Biomass gasification in an atmospheric fluidised bed: Tar elimination with commercial iron-based catalysts

Vera Nemanova*, Thomas Nordgreen, Krister Sjöström
Department of Chemical Engineering and Technology, Chemical Technology, KTH
SE-10044 Stockholm, Sweden
*nemanova@kth.se

Introduction

The use of biomass as an energy resource is responsible for the decreasing in the emission of CO_2, CO, NO_x, SO_x and unburned hydrocarbons into the atmosphere. The producer gas contains tars, which cause serious problems downstream the gasification process, e.g. corrosion in equipment and blockage of pipes.

Several gasification experiments have been performed in the KTH atmospheric fluidised bed gasifier [1]. The aim was to explore the performance of different kinds of metallic iron catalysts. In previous works at KTH it has been established that metallic iron has a pronounced ability to decompose tars that originates from the gasification process [2]. The decomposed tars normally enhance the gas yield and the concentration of permanent gases as CO, CO_2, H_2 are increased.

Three different commercial iron-based catalysts were tested for tar removal in a flue gas from an atmospheric fluidized bed biomass gasifier. The catalysts were provided by Höganäs AB. All catalysts provide a similar activity.

Materials and Methods

The gasification experiment was performed in a fluidised bed gasification system. Its major components are: a fluidized bed reactor, a biomass feeder, a ceramic filter and a catalytic bed reactor. The cool, dry, clean gas product was measured with a gas chromatograph (Model Shimadzu, Japan) which was equipped with a flame ionization detector (FID) and a thermal conductivity detector (TCD). The tar sampling and analysis was accomplished using the solid phase adsorption (SPA) method [3]. The fuel Swedish birch with a particle size of 1-2,5 mm was fed into the hot bed with a screw feeder that operates continuously at 0,22 kg/hour. The bed that consisted of silica was heated to a temperature of 850 °C in all experiments. The temperature in the catalytic bed reactor was varied between 700 and 850 °C.

Three types of iron (A, B, C) from Höganäs AB (right now the information is confidential) were introduced as catalysts for tar cracking and as a bed material. The catalysts used have been described and characterized (BET surface area and concentration of C, N, O and S).

To ensure the reliability of the test data, each test was repeated twice and the results had good agreement. The data reported is average values of the two times.

Results and Discussion

Several gasification experiments have been performed. The tar content and the gas composition have been monitored. The results confirm to some extent the expectations.

The experimental results from the first series of tests are presented in Table 1.

Table 1. Experimental results of different fixed bed temperature and different catalysts type

	Gas composition including nitrogen (vol %)				
Temperature (°C)	**H_2**	**CH_4**	**CO**	**CO_2**	**N2**
		Fe, A			
700	7,49	2,78	11,74	8,44	69,09
750	7,57	2,87	11,69	8,5	68,88
800	8,18	3,25	13,6	8,74	65,52
850	8,21	3,42	13,77	8,65	65,32
		Fe, B			
700	7,37	2,61	11,36	8,46	69,7
750	7,47	2,74	11,4	8,61	66,22
800	7,6	2,91	11,94	8,53	68,42
850	7,66	3,11	12,67	8,46	67,54
		Fe, C			
700	7,92	2,81	12,19	8,96	67,66
750	8,13	2,96	12,27	8,97	67,16
800	8,38	3,27	12,74	9,15	65,87
850	8,36	3,31	13,19	8,78	65,83

From the results shown in Table 1, it may be seen that the most effective catalysts under prevailing conditions is the A and C type. This is also in accordance with theory since these two types has the largest surface area. Although the differences between the three types of catalysts tested are in the region of 10 %.

References

1. Heginuz E., Liliedahl T., Sjöström K., *Studies on solid fuel pyrolysis and fluidization in a laboratory-scale, atmospheric, fluidized bed reactor, Finnish-Swedish Flame days, Proceeding, Naantali, Finland (1996).*
2. Nordgreen T., *Metallic iron: Potential to function as tar breakdown catalyst in waste gasification, Licentiate Thesis in Chemical Engineering, KTH (2005).*
3. Brage C., Yu Q., Chen G., Sjöström K., *Use of amino phase adsorbent for biomass tar sampling and separation, Fuel 76:137-142 (1997).*