Fuel Processing Technology 132 (2015) 49–54

Contents lists available at ScienceDirect

Fuel Processing Technology

journal homepage: www.elsevier.com/locate/fuproc

Experimental investigations with a modified briquetting press as feeding system for brown coal into pressurized gasifiers

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A R T I C L E I N F O

Article history:
Received 9 September 2014
Received in revised form 4 December 2014
Accepted 22 December 2014
Available online 10 January 2015

Keywords:
Brown coal
Fuel feeding system
Briquetting press
Gas flow
Gasification reactor
Pressurized gasification

A B S T R A C T

The development of gasification processes with higher operating pressures in order to increase the gasification process throughput and to avoid the densification of the syngas for the following processes requires also the design or adaptation of feeding systems to the new demanding process conditions. One of the most important requirements is the realization of a continuous lock-free and gas tight operation mode. The basic suitability of a briquetting press as an alternative feeding system has been studied within the framework of fundamental research on the test rig, which simulates the principle of the briquetting press with an open press channel. In the scope of preliminary investigations, the influence of briquetting parameters on the gas tightness of a briquette plug and the optimum press channel geometry for different types of coal were studied. Based on these fundamental research results, the modification of a briquetting press was made. The systematic investigations with a modified briquetting press on optimization of the operating parameters were carried out in order to ensure a stable briquetting pressure profile. This is a prerequisite for the sealing of the press channel between feeding system and pressurized gasifier. For the experimental simulation of the pressurized gasifier a pressure vessel with a volume about 250 l and a maximum operating pressure of 65 bar was constructed and built. In the feeding experiments, a stable continuous lock-free feeding against a gas pressure of 65 bar could be realized and therefore the feasibility of the developed technical solution was successfully demonstrated.

1. Introduction

The trend in the gasification technology leads to the development of new gasifiers with higher operating pressures to increase the productivity of the process and the yield of the target products. The rise of the operating pressure in a new generation coal gasifiers (up to 65 bar), to increase the efficiency, leads to more stringent requirements to wear resistance and sealing, so that in addition to the gasifier also peripheral systems such as feeding systems should be further developed. A promising approach is to explore the possibility of using well-known technical solutions as an alternative continuous lock-free feeding system for pressurized gasifiers. The gasification under high pressure is an advantage, so that practically all modern gasification processes operate at pressures of at least 10 bar to 100 bar [1]. The operating pressure of fixed-bed gasifiers is typically about 20 bar [2]; the entrained flow gasifiers work in the pressure range of 20–80 bar [3,4]. A higher operating pressure of the gasification process leads to an increase in the throughput. In addition, high operating pressures are required, because all known synthesis processes for basic chemicals operate at pressures above 50 bar, so that the extensive compression of the generated synthesis gas can be avoided. The advantage of gasification at elevated pressures can be illustrated using the example of the “Ruhr 100” gasifier. The Lurgy dry-bottom gasifier was designed for operation at 100 bar. Increasing the pressure from 25 bar to 95 bar approximately doubled the throughput of the reactor. The pressure increase also increased the methane production from about 9 mol.% in the product gas to 16 mol.% [1]. The currently used feeding systems using locks, transport gas and slurry have several disadvantages such as leakage problems, high complexity of the system and reduced energy efficiency. Currently, two options of coal feeding are most important. These are dry- and wet-coal feeding. The dry-coal feeders operate mainly using locks (lock-hopper systems) and using transport gas as a carrier medium. The maximum operating pressure of such systems is limited by the amount of carrier gas. With increasing pressure the amount of transport gas rises, which leads to a negative impact on the process efficiency and system dimensioning. The wet-feeding systems use slurry pumps for supplying the coal slurry into the gasifier. The dry-coal feeding is associated with a large amount of inert gas to be conveyed into the gasifier, so that the feeding pressure does not exceed the value of 40 bar [5]. For this reason, the requirements for the development of alternative feeding systems of a new generation avoid the use of locks and carrier media. Taking all aspects mentioned into account, there is a promising way for a gas-tight separation between the pressurized gasifier and the feeding system by producing a very strong compacted brown coal plug in the transport channel to the gasifier with the briquetting press being an alternative

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http://dx.doi.org/10.1016/j.fuproc.2014.12.038
0378-3820/

feeding system. The studies on an experimental apparatus on laboratory scale have shown, that the sufficient cross-bracing of the briquettes in the press channel for sealing against 65 bar gas pressure and the sufficient gas tightness of the briquette structure can be achieved [6–8]. The operation mode of the briquetting press is shown in Fig. 1. The press stamp is moved in the press channel forwards and backwards. While the press stamp is in the rear position, the preheated crushed brown coal with a particular grain size falls down from the silo in front of the press stamp, so that the press stamp compresses during the forward movement the brown coal against the previously pressed briquettes in the press channel. This creates a new briquette. The whole briquette plug is thereby pushed forward by a distance corresponding to the thickness of a briquette. The applied briquetting pressure of approx. 1400 bar leads to the cross-bracing of briquettes in the press channel. This cross-bracing is crucial for the sealing in the edge region between the briquettes and the press channel wall. The sealing against the gas flow through the porosity of briquettes is obtained by strong compression of the pulverized coal to a highly compacted briquette structure. A further possibility of the continuous fuel feeding into the pressurized gasifier is to produce a fuel plug of sufficient length and the sealing of the interparticle space with suitable additives in order to reduce the gas flow through this plug. This method can be used in combination with an alternative feeding system using lower feeding pressures, at which no sufficient density of fuel plug structure at the feeding pressure can be achieved. An example would be the slurry pump with a delivery pressure of up to about 150 bar. In our project the investigations with the slurry pump as an alternative feeding system have been in the focus of research in addition to the studies with the briquetting press.

2. Materials

The aim of the investigations is the demonstration of a continuous lock-free coal feeding into a pressure vessel with the maximum gas pressure of 65 bar. The adjustment of the feedstock parameters (water content, and grain size) and operating parameters (briquetting pressure, briquetting velocity), identified in our preliminary studies [6–8], has a decisive importance for the success of the investigations. The optimum combination of material parameters is crucial for the gas tightness of a briquette structure. The operating parameters influence the briquetting pressure build-up and the cross-bracing of the briquettes in the press channel. For the studies on a technical scale, the classical briquetting press was modified. The novel press channel geometry was designed and constructed. The results of this development are presented below. During the investigations, the brown coal of supplier Romonta (Central German brown coal) was used. This coal was selected for this experiment due to its briquetting-friendly behavior. In particular, the high wax content has a positive effect on the briquetting. The elemental composition of this coal is shown in Table 1. Several physical properties of the coal play a significant role in briquetting, including grain size and water content. The grain size affects the development of the binding forces between the individual coal particles; the water content influences the hydrogen bonds in the briquette structure and

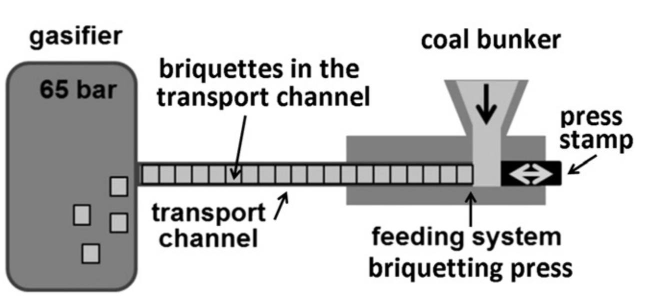

Fig. 1. Schematic representation of the principle for the coal feeding with briquetting press.

Table 1
Elemental composition of Romonta brown coal (Central German brown coal—coal deposit Amsdorf).

Ash	Water	C	H	S	O
Mass-%					
9.62	18.35	53.43	4.54	3.47	11.81

the sealing of the structure porosity against the gas flow. The grain size of the brown coal used was 0–4 mm with a water content of 20%. The usual grain size for the coal briquetting ranges between 0–1 and 0–4 mm. From the viewpoint of briquetting, the use of finer particles is not necessary. In addition, the fine grinding of coal would mean additional costs and handling problems, due to the high coal dust production. If one were to use the fine coal up to 70 microns for briquetting, these fine grains would not survive the pressure agglomeration process in the briquetting press. After briquetting the particles are no longer separate, but in the form of briquettes regardless of their grain size prior to briquetting.

3. Modified briquetting press and pressure vessel

The tests on the test apparatus on a laboratory scale have shown that a sufficient cross-braced briquette plug of a high density is able to withstand the gas pressure of 65 bar [6–8]. The next step of the investigations will be the transition from the laboratory scale to technical scale (extended laboratory scale). The basis for further study is the modification of the classical briquetting press. In a first step before the modification of the press as feeding system, some extensive basic research was carried out into a specially designed laboratory scale test rig. In particular, the influence of the press channel geometry and briquetting parameters was analyzed and investigated for the production of the briquettes with a high gas tightness [6–8]. In the next step, after finishing the laboratory scale research the modification of the briquetting press was carried out. In particular, it relates to the design of the press channel. The new press channel has a rigid circular cross-section, which has a special internal geometry. The classical press channel used in brown coal briquetting with a rectangular composite cross-section consisting of 4 parts is not suitable for the function as a gas-tight feeding system. This is due to the gaps between the individual parts forming this press channel. In conventional brown coal briquetting the rigid structure of the press channel is not required. On the contrary, a movable mounting of the upper part of the press channel is implemented in order to influence the pressure conditions in the press channel by its lifting and lowering. The press channel of a feeding system must be designed as a rigid body, so that the gas leakage can be excluded at this point. The press channel with a circular cross-section made as one component part is a possible way to achieve gas-tight sealing. The internal geometry is realized by the use of exchangeable insertion tubes. The impact on the briquetting pressure conditions in the press channel can be controlled by water cooling of the press channel. For this purpose the cooling channels were positioned around the press channel. In the study it was found out, that different coal types need various press channel geometries due to their different elemental composition, petrography and briquetting behavior. This is achieved by the use of interchangeable insertion tubes. The total internal geometry consists of an inlet tube and an outlet tube. The cross-section of the briquetting press with insertion tubes in the press channel is shown in Fig. 2.

This approach gives the necessary flexibility in the design of the internal geometry through various combinations of different inlets and outlets to adapt the briquetting behavior to different types of coal. The adaptation of the press channel geometry to the briquetting behavior of various coal types was carried out during the basic research on a separate test rig. Moreover, the level of cross-bracing (transversal pressure) in the internal geometry (restriction) was measured and