Improve Your Business by Generating Money from Waste

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ABSTRACT

Energy is currently the second biggest cost factor in the recycled paper production with the highest lever for cost improvement. Energy generation from sorting and process rejects, provides a considerable substitution and saving of fossil fuel as well as a reduction of greenhouse gas emissions and a significant reduction of landfill costs.

Decentralized treatment units, which combust local waste streams and which cover local heat demands, provide high overall plant efficiencies, short investment payback rates and represent an environmentally sustainable solution with high public acceptance.

“Reject to Power” technology presents an optimized solution for waste fuels in the range of 5 to 30 MWth. The innovative principle of fuel injection via spinning wheels allows high flexibilities regarding fuel compositions and heating values. The combustion concept results in low grate temperatures, low emission values and excellent burn out rates.

The 22 MWth Energy Recovery Boiler at SAICA Partington generates 30 t/h steam.

1. INTRODUCTION

The Reject to Power (R2P) concept was developed in the 1990’s for combustion of wood chips. In 2003 the advantageous principle was adopted to thermal treatment of residual materials and complemented with water tube boiler and flue gas treatment system.

There are 3 different combustion systems mainly used for waste incineration and the Reject to Power system was engineered as an alternative system to them. The main systems are the conventional grate system with feed ram fuel supply and fluidized bed technologies (stationary as well as circulating). R2P combines the advantages from grate (robustness) with the circulating fluidized bed (fuel distribution in combustion chamber) technology. It is a simple and reliable system which is easy to operate.

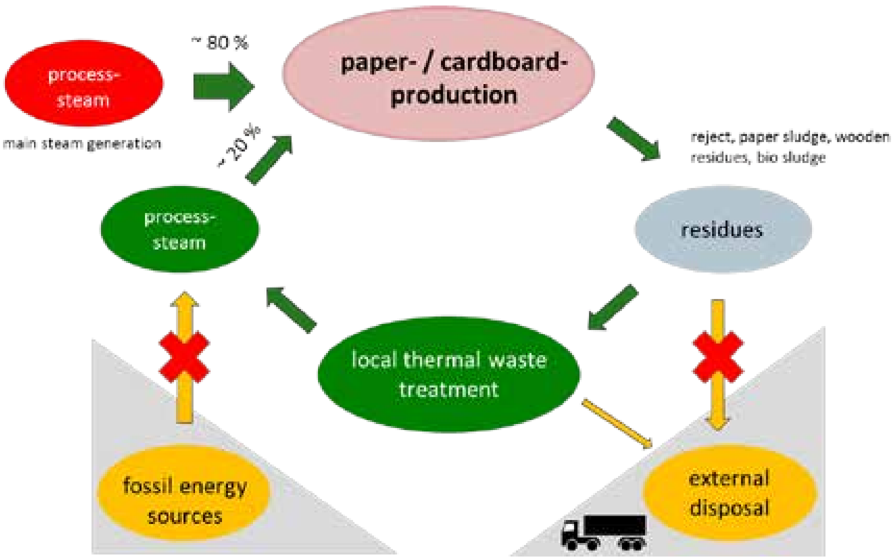

Figure 1: Steam supply through thermal waste treatment

The concept uses waste from production to produce steam which is supplied to the production process. Approx. 20-30% of the necessary overall steam amount is supplied through the heat value of waste (see Figure 1). The amount for landfill is tremendous reduced, even a big portion of the ash amount could be used as raw material in the construction industry. Additionally fossil fuel consumption of the cardboard mill is reduced about 20%.

The first “Reject to Power” plant with 4.8 MW thermal capacity started commercial operation in 2005 at a cardboard factory in Austria using rejects, wood chips and wet bio-sludge as fuels. The technology was improved and enhanced by Siemens Austria from 2006 to 2013, but focusing on core business lead to a transfer of this product to Christof Group by end of 2013.

The medium sized power range of units from 5 to 30 MW thermal firing capacity is favorable for decentralized units, which treat the local waste streams of factories or communities and which cover the local heat demands for process and district heating needs and / or generate electricity.

2. COMBUSTION TECHNOLOGY

The key elements of the Reject to Power Technology are the special combustion chamber with a sectional horizontal grate, the injection of pre-processed waste and rejects via spinning wheels and the sophisticated combustion air and re-circulation gas supplies.

2.1 Combustion chamber and fuel injection

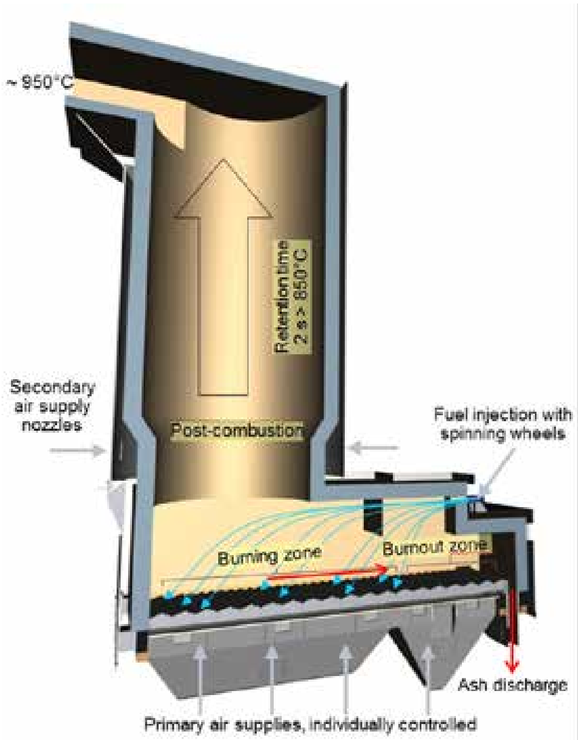

Figure 2: Combustion Chamber

Rejects are thrown into the combustion chamber by using the spinning wheel injection. The particles are spread evenly over the grate surface in the burning zone. During the flight phase fuel particles gets partly dried or are ignited and drop into an already glowing and burning bed with optimal burning conditions. This concept unifies elements of fluidized bed technology and grate technology. The combustion process takes place from top to bottom on the grate. The ash isolates the grate bars, therefore grate cooling with water is not required. Particles falling through the grate consist entirely of ash. Temperatures on the grate are uniform and significantly lower compared to conventional grate combustion.

The moving grate conveys the glowing fuel/ash layer reverse to the throwing direction of spinning wheels towards the burn-out and cool-down zone, where at its end ash drops into the extraction chute for automatic removal (see red arrows in Figure 2).

Figure 3: Moving grate with 2 lines

Basically combustion occurs in two-thirds of the grate area opposite to the fuel injection, where fuel particles are distributed. On one third of the grate area no fuel is dropped onto the fire bed in order that all combustible burns off and the ash cools down (see Figure 2). The two areas are supplied with different amounts of primary combustion air or mixture with re-circulation flue gas. To assure stable combustion conditions also for fuel with low heating values the combustion air can be preheated up to 200°C.

Secondary combustion air is added when flue gases enter the post-combustion zone. The secondary air flow is controlled to maintain set point of oxygen content in the flue gas. This oxidation zone is followed by an adiabatically operated combustion chamber without heat removal, which secures a 2 seconds retention time of flue gases above 850°C according to the Waste Incineration Directive regulations. This design further avoids formation of deposits within the combustion chamber and it creates an optimal environment for NOx reduction measures by the SNCR (Selective Non Catalytic Reduction) method. For temperature limitation re-circulated flue gas can be supplied into the post-combustion zone. Flue gases pass to the heat recovery boiler with temperatures around 950°C (operating range 850 – 1,050 °C).

The combustion chamber is equipped with one or two start-up gas burners, which can be used also as back-up firing to keep flue gas temperature above 850°C during operation.

2.2 Waste and rejects

Waste and rejects have to be pre-processed (shredded, limited contents of foreign matters like metals, glass, stones, etc.), with the advantage that combustion process is simplified and emissions peaks are significantly reduced compared to standard pushing grate technology.

Waste and reject mixtures within following characteristics can be treated:

- Lower heating value: 6.5 to 18 MJ/kg
- Water content: ≤ 45%
- Ash melting temperature: ≥ 1,050°C
- Particle sizes: ≤ 80 mm
- Sum of length+ width + height: ≤ 180 mm
- Ash content (dry substance): ≤ 35%

Deviations from these parameters are possible after review of overall conditions and possible design modifications.

2.3 Capacity range, steam boiler parameters

Standardized combustion units are available from 5 to 30 MW of thermal firing capacity with steam boilers from 15 to 80 bar operating pressure. The steam temperature depends on waste analysis, composition and on designated application.

3. REFERENCE PAPER INDUSTRY

The energy recovery boiler plant at SAICA PM11 site in Partington (near Manchester, UK) serves for thermal treatment of the residues from the cardboard making process and is designed in accordance with the requirements of the Waste Incineration Directive. The fuels are rejects from the stock preparation and sludge (fibrous sludge and bio sludge) from the effluent water treatment plant. The heat recovery boiler generates steam, which is used as process steam in the production. The plant can save up to 17,000,000 m³ of natural gas per year by energy recovering from the paper mills waste resources. The plant was started up in 2012 and shortly has successfully passed the performance and guarantee run.

3.1 Plant design figures and configuration

The combustion plant is designed for a continuous thermal firing capacity of 21.9 MW (24.1 MW max. peak load, 13 MW min. load).

Fuels:
Rejects: 35,000 t/a
design flow 4.5 t/h, LHV 12 MJ/kg, 55% dry substance (DS), ash in DS 11%; approximately 55% biomass content.
Sludge: 45,000 t/a
mixture: design flow 5.8 t/h, LHV 4.3 MJ/kg, water content < 50%, ash in DS 32%; 100% biomass.

The standard fuel mixture of reject and sludge is defined with a lower heating value of 7.7 MJ/kg.

Steam boiler parameters:
Steam output (maximum): 33 t/h saturated at 20 bar
Boiler design pressure: 30 bar, Feed water temp.: 130 °C

A SNCR Denox system reduces NOx levels and a flue gas treatment system with injection of lime and activated carbon serves for neutralization of acid gases. Dust is removed from flue gas by cyclones and fabric filters.

3.2 Operation data and experiences

During the one year reliability run period from 1st of March 2013 until 28th of February 2014 the ERB plant supplied more than 200,000 metric tons of steam to the cardboard mill by thermal treatment of about 22,000 tons of rejects and about 25,000 tons of sludge and saved more than 13 million m^3 of natural gas.
The system has proved its high flexibility regarding fuel mixture variations. The unit was operated from 100% reject as fuel to a ratio of 20% reject and 80% sludge.

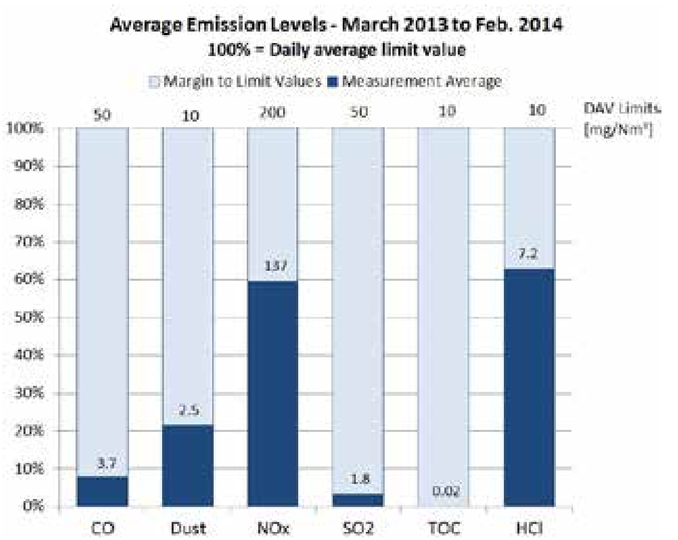

Figure 4: Emission measurement results

The continuous emission monitoring system measures and records the content of dust, CO, NOx, SO2, HCl and TOC in the stack (limits according to the European Waste Directive).

Starting with commissioning of the plant all emissions were within the limits. The emission measurement results of the one year reliability run period show that stack emissions are far below the limits (see Figure 4). The very low contents of CO and TOC prove the excellent combustion conditions of the system.

Other harmful substances in the stack flue gas like Dioxins, Furans, Hydrogen fluorides, Ammonia etc. are measured quarterly by an accredited MCERTS Testhouse. All test results fulfill the permit limits.

The electric power needs for plant operation are below 260 kW without consideration of fuel preparation and handling up to the storage silos.

3.3 Efficiency and availability figures

The heat provided by the fuel will be recovered into steam with an efficiency of 83 % under full load conditions and at a flue gas oxygen content of 6.0 %.
During the one year reliability test run the availability of the Reject to Power plant was higher than 97 %.

3.4 Economic aspects

The calculated payback period of investment costs is shorter than three years under consideration of site specific cost structures and estimated costs for civil works, fuel storage and handling, electric equipment and interface works executed by the customer himself.

4. SYSTEM CHARACTERISTICS AND BENEFITS

The combustion with spinning wheel system is a robust, reliable and best practice technology for medium sized units, which offers attractive investment and operation costs.

Energy is currently the second biggest cost factor in the recycled paper production with the highest lever for cost improvement. By using the caloric value of the waste we can produce a big portion of steam for free. Energy generation from sorting and process rejects, provides a considerable substitution and saving of fossil fuel as well as a reduction of greenhouse gas emissions and a significant reduction of landfill costs.

Injection of waste and rejects via spinning wheels provides advantages regarding

- uniform and low temperatures on entire grate
- air cooling of moving grate sufficient
- thin layer of ash, glow and fuel on grate
- minimizing of slag formation, no slag breakers required
- fine fuel particles combust during flight phase
- complete ash burnout, dry ash removal

The adiabatic combustion chamber avoids formation of deposits on chamber walls and presents an optimal condition for a SNCR Denox system.

The technology provides high flexibilities regarding fuels and its characteristics (heating value, water and ash content). The minimum firing load can be reduced down to 40% (depending on fuel). The thin layer and low amount of fuel on the grate allows quick load change reactions.

5. APPLICATIONS

The Reject to Power technology covers a high range from standard biomass to waste and rejects from the paper industry. Combustion tests with positive results have also been done with residues from biodiesel plants and household waste fractions.