

An integrated process for hydrogen production from solid fuel gasification

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ABSTRACT

Among solid fuels, biomasses represent a renewable energy source and can be considered as CO₂-neutral fuels, giving no contribution to the CO₂ level in the atmosphere when used to produce energy. This is especially the case of materials from energy crops with optimized harvesting cycles, e.g., poplar and miscanthus, as well as residues and wastes from agricultural and food industry, e.g., olive cake and pruning from vines. Tuscany, where this study is conceived, offers a variety of these biomasses and the intrinsic problem of the desultory availability of these fuels can be overcome by a programmed collection.

Further advantages of biomasses with respect to fossil fuels are the low content in sulfur and heavy metals with consequent lower emissions in combustion processes. As a matter of fact many drawbacks limit the use of these fuels, e.g., the low heating value (also diminished if considering the relatively high moisture content) and the fouling/slugging phenomena (due to tar formation and alkali compound deposition), which reduce the heat transfer and the energetic efficiency.

Most of these issues can be overcome in the gasification process, which transforms a solid fuel into a syngas (used as gas fuel or converted into chemicals, e.g., methanol or hydrogen). The process is more versatile as for fuel input and product output than combustion. If air is used as the gasifying agent, the syngas has a low heating value and conversion processes can be hardly applied. Pure oxygen should be used in the gasifier to produce a syngas without nitrogen and, thus, with a higher heating value (increasing the efficiency of the following combustion step) and indicated for production of chemicals. In particular, hydrogen is a valuable energy carrier giving no pollutant (including CO₂) emissions in distributed utilizations, e.g., vehicles and residential uses. Steam can be also added in the gasifier to increase the hydrogen yield. Moreover, the CCS (Carbon Capture and Sequestration) option can be considered in the gasification plant to eliminate the emissions of CO₂ in the atmosphere.

Gasification with oxygen is generally operated using coal and large plants, which justify the cost of the air separation unit. For biomass fuels, relatively small plants (100-500 kg/h of biomass) can be considered to avoid the economic penalty due to large distance transportation. On this scale, cryogenic air separation is not suitable and the economic feasibility of other solutions (e.g., storage of liquid oxygen) is arguable.

In this work, an integrated process for hydrogen production from the gasification of biomass fuels is studied. The idea is to associate two systems of hydrogen production of different purity and, thus, different uses. The first system, based on the electrolysis of water, produces high purity hydrogen for fuel cell applications. The second is based on the gasification of biomass fuels, using the oxygen produced in the previous system for producing hydrogen of a relatively lower purity for internal combustion engines. These applications are the scenarios of the project "Filiera Idrogeno" funded by Regione Toscana.

The study is on the technical feasibility of the integrated process, for quantifying the energetic needs and the efficiency in different conditions and different configurations. A

process model is developed with detailed descriptions of main units (syngas treatment and separation) to evaluate the size of the equipment (e.g., amount of catalyst in the water gas shift reactors and the area of membranes for hydrogen separation).

Different solutions are also considered as for the energy source of electricity production in the electrolysis plant: wind, geothermy and the same gasification/combustion scheme from biomass (as in the attached scheme). All these sources are available in the studied area.

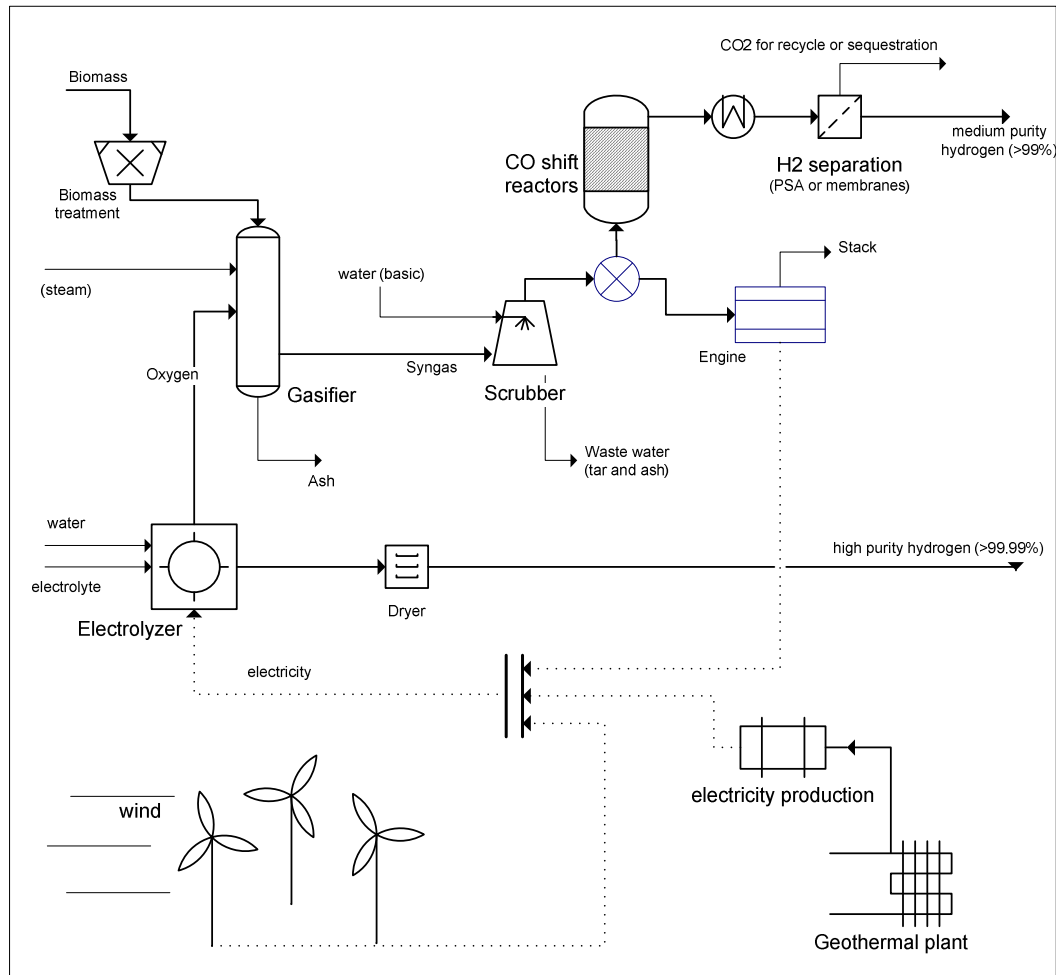


Figure 1. Scheme of the integrated process for hydrogen production

Keywords: process model, flowsheeting tools, biomass, residues, wastes.

Proposed Topic: Pre-Combustion