
Summary

BTG Biomass Technology group BV carried out a study to the state of the art of feeding systems for biomass gasifiers. The study is performed by order of NOVEM, within the program 'Energy Production from Waste and Biomass' (EWAB).

In this study a division is made between feeding systems for fixed bed, atmospheric fluid bed, and pressurized fluid bed gasifiers. Subsequently feeding system components for feeding (1) fluffy low density materials, (2) powder type materials, (3) high density chips-alike materials and (4) high density blocks are distinguished.

Box 1: Presented biomass gasifiers

1	Vermont, FERCO, Batelle Columbus	14	EVN Domsland, AHT design
2	Lahti Foster Wheeler	15	Siebenlehn, Juch design
3	Bioelettrica, Cascina	16	Sludge gasification de Schelde
4	Enviropower, Carbona	17	HTW process, Kemira Oy
5	PDU unit, Chicago, Renugas, IGT	18	Pyroflow, Foster Wheeler
6	BGF unit, Hawaii, Renugas, IGT	19	Espenhain, Juch design
7	Vølund Harboøre	20	Easymod, Boizenburg
8	AMER centrale Lurgi	21	Värö mill, Götaverken
9	Goor, fixed bed, Netherlands	22	Zellstoffwerke Pöls, Lurgi
10	Arbre, TPS	23	Wisaforest, Pietersaari, Ahlstrom
11	Värnamo, Sydkraft, Foster Wheeler	24	LR-Lurgi Residue process
12	MINO process, TPS	25	EPI Energy Products
13	UET Freiburg		

The evaluation is based on descriptions of 25 gasifier feeding systems. See box 1 and annex B. Nine of these feeding system descriptions (no's 1 to 9) are worked out in detail in annex D.

Fixed bed gasifiers

Feeding system description

Feeding of fixed bed gasifiers can be realized either manually or automatically. Manual feeding is very robust and almost any type of fuel can be fed. Because of labor costs and possible health risks, the common practice is automated feeding.

In a state of the art feeding system for fixed bed gasifiers biomass is screwed from a fuel bunker on a belt conveyor or elevator to an intermediate storage, from which the fuel is fed via a lock hopper or a rotary valve into the gasifier reactor.

Feeding problems and solutions

Possible problems with fixed bed gasifiers are bridging, tar accumulation on the entry valve, and excess supply of biomass. Possible solutions are, respectively, fuel pretreatment, working at under pressure conditions, and adjustment of fuel supply with the process speed.

Atmospheric fluid bed gasifiers

Feeding system description

Feeding systems for atmospheric fluid bed gasifiers are more complex than those for fixed bed gasifiers, and generally include a fuel reception bunker with life bottom, a section for removal of metals and oversized components, and rotary drum dryers. Rotary valves are most commonly used for sealing. Screw systems are used for injection of the fuel into the gasification unit.

Feeding problems and solutions

Feeding problems of the investigated atmospheric fluid bed gasifiers are barely described. The most serious observed feeding problem is blockage and damage to feeding screws due to foreign materials in the biomass fuel, like metals etceteras. One solution is to accept only clean biomass which is free from foreign materials, but this could restrict the supply of cheap biomass fuel like demolition wood, and still accidentally foreign materials can enter the feeding system. Investments in metal removers and de-stoners will be needed, and will require considerable engineering effort. Feeding problems like bridging, plugging, and moisture related feeding problems are expected to be found, but are not described in the consulted literature.

Pressurized fluid bed systems

Feeding system description

In pressurized systems lock hoppers are preferred above rotary valves for sealing the feeding system. To pressurize a lock hopper, usually an inert gas like nitrogen is used, but theoretically the flue gas could be used as well. The most suitable way to transport biomass into the gasification unit is a variable speed dosing screw which feeds a continuous rotating injection screw.

Feeding problems and solutions

Problems with feeding chips alike materials to pressurized systems are not documented. Fluffy materials are difficult to handle, as it lumps and has a low density. The BGF unit in Hawaii encountered additional problems like foreign materials in the fuel, and varying moisture and dust contents of the fuel causing blockades and bridge formation. Solutions include application of de-stoners, metal removers, and adjustable drying equipment like

rotary drum dryers. After implementation of improvements the system did still not work satisfactory.

State of the art

Table 1 shows which feeding system components are used in state of the art fixed bed, atmospheric fluid bed, and pressurized fluid bed gasifiers for feeding *wood chips*. Of course the table is a generalized layout and local differences in capacity, design and fuel input will affect the resulting feeding system design.

Table 1 State of the art feeding systems for typical fixed bed, atmospheric and pressurized fluid bed gasifiers for feeding *wood chips* including pretreatment equipment

<i>Fixed bed gasifiers</i>	<i>Atmospheric fluid bed gasifiers</i>	<i>Pressurized fluid bed gasifiers</i>
Storage bunker to receive the feedstock	Fuel silo with 'life bottom', i.e. multiple screws that convey the biomass fuel	Fuel silo with 'life bottom', i.e. multiple screws that convey the biomass fuel
Transport screw	Transport belt	Transport belt
Inclined conveyor belt	Metal removal system and disc screen	Metal removal system and disc screen
Small buffer vessel	Cutters, crushers and/or sieves	Cutters, crushers and/or sieves
<i>Lock hopper or rotating sluice on top of gasification unit</i>	Wet fuel bunker	Wet fuel bunker
	Rotary drum dryer	Rotary drum dryer
	Elevator	Elevator
	Dry fuel bunker	Dry fuel bunker
	Screw feeder	Screw feeder
	Buffer bin in top of lock hopper or rotary valve	Buffer bin in top of lock hopper
	<i>Lock hopper or rotary valves</i>	<i>Lock hopper</i>
	Variable speed dosage screws	Variable speed dosage screws
	Fixed fast speed feeding screws	Fixed fast speed feeding screws

Additionally, table 2 shows which feeding system components should be used to *seal* and *inject* other types of biomass fuels.

Table 2 State of the art feeding system components for *sealing* and *fuel injection* in biomass gasifiers

<i>Fuel type</i>	<i>Examples</i>	<i>Feeding system components</i>			
		<i>Fixed bed</i>	<i>Atmospheric fluid bed</i>	<i>Pressurized fluid bed</i>	<i>Entrained flow</i>
Fluffy low density materials (uncut fibers)	Straw, bagasse	Manual	n.a. ¹	n.a.	n.a.
Fluffy low density materials (short fibers)	Rice husk, cut straw, cut bagasse	Manual, or cylindric lock hopper	Lock hopper + screw	Lock hopper + screw	n.a.
Powder type materials (<5 mm)	Sawdust, dried slurries, chicken manure	n.a.	Rotary valve + screw	Lock hopper + screw	Pneumatic feeder
High density materials (5-50 mm)	Wood chips	Rotary valve, or lock hopper	Lock hopper + screw; or rotary valve + screw	Lock hopper + screw	n.a.
High density materials (>50 mm)	Wood blocks	Lock hopper, or manual	n.a.	n.a.	n.a.

¹ n.a.: not applicable, in this situation the specific type of biomass cannot be fed