Thermal Utilization

of

Ash-Rich Waste

Engineering GmbH
H&C VGU
Energy • Hydrogen • Environment

Mozartstr. 4
D-51643 Gummersbach/Germany

Telefon: +49 2261 / 804640
Telefax: +49 2261 / 804641

e-mail: info@huc-vgu.de
http://www.huc-vgu.de

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1. General

Thermal utilization of waste is a necessary part of an environment conscious disposal policy. With the thermal conversion of resources in waste a method has to be installed by which the electrical and usable thermal energy can be recovered with a high efficiency and - as far as possible - no by-products are produced that can affect the environment.

It can be assessed clearly that small decentralised thermal conversion plants should be preferred in future because their acceptance in public opinion seems to be more easily achievable. In addition to this industry - especially small and medium enterprises can convert their waste streams on it's own.

The overall concept for thermal conversion of resources in waste developed by H&C-VGU is designed to recover energy and re-usable by-products from waste streams with a high content of ashes (minerals) at competitive prices.

2. Description of the process and plant

H&C-VGU has developed a new method for the thermal treatment of waste streams rich in ash content. Key component of the system is a melting cyclone in which all non combustible constituents are melted (see flow chart in Figure 1).

The waste with a minimum of water content is – if necessary – broken down into small particles and after mixing with primary air is injected tangentially into the melting cyclone using two burners (Figure 2).

The particles circle with a high radial velocity around the combustion chamber axis. Centrifugal forces cause the particles to move to the combustion chamber's wall. There they are attached to a sticky layer of molten ashes where they can burn out. Inert constituents of the waste stream (which are up to 50% of the dry solid substances e.g. sewage sludge) are carried out of the combustion chamber as molten mass. The molten mass is cooled by a water cycle with heat recovery and converted to the usable end product. To minimise the generation of nitrogen-oxides (NO_x) the combustion air is rated as primary, secondary and tertiary air 1 and 2 when injected into the combustion chamber.

The hot combustion gas flows through the central pipe from the melting chamber into the steam boiler which consists of a radiation and a convection part. In the radiation heat exchanger the temperature is taken down far enough to avoid sticky ash particles. The convection heat exchanger is built as a tubular heat exchanger with the flue gas streaming through the tubes. The steam is expanded through a gas turbine or a gas motor connected to a generator. The steam is condensed behind the turbine and re-circled into the steam boiler. Before the combustion products enter the steam boiler calcium hydrate and ammonia water are injected to absorb SO_2 and to reduce NO_x. This process is the first step of flue gas cleaning system.

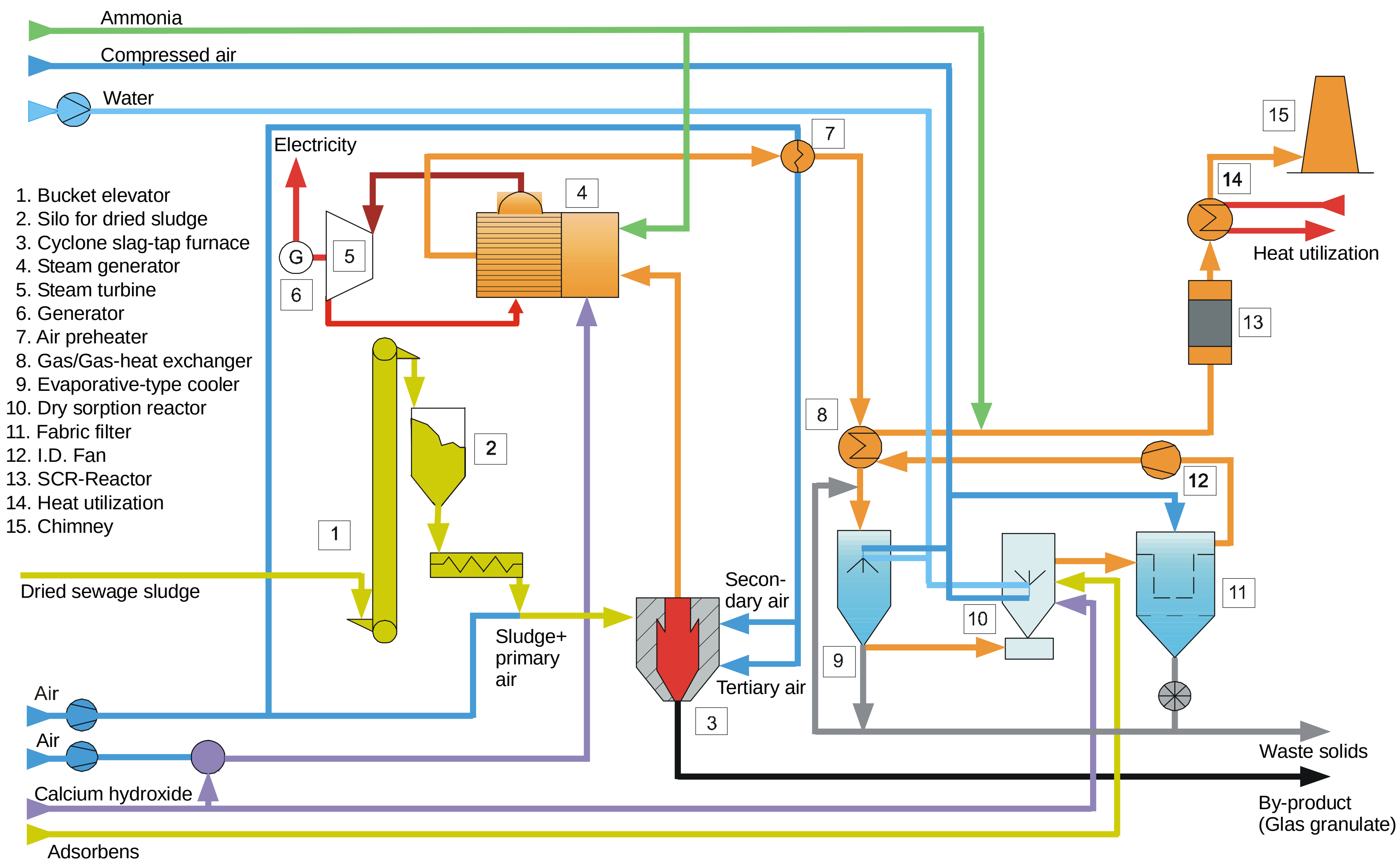

Figure 1: Schematic flow diagram of a thermal utilization plant for ash-rich wastes

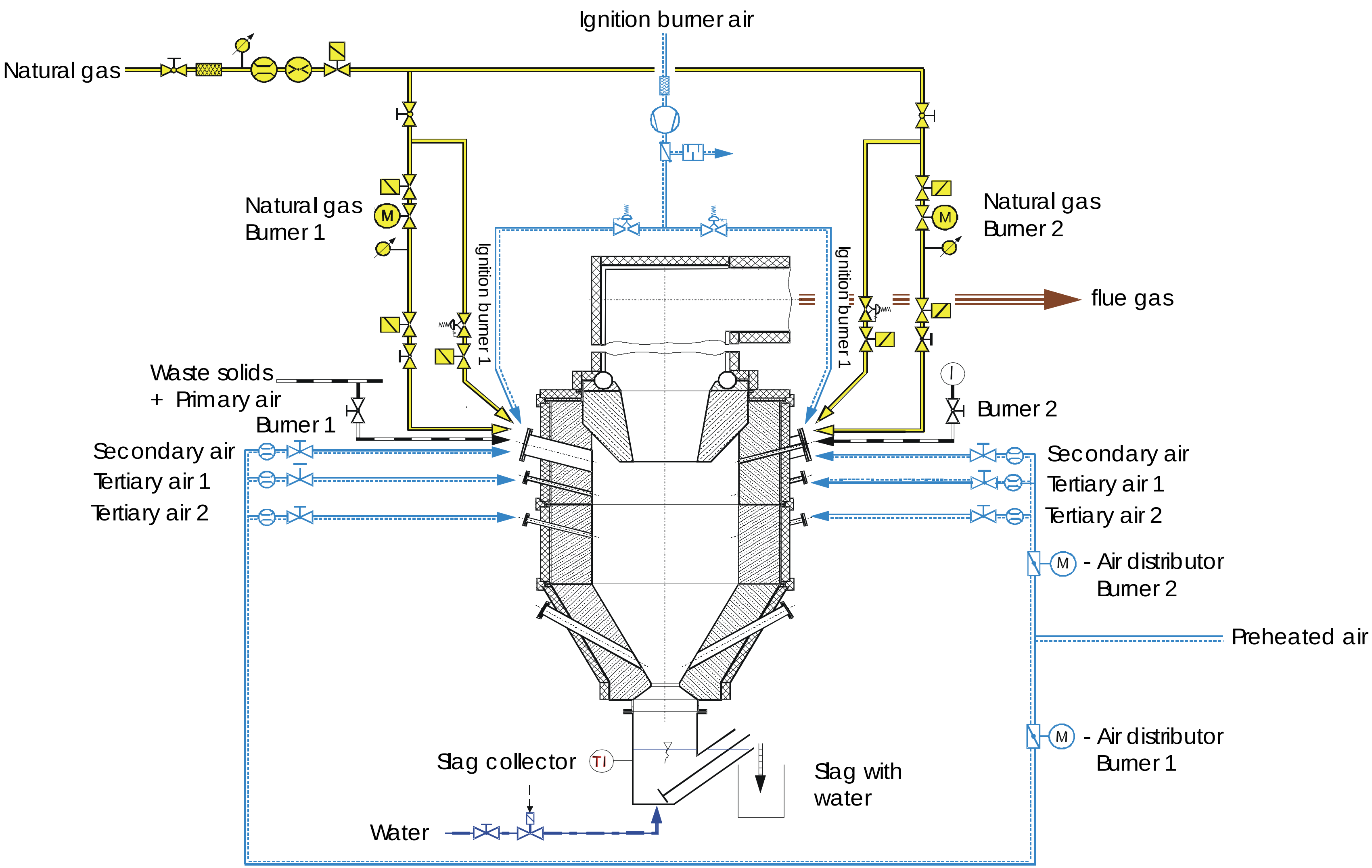

Figure 2: Cyclone slag-tap furnace for thermal utilization of ash-rich waste

The combustion products coming from the steam boiler with 450℃ enter into the air pre-heater and raise the incoming combustion air temperature to 400℃ . After this the flue gases are cooled down to app. 220℃ by the regenerative type flue gas heater (REGAVO).

Behind the REGAVO we have a multi-level flue gas cleaning system to bind SO_2 and heavy metals and – if present – to bind dioxin. In the evaporative-type cooler the flue
gases are conditioned with water for the dry flue gas cleaning in the dry sorption reactor (DSR).

Behind the dry sorption reactor there is a bag house filter. This filter has at the same time the function of a particle filter as well as that of a reaction filter. The separated constituents are for better use of the sorbent agents re-circulated in front of the DSR and the evaporative-type cooler and a part is used as a sink for pollutants and is extracted with the final end-product as a waste.

The combustion products are taken with induced draft fan via the regenerative flue gas heater (REGAVO) to the selective catalytic reduction (SCR) System. The reduction of nitrogen oxides takes place in presence of NH_3 with the use of a catalyst at a temperature of app. 230℃. Before the flue gases leave the plant through the chimney they are cooled down to 150℃ u sing pre-heater for combustion air.

3. Mass and energy flow

In Figure 3 and 4 the mass and energy flow are listed as an example for a plant for thermal conversion of municipal sewage sludge having a capacity of 500 kg/h solid substance (dry). The specific mass of flue gas is 5.35 kg per kg sewage sludge measured as dry solids. This is only half of the respective figure in a dry combustion process (as for example in a fluidised bed combustion). The filter ashes to be disposed of at the end is only 7% of the dry mass of the sewage sludge fed into the plant.

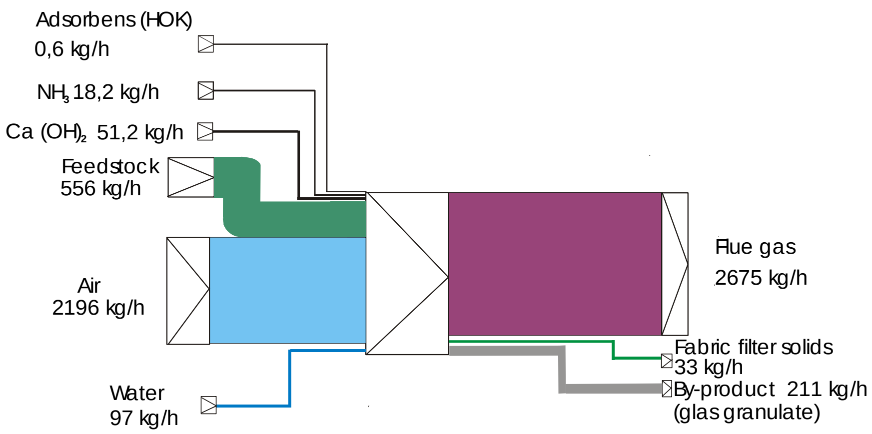

Figure 3: Mass flow diagram

In the energy flow diagram the usable energy streams derived from the plant operation (electricity, steam, hot water) amount to 80% of the energy fed into the plant with the sewage sludge. For the generation of electricity a steam engine is employed expanding the supersaturated steam from 20 bar down to 1.3 bar. The steam coming out of this process with a temperature of 120℃ is condensed by external heat recovery. This process results in a total exploitation of thermal energy of app. 1.1 MW.

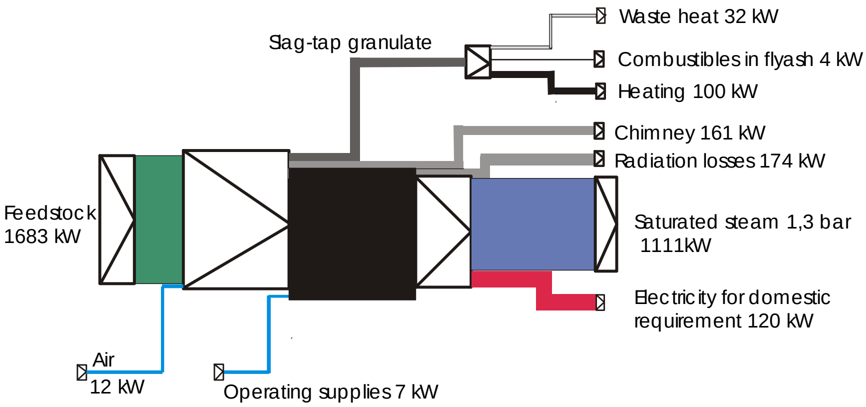

Figure 4: Energy flow diagram

4. Advantages of the H&C-VGU Cyclone-furnace

The H&C-VGU cyclone-combustion is so elementary in it‘s design, that it can be used economically even in small plants. The features are as follows:

- Due to the operating temperature of app. 1400℃ al l organic substances are securely destroyed.
- Combustion residuals, that are carried out as a glass-like molten mass are re-usable compounds. The glass-like material's hardness and resistance against acids is higher as for granite. It can be used as building material, as particles for corund and abrasive surfaces or as high-temperature insulation material in the form of glass fibres or foam-glass.
- Because of the dry flue gas cleaning system there is no contaminated waste water to be disposed off.
- The partial re-circulation of filter material into the furnace chamber allows a progressive concentration of highly volatile heavy metals i.e. mercury in the filter cakes. Due to this feature the end product to be disposed of can be compacted / reduced down to a minimum of 7 % of the inlet dry material. Conventional plants can only reduce this down to app. 50% of the inlet dry material.

- In normal operation mode the plant does not use any additional fuel.
- Due to the lower excess air of the melting combustion technology - compared to fluidised bed combustion - as well the absolute load of pollutants released to the atmosphere is reduced.
- The parameters of the combustion that is applied in our concept of the melting combustion technology do not result in the generation of N_2O whereas in fluidised bed combustion processes N_2O is released in large volume. N_2O is a long-lasting pollutant that is essentially contributing to the green house effect of the earth atmosphere. Up to this date there is no concentration limit for the emission of this pollutant.
- The melting furnace combustion was developed in Germany.
- The total cost for treatment and disposal of sewage sludge is smaller with our small decentralised plants than with existing large scale plants.

5. Economic comparison of H&C-VGU-Technology with fluidized bed combustion plant

	Plant capacity and operating supplies						**Remarks**
	Feedstock						
			Sewage sludge				
			Input (DS)		500	kg/h	
			Dry solids (DS)		90	%	
			LHV (DS)		12.00	MJ/kg	
	Operating supplies						
	Natural gas				0.67	m^3/h	In mean only for start-ups
	Electricity				0.80	KW	
	Fresh water				97.00	kg/h	
	Calcium hydroxide				51.20	kg/h	
	Nitrogen				5.00	m^3/h	
	Adsorbens				0.60	kg/h	
	Ammonia				18.20	kg/h	
	Waste material				33.00	kg/h	
	Usable by-product (molten glas)				211.00	kg/h	
	Operating hours				7,500	h/a	
Economic Analysis							
1.	**Investment costs**						
		Interest Rate	Life time	Annual depreciation	Amount	Operating costs	
		%		%	EUR	EUR/a	
	Plant equipment						
	Refining	5.5	10	13.27	400,000. -	53,080.-	Interest rate e.g. DtA Bank
	Combustion and fuel gas cleaning	5.5	10	13.27	3,350,500.-	444,611.-	
	Total 1				**3,750,500.-**	**497,691.-**	
2.	**Fixed operating costs**					EUR/a	
	Repairs and maintenance						
	Refining	2	% of Investment			8,000.-	
	Combustion and flue gas cleaning	2	% of Investment			67,010.-	
	Personnel costs	2	Persons salary/a		50,000.-	100,000.-	
	Taxes, insurances and administration	1	% of investment			37,505.-	
	Total 2					**212,515.-**	
3.	**Variable operating costs**	supplies	Unit	Sp. price	Unit	Operating costs	
						EUR/a	
	Natural gas	5,000	m^3/a	0.20	EUR/m^3	1,000.-	
	Electricity	6,000	kWh/a	0.10	EUR/kWh	600.-	
	Fresh water	728	t/a	1	EUR/t	728.-	
	Calcium hydroxide	384	t/a	100	EUR/t	38,400.-	
	Nitrogen	37,500	m^3/a	0,1	EUR/m^3	3,750.-	
	Adsorbens	4.50	t/a	1500	EUR/t	6,750.-	
	Waste material	247.50	t/a	150	EUR/t	37,120.-	
	Usable by-product (molten glas)	1582.50	t/a	-10	EUR/t	-15,825.-	Income of molten glas
	Total 3					**72,523.-**	
4.	**Summary of economic analysis**						
	Investment costs				EUR/a	497,691.-	
	Fixed operating costs				EUR/a	212,515.-	
	Variable operating costs				EUR/a	72,523.-	
	Total costs				**EUR/a**	**782,729.-**	
	Costs per t feedstock (dry solids)				**EUR/t (DS)**	**209.-**	

The annual total costs amount to **EUR 782,729.00** for a throughput of 3750 t/a resulting in specific sewage sludge utilization cost of

209 EUR/t dry solids.

Comparison of operating cost with the state of the art technology as fluidized bed:

The existing combustion plants for sewage sludge are normally designed for throughput of 4-5 t/h. To compare the cost of H&C-VGU technology with the cost of e.g. fluidized bed, the total cost must be developed for the same size of the plant.

The specific cost for scaling up the H&C-VGU plant amount to 175 EUR/t dry material. Whereas the specific cost of fluidized bed technology figures in the range of 400 EUR/t dry material.

6. Outlook

The slag-tap cyclone combustion for waste materials is a new technology with high grade of innovation. The realization of H&C-VGU technology can be subsidized from Provincial, Federal or European authorities.