Process Equipment for the Implementation of Industry 4.0-Approaches on Mechanical Treatment of Municipal Solid Waste

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Recycling and Recovery of Waste 4.0 (ReWaste4.0, project number: 860884) is a COMET programme, dealing with the application of industry 4.0 approaches like digital networking and material-machine-communication on the mechanical processing of municipal solid waste (MSW). The project consortium consists of numerous partners from science and industry, namely:

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    - Chair of Waste Processing Technology and Waste Management
    - Chair of Process Technology and Industrial Environmental Protection
    - Chair of Automation
    - Chair of Information Technology
- FH Münster: Institute for Infrastructure, Water, Resources and Environment
- IFE Aufbereitungstechnik GmbH
- IUT GmbH
- Komptech GmbH
- Lafarge Zementwerke GmbH
- Mayer Recycling GmbH
- M-U-T Maschinen-Umwelttechnik-Transportanlagen GmbH
- Redwave / BTW Binder GmbH
- Saubermacher Dienstleistungs AG

There are various challenges in digitalising and automating MSW-treatment plants dealing within the project. These include the online/on-time-classification of input materials and quality control of the plant's output, as well as considering new opportunities for valuables contained in the waste and strategies for dealing with contaminants. Furthermore, process approaches for future smart waste factories need to be designed and the necessary equipment has to be specified and developed. This development is covered in Process Equipment 4.0, one of seven subprojects of ReWaste4.0.

Process Equipment

At first a definition of what is meant by process equipment is needed. Regarding ReWaste4.0 it addresses the machines, performing the single unit operations in mechanical MSW-processing. These unit operations consist of comminution, sorting and classifying, performed by various kinds of machines [1].

In state of the art MSW-treatment plants comminution is usually the first step, performed by a coarse shredder. It is followed by a number of classifying and sorting steps, implemented through screens, ballistic separators, air classifiers, magnetic separators, or eddy current separators or wind shifters.. Dependent on downstream recovery purpose some fractions are then shredded a second time, e.g. to fulfil grain size criteria for specific classes of solid recovered fuel [1].

Another technology that is being applied progressively for material separation is sensor-based sorting. It consists of one or more kinds of sensors, an evaluation unit and an actuator for separating materials, usually air jets. The most common sensors are VIS-sensors, using the spectrum of visual light for colour separation and NIR-sensors using near-infrared spectrums for classifying materials, often plastics like PET or PVC [2].

Challenges regarding Plant Automation

Automatic plants need controllable actuators to change specific machine and process parameters. Examples could be gap width and rotation speed for shredders or current, distance and belt speed for electromagnetic overband separators. In addition, buffer storages could allow controlling the mass flow through the single machines, while automatic feed systems could provide defined mixtures of different types of waste for optimal plant operation.

In state of the art plants, most of these parameters are usually not controllable yet, either due to the absence of actuators or application programming interfaces (APIs). A reason for this is the lack of an actual use case: the materials interfere, regarding sorting efficiency. An obvious example is the negative impact of 2-dimensional materials, like plastic films, on screening efficiency [3]. These interferences, combined with the variability of the waste stream, prohibit process control through quality measurements of the plant output, as the input composition is already different when the control instruction is obtained. Thus, optimal process parameters for a specific waste stream need to be known before plant entry, so prediction models of sorting efficiency are needed. In addition, an economic detailed ontime classification of input stream composition is not possible yet.

Approaches and Outlook

Screening experiments will be performed to gain first insights on relevant actuators. Further statistical models are an approach for modelling the influence of process- and machine-parameters as well as waste composition on sorting efficiencies to get knowledge about process optima.

Further it is intended to thoroughly describe waste compositions through multivariate probability density functions in combination with log-ratio transformations for compositional data [4].

These mathematical approaches are currently being tested in lab-scale and shall then be applied on real machines.

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