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Experimental Stress Analysis

# Measurement and evaluation of textile straining

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**Abstract:** The article deals with some measurements of moving textiles using strain gauge sensor. Time behavior of dynamic forces during roll winding are shown. Textile straining is evaluated using dynamical and static parameters. Model of dynamic properties of force sensor is shown as well. Calculations are done using MATLAB-Simulink software.

**Keywords:** Dynamic force in yarn, Warp, Yarn tension measuring system

## 1. Introduction

The yarn manufacturers, especially synthetic fibres industry and manufacturers of textile machine, come more and more to knowledge of cardinal importance of tension force for their productivity and product quality. Measurement of tension force in warp end is the most important tool for optimisation of setting and manufacturing parameters of weaving machine.

There is a common effort to offer products with tension force parameter independent on time and place. At flow of material through the machine there is always a change of this process parameter from different causes, e.g. owing to machine fault, material or surroundings. With increasing weaving performance there is an increase of static and dynamic stress of the yarn.There are common discusses about measuring on single yarn or on group of yarns.

We prefer single yarn measurement, because at group of yarns there are indispensable information losses during signal filtration. The single yarn measurement is advantageous in praxis because of easier and quicker handling and also allows measurement without weaving machine shutdown. The result of the measurement is a characteristic time response of tension force, which differs more or less from the optimum tension force in the yarn.

Evaluation of results can proceed either only visually or more often by the help of defined mathematical operations which are realized using hardware (analog or numerical) or software (measuring system is connected with PC via transducer unit)

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## 2. Method used

We can define the optimum tension force F for textile process by inequation

$$\left|F(t) - F_{opt}\right| \leq \Delta F \tag{1}$$

in every instant of time *t* so that its value and uniformity (in one yarn or in group of yarns) will enable maximum productivity and required quality of the product.

The value of maximum allowed oscillation ΔF in time is chosen empirically for each case of material processing apart.

It is possible to trace typical characteristics and parameters of group of curves representing tension force measured:

- typical course of measured signal produced by averaging of a number of repeated measuring cycles with some dispersion and interference noise.
- essential values of the course, e. g. mean, maximum and minimum value of tension force (at looming e. g. force at the moment of blow or tension force at upper and lower shed, values in lower / upper dead point at unreeling weft from stock
- selected characteristic parameters of the course, such as tension non-uniformity

  $$\delta F = \frac{F_{\max} - F_{\min}}{F_{\min}} \cdot 100 \; [\%] \tag{2}$$

  tension force impuls

  $$I(t) = \int_0^t F(t)dt \tag{3}$$

  Static characteristics acquaint with measured values distribution. It also shows probability of above and below average values occurrence, quantifying of higher static moments, etc.
- extremal distribution, e. g. tension force peak distribution in the yarn at the textile machine, yarn strength distribution, etc. frequency responses (spectra) show measured quantity dependence on process velocity or disclose any machine mechanism affecting tension force curve by an undesirable way.
- Spectral power density (power spectrum). Using this function we can estimate the percentage of the frequency in the interval from $f_1$ to $f_2$ participating considered random process with respect to general dispersion. Power spectrum gives mean value of the power in the frequency range from $f_1$ to $f_2$ using electrotechnical analogy (equation for current power at 1 ohm resistor).

- Correlation and autocorrelation functions. It defines a relation between two processes running in the machine, e. g. between a velocity of the yarn movement and tension force.
- Static and dynamic model of examined process in a form functional relation between variables and parameters in 2D or 3D area or in the form of differential equations system showing process changes in time. Measured and evaluated responses are useful as a constructional or technological parameters and state variables in the equations. Measuring plays significant role in verification and specifying of model in simulation process as well.

The main part in interpretation of measurement results has submitter (technologist, constructor) disposing with required knowledge of machine properties, material, environment and a set of empirical findings about examined problem. In contrast, machine operation and verification of measurement is an issue for specialists – electrical engineers equipped with measuring and computer techniques including required software.

Cooperation of all participating partners in process of experiment planning, measurement and results evaluation is useful because it can reduce the number of experiments uninteresting for the submitter. It can also lead to carrying out new variants of testing parameters and deeper knowledge of technological or construction problems.

## 3. Results and discussion

In order to maximum utilization of tension force signal information, fast processes have to be measured with high frequency sensors. Mechanical or handheld devices don’t meet these requirements and electronic device together with PC is the one possibility for measuring of tension force in warp end. The result of electronic measurement is a diagram of tension force at warp end, e.g. in the form which is shown on Fig. 1. Examples of measured weaving velocity and time dependencies of force are shown on Fig. 2 and Fig. 3 respectively. It can be evaluated using above stated characteristic parameters. Graphical evaluation is very difficult because of discovering parameters of a large set of yarns and also from many weaving cycles.

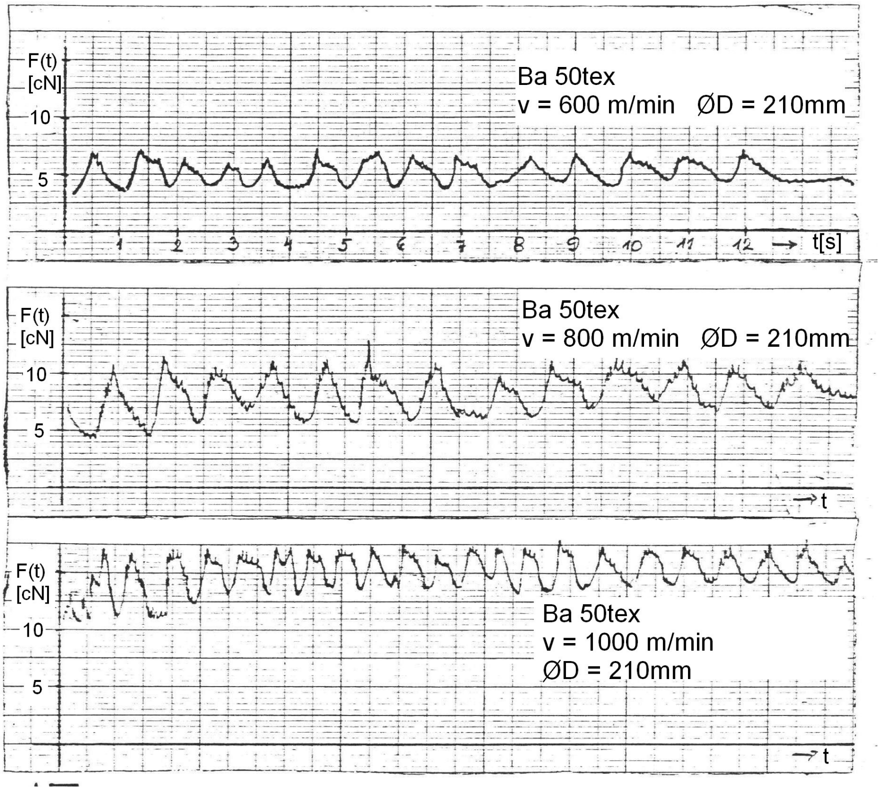


**Fig. 1.** Example output of electronic measurement result.

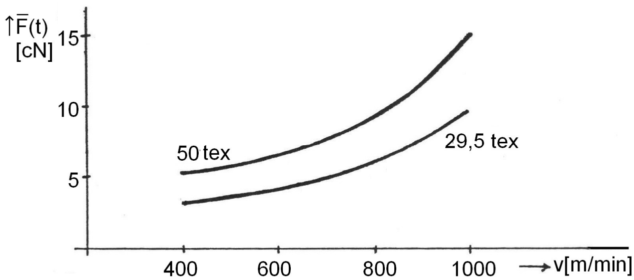


**Fig. 2.** Example weaving velocity dependence of force.

The measurement evaluating software was developed to help users with evaluation of results. Required hardware is shown on Fig. 4. Measuring head of tension force sensor is built-in between oscillating shaft and webs of warp stop motion in yarn track. Measuring signal is adjusted in A/D transducer for handheld computer.

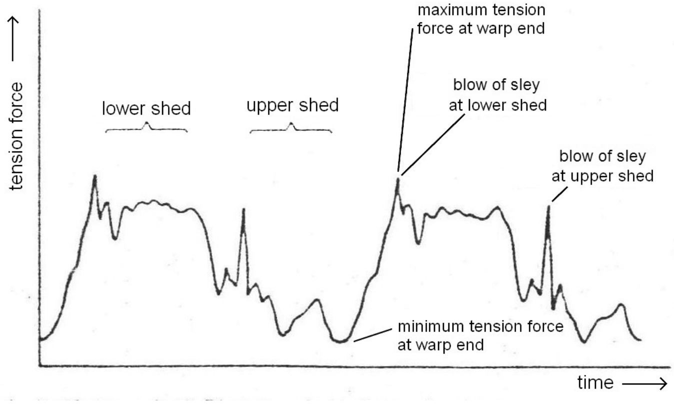


**Fig. 3.** Example time behaviour of tension force.

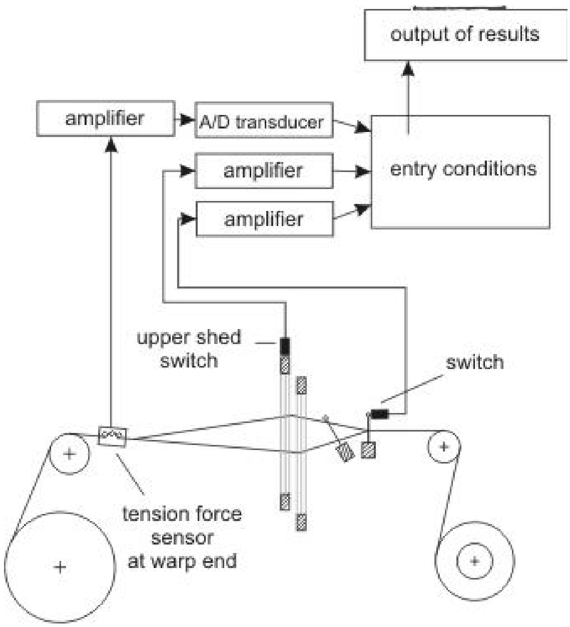


**Fig. 4.** Measurement scheme.

Computer needs even two more information for evaluation of tension force signal:

1) moment of sley blow
2) if the sheet is at upper or lower shed

These information are collected from two induction sensors (Fig. 4.).

The PC ask user to testing data, products and machine specification in dialog window. These data are then shown in testing report. In addition, time of measurement, scanning frequency, range of upper and lower shed (angular degree) are requested. When measurement is finished, the computer prints a report including following results:

1) time behaviour of tension force at warp end
2) mean tension force at warp end and its variation coefficient
3) mean tension force at upper shed
4) mean tension force at lower shed
5) yarn tension force during blow of sley at upper shed and its variation coefficient
6) yarn tension force during blow of sley at lower shed and its variation coefficient
7) maximum tension force of yarn
8) minimum tension force of yarn
9) difference between maximum and minimum tension force of yarn (extent of dynamical straining)

Focusing this analysis on single yarns in every sheet, quality of machine adjustment is evident. Any adjustment change can be controlled by the measuring technique with respect to yarn straining.

Tension force values processed by this way can be used for weaving machine control in the future.

## 4. Conclusion

Using developed measuring and evaluating system we can deduce whether the weaving machine is adjusted correctly or it can be adjusted better. Weaving machine adjustment affects tension forces of warp end which are strongly responsible for warp end straining. It shows in detail whether:

- tension force of warp end is too high or low
- weaving is too strong (warp stop motion, back rail, position etc.)
- sheet uplift is chosen correctly
- sheets are adjusted correctly

- tension force is too small when warp end goes through the shed
- wide difference exist between maximum and minimum tension force (too high dynamic straining)

## References


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