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

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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*

3. RESULTS AND DISCUSSIONS (continuation)

3.2. CP Method (Causes, Remediation Possibilities)

Using this method, the main defect-causing factors and possible remediation options can be identified through preventive and corrective actions. Preventive actions are taken with the aim of avoiding the occurrence of defects and include proper organization, ensuring that the production process is carried out under optimal conditions, and implementing appropriate measures for transportation, packaging, and storage. Corrective actions are implemented when an issue arises, and measures must be taken on both machines and products to eliminate or mitigate the problem. Table 4 presents the correspondence between the causes of defects and the remediation options.

Table 4: *Defects – Causes – Remedies in webbing weaving machines*

No.	Defect	Causes of defect occurrence	Corrective and Preventive Actions
1.	Yarn binding errors	- malfunction of the shed formation mechanism -incorrect command for the heddle movement	-inspection and adjustment of the shed mechanism -correct handling of shed searching -adjustment of the warp and weft yarn control mechanisms -adjustment of the shed searching mechanism
2.	Missing weft yarn	-malfunctions in the weft yarn feeding -malfunctions of the weft yarn feeding mechanism --errors in shed selection during yarns -breakage clearance -improper adjustment of the temple	-inspection of the weft bobbins before use - proper adjustment of the weft yarn controller and the main shaft brake - inspection and adjustment of the shed mechanism
3.	Warp yarn floating with varying lengths	- yarn tension release - incorrect shaft position - defective healds - slub - different warp yarn contractions - low warp tension - improper adjustment of the shed	- bobbins inspection - healds Inspection - removal of slubs - proper adjustment of the shed - increased attention to the warping operation
4.	Excessively tensioned warp yarn	-overloading of the yarns due to lint -tension differences between the warp yarns -stuck yarns -defects in the yarn knotting operation	-air blowing for cleaning the heddles -proper use of spools -proper adjustment of the yarn tensioning devices -proper positioning of the bobbins in the rack
5.	Frayed/ Destroyed Webbing (nests)	-warp yarn breakage -warp yarn snagging - lint - devices not replaced on time on the weaving machine -use of inappropriate yarns (linted, with thinning and thickening)	-inspection of yarn bobbins -performing preventive maintenance -carrying out current repairs -removal of lint
6.	Missing warp yarn	- incorrectly adjusted machine -improper functioning of the warp controller -non-compliant accessories leading to warp yarn breakage -use of warp yarns with different tensions -breaking of heddle teeth -operator negligence -improper microclimate	-proper adjustment of the machine -Proper adjustment and maintenance of the warp controller -replacement of worn accessories -adjustment of the warp yarn tension
7.	Knots	-large yarn end lengths -incorrect joining of warp or weft yarns -too large knots	-stronger knots - use of knotting machines - familiarizing operators with the proper knotting procedure

3.3 The frequency method

The frequency of each defect is determined by formula (1)

$$\text{Frecvency} = \frac{\text{Number of defects}}{\text{Controlled length}} \cdot 100 \qquad \textbf{(1)}$$

Table 5: *Frecvency of defects*

No	Defect type	Number of defects	Frecvency (defects /100 m)
1.	Warp yarn floating	70	7
2.	Missing weft yarn	49	4,9
3.	Excessively tensioned warp yarn	13	1,3
4.	Yarn Binding Errors	12	1,2

5.	Knots	8	0,8
6.	Missing warp yarn	7	0,7
7.	Frayed/ Destroyed Webbing (nests)	5	0,5

If the frequency is >1 defect per 100 meters, it is considered that exists a recurring issue, and corrective actions must be taken (Warp yarn floating, Missing weft yarn, Excessively tensioned warp yarn, Yarn binding errors.

If the frequency is between 0,5 and 1 defect per 100 meters, the process is monitored, and are checked possible adjustments (Knots, Missing warp yarn, Frayed belt (nests)).

If the frequency is <0.5 defects per 100 meters, the defect is considered minor and does not require urgent interventions.

Corrective actions: are presented in table no. 4.

Conclusion: This method enables a clear assessment of fabric quality and contributes to the reduction of defects during the manufacturing process [1]

The Pareto method is a graphical tool with wide-ranging applications, based on the frequency of defect occurrence over time (e.g., number of defects per unit time) or relative to the product (e.g., number of defects per square meter, per meter, per kilogram of product, etc.). [2], [3].

Industrial practice has shown that only two or three types of defects account for the highest proportion (70–80%) of total occurrences, generating the most significant losses in production efficiency and product quality.

For the application of the Pareto chart in defect analysis, the following steps can be undertaken [4], [5]:

- identification of potential defects and the method of recording them
- determination of the data collection period
- calculation of defect frequency and documentation in the observation sheet
- construction of the Pareto chart

Table 6: *Defect frequency*

No.	Defect type	Number of defects	Percentage, %	Cumulative number of defects	Cumulative percentage,%
1	Warp yarn floating	70	42,7%	70	42.7%
2	Missing weft yarn	49	29,9%	119	72,6%
3	Excessively tensioned warp yarn	13	7,9%	132	80,5%
4	Yarn Binding Errors	12	7,3%	144	87,8%
5	Knots	8	4,9%	152	92,7%
6	Missing warp yarn	7	4,3%	159	97,0%
7	Frayed/ Destroyed Webbing (nests)	5	3,0%	164	100,0%

The Pareto chart [6], obtained by plotting the defects on the x-axis in descending order of frequency, with the number of defects on the left y-axis and the cumulative percentage on the right y-axis, is shown in Figure 3.

Analyzing the Pareto chart obtained, it can be observed that the first two types of defects account for over 70% of the total defects. The red line represents the cumulative percentage of defects and is crucial in Pareto analysis, helping to identify the causes that have the greatest impact on the problems. Each point on the red line indicates what percentage of the total defects could be eliminated if we focus solely on the primary causes of defects.

Looking at the first two bars (Warp yarn float and Missing weft yarn), the red line indicates that they account for over 70% of the total defects. This suggests that if the company improves these two aspects, it could resolve the majority of the defects without necessarily focusing on the other, less significant causes. In practice, the red line helps apply the 80/20 principle: 80% of the defects are caused by 20% of the problems. Without this line, it would be more difficult to identify this pattern.

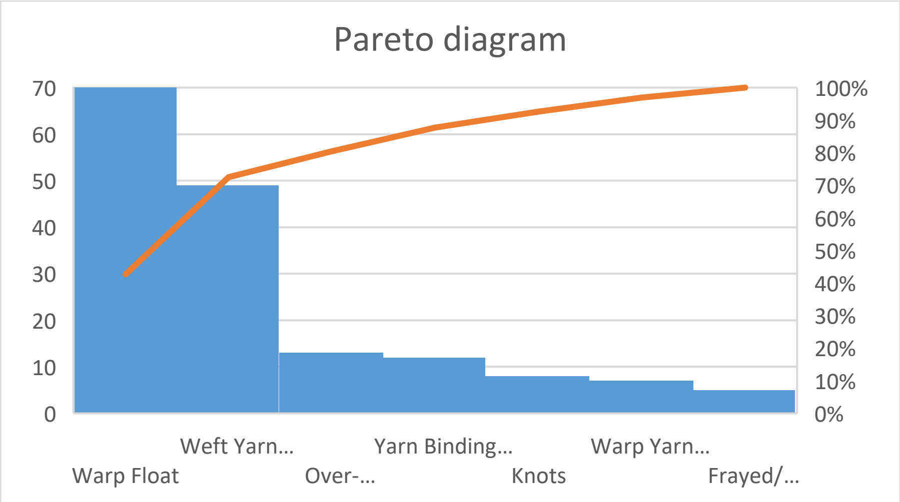

Fig. 3*: Pareto Diagram*

If the first two types of defects (Warp yarn float and Missing weft yarn) are associated with their root causes (yarn tension release, incorrect shaft position, defective healds, slub, different warp yarn contractions, low warp tension, improper adjustment of the shed, defects in the machine's weft feeding system, malfunctions of the weft yarn feeding mechanism, errors in shed selection during yarns breakage clearance, improper adjustment of the temple) presented in table no. 4 . The most effective corrective and preventive actions to improve the quality of webbings can be established, concomitant with the increase in machine productivity - bobbins inspection, healds Inspection, removal of slubs, proper adjustment of the shed, increased attention to the warping operation, inspection of the weft bobbins before use, proper adjustment of the weft yarn controller and the main shaft brake, proper adjustment of the weft yarn controller and the main shaft brake, inspection and adjustment of the shed mechanism.

Based on this diagram, both the defects of the products and an analysis of the machine malfunctions involved in the process, as well as the planning of maintenance activities, can be analyzed.

Conclusion: By directing preventive and corrective actions towards the defects with the highest weight, an improvement in product quality can be achieved, resulting in an increase in economic efficiency.

3.4. The MGF method (size, gravity, frequency)

Is used to assess production defects based on three factors:

- ✓ **Size** – the dimension of the defect in relation to the product (1 – minor, 5 – major),
- ✓ **Severity** – the impact of the defect on functionality and quality (1 – insignificant, 5 – critical),
- ✓ **Frequency** – how often the defect occurs (defects /100 m).

The score is calculated as follows: MGF Score = M x G x F

Table 7: *The MGF method*

No.	Type of defect	Size (1-5)	Gravity (1-5)	Frecvency (defects /100 m)	Scor MGF	Risk classification
1.	Warp yarn floating	3	4	7	84	Very high
2	Missing weft yarn	5	5	4,9	178,43	Very high
3	Excessively tensioned warp yarn	3	3	1,3	11,7	Low
4	Yarn Binding Errors	2	5	1,2	12	Low
5	Knots	2	4	0,8	6,4	Low
6	Missing warp yarn	5	5	0,7	17,5	Low
7	Frayed/ Destroyed Webbing (nests)	4	5	0,5	10	Low

The following scales can be used:

- 1-3 – for quick and simplified evaluations (1 – minor, 2 – medium, 3 – major), used when detailed analysis is not required.
- 1-5 – for precise and simplified evaluations (1 – minor, 3 – medium, 5 – major), most commonly used in production.
- 1-10 – for finer evaluations (1-3 – minor defect, 4-6 – medium defect, 7-9 – major defect, 10 – critical defect), used when there are large variations in the impact of defects.

Interpretation table:

- Score 1-20 – low risk – requires standard monitoring and quality control.
- Score 21-40 – medium risk – requires stricter monitoring and quality control.
- Score 41-60 – high risk – requires optimization and quick interventions to prevent major defects.
- Score >60 – very high risk – critical issue, requires revision of the manufacturing process.

Proposed measures:

- ✓ For Floating Warp Yarn – score 84 – high risk:
  It is necessary to check the bobbins, check the heddles, remove lint, and properly adjust the shed formation mechanism.
- ✓ For Missing Weft Yarn – score 178.43 – high risk:
  It is necessary to check the weft bobbins before use, properly adjust the weft yarn controller and the main shaft brake, and inspect and adjust the shed formation mechanism.
- ✓ For Excessively Tensioned Warp Yarn – score 11.7 – low risk:
  It is necessary to blow air to clean the heddles, use the dividing correctly, properly adjust the yarn tensioning devices, and properly position the bobbins in the rack.
- ✓ For Yarn Joining Errors – score 12 – low risk:
  It is necessary to inspect and adjust the shed formation mechanism, adjust the warp and weft yarn control mechanisms, and adjust the shed searching mechanism
- ✓ For Knots – score 6.4 – low risk:
  It is necessary to make firmer knots, use knotting machines, and familiarize operators with the proper knotting procedure.
- ✓ For Missing Warp Yarn – score 17.5 – low risk:
  It is necessary to properly adjust the machine, ensure correct adjustment and maintenance of the warp controller, replace worn-out accessories, and adjust the tension of the warp yarns.

- ✓ For Frayed Ropes (Nestings) – score 10 – low risk:
  It is necessary to check the yarn bobbins, perform preventive maintenance, carry out current repairs, and remove lint.

Conclusion: The MGF method allows for an objective and efficient assessment of defects resulting from the weaving of cords and enables quick decision-making to improve the quality of the cords.

4. CONCLUSIONS

- The Pareto diagram is a fundamental tool in decision-making regarding quality improvement.
- By directing preventive and corrective actions towards the defects with the highest weight, an improvement in product quality and, implicitly, an increase in economic efficiency can be achieved.
- The Ishikawa diagram, used in the analysis of industrial processes (product design and quality defect prevention), quickly identifies major causes, which are then broken down into sub-causes and further subdivisions.
- Identifying the main types of defects and their causes has allowed the proposal of effective corrective measures aimed at reducing error rates and improving the quality of the final product.
- The methods used, such as Ishikawa and Pareto diagrams, have highlighted that most problems are generated by factors related to machine parameters and raw materials.
- By implementing corrective actions, production can be optimized, minimizing losses and increasing customer satisfaction.
- This case study confirms the effectiveness of quality and non-quality analysis techniques in defect prevention and in increasing the competitiveness of the textile industry.

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