

New process design for the gasification of waste using Fresnel solar collectors.

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Sustainable Waste Management is crucial for reducing environmental impact of human activity. Various technologies have been devised to transform biomass and other waste into environmentally friendly energy sources, encompassing fuel, heat, electricity and organic fertilizer.

The supercritical water gasification (SCWG) process could be a viable alternative to conventional treatments. SCWG involves the conversion of organic matter (OM) into gaseous products in water above its critical point (i.e. 374 °C and 22.1 MPa). Beyond the critical point, both density and viscosity decrease, enhancing the diffusivity and reducing transport limitations. Moreover, the reaction kinetics increase, because of the high temperatures, favoring cracking of heavy organic compounds to light ones. As result of the gasification of OM, a high-quality syngas is obtained. To minimize the cost-effectiveness of SCWG, in this work we propose the use of solar thermal energy supplied by Fresnell solar collectors specifically designed for high-pressure fluids and stored in an innovative heat-storing system. The Fresnel linear collector is a device capable of heating a fluid thanks to the energy coming from solar rays. It consists of a series of linear heliostats, placed horizontally near the ground, which reflect and concentrate solar radiation on a thermally insulated tube, placed about ten meters from the ground. The heliostats are able to rotate along the longitudinal axis in order to follow the motion of the sun and constantly maintain the solar radiation reflected on the receiver tube.

The design consists of serpentine formed by a high-pressure Inconel 625 piping. This tube presents an external diameter of 6 mm, an internal diameter of 3 mm and the bundle is housed inside a steel tube of the solar receiver. In order to transfer energy from the internal wall of the steel tube, hit by solar radiation, it is necessary to insert, between the spaces surrounding the individual high-pressure tubes, a highly conductive material, identified in a compact matrix of molten aluminum. In the final stage of manufacturing the high-pressure receiver, the tube bundle, already equipped with an aluminum matrix, is inserted inside the absorber tube. To further ensure heat transfer between the walls, the external surface of the matrix is covered with highly conductive paste.

Inside the tube bundle, water flows in supercritical conditions along the coil's total length, divided in 37 folds, each 4 meters long, for a total length of 148 meters. This new process has been called SUNGAS and aims to significantly reduce operational costs by the exploitation of two different renewable sources, as solar thermal energy and solid wastes, thus promoting the application of this technology on an industrial scale.

In the present paper, the design of the innovative continuous solar reactor at industrial scale is presented, together with thermal and kinetic modeling. Results show that SUNGAS could represent a feasible method for syngas production from OM and similar biomass waste.

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