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Conformity of finished forming sieves for paper industry

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Abstract
The sieves' manufacturers that want to be competitive at the market must have the implemented quality control system. Different methods, based on taking the sample, which is a representative of the total quantity of the forming sieves production, are applied for evaluation of the sieve's conformity. The basic characteristics of this type of the quality function are control, measuring and testing of the forming sieves' properties at the end of the manufacturing process. The objective is to detect and separate the products that deviate from the set criteria, to remain in the factory, then to be repaired if possible or discarded in the opposite case and thus to prevent delivery of the defective sieves to the paper manufacturers.

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1. Introduction

Based on the contemporary understanding of the notion of quality, it follows that all the jobs can be measured. By measurements one obtains the presentation of the ongoing or potential problems, due to non-conformity to requirements, in a manner that enables objective evaluation and the corrective measures. Measurements provide information whether the progress is achieved in the sieves production and how big that progress is. The sieves' manufacturing assumes defining all the activities, from the moment when the order for manufacturing is issued until the delivery of the finished product into the finished products storage, with objective of the manufacturing process execution in the controlled conditions. The manufacturing process itself unfolds according to technological phases and operations that are prescribed by technological procedures. The sieve represents the wires interlace, which is formed by joining the two systems of wires by weaving of the base and weft wires at a right angle, (Bojić et al., 2011; Bojic et al., 2012; Bojić et al., 2013). That is done on the weaving machine shown in Figure 1.

Different types of sieves are produced, depending on the purpose, as: metal sieves, sieves for paper and cellulose manufacturing (drying and forming sieves) and technical synthetic sieves (for wood industry and filtration cloths). For a quality sheet of paper to be formed, it is necessary to produce the forming sieve of a certain quality (of certain

Fig. 1. The weaving machine

mechanical properties) (Golubović, 1984; Ćorlukić, 1987). The forming sieves are produces as thermally stabilized with short woven unmarked joints and processed edges, with permeability according to the CFM 300 – 700 requirement. The microscopical appearance of the forming sieve is shown in Figure 2.

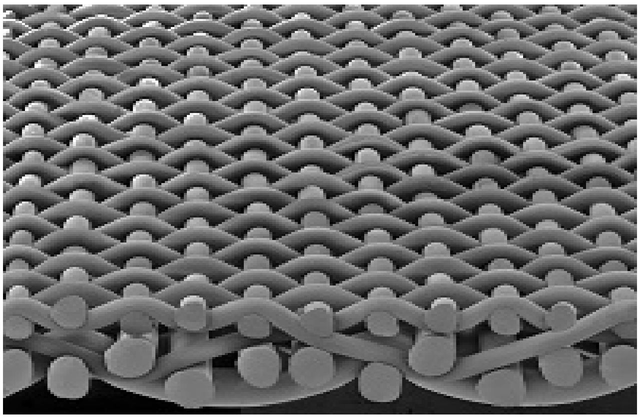

Fig. 2. The forming sieve (200 ×)

The construction of the forming sieves is being adapted to the manufacturing program and each type of paper – machine through the weaving system, sieve's number, kind, type and dimensions of a material. Properties like wear resistance, resistance to soiling, sieve's stability and chemical persistence are being obtained by special treatments. The forming sieves are manufactured as single-layered, one and half-layered, double layered, two and a half layered and multi layered. In the paper and cellulose industry are used the forming sieves are the most frequently used the double-layered sieves that are being the subject of research in this paper.

2. Measurement of the finished forming sieve properties

Monitoring and measuring of the product characteristics and the process parameters during the manufacturing process is done by input and inter-phase control staff, (Radlovački, 2007). After the final processing of the product, the control of the finished product is performed and there the most important role belongs to the final control. The final control checks the quality of the cut sieve (for the sieve of the lower degree of processing), gives the final evaluation on the sieve quality based on its mechanical properties (elongations, breaking force etc.) in a way that is prescribed by the procedure "Monitoring and measuring of product and process of the sieve manufacturing" (in the Fasil a.d. company) and the certificate is issued to the buyer, (Bošković and Radosavljević, 2015). The most important sieve's properties for the paper manufacturer, certified by the final control, are the sieve's mechanical properties. Determination of each property measurement is based on the fact that it *can be measured* and that functionality and not mere appearance are controlled, (Bošković and Radosavljević, 2015; Popovic and Boškovic, 2011). There are two types of properties: variables and attributes. The variables are measured continuously (like the wire diameter, the sieve's thickness, the breaking force, elongation). The attributes are measured by the discrete values of the two states. The property that is important for the buyer is "kindness", however it is immeasurable, (Heleta, 2008; Bošković and Andjelković-Pešić, 2011; Simeunović, 2015). The variables and attributes of the forming sieve are given in Table 1.

Table 1. Attributes and variables of the forming sieve

Attributes	Variables
Sieve is good or defective	Measuring of the continuous variable
The forming sieve is functional or not	Measuring of the mechanical properties

Determined parameters and properties of the forming sieves, which are being monitored during the realization of the set objectives, enable their measurability whose value is being determined by asking the following questions: What is being measured? What are the units of the measured variable? At which sieve? How is the improvement planned?, (De Toni and Tonchia, 2001)). Sieves for which the results of control and tests have confirmed the conformity with the set requirements are being treated according to procedure "Identification, status and traceability of products in the sieves manufacturing". Al the non-conforming products in the manufacturing process are marked as "Non-conforming" and they are marked according to the same procedure and being treated according to procedure "Control of the non-conforming products", (Bošković and Radosavljević, 2015).

3. Experimental setup

Experiment was conducted in the factory for sieves and bearings "Fadil" a.d. in Arilje, Serbia, where the properties of the forming sieve were measured. Based on obtained results the directives for improvement were proposed. The testing was done on the universal testing machine ZWICK Roell Z010 with maximal force of 10000 *N* and the maximal distance between the jaws of 590 *mm*, which is used for measuring and control of the forming sieve. The machine was calibrated according to the prescribed procedure "Control of devices for monitoring and measurements", (Bošković and Radosavljević, 2015). The tensile testing of the sieves fibers was done at the constant load rate and the curve force-elongation was recorded. The tests were performed at the room temperature, on 6 samples, with dimensions 230×30×1 *mm*, of the forming sieve of the P2671 type and the number Nº42, made of the highest quality polyester and polyamides with high mechanical and physical properties. The wires had the following characteristics: the base wire diameter was 0.25 *mm* for all the samples, while the weft wires were different: for the first type of samples diameters were 0.25 *mm* on the face side and 0.35 *mm* on the back side, while for the second type the weft wire diameters were 0.17 *mm* on the face side and 0.35 *mm* on the back side. Three samples were tested at restriction of the F_{max} to 60% and the other three at restriction of the F_{max} to 30%. The maximum distance between the machine jaws was 200 *mm*, the extension rate was 400 *mm*/*min*, the force was limited to 5000 *N*, preloading was 30 *N*, preloading rate was 20 *mm*/*min*, loading rate was 5 *mm*/*min*.

Example 1. Maximal force limited to 60% F_{max}; the recorded stress-strain diagram is shown in Figure 3. In table 2 are presented values of variables obtained in the tensile test of the sieve type 1.

Variables, presented in Table 2 (and Table 3) are: a_0 – the sieve sample's thickness, b_0 – the sieve sample's width, L_0 – the sieve sample's length, F_{max} – maximal force, F_{break} – force at break, ε_{break} – extension at break, ε_{Fmax} – maximal extension.

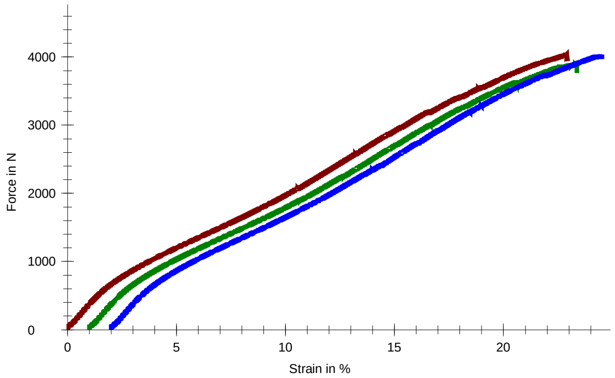

Fig. 3. The stress-strain diagram for the sieve type #1

Table 2. Tensile test results for the sieve type #1

	a_0	b_0	L_0	F_{max}	F_{Break}	ε_{Break}	ε_{Fmax}
#	mm	mm	mm	N	N	%	%
1	1.1	30	200.50	4035.88	3972.26	22.92	22.89
2	1.1	30	200.43	3885.37	3794.76	22.37	22.36
3	1.1	30	200.49	4010.02	4002.64	22.52	22.49

Example 2. Maximal force limited to 30% F_{max}; the recorded stress-strain diagram is shown in Figure 4. In table 3 are presented values of variables obtained in the tensile test of the sieve type 2.

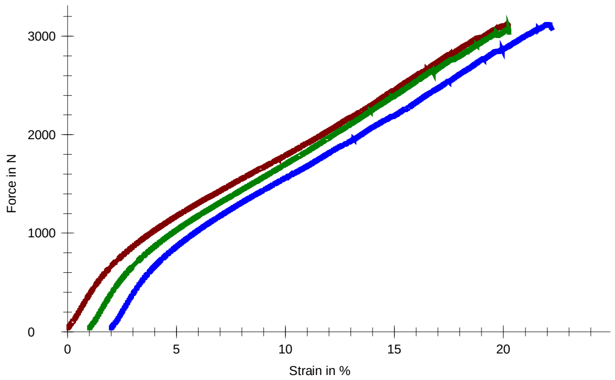

Fig. 4. The stress-strain diagram for the sieve type #2

Table 3. Tensile test results for the sieve type #2

	a_0	b_0	L_0	F_{max}	F_{Break}	ε_{Break}	ε_{Fmax}
#	mm	mm	mm	N	N	%	%
1	1.1	30	200.21	3117.14	3099.32	20.24	20.11
2	1.1	30	200.30	3078.23	3038.43	19.26	19.24
3	1.1	30	200.29	3124.05	3081.10	20.21	20.04

4. Discussion of results and conclusions

The tensile testing of the finished forming sieves serves as a basis for considering the need for initiating the corrective and/or preventive measures with the purpose of constant improving the forming sieves quality.

The test results show that the sieve loaded by 60% of the maximal force possesses the good load carrying capacity; however it is elongated for 2% more than the sieve loaded by the 30% of the maximal force. The elongation of the sieve at 60% F_{max} points to the fact that forming of a paper on such a sieve should be avoided, due to that larger elongation, since that would cause significantly worse technological effects like retention, formation and drainage.

Though the increase is only 2%, in the paper industry that is considered as a very large percent, since the bulges of the wire, which are produced by stretching, would lead to the initial cracks of the forming paper, which is not a feature that is sought in a sieve, (Gavelin, 1998; Smook, 2003).

Results of control and testing of sieves loaded by the 60% F_{max} did not confirm their conformity with the set quality requirements, thus those sieves are, according to the defined procedure, marked as the "non-conforming". On the other hand, the sieves loaded at the 30% F_{max}, for which the control and tests confirmed that their conformity is within the set requirements, are marked as the "conforming" and are ready for exploitation in the paper industry.

The notion of the sieve "quality assurance" suggests that this assumes some sort of prevention. In that sense, it is recommended that the sieves are preventively tested for quality (their properties), what is a very important factor in the total function of the quality assurance. Even in the case of very rigorous and comprehensive controls, users can still find the sieve with some sort of defects, because the causes of errors are not always known; there are many features that affect the "conformity" of a sieve.

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造纸工业成品筛的整合

關鍵詞
形成筛子
质量控制系统
一致性
测量

摘要
希望在市场上具有竞争力的筛网制造商必须拥有实施的质量控制系统。　基于取样的不同方法（其代表成形筛生产的总量）用于评价筛的一致性。　这种质量功能的基本特征是在制造过程结束时控制，测量和测试成型筛的性能。　目的是检测和分离偏离设定标准的产品，留在工厂，然后在可能的情况下进行修理或在相反的情况下丢弃，从而防止有缺陷的筛子输送给造纸厂。