Projekttitel: Development of a control system to increase the energy efficiency of pneumatic fiber transport and filtration systems - DYNAIR

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Laufzeit: 08/2017-06/2019

Förderträger: AiF/ZIM

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Mein Zeichen: CM
30.01.2020

Mission Statement:

In spinning mills and in production for carding and airlay nonwovens, staple fibres are processed into slivers and nonwovens. The transport between the individual machines of the large plants is done by pneumatic fibre transport systems. A total of about 3,600 such transport systems are operated in the EU, Turkey and Russia. To ensure the smooth operation of the plants, a sufficient exhaust air flow for cleaning must also be ensured by a filter system. The extraction of the plants through the filter system is also carried out via pneumatic pipe systems.

Despite the low energy efficiency of pneumatic fibre transport systems, there is no alternative to this type of transport. In addition, the drives of the transport systems are usually oversized by about 30 %. The drives of filter systems with installed capacities of up to 160 kW are sometimes up to 2 times oversized, depending on the production order. The reason for overdimensioning is that if the power is too low, the pipelines or machines can become clogged or fibres can be damaged. The consequence is an emergency stop which has to be prevented at all times. Most plants are therefore not operated at the point of optimised energetically processing.

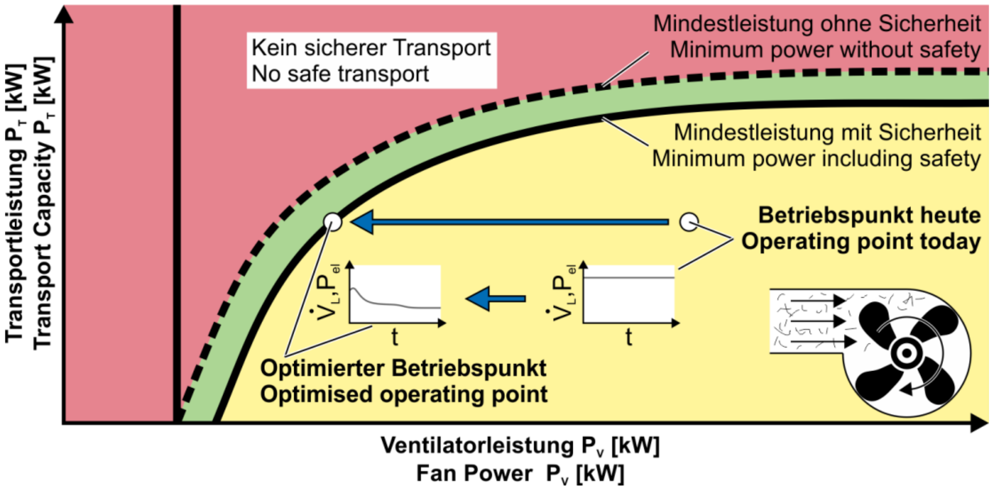

Figure 1: Mission objective - Reduction of energy consumption

The aim of the DYNAIR project is therefore to reduce the speed of the transport fans in pneumatic fibre transport systems by a control system to such an extent (by at least 20 %) that transport takes place safely and with the lowest possible energy consumption.

Approach:

In the state of the art, four conditions are known for the pneumatic transport of bulk materials. At high air velocities, there is air conveyance. If the air speed is lowered, the states dilute phase conveyance, bale conveyance and plug conveyance occur one after another. Depending on the application, pneumatic fibre transport can be used in state of flight conveyance (higher energy input, lower fibre damage) and in dilute phase conveyance (lower energy input, higher fibre damage).

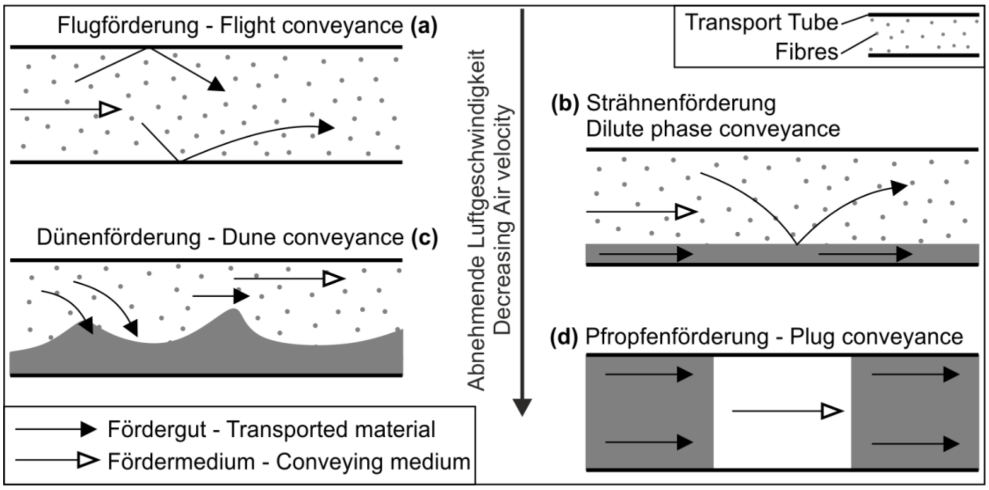

Abbildung 2: Automatische Erkennung der Transportzustände

In order to enable the control of speed of the conveying fans, the development of an automatic evaluation function for the states of transport will be developed within the project using the fibre transport test rig at the ITA. The evaluation function will be further developed and validated in combination with a process control on an industrial test facility. The project partner proCtec is simultaneously developing a system for the energy-efficient control of filter drives and a superimposed intelligent energy efficient process control for the whole fibre preparation.

Results:

Within the DYNAIR project, experiments were carried out on the fibre transport test rig at the ITA, in which the flight behaviour of staple fibre flocks has been investigated by means of high-speed video analysis. The changes caused by the type of material, the titer, the fibre length as well as the fibre mass flow and the air velocity have been investigated. The existence of the four transport states of pneumatic transport of bulk materials was proven for fibres.

The video signal was evaluated in regard to different optical parameters, such as flock size, flight altitude and flock speed. The measured parameters were then analysed in a significance analysis. The three significant parameters determined were then used to create an automated evaluation function.

As a basis for the training of the automatic evaluation function, tests were carried out on an industrial fibre transport system. Based on the test data, a process simulation model was then created for the parameters previously determined to be significant. The simulation model was then used to train and validate the evaluation function.

Figure 3 contains a diagram in which the fibre velocity is plotted over the mass flow. The markings shown in the diagram describe test points that have been evaluated by experts with regard to the transport condition. The background colouring shows the transport states determined on the basis of the state recognition in the same colour coding.

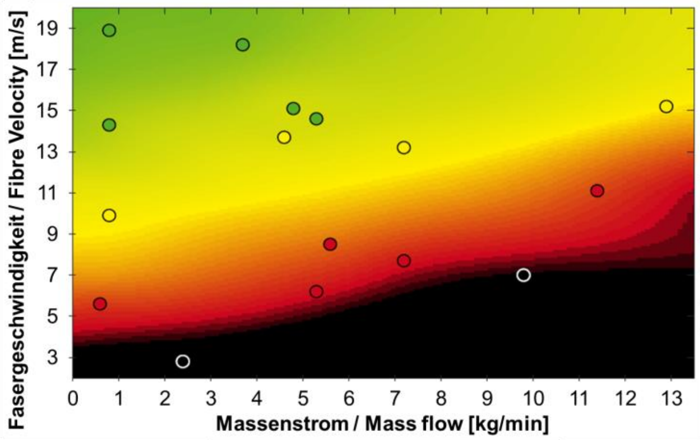

Figure 3: Automatic state detection

With the developed function for state detection it is principally possible to determine the states of the pneumatic fibre transport. The detection function has to be trained for the used fibre type and process. After the creation of further data sets in the future an accelerated training by transfer learning or by the determination of correlations is feasible.

By using the evaluation function and the associated reduction of the fan speed, potential energy savings of up to 86% were possible at the considered industrial process and for the considered fibre material. This value is plausible, since the considered transport system was also designed for the transport of materials with difficult transport behaviour, which have an increased energy demand. The type of fibres in the experimental design was a relatively easy to transport polyester fibre. In practice, the potential for energy savings may be lower. However, plants designed for fibres of varying degrees of transport difficulty offer a high application potential.

Acknowledgement:

The ZIM project DynAir (ZF4018773LP7) is funded by the Federal Ministry of Economics and Energy within the framework of the Zentralen Innovationsprogramm Mittelstand (ZIM).

ZIM Zentrales Innovationsprogramm Mittelstand