

Table 3: *Factors influencing the missing weft yarns*

Raw material	**The direction of influence**	**Weaving machine**	**The efect**	Type of defect
Yarn with thinning	→	High tension in the yarn	Yarn breakage	Missing weft yarns due to yarn breakage
Broken weft yarn	→	Defective weft yarn detection sensors	Operation of the weaving machine without weft yarn	Missing weft yarns due to improper functioning of the weaving machine
Incorrect weft yarn feeding	←	Malfunctions in the weft yarn feeding mechanism	Operation of the weaving machine without weft yarn	Missing weft yarns due to improper functioning of the weaving machine
Overstress of the weft yarn	←	Mismatch between the needle mechanism and the weft yarn feeding mechanism	Yarn breakage	Missing weft yarns due to yarn breakage

The Ishikawa diagram applied in the analysis of the missing weft yarn defect is presented in Figure 2.

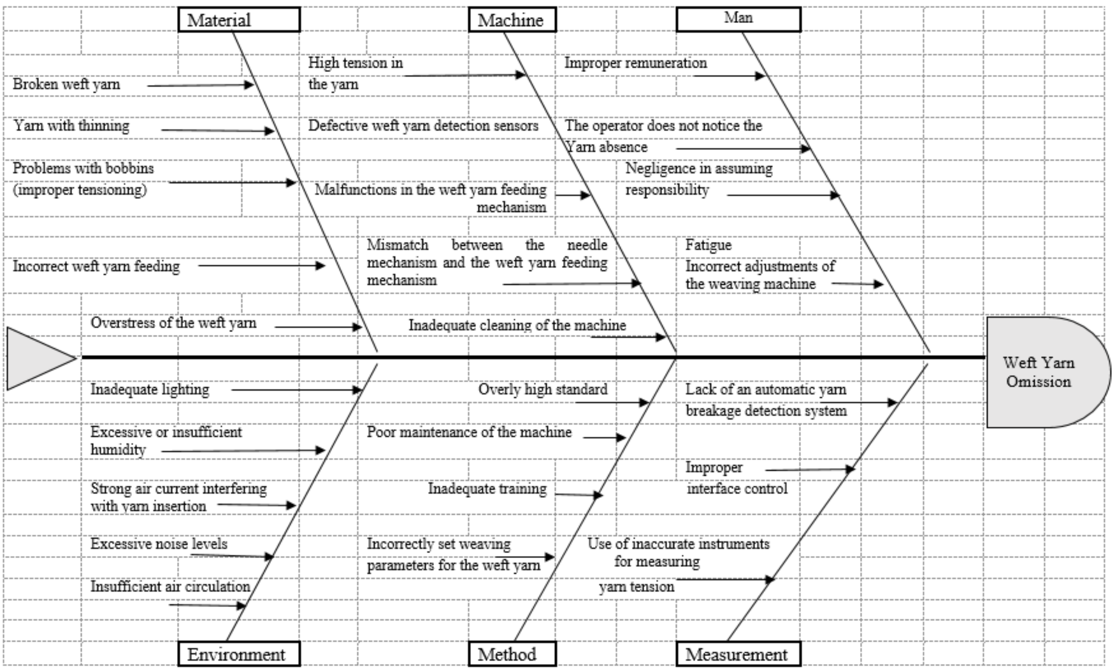

Fig. 2*: Ishikawa diagram applied in missing weft yarn*

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