Modelling of a Wool Hydrolysis Reactor

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Abstract

Introduction: Wool from EU sheep farming and butchery industry is essentially a worth noting by-product perceived as a waste which is mostly disposed of. The Life+ GreenWoolF project is aimed at demonstrating that green hydrolysis with superheated water is an effective and profitable way to convert wool wastes into organic nitrogen fertilizers with good soil amendment properties.

This is carried out designing, building and testing a pilot plant equipment able to convert small amounts of wool into organic fertilizer. The core of the process is represented by the reaction tank (Figure 1), in which the wool proteins hydrolyses reaction takes place. One of the most influencing parameter is represented by the temperature of the material during the reaction, which has to be as homogeneous as possible within the tank, and is directly connected with the bulk density of the material, the reaction time and the amount of water needed for the reaction.

Use of COMSOL Multiphysics®: 2D and 3D simulations of the reaction tank have been used to study the heat transfer propagation and temperature distribution within the tank, considering proper heating sources (e.g. electrical resistances or direct steam heating), different wool bulk densities and suitable operative conditions. Wool fibers agglomerates have been considered as a porous matrix, completely filled with water, thus the Heat Transfer in Porous Media interface has been used for the study. Some physical correlations and ODEs have been manually implemented in the model.

Results: The propagation of the thermal front through the fibrous material is highly dependent on the geometry of the reactor, thus considering also type and position of the heat source, and the density of wool fibers agglomerates.

From an energy saving point of view, it is however advantageous to reach a high bulk density with the lowest water content, but this is in contrast with the propagation of the heat transfer front from the outer to the inner part of the fibrous material. Furthermore, the presence of an endothermic reaction, due to the wool hydrolyses, contributes to the great difference (from 10 to 20 °C) between the outer and the inner temperature (e.g. Figure 2). These phenomena could be extremely generating a nonhomogeneous hydrolyses.

Conclusions: The study has brought to valuable results, validated by experimental data carried out with the pilot plant equipment. In this view, the present study will be of great importance for

the scale-up and the design of the final equipment, which will able to convert a minimum of 500 kg/day of wool wastes into organic nitrogen fertilizers.

Figures used in the abstract

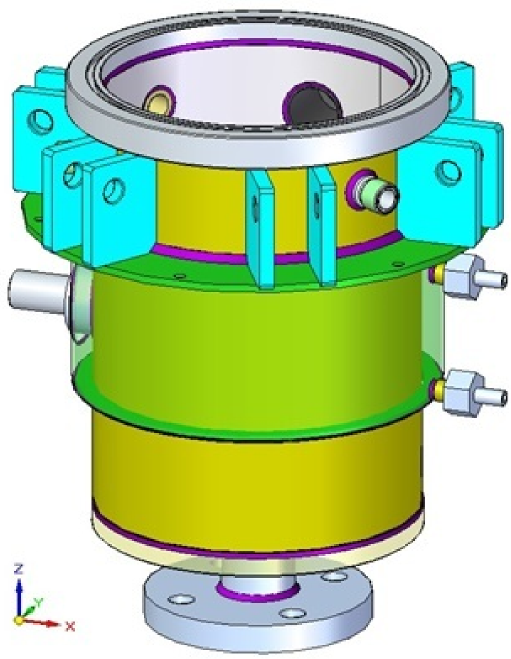

Figure 1: 3D view of the reaction tank of the pilot plant equipment.

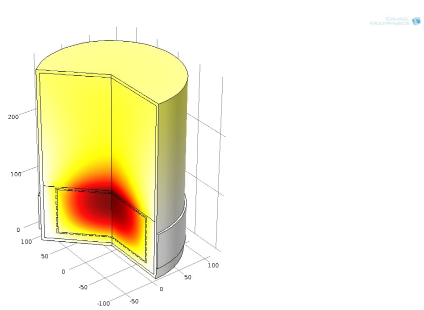

Figure 2: Temperature distribution within the reactor using an electrical resistance as heat source.