DIGITALIZATION OF NONWOVEN CARDS

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ABSTRACT

Although automation technology is developing rapidly, setup and control of nonwoven cards is still done manually and based on the experience of the machine user. In Germany alone this leads to scrap production worth 50 Mio. € per year.
Aim of the Easy Nonwoven 4.0 project is to develop a cost/effort based setting aid for the most important drive speeds of nonwoven cards. The goal will be achieved by an improving optical inspection systems placed directly behind the card doffer, a measuring and automation system, which will collect production and product data and a multi-criteria optimisation routine.
The systems have been installed on a pilot line and an industrial production line. The gathered big data has successfully been used to model the quality parameters and energy consumption based on the machine settings, material parameters and surrounding conditions. The neural networks used for the modeling are precise enought to simulate the carding process in a multi-criteria optimization.

Key Words: MODELING, NONWOVEN, SELF-OPTIMISATION

1. INTRODUCTION

Measurement and automation technology has developed rapidly in the last decades. In the framework of digitalization machine data of highly complex processes can be collected in order to optimize the production. Setup and control of nonwoven cards is still done manually and based on experience of the machine user. If the weather changes, process errors occur frequently or the product is changed, the machine user changes the setup parameters based on his experience. If errors are not recognised fast enough, scrap is produced or the machine is stopped. In Germany scrap production from the nonwoven industry in the value of 50 Mio. € is recycled every year.
Optical inspection systems for the detection of product defects like holes, stains and fiber lumps are available, but are only used rarely, as the use as a pure surveillance system is not economic. Therefore those systems are mostly used for the documentation of product errors in the production of quality sensible nonwovens [1]. Neither is the measured data analyzed using additional data, nor are the quality values feed back into the System. Measuring the subjective quality of nonwoven webs is very difficult. An approach using fuzzy logic was introduced [2], but has never been realized in praxis.
Automation technology of nonwoven cards is mostly just used to control the drive speeds during the process. Closed loop controls are rare. Furthermore is the generated measurement data mostly not stored. A systematic analysis of the data and modeling of the nonwoven card has never been done.

2. METHODS

The “Easy Nonwoven 4.0“ concept (see Fig. 1) was developed at Institute für Textiltechnik (ITA) to solve the described deficits. Within the collaborative research project Dr. Schenk GmbH, Planegg, Germany, a supplier for optical inspection systems, develops the optical inspection system to measure product errors (defects) and the subjective product quality like the machine user is experiencing it, during the production process. The iba AG, Fürth, Germany, a supplier of measurement and automation systems, is developing a measurement and automation system for nonwoven machinery that can be easily adapted for existing and new machines. The iba system saves the measurement data of the nonwoven machines and the optical inspection system and transmits the optimised setting values to the machine.
ITA develops a cost/effort based setting aid for the most important drive speeds of the card. The setting aid takes not only the qualitative but also the economic impact of the settings into account. This prevents that the optimization routine choses a setting point, where the product quality is optimised, but a production without profit is not possible.

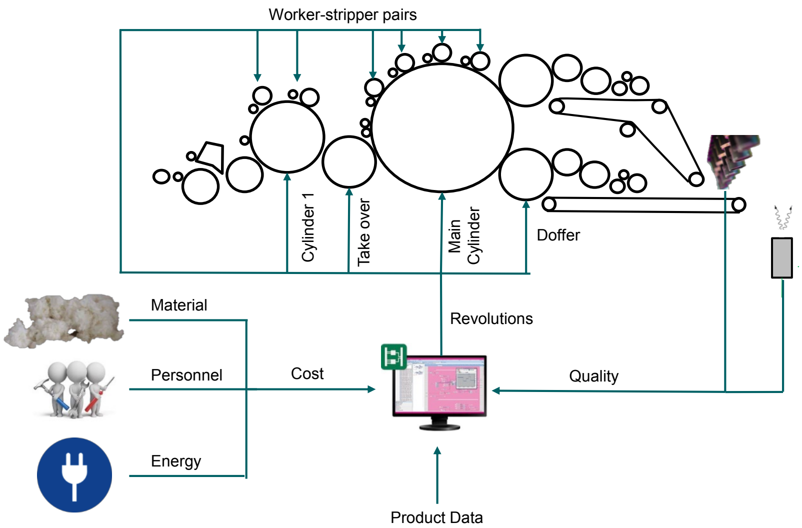

Figure 1. The “Easy Nonwoven 4.0” concept

3. PROCEDURES AND RESULTS

A measurement system was installed at a pilot line and an industrial nonwoven card. The measurement system gathers data in a database from the machine (actual drive speeds, mass feed, settings, energy consumption) using a TCP/IP Link between the programmable logic controller (PLC) and the measurement system. The climate conditions and machine temperatures are measured using additional sensors and stored in the database of the measurement system.
Furthermore, optical inspection systems were installed at both lines. The optical inspection system measures the weight and weight distribution of the nonwoven web directly behind the card. Therefore, a material calibration using a linear regression was done. Furthermore, the fiber orientation is measured online by the system. Defects are classified and count per produced area. The measured values are send to the measurement system, which stores the values according to the settings.

Neural Networks are trained with historical data from the production. Additional data was gained using a design of experiments for the speeds of the most important drives.

The neural networks are used in a simulation in order to predict quality and energy consumption based on the machine settings, material parameters and surrounding conditions. In the proposed multi-criteria optimization system:

1) The user enters the quality boundaries of the product.
2) A black-box model simulates the quality and energy demand at different setting points for the given surrounding conditions and material properties using a trained neuronal networks
3) The white-box production cost model is used to calculate the production cost for each setting point.
4) The ε-constraint method choses the setting point, where the desired minimum quality is produced and the production cost are minimized.

The neural networks can be trained successfully. The prediction of the energy demand is very precise (> 95 % accuracy). Areal weight and coefficients of variation can be predicted sufficiently (> 85 % accuracy). Therefore, the optimization for these parameters can be successfully done using the trained networks.

4. REFERENCES

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