

A Review of Multi-Stage Allothermal Gasifiers

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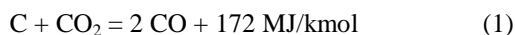
A review of the present development of multi-stage allothermal gasifiers is given. These reactors obtain part or all heat necessary for endothermic gasification reactions outside of the reactor space, and are usually only a segment in complex systems for cogeneration and production of other biofuels and chemicals. Their purpose is to produce as clean as possible product gas with the composition adapted to the final use of the gas. In this way designed gasifiers, substantially improve the efficiency of biomass conversion and the economics of the systems since they require less expensive gas cleaning equipment downstream of the reactor. Different types of gasifiers that obtain heat for endothermic gasification reactions by the use of: preheated medium, chemically active or not hot bed material, high heat fluxes over the solid reactor surfaces, electrical and solar energy are presented. They have significant potential for the combine use of biomass energy together with solar energy, excess electricity and high temperature waste heat.

Keywords: biomass gasification, allothermal gasification, gasifier, multi-stage gasifiers.

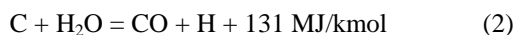
0. INTRODUCTION

Taking into consideration current developments in the construction of biomass gasifiers, the future belongs to allothermal reactors, i.e. the reactors that obtain all or part of the heat necessary for endothermic gasification reactions outside of the reactor. These gasifiers should enable the combine use of the energy of biomass and different forms of energy: thermal energy of the product gas, solar energy, recuperated high temperature industrial waste heat, excess electric power etc. By employing these methods it is possible to produce a product gas with medium or high heating values

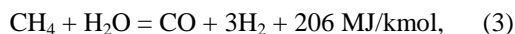
The contemporary multi-stage gasifiers have arisen from the need to produce the gas with required composition, heating value, free from tar and other impurities, and to optimize the reactor in accordance to the characteristics of the used biomass. The development of the reactors is of a high importance to the complex systems that use the product gas for cogeneration and production of other biofuels. In these systems the gasifiers are the least efficient devices and present bottleneck for wider application of these technologies [1], [2]. E.g. it is of great importance for the Fischer-Tropsch synthesis of liquid biofuels to produce so called synthesis gas free from methane and with the desired ratio of $H_2/CO \approx 2$. Auto-thermal reactors that are self-sufficient in heat, obtain heat for the endothermic reactions: Boudouard reaction,



heterogeneous water-gas reaction,



and homogeneous methane reforming reaction



by simultaneous exothermic oxidation reactions. In allothermal gasifiers, the heat required for the endothermic gasification reactions is obtained in numerous ways (3) by:

- ✓ preheating gasifying medium (air, oxygen, water vapor or their mixtures). In this way only part of the heat necessary for conducting the endothermic reactions is obtained. When steam is used as the gasifying medium the rest of the heat for the completion of the endothermic reactions is obtained by one of other methods given in this classification.
- ✓ supplying a hot solid material (usually sand or mixture of sand, a catalyst and biomass ash), which is heated by an exothermic reaction in the second reactor and circulates between the endothermic gasification reactor and an exothermic reactor. These are usually fluidized bed reactors.
- ✓ addition of heat into an allothermal reactor over a solid surface. This way has become common in allothermal gasifiers. Usually the sensible heat of the product gas is used to

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