STATE OF THE ART AUGER REACTOR DESIGN AND SCALE UP FOR BIOMASS FAST PYROLYSIS

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The scale-up and design of auger reactors for biomass pyrolysis is still a challenging topic. Even though the fundamental design has been applied since several decades, things like granular mixing and transport are still not well understood. This leads to the reliance on empirical data or in-house experience for the reactor design. For that reason, it is important to develop reasonable guidelines and design tools that are based on scientific principles, which can then be further validated by experiments and simulations. In this work, findings from a dimensional analysis (Funke, Henrich, et al. 2017) are combined with auger reactor design criteria that were developed in the 1960's based on extensive experimental work and that were only available in German literature up until now (Peters 1963).

The conducted dimensional analysis is not only helpful to enable scale up of auger reactors, but also to define a set of relevant dimensionless numbers that are required to describe the physical phenomena. Common dimensionless numbers in the field of Pyrolysis are the Biot number (Bi), as well as the internal (Py) and external (Py') Pyrolysis number. However, these have been proven to be just a fraction of numbers relevant for reactor design, which easily approaches a complex set of 35 total.

Different strategies can be applied to reduce the complexity and focus on the rate defining steps. With the postulates that an even distribution of heat carrier and biomass particles is sufficient to achieve the high heating rates required for fast pyrolysis and that such a mixture is achieved upon transportation inside the auger reactor, the problem is reduced to that of transportation efficiency. These postulates were proven to be reasonable by a later study (Funke, Grandl, et al. 2018).

Interestingly, transport efficiency is a design criterion that was extensively investigated through experiments in the 1960's in Germany. In combination with the previously mentioned findings of the dimensional analysis and heat transfer/ mixing conditions inside an auger reactor, this turns out to be a promising tool to enable auger reactor design for fast pyrolysis.

In that work, he postulated that 4 independent dimensional numbers are enough to describe the throughput of an auger reactor. With the slope β, the pitch tan (φ), and the Froude number Fr, the transport efficiency can be described as a function $\eta = (\beta;\ \tan(\varphi); Fr)$. If only horizontal reactors are investigated, it can even be reduced to the 3 dimensionless numbers. To test his hypotheses he did multiple experiments with different pitches, slopes and diameters. With those, the earlier postulated hypotheses could be confirmed (Peters 1963).
To close gaps and to further test the hypotheses in areas that till now are not validated experimentally, simulations of a reactor model will be used. Because Peters focused more on single screw reactors for the experiments and did only a few with a double screw, investigating if the developed function for the transport efficiency holds true over a wider range of reactor parameters is therefore of interest.

Funke, A., Grandl, R., Ernst, M. & Dahmen, N., 2018. Modelling and improvement of heat transfer coefficient in auger type reactors for fast pyrolysis application. Chemical Engineering and Processing - Process Intensification, pp. 67-75.
Funke, A., Henrich, E., Dahmen, N. & Jörg, S., 2017. Dimensional Analysis of Auger-Type Fast Pyrolysis Reactors. Pyrolysis for Energy Technologies, January, pp. 119-129.
Peters, W., 1963. Schnellentgasung von Steinkohlen. Habilitationsschrift RWTH Aachen.