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Determination of Error Probability Concerning the Study of Vibrations at the Rotary Knitting Machine with two Cylinders, of MATEC Type

Adriana Balta[1], Horia Balta[2], Adrian Chiriac[1]

Abstract – In the normal working of a knitting machine, defects appear in the fabric because of the uninterception of the yarn by the needle. Their causes, excluding the irreversible defects, are the mechanical or electrical shocks, vibrations etc.
In this paper it is presented a study about mechanical vibrations produced by the knitting machine Matec, with the purpose to estimate the probability of uninterception of the yarn by the knitting needle. There were considered a few of the main normal working regimes of the machine.
Keywords: knitting machine, mechanical vibrations, statistical analyze, error probability.

I. INTRODUCTION

In the working of the knitting machines, it appears defects, which have an unknown or a random cause, difficult to prognosticate [1]. So, the necessity of repairing appears which means time consuming and sometimes, fabrication defects. The systems based on the detection of fabrication defects, basically consist in photoelectric cells, located close to the fabric, inside or at one side of the machine cylinder. With the help of a conveniently orientated lamp, these systems detect holes and dropped stitches. The systems used for the surveillance of defective knitting elements are normally optical or capacitive sensors, respectively, the shadow produced by the knitting element or the electric field variation produced by the elements, looking for broken needles, closed latches and broken sinkers. These systems are very effective and capable to detect, with high accuracy, the position of the defect, stopping immediately the knitting machine, thus reducing loss. Unfortunately, they do not give further information related to the knitting process and the cause of the defect. Furthermore, some abnormalities pass undetected [1].

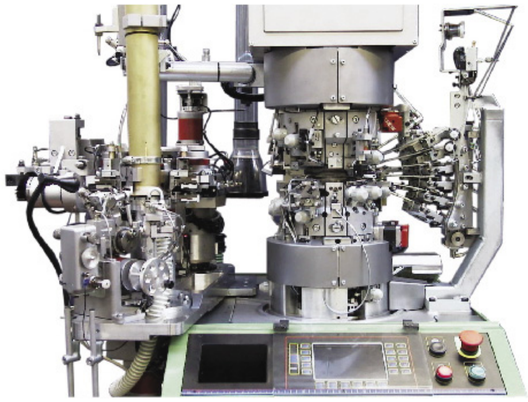

Fig.1 Knitting machine MATEC-1 Silver

The aim of the paper is to estimate error probability, starting from the study of the machine vibrations. On the basis of the vibration statistics, it was estimated the chance of flaw appearance.
The equipment used was a circular knitting machine „MATEC-1 Silver", Fig.1, with a 3.75" cylinder diameter, gauge 18 (corresponding to a set of 216 needles) and one single feeder [2]. The machine is equipped with a roller type positive feeding system and the yarn speed can be adjusted by the means of a worm screw. A speed inverter, connected to the knitting machine motor, allows the adjustment of the cylinder speed with a coefficient of variation of 0.5 %.
The most important pieces which work to obtain the fabric are presented in Fig.2. The knit needle (1) and slider (not presented for simplicity) pair is located in the channels of the two vertical cylinders (2), along their generatrix. The cylinders are rotated in trigonometric direction, with a speed which depends on the quality of the machine, fabric type, and quality of the yarn and stage in execution.

[1] Facultatea de Mecanică, Departamentul Mecanică şi Vibraţii
M. Viteazu Nr. 1, 300223 Timişoara, e-mail balta_adriana@yahoo.com ; chiriac@mec.utt.ro
[2] Facultatea de Electronică şi Telecomunicaţii, Departamentul
Comunicaţii Bd. V. Pârvan Nr. 2, 300223 Timişoara, e-mail horia.balta@etc.utt.ro

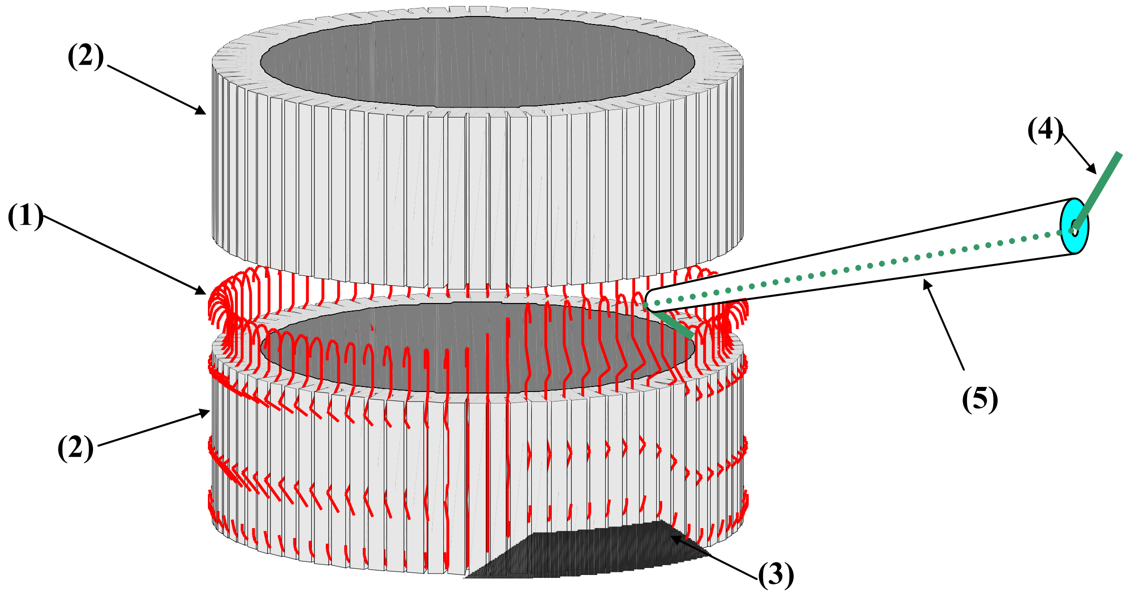

Fig.2 The main elements which realize fabric

For the toes and hells of the sock fabric, the motion of cylinders is of swinging type. The stages of stitched forming are specific to the knitting with final loop. When the needles, due to the cylinder rotation, reach the cam level, these ones give to the needles a vertical motion, through the needle slider (Fig. 2). Through this vertical motion, the needles release the old loop and through yarn retention (4), form the new loop. The yarn of trick is delivered by the yarn roller (5).

A fabric defect appears when the needle, in its reverse motion, does not catch the yarn. The probable cause that was supposed is the moving off of the yarn roller, because of the mechanical vibrations of the machine [3].

In this paper it is proposed to estimate the chances that this moving-off between the yarn trajectory and the delivered yarn, to exceed the *d* needle opening, which is of 1.3 mm, Fig.3. The mechanical vibrations were measured on the slider, through the acquisition system – Fig.4 [4]. Using these values and supposition that the needle and the cylinder have not vibrations, namely the needle trajectory is rigorously correct, in the III^{-th} paragraph, it was determinate the statistics of the yarn moving-off, due to the mechanical vibrations. Through that statistics, in the IV^{-th} paragraph, it was determinate the error probability. In the paragraph V, some concluding remarks are made.

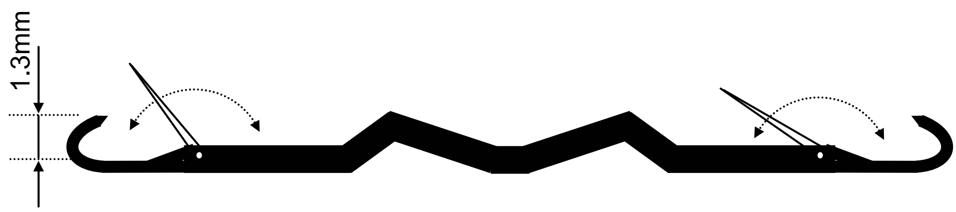

Fig.3 Knitting needle of the machine MATEC-1

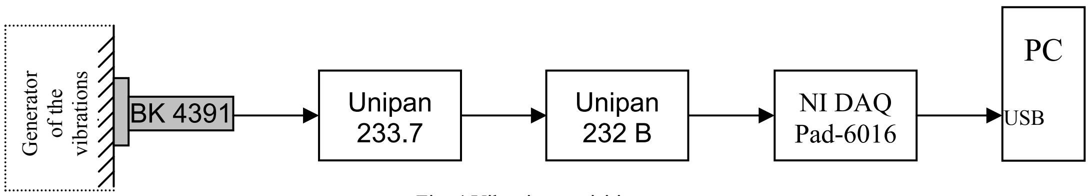

Fig. 4 Vibration aquisition system

II. VIBRATION MEASURING SYSTEM

In Fig.4, it is presented the draft chart of the acquisition system [4]. It was used a piezoelectric accelerometer „Brüel&Kjaer 4391" which has a frequency band 5 Hz – 10 kHz and a sensitivity of 1pC/(m/s^2) for a proper capacity, C=1100pF. The positioning of the accelerometer on the yarn roller is made with a magnet. The signal, generated by the accelerometer is amplified with the preamplifier "Unipan 233-7" and the selective nanovoltmeter „Unipan 232-B" with amplifier role. The amplified signal is taken by PC through an acquisition board from National Instruments, type NI DAQ – 6016 [4]. The utilized sampling rate was of 10000 samples per second. The preamplifier "Unipan 233-7" has input impedance composed by a resistance of 100 MΩ and a capacity of 1.5 pF and the amplification is of 20 dB, equal to the nano-voltmeter amplification.

III. EXPERIMENTAL DETERMINATIONS

There were taken the vibrations values of the yarn roller (Fig.2), during the fabrication of a shock (welt, leg–zone, hell, foot, toe, set up, press off) [5].
In Fig. 5a and b, there is presented the acquired signal, corresponding to a block (10000 samples), during the welt fabric.
In its spectrum (Fig.5b), it distinguishes the spectral components. The dominant component has a frequency of 900Hz and is due to the impact between needles and cams. For example, considering a normal number of rotations of the cylinders, of 250 rot/min and 216 needles, it results a needle frequency of 900Hz. If the model imposes a rib fabric, than the periodicity is of 2 needles and it is obtained a frequency of 450Hz.

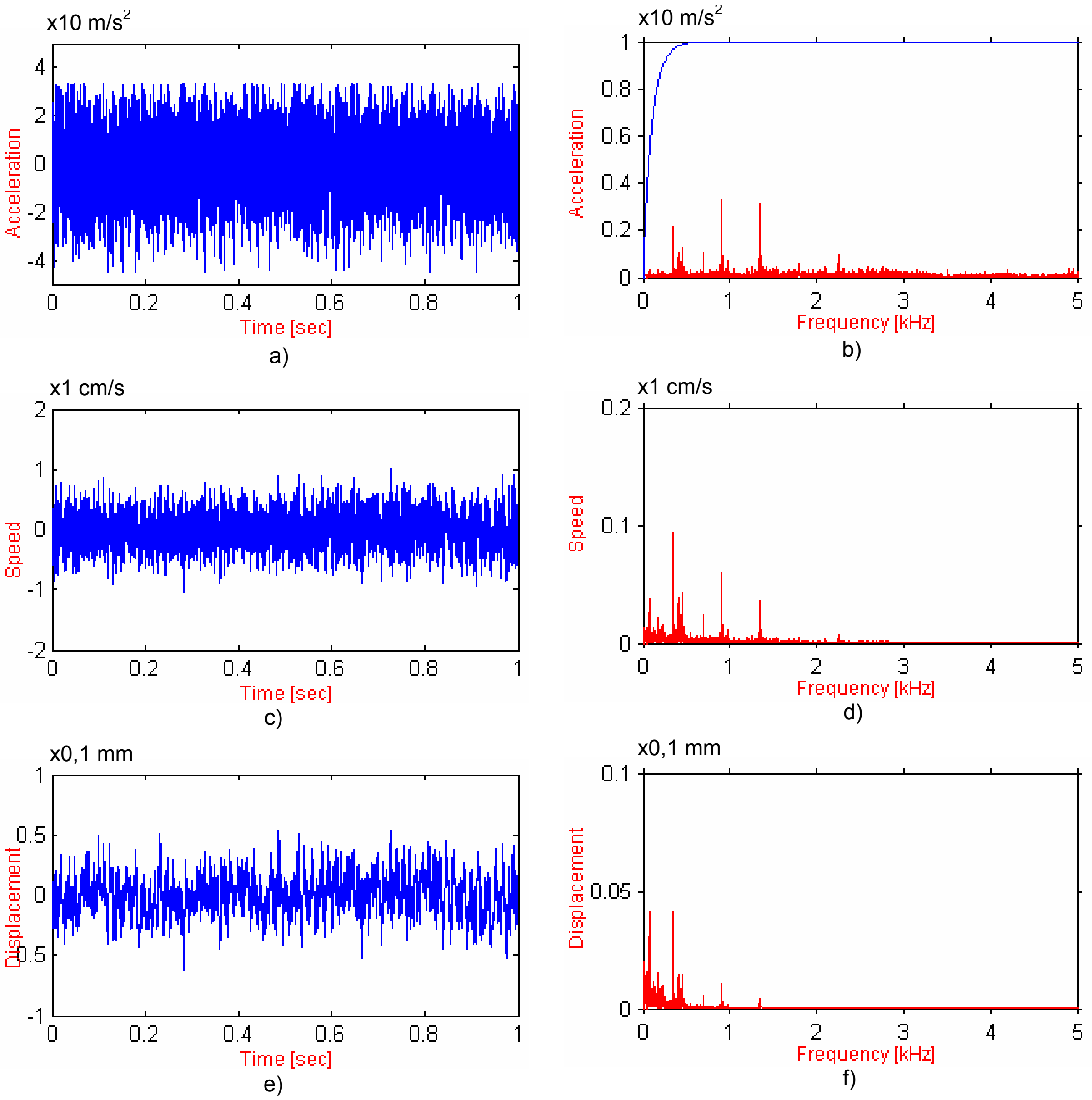

Fig.5 Example of measurement results

The diagrams c, d, e, f present a speed signal and its spectrum, respectively, the displacement signal and its spectrum [6].
To obtain the speed and displacement spectrum, it is utilized a high pass filter, in order to eliminate the very low parasite frequency components (because of some vices of the acquisition system).

IV. CALCULATION OF ERROR PROBABILITY

For the determination of the error probability, it was constructed the distribution of the displacement values of the yarn roller, in relation to the cylinders with needles, which were considered unvibrating [7]. In Fig.6a, it is presented the obtained distribution on the basis of the signal of Fig.5, as well as its approximation by a normal distribution (Gaussian) with a null average. It was considerate the appearance probability of a defect, if the yarn is not intercepted by the needle, in the case when the yarn displacement exceeds the d value, defined in the paragraph 1.
In Fig.6b, it is represented the function

$$F(z) = 1-2\int_0^z p(x)dx = erfc\left(\frac{z}{\sqrt{2\cdot\sigma^2}}\right), \qquad (1)$$

where *p(x)* represents the normal distribution, previously determined, *F(z)* represents the probability that, because of the yarn roller vibrations, to be positioned at the z distance to the rest position; than

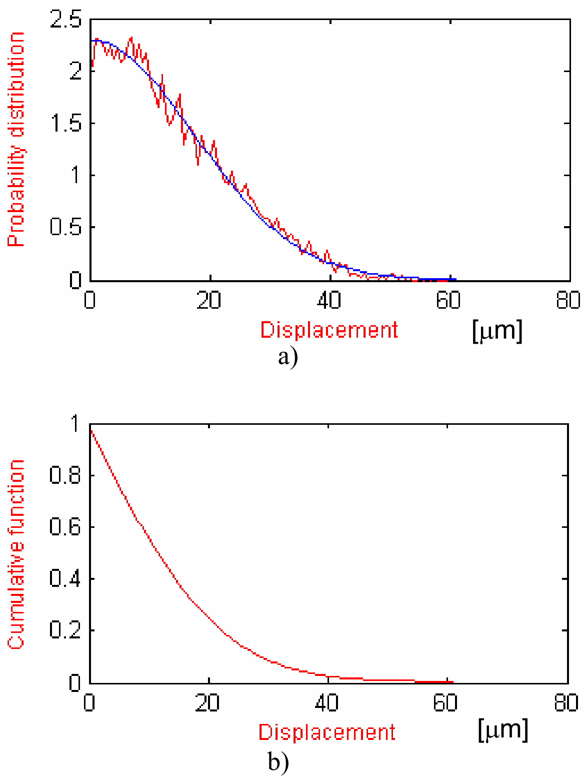

Fig.6 Displacement statistic

Table 1

Working regime	Dispersion $\sigma^2[mm^2]$	*F(z)*
Starting moment for the knitting welt	0.0505	$7.2545\cdot10^{-9}$
Stop of machine by the operator	0.1192	$1.6632\cdot10^{-4}$
Continuous working of machine (Fig.5)	0.0330	$8.2905\cdot10^{-13}$

F(d) represents the probability that *z>d*, i.e. the appearance of a defect; σ^2 is the dispersion of the values of displacement signal and *erfc( )* is the error function.
In Table 1 there are presented, fore some phases from the working process of the knitting machine, the determined values of the dispersion σ^2 and, respectively, the resulted values for the probability that a dropped sinker to exist.

V. REMARKS

In this paper it was determined the probability of appearance of the defect of “dropped sinker” type, in the normal working of the knitting machine Silver Matec -1, due to the mechanical vibrations. In the determination of this probability, it was supposed that the needle trajectories are rigorously correct, the vibrating element being vibrating the yarn roller. It was supposed that the defect is exclusively due to the moving-off of the yarn and yarn roller in relation to the needle trajectory, so that the needle does not hold the yarn.
All measurements were made on the yarn roller with a piezoelectric accelerometer B&K4591. From the measured signal of acceleration, there were obtained, by calculus, the speed and displacement signals-Fig.5. By the statistic analysis of the displacement signal, it was determined the probability that the yarn to moving-off from the needle trajectory with a distance, bigger than the needle opening, fact which is considered as the apparition of a defect of “droppe stich” type.
The measurements were made in the normal regimes of working of the knitting machine (excluding the damage cases). The resulted probabilities are presented in Table 1. Apparently, the presented values are negligible. It must make some remarks. Firstly, these probabilities are giving for *a single sinker*. But, if this one appears at a product, the whole product is defect. So, the probability to appear to a product (in this case, a sock) is of *N* times bigger, where *N* represents the number of sliders for the whole product. For an ordinary sock, *N* has a value of 10^5-10^6 order, depending on the thinness of the knitting machine and the product type and there is the possibility that these values to be bigger.
Another observation consist in the fact that in the determination of the displacement signal, it was utilized a filtration of high pass type, to remove the low frequency components. This filtration was necessary because, due to the imperfection of the

acquisition system, the displacement signal, in the absence of this filtration, presents abnormally deviations. But, because of this way of processing of signal, it was also lost the information about the very low frequency components, which normally lead to much bigger values in displacement. (If *a*, *v* and *s* are the acceleration, speed and, respectively, displacement signals, harmonic of *f* frequency, than between their amplitude values, it exist the relation: $A=2\cdot\pi\cdot f\cdot V$, $V=2\cdot\pi\cdot f\cdot S$.). The determined values of the defect probability in Table 1 correspond to the average and high frequency spectrum, being able to be bigger in reality. It results that these ones are minimal values for the defect probability.

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