Energetic valorisation of biomass wastes through gasification with coal

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The continuous growth of world population leads to substantial increase on energy demand and simultaneously greater consumptions of goods that originate enormous amounts of wastes. These wastes need to be treated adequately to prevent environmental problems and make possible a sustained development of modern society. Portugal, as most EU countries, is highly dependent on imported petroleum and has no reserves of fossil fuels. All the EU countries have been involved in encouraging the use of renewable energies and have created their own programmes which aim at satisfying the EU target of getting renewable energy contribution to attain 12% of energy needs of EU by 2010.

The utilisation of biomass as an energy source has several advantages. Biomass is a sustainable and renewable resource, particularly in those countries, which have very little or no reserves of good--quality fossil fuels, as in many EU countries. Biomass contains no sulphur, very small amounts of chlorine or heavy metals and therefore produces virtually none of the emissions associated with air pollution which requires costly control techniques. Global warming is minimised if biomass is produced on a sustainable basis, since growing new plants absorbs most of CO_2 released. The potential of biomass as an energy resource is very considerable, particularly in rural regions of the European Union. It is estimated that it could reach up to 70 MTOE. The use of biomass as fuel will also diversify the fuel supply possibilities, which will increase competition that could have a controlling effect on prices. Biomass wastes obtained from cleaning of forests and from agriculture and industrial activities may be used as fuel.

The main obstacle for the use of biomass is that its amounts may be still far from desired levels of required security in supply in areas, where there is a need for increased energy demand and this may mean high transportation costs. A feasible alternative could be developing a process that could use either coal or wastes, including biomass and plastics, which would reduce problems associated to the shortness of one of these wastes. As most plastics are not biodegraded, there is an increasing accumulation of enormous amounts of plastic wastes. Therefore, the necessity of creating new processes to upgrade plastic and biomass wastes to reduce their negative impact on environment has led to the idea of applying gasification technology to mixtures of coal and biomass and plastic waste. This subject is not much studied and only few authors have analysed this area [1 to 8].

In the present work gasification of mixtures of biomass, coal and plastic wastes was studied. The experimental work was carried out under atmospheric pressure, in a bench scale fluidised bed gasifier. The gasifier was circular in cross-section with an inside diameter of 70 mm and was 500 mm in total height [5-6]. The presence of coal helps to stabilise gasification conditions and prevents problems due to any seasonal shortness of any of these wastes. Pine was the biomass species chosen for this work, because it is the most abundant species in Portugal. Bagasse, the waste from olive oil extraction industry, was another biomass studied in this work, due to the large quantities of this waste, either in Portugal or in other southern European countries. The main plastic present in municipal solid waste, polyethylene (PE) was chosen. Blendings with different compositions of mixtures of biomass, coal and plastic wastes were tested to study theirs influence on products yields and gas composition. It was also studied the effect of other experimental conditions on gasification process, such as: run temperature, biomass/steam ratio, air/steam ratio, biomass/plastic waste ratio. This paper analyses the effect of the experimental conditions used on the results obtained in order to optimise the process both technically and economically.

Main Conclusions

- Gasification has proven to be a potentially promising way of converting an environmental dangerous waste into economically valuable products, as through this process it was possible to obtain gas yields higher than 70%, depending on the experimental conditions selected. The main components of the gases produced were: H_2, CO_2, CO, methane and ethane, which suggest that the gas could be used either as fuel or as synthesis gas. However, further aspects need to be studied such as gas cleaning and determination of pollutant emissions.
- The increase in the amount of wastes in the feedstock led to a decrease in hydrogen release and an increase in hydrocarbons content, which was even higher when higher amounts of PE wastes were present in the feedstock. When 40% of PE was used, hydrocarbons concentration was around ten times those produced when only coal was used.
- Gas composition was affected by the amount of waste in the feedstock, but not much by the type of waste (biomass or PE). Therefore, it seems possible to substitute one type of waste by the other when there is shortness of biomass or PE. The main difference obtained was an increase in concentrations of methane and heavier hydrocarbons. At 900ºC, when 40% of PE was used, the gas produced had 11% (v/v) of H_2 and 7.1% of C_nH_m, while when a mixture of 20% of PE and 20% of pine was tested 8.9% (v/v) of H_2 and 5.3% of C_nH_m were obtained. Probably, this happened because PE produced more hydrocarbons, through cracking reactions.
- The experimental parameter that most affected was run temperature. The rise of run temperature promoted hydrocarbons further reactions, leading to a decrease in hydrocarbons content and an increase in H_2 release.
- Part of the energy necessary for the gasification process could be supplied by oxygen, due to partial combustion. As it was expected, the increase in oxygen favoured oxidation reactions and therefore CO_2 increased, whilst CO and H_2 decreased.
- Co-gasification of coal with wastes needs to be further studied and analysed, having in mind the more suitable end-use application for the produced gases and the characteristics of the available feedstock.

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