Industry 4.0 – How will the nonwoven production of tomorrow look like?

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Abstract
Industry 4.0 stands for the on-going fourth industrial revolution, which uses cyber physical systems. In the textile industry the terms of industry 4.0 are not sufficiently known yet. First developments of industry 4.0 are mainly visible in the weaving industry. The cost structure of the nonwoven industry is unique in the textile industry. High shares of personnel, energy and machine costs are distinctive for nonwoven producers. Therefore the industry 4.0 developments in the nonwoven industry should concentrate on reducing these shares by using the work force efficiently and by increasing the productivity of first-rate quality and therefore decreasing waste production and downtimes. Using the McKinsey digital compass three main working fields are necessary: Self-optimizing nonwoven machines, big data analytics and assistance systems. Concepts for the nonwoven industry are shown, like the “EasyNonwoven” concept, which aims on economically optimizing the machine settings using self-optimization routines.

Keywords: nonwovens, industry 4.0, digitalisation, self-optimization

1. Introduction
The term Industry 4.0 stands for the on-going fourth industrial revolution. The first industrial revolution was the mechanisation of work and started with the first mechanical loom in 1784. The second industrial revolution started with the introduction of series production lines based on the division of labor. The third industrial revolution followed the introduction of the first programmable logic controller in 1969. The fourth industrial revolution uses cyber-physical systems to increase the productivity and flexibility of production. A cyber physical system results from the fusion of real objects, like a product or a machine, with information-processing virtual objects. [1] In a survey of the Institute for textile technology at RWTH Aachen University under German textile engineering companies and textile producers showed, that terms like Industry 4.0, cyber-physical systems or smart factory are not sufficiently known yet. [2] The variety of textile products currently inhibits the textile industry to implement industry 4.0 solutions.

The most advances were made in research and development of industry 4.0 solutions in the weaving industry. For example a self-optimization algorithm for a weaving loom was developed. The self-optimization is based on 4 step routine. First a design of experiment is generated with the loom...
settings as the input parameters. Three setting parameters (e.g.: mean warp tension, position of the warp stop motion and machine speed) result in 24 different setups. In the second steps, the test procedure, all setups are run on the loom. Sensors gather information about the warp tension in the different setups. Key values of the warp tension are calculated from the measured, repetitive course of the warp tension. In the third step, the modelling a pure quadratic regression model is used to calculate the the effect of the settings on the key values of the warp tension. A Gauss-Markow-Algorithm is used to calculate the best settings of the machine in the fourth step. [3].

Also a camera based onloom material inspection was developed to skip the manual inspection of the fabric [4]. Several assistance systems have been developed to support the weaver and to teach new personnel the handling of a loom [5].

In the nonwoven production there are currently no efforts of the machine or fabric producers to implement industry 4.0 solutions visible. This work highlights the situation of the nonwoven industry in terms of industry 4.0 and gives an outlook of what has to be developed first to gain the biggest advantages first.

2. Value drivers of the nonwoven production

McKinsey has examined the expected impacts of industry 4.0 in a study called the “digital compass”. The study claims that industry 4.0 will have impact on the eight basic value drivers resource / process, asset utilization, labour, inventories, quality, supply-demand match, time to market and services / aftersales [6]. In order to identify the cost relevant value drivers for the nonwoven industry the cost structure without material costs has to be examined. This leads to a cost distribution, where the biggest shares are personnel, energy and machine costs [7]. The relevant value drivers for the nonwoven industry are therefore resource/process, asset utilization, service / aftersales, labour and quality. Industry 4.0 developments in the nonwoven industry should therefore aim for reducing the share of personnel, energy and machine costs. This can be achieved by using labour efficiently and by increasing the productivity of first-rate quality and therefore decreasing waste production and downtimes. The relevant industry 4.0 technologies are therefore intelligent machines, online machine optimization, smart energy consumption, predictive maintenance, assistance systems for maintenance, repair and operation, automating knowledge work, advanced process control and the use of big data analytics. The expected impact is an increase of 3-5 % productivity, a reduction of 30-50 % of the total machine downtime, an increase of 20 -40 % of machine life and an increase of 45 – 55 % increase of labour productivity. Moreover a reduction of 10 – 20 % for the costs of quality is expected. [6]

3. Necessary developments to realise industry 4.0 in the nonwoven production

Based on the identified relevant value drivers the first and most important steps for the realisation of industry 4.0 in the nonwoven production are;

- Self-optimizing nonwoven machines in order to reduce the waste production and machine downtime
- Big data analytics to reduce the machine downtime
- Assistance systems to reduce the machine downtime and increase the labour efficiency

A first step for self-optimizing machine is made by ITA with the “EasyNonwoven Concept”, which concentrates on the card as the machine which predominantly determines the quality of the product (see Figure 1). In order to develop a self-optimizing card electronic quality inspections have to be made directly on the unconsolidated web. The quality data and the costs for material, personnel and energy can be used by a self-optimization algorithm which also uses the product data in order to set the revolutions of the card rollers.
Big data is characterized by the four V’s: Volume, Variety, Velocity and Veracity. Big data analytics are Technologies, Concepts, IT-structures and tools capable of analysing and economically use big amounts of data in different formats [8]. Big data analytics offers the chance for constant optimization of the production and maintenance. Furthermore perfect product traceability and fault prevention over company borders is possible. For the nonwoven industry the biggest challenges concerning big data technologies are the save transport of data between companies and the storage and analytic of the data without risking knowledge loss. Therefore the DigiTextil Concepts was developed, which enables a safe data transport and storage of multiple companies in a safe third party cloud. If a product error occurs, the cloud company is able to interconnect the companies if they are both willing to talk to each other. The knowledge of the cloud, which rises the more process chains deliver their data into the cloud, can give advice on how to prevent the error in the future. Assistance Systems are developed to lead the worker to the correct places and guarantee a quicker reaction to extraordinary behaviour of the machine. Augmented Reality can be used to have the necessary information directly in the field of view. Concerning the nonwoven industry an alarm system would be possible to guide the worker to the correct places along the production line. Therefore errors can be detected earlier and greater damages or waste production is avoided.

4. Conclusion
The relevant value drivers of the nonwoven production were identified using the cost structure of nonwoven producers. Therefore developments should concentrate on solutions that reduce the relative share of labour costs, energy costs and machine costs. This can be achieved by developing self-optimizing machines, safe big data analytics and assistance systems for the nonwoven industry.

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