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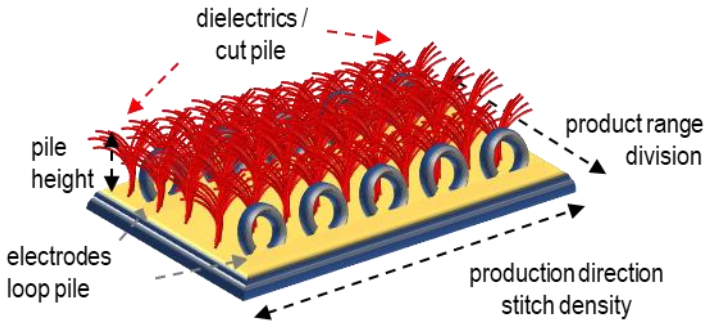
Dielectrophoretic filters for particle separation and their exemplary application for the removal of microplastics from wastewater produced in the cleaning industry

The increasing prevalence of plastics in aquatic and terrestrial environments is cause for concern, as little is known about the resulting ecological and human toxicological hazards; these are the subject of scientific studies. Due to the high persistence of plastics in the environment, further accumulation is to be expected.

Against this background, the wfk - Cleaning Technology Institute e.V., in cooperation with the TFI - Institut für Bodensysteme an der RWTH Aachen e.V., has developed a dielectrophoretic filter for removing microplastics from industrial processes and wastewater. In dielectrophoretic filtration, the particles are trapped in so-called “field cages,” which are generated by interactions between a homogeneous electric field and the filter medium (a non-ideal dielectric); thus, the flow channels in the filter medium can be many times larger than the particles to be separated. Consequently, dielectrophoretic filters are less susceptible to fouling.

Special textile structures, known as “tufting structures,” were developed as filter media. These consist of electrically conductive yarns (electrodes) interspersed with non-conductive yarns. The conductive yarns generate an electric field, which is disrupted by the non-conductive yarns. This leads to the formation of “field cages” in which the particles are trapped.

First, the influence of design parameters (electrode spacing, materials used, etc.), particle properties (size, charge), and operating and field parameters (e.g., mass flow, frequency, voltage) on particle retention was analyzed using simulations. Based on the results, special filter patterns were developed, which were used to verify the simulation results. This revealed that particle retention did not occur exclusively in field cages, but also through conventional filtration effects (e.g., adsorption on yarn filaments, sieving effects). The separation efficiency decreased with repeated filter use; no influence of fouling agents on particle retention was observed. Filter regeneration was possible both by rinsing with water and by applying mechanical force (vibration) after drying the filter sample. When filtering a basic cleaning liquor (wastewater generated during the basic cleaning of elastic floor coverings) as well as a rinsing liquor from textile reprocessing (process water), particle retention in the filter pattern was significantly increased by the electric field. Furthermore, process recommendations and a concept for a filter module were developed.



Tufting structure with integrated electrodes: a loop pile made of an electrically conductive yarn and a cut pile made of a non-conductive yarn (dielectric)

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