Method and Device for Yarn Packages Classification

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Abstract. *For the purpose of yarn dyeing the yarn packages is characterised by the properties which influence the dyeing process indirectly only. Newly developed method and device is aimed to classify the packages by means of air flow resistance, the property similar to dyeing process driving one. The first tests display the close relationship between the air flow resistance and the yarn package density and prove the sensitivity of new developed method is better than the density measuring.*

Keywords: Yarn Package Hardness, Yarn Package Density, Air Flow Resistance, Yarn Dyeing

1. Introduction

The yarn is usually dyed in the form of packages wound on dying spring submerged to dyebath in pressurised tank. The dyebath is pushed through the package in and out saturating the yarn. This process is not elementary and it depends strongly on the package properties which in present are mostly valuated by the mean of package density or hardness. Thus these properties influence the dyeing process indirectly. Because it is necessary to set the dyeing process in a correct way to ensure the augmentative quality, there are set higher requirements on recognition the package properties. Therefore the new, fast and compact method for recognition parameters of the yarn package has been designed.

2. Newly developed method

The target set to new method is to find the simply and quick measurable property which can characterize the yarn package for purpose of dyeing in more direct way. The air flow resistance seems to be suitable for it well. Air flow resistance is given:

$$r = \Delta p / Q \tag{2}$$

where

- Δp loss of pressure on the porous layer
- Q volumetric flow rate

Numerical simulation

First the numerical simulation of the air flow through the yarn package, which was represented by a porous layer, was done. There the air flow velocity was expected low and the porous layer

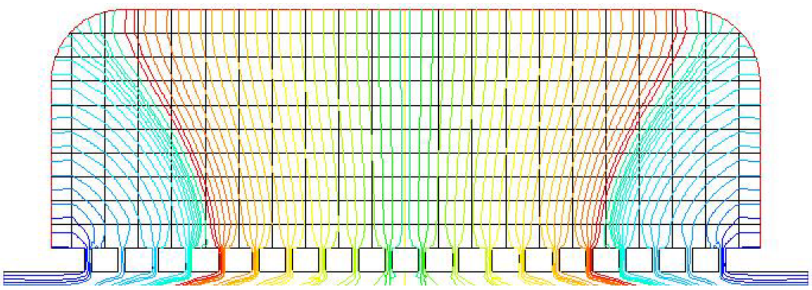

Fig. 1. Shape of the streamlines as a result of numerical model simulation – half of the package cross-section

homogenous. The shape of the streamlines is presented in Fig. 1 where the half of the package cross-section is shown (axis is horizontal). It is clearly seen the air tends to flow in the direction of the thinnest layer, the streamlines are near parallel in the middle part.

3. Testing device

The prototype of yarn package classification device suitable for pilot use in dye-works laboratories was designed and built. It is based on the measurement of air flow resistance. According the numerical model results the measuring zone is localized to the package middle part only.

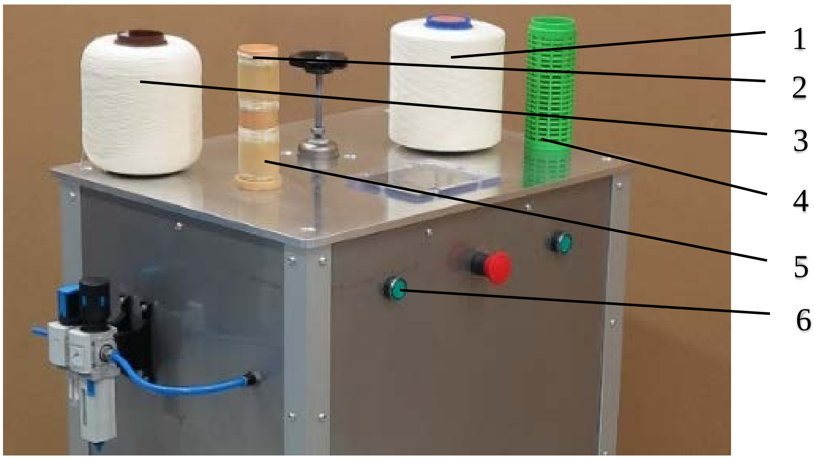

Fig. 2. Prototype of new package testing device based on the measurement of flow resistance. Two kinds of tested packages and plastic spring tube are also shown

The prototype of that device is shown in Fig. 2. The tested package is slipped freely over the measuring thorn, item 2. The measuring thorn shoulder defines position of the yarn package. When pushing the start button, item 6, the measuring line valve is open. Compressed air in measuring line will start to flow through the tested yarn package, item 3. Sealing bags item 5 are inflated to seal the measuring thorn and the inner surface of the spring tube, whereby the measuring zone is delimited between the top and bottom bag. Duration of measuring cycle is driven by time delay relay. Two kinds of yarn package, item 1 and 3, and used spring tube, item 4, can be seen on the top of the prototype.

Fig. 3 presents the pneumatic schema arrangement. On entrance to system there is pressured air reduced to 0.2 MPa by the pressure control valve (item 1). The next is the diaphragm pressure reducer (item 2) deflating the air to requisite pressure, usually 5 kPa. Item 3 is the differential pressure sensor indicating the pressure of air incoming to the measuring line. Solenoid valve, item 4, opens the measuring line. The flow sensor, item 5, measures the volume flow rate of compressed air running through the package. Pressure sensor, item 6, measures the air pressure just in front of the yarn package. Since this sensor measures the pressure difference between the air pressure just in front of the package and the atmospheric pressure, it is in principle the flow loss on the yarn package.

The pressured air is incoming into the central zone of perforated spring tube only, the rest of the tube hole is sealed by inflatable bags. It avoids air leakage through the package front ends. Data acquisition from flow sensor 5 and pressure sensor 6 is provided by analyser Waweon of our own design connected to the master PC. Data evaluation is done by this PC.

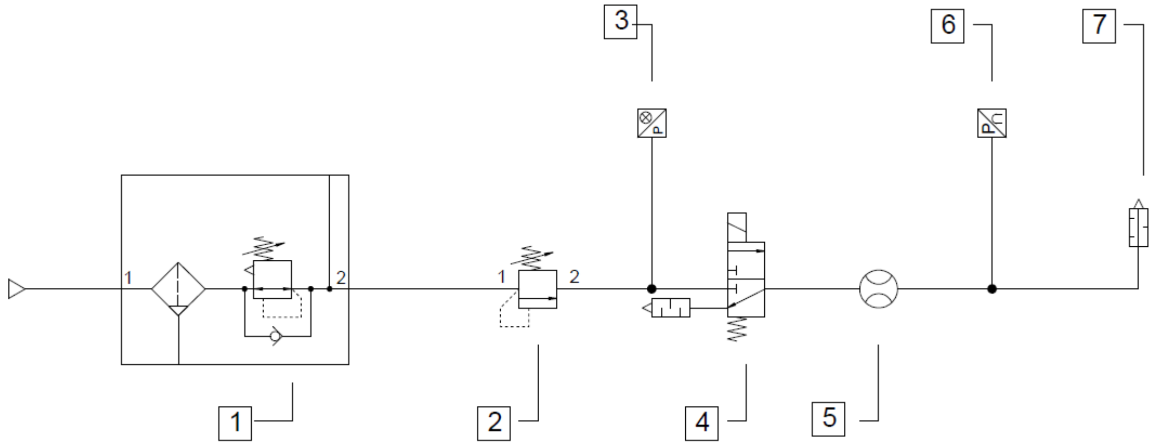

Fig. 3. Pneumatic schema of measuring device: 1 – Filter-pressure regulator unit, 2- Pressure reducing valve, 3 – Input pressure sensor, 4 – Solenoid valve, 5 – Flow rate sensor, 6 – Outgoing pressure sensor, 7 – Measured yarn packing

4. Experiments and Results

The method and the designed sorting device were verified by testing of two sets of yarn packages. It was cotton yarn of linear mass density 16×2 tex. Samples on the blue tubes were wounded with wide range of package density (0.2528–0.4501 g/cm^3). The density range of packages wounded on the brown tubes is relative narrow and it corresponds to typical packages prepared for dyeing (0.2875–0.2980 g/cm^3).

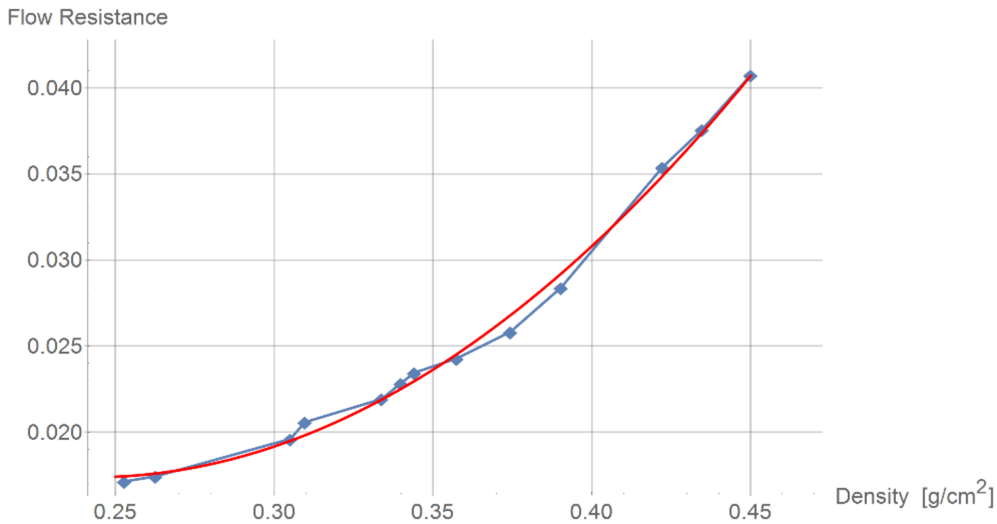

Fig. 4. Flow Resistance of blue packages with wide range of density. Line with points depicted is measured and the smooth line is quadratic fit of measured data

As you can see in Fig. 2 the shape of packages on blue and brown tubes is not the same. The brown packages' edges are rounded. Because the volume measurement neglected the shape details the density of blue and brown packages cannot be compared. Thus it is not needed as the method should typically sort the packages of the same type.

In Fig. 4 there is the dependency of the flow resistance on the package density, line with points depicted. Measured data were interpolated by polynomial function of degree 2, smooth line. The very close dependency was found.

The repeated measurement of flow resistance on the brown package is captured in Fig. 5. The mean value of this is highlighted by black punctuated line. Every curve in Fig. 5 represents the values measured on one set of samples immediately one sample after the other. The packages relaxed for one hour before next measurement set except of the lines 6, 7 and 8 which were obtained without delay. It is clear the shape of every curve does not change. The lines slightly move up and down, there are almost no intersections of these. It can be concluded that the diameter *D* deviation of 1 mm, and it can occurre if the dimensions are measured manually leads to density deviation of 0,005 g/cm^3. That deviation can rapidly change the shape of presented curves.

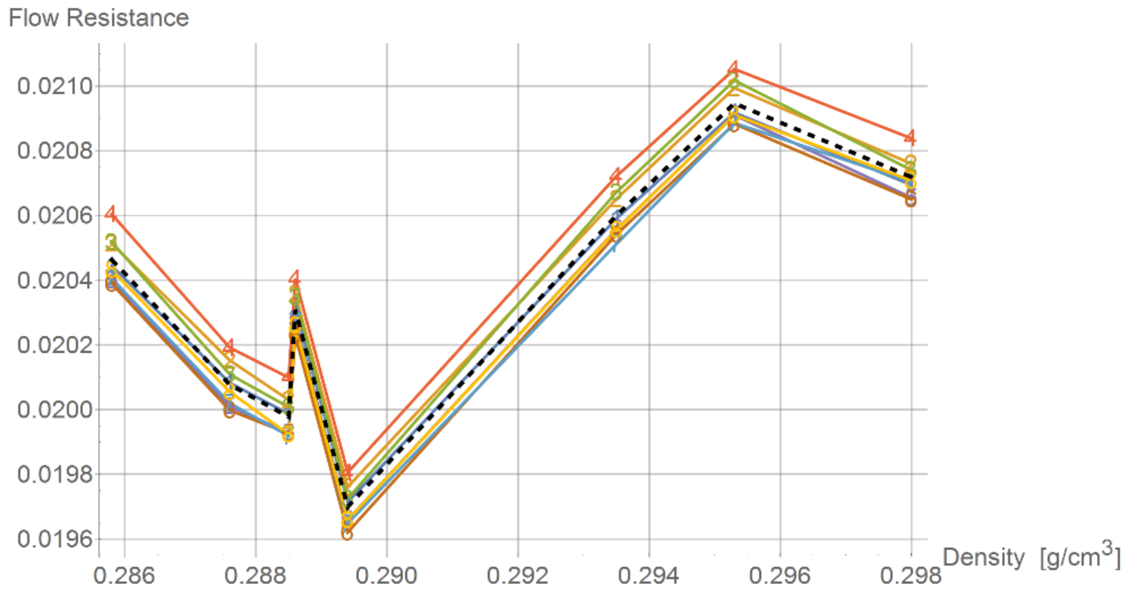

Fig. 5. Method stability measured on samples with narrow range of package density, black dashed line is the mean value of measured data

5. Conclusion

The method and device for measuring the air flow resistance, which represents the yarn packages quality from the dyeing point of view in much exact way than present used ones, was introduced. The first tests results, which compared the measured air flow resistance and the package density, proof the device sensitive is at least as good as the density measurement. The actual long term field test in dye-works has to confirm the conclusions of laboratory tests and find the direct dependences between the air flow resistance determined by introduced device and dying quality or needed setting of dying process.

Acknowledgement

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References

[1] Sinaiski E. G. Hydromechanics. John Wiley & Sons, 2011.

[2] Adámek K. Fabric air permeability numerical modeling. Strutex 2006, 16-17.

[3] Bušek M., Čejka V., Klouček P., Šidlof P., Škop P. Method of measuring the hardness and/or density of yarn packages and a device for carrying out the method. International patent no. EP1653212 (A2), 2006.

[4] Křemenáková D., Rubnerová J., Aneja A. P. Influence of fibers geometry on the polyester yarns packing density and porosity. The Fiber Society, Fall 2001 Annual Technical Conference, 47-48.

[5] Shamey R., Zhao X. Properties of Yarn. Modelling, Simulation and Control of the Dyeing Process. Elsevier, 2014.