188c Catalytic Hot Gas Cleaning with Monoliths in Biomass Gasification in Fluidized Bed. Modeling of the 2nd Generation Two Layers Monolithic Reactor

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Monoliths containing nickel or other compounds can be used to eliminate tar and ammonia in a real biomass gasification gas. They can work with a fuel gas containing important amounts of particulates, as in the case of the fuel gas produced with fluidized bed gasifiers. They avoid then the use of ceramic filters under a tar-containing atmosphere. The use of monoliths in biomass gasification is a very recent and promising technology which has not yet reached its commercialisation stage and requires experimental studies at pilot scale. Experimental studies at UCM indicate that tar and ammonia conversions (eliminations) with monoliths depend on so many experimental variables that a model is needed to understand, correlate and compare the results obtained with monoliths. The presentation of such a model is the main objective of this communication.

An advanced macrokinetic model is presented here both for the monolith itself and for the whole monolithic reactor. The overall model is based on two microkinetic models for the tar and NH_3 elimination reactions (which use effective or apparent kinetic constants for the overall tar and NH_3 elimination), two mass balances for tar and NH_3 and a heat balance in the monolith. The macrokinetic model is developed according to the basic rules of Chemical Reaction Engineering.

Several important and noticeable facts appear in these monoliths, such as the non-Arrhenius dependence on temperature of the effective kinetic constants, and the big delta-T across the monolith. The fist fact is due to the control by the external diffusion (mass transfer) in the channels of the monolith which is here proved both experimental and theoretically. It makes that the superficial gas or face gas velocity has to be higher than 1 m/s to have important tar conversions. It, in turn, originates the need of using several layers of monoliths to get an enough gas residence time in the monolith. The big axial DT in the monolith is due to the predominancy of the endothermal reactions in the existing reaction network. It makes that at the monolith exit temperatures lower than 750 ºC may appear which would originate the formation of a whisker-type coke with the consequent irreversible deactivation of the monolith.

The equations developed for the macrokinetic model are easy to handle and allow a correct analysis of the experimental data, obtained at small pilot plant scale. The model has also been used to design a 2nd generation monolithic reactor for this new application which is already being used at UCM.