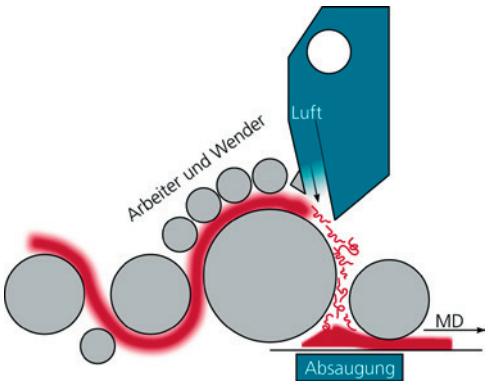
How Solutions From Our Departments "Flowed Together" in "ViDestoP"

Nonwovens are versatile and can be used in a wide range of applications – for example in medicine as protective clothing or in car interiors. Demand for the fabrics is growing, and with it the requirements for product properties. In an increasingly complex industry, the optimization of manufacturing processes is a key competence, which our researchers are addressing across departments in the "ViDestoP" project (Virtual Design and Stochastic Prototyping).

3 Departments, one project and a whole chain in view

Today, process and product optimization is usually carried out by trial-and-error tests directly on the production lines. This is a costly and time-consuming process due to the necessary production interruptions. In some areas of nonwovens production, digital twins and software solutions from our institute have already enabled virtual optimization. The interdisciplinary ViDestoP team has now extended the focus to the entire production chain.



Sketch of the airlay nonwoven production process

Simulation of Process and Product Properties

In the production of nonwovens of any kind, the interactions that occur between the fibers and air flows are particularly important for the end product. In the so-called "airlay process", individual fibers are first extracted from the plastic raw material and then swirled together by an air flow with the aid of a large cylinder. The highly turbulent air flow then deposits the fibers on a conveyor belt. There, they are compressed into a nonwoven fabric by an air suction system and further processed. Depending on the material and process properties, different nonwovens are produced in this way.

Our "Transport Processes" department has been simulating these dynamics of fibers in turbulent flows with the software FIDYST (Fiber Dynamics Simulation Tool) for years, focusing on energy consumption and fiber deposition on the conveyor belt. For the simulation of mechanical and thermal material properties, our "Flow and Material Simulation" department has also used the digital material laboratory GeoDict. The software can be used, for example, to calculate nonwoven properties such as permeability or conductivity and much more. In the ViDestoP project, these established ITWM software solutions for the process (FIDYST) and the material properties (GeoDict) were combined to form an integrated solution. Project manager Prof. Dr. Simone Gramsch emphasizes: "ViDestoP has not only closed the chain of our simulation tools, but also strengthened the connection between the departments and completely new ideas have emerged."

Fiber Deposition as a Stochastic 3D Model Validated With 3D Printing

In the course of the process simulation, a novel 3D model was developed to represent the superimposition of the fibers, so that both the individual fiber deposition and the process parameters of the production plant are taken into account. With this model, it is possible for the first time to simulate a three-dimensional nonwoven with real thickness, width and a sufficiently large length. What then followed was new conceptual and methodological territory: to validate the simulated product properties, a team from the "Materials Characterization and Testing" department created 3D prints in various steps. Based on this work, the microscopic models of the simulations could in turn be adapted and refined. This procedure is called "stochastic prototyping", which also explains the title of the project.

Demonstrator as a Practical Test: Optimizing an Insulation Material

To prove the application of virtual design in optimizing nonwoven products, the researchers tested the process using a demonstrator. From the Design of Experiments (DoE), an optimal virtual microstructure for the insulation material was derived and validated by 3D printed fabrications. From this, clear conclusions for the manufacturing process can be derived in the industry. With this portfolio, the ViDestoP team is ideally equipped to support companies in the production of nonwovens by simulations in their questions through simulations.

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