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WASTE TO ENERGY

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INTRODUCTION

For centuries mankind has produced waste from its activities which have created an environmental load, one of which is the pollution from waste.

As industrialization has taken place worldwide the load on the environment has increased and today the environment's worst enemy is mankind. We produce globally more than 1 billion tons of waste per year.

Today we have to realize that the production of waste has to be minimized and the remaining waste to be treated in an environmentally safe way. For the present population on earth one could say that mankind's obligation is to preserve and improve the environment for the future generations.

One of the solutions for minimizing the waste in an environmentally safe and controllable way is waste incineration with energy production, on which subject I will elaborate further in the following.

SYSTEMS AND TECHNOLOGIES OF WASTE INCINERATION

Waste for incineration can be divided into four categories:

- Municipal waste
  - Efficient and environmentally safe systems for municipal solid waste treatment.
- Industrial waste
  - Handling and treatment of bulk material.
- Chemical waste
  - Environmentally safe treatment and incineration of hazardous wastes.
- Hospital waste
  - Biomedical waste handling, treatment, and incineration.

Ansaldo Vølund A/S is able to handle the above types of waste.

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Basically, the treatment systems for the above mentioned types of waste is built on the same principle. They all consist of a feeding system, furnace, heat recovery system and a flue gas treatment system.

The emphasis will in this session be put on the municipal and industrial waste incineration system.

Looking at the municipal and industrial incinerator the mechanical part of the waste-to-energy plants is composed of:

> Weigh bridge, travelling crane with grab, complete combustion furnace with combustion air equipment, energy recovery unit in the form of boilers, turbine/generator, flue gas cleaning equipment, induced draught fans and chimneys, ash handling equipment, instruments, controls and electrical equipment. In certain countries, HCl/NOx/NO_x removal equipment will also be required.

Buildingwise a plant is composed of three main parts:

> Waste silo, furnace hall and control room with offices and auxiliary equipment rooms.

The following is a general description of the function of the plant.

The waste is delivered to the plant i.e. by closed compactor trucks, open lorries, and containers which are being weighed on a weigh bridge for registration of the net weight of each truck before entering into the tipping hall.

Waste Bunker or Silo

The plant stores the waste in the silo until it can be handled. The silo volume is designed, taking into consideration the number of days of collection and the plant capacity per day.

Waste Crane

From the silo the waste is taken to the furnace by an overhead travelling crane equipped with a poly grab. The crane capacity is designed in order to allow for the necessary mixing of waste in the bunker before it is fed into the furnace.

The operation is carried out from a stationary closed crane operator's cabin situated with a clear view of the silo.

Feeding Hopper

The crane discharges the waste from the silo into the furnace. The hoppers lead the waste into the feeding chute.

Feeding Chute

The chute leads the waste to the first grate of the furnace which is constantly filled with waste during operation, thus creating tightness between the furnace, the combustion chamber, and the exterior atmosphere.

Grate

For combustion of waste Vølund uses its own well-known step grate where every second grate beam, which supports the actual combustion grates, is movable. This type of grate is characterized by:

- an effective transport capacity even of heterogeneous waste. No burn-through on the grate, as voids, if any, are immediately closed,
- an effective cooling of the grate. The grate has a large air-flow area and a long life,
- modest wearing of the grate block, resulting in low costs of maintenance,
- hydraulic, uncomplicated grate drives, enabling a variable length of grate stroke and continuous adjustment of the grate speed. An important advantage for automation of incineration plants.

The grates, and thus the movement of the waste, are actuated as follows:

1. The waste is pushed forward by means of the grate blocks mounted on the movable grate beam.
2. The waste resting on the actuated grate beam is lifted vertically as the propulsion is obtained by a pendulum movement.

By the forward movement of the grate beam, the waste on the stationary grate beam will be actuated by friction in the waste layer. This means that the entangled waste on the stationary grate beams will be less effective, i.e. it is transported slower than on the moveable grate beams. In this way ripping and ventilation of the waste are obtained.

The friction on the stationary grate beam is greatest when the waste layer is even. In case of light waste or burn-through, the waste is transported considerably fast. This is due to the lower friction. In this way a more uniform pressure drop across the grate is ensured.

It goes without saying that the lifting movement will break the waste layer and allow distribution of the combustion air through the whole waste layer, which results in the best possible conditions for drying, ignition and combustion.

The grate system can also be provided with the double movable grate system, where no beams are stationary.

Pressure drop across the grate construction

This subject is referred to in very different ways. It is obvious that different grate designs have different constructive characteristics and different operational techniques. But it is common for all grate designs that the primary air necessary for combustion is to be used for cooling of grate castings as well. Cooling is produced by blowing air at high velocity through a "small" air flow area, which involves a high pressure drop. Or at low velocity, which results in a sufficient cooling capacity and a low pressure drop.

The combustion air (primary air) must be introduced where the degasification and the combustion are. Degasification often takes place by means of preheated air up to 200EC in the fuel layer. The combustion on the surface of the fuel, like fluid-bed combustion, ensures an even mixture of the combustion material and the air.

Everything mentioned above regarding the primary air deals with the quality of the secondary air injection. We do however have to be realistic when discussing a theoretically distributed air volume over the entire grate surface.

In practice, waste is fed by the crane, 3 to 8 mè per grab of mixed waste, i.e. paper, leather, wool, polyethylene, PVC, rubber, carbon, etc. If we pick out two of these matters and consider them separately we find that the air requirement for paper and polyethylene respectively at a combustion temperature of 1,000EC is about 8 Nm^3/kg and 25 Nm^3/kg. In this connection, even distribution of air through the grate is of low importance.

For this reason ANSALDO VØLUND has developed an automatic controlled combustion system that ensures optimal combustion.

Primary air is injected under the grates in sections, typically 3 to 8 sections, where a flowmeter controls that the continuously calculated air volume is injected at the individual grate sections.

Today, this automatic grate control, which further comprises automatic control of secondary air as well as steam and water flow control etc., has been sufficiently tested, and DCS - Distributed Control System for all plant components, including flue gas cleaning, is handled by a computer and display stations without mechanical, i.e. relay-controlled, back-up.

Combustion Chamber

The combustion chamber serves to ensure the correct temperature conditions in the combustion zones thus getting the best possible outburning of the waste and the generated flue gas.

The combustion chamber is refractory-lined with the best choice of refractory qualities for the various zones of combustion.

Rotary Kiln

For further improvement of the quality of the bottom ash, a rotating refractory-lined furnace, the rotary kiln, can be installed.

After the last grate, the burning mass of waste slides into the rotary kiln, where the complete sintering takes place.

The rotating movement will ensure continuous oxidation of all particles in an effective burning process by tumbling and braking up the layer, thus ensuring complete burn-up of all particles.

The rotary kiln has the advantage that the retention time can be varied from short to long by increasing or decreasing the speed of the kiln so that even large, solid, difficult combustible parts are completely burned up, and a residue suitable for reuse after a simple sorting out of the scrap-iron pieces is obtained.

The rotary kiln plant can be built from approx. 6 tons of waste per hour to 20 tons of waste per hour. The capacity is typically in the area from 7 tons of waste per hour to 15 tons of waste per hour.

Afterburning Chamber

The flue gas from the rotary kiln and combustion chamber is led to a refractory-lined afterburning chamber. Waste being of variable composition, formation of zones with varying flue gas composition and temperature during incineration cannot be avoided, especially flue gases containing reducing atmosphere, i.e. flue gas which is not yet completely burned up. If this flue gas gets in contact with the heating surfaces of the succeeding boiler, it will quickly result in damage by corrosion. A simple supply of combustion does not solve the problem as the mixture will only take place when the air and the flue gas reach the same temperature.

The necessary afterburning combustion air (secondary air) is supplied to the combustion chamber, and the flue gas and the hot air are led to the afterburning chamber where an efficient mixing with the hot flue gases from the rotary kiln takes place, resulting in a complete burning up.

The danger of high temperature corrosion in the boiler is therefore reduced to its maximum limits.

Combustion Air

The combustion air necessary for the combustion of waste is admitted to the furnace in a primary and secondary air system, which is made as two independent, separate systems.

Through both systems with one forced draught fan in each the combustion air is drawn from the waste silo to maintain a subpressure, thus minimizing the odour nuisances from the stored waste. The primary air is led under the grates, passing evenly distributed over the entire grate area, and through the waste layer.

Preheating of Air

To stabilize the combustion and to ensure sufficiently high combustion temperatures, the fresh air can be, and is, pre-heated.

The preheating is carried out by using the steam produced in the boiler.

For difficult waste, oil burners are used for start-up and, when necessary, to maintain furnace temperature (above 850EC)

Boiler

The energy contained in the hot and burned-up flue gas produced in the furnace is led from the afterburning chamber to the boiler.

The flue gas is led into the first part of the boiler, the radiation part, at very low speed so that large dust particles contained in the flue gas fall back to the bottom of the afterburning chamber. The flue gas gives off part of its heat content to the large cooled wall surfaces. The lowered flue gas temperature thus reduces the risks of slag adherence on the succeeding convection surfaces. In the boiler the flue gas temperature is reduced from the inlet

950EC - 1,000EC to outlet 150EC - 210EC and the heat released is absorbed by the boiler transforming the water contained in the vessel to steam of high temperature and pressure.

Turbine/generator

The turbine/generator system is set to utilize the steam generated from the combustion of waste to generate electricity. Furthermore, it is normal to produce hot water for district heating, especially in the Nordic countries.

Flue Gas Cleaning

Each unit is equipped with a flue gas cleaning system, which is designed to meet the demands of the environmental authorities.

The flue gas is led from the boiler through a flue gas duct to the flue gas cleaning system. The plant can be equipped with advanced absorption systems, such as Dry, Semi-Dry and Wet Scrubbing Systems.

The complete burning out of the flue gases and their solids will allow for a more economical and effective flue gas cleaning.

The ANSALDO VØLUND system, properly operated with a temperature ranging about 1000EC, leaves only fractions of chlorinated hydrocarbons in the flue gases, thus eliminating a highly toxic component.

NO_x Control

All combustion processes will produce No_X in various amounts.

The strict controls of the temperature in the combustion zones cause a reduction in nitrogen oxides.

Incorporation of the ANSALDO VØLUND flue gas recirculation system of temperature control in combustion chamber reduces the emission of nitrogen oxides to a level accepted in most areas without installing deNO_X-equipment.

Fly Ash

The high content of incombustible matter in the waste is reflected in the high content of fly ash in the flue gases.

HCl Removal

The chemical composition of the waste is reflected in the composition of the flue gases.

Several components of the waste cause formation of hydroposition of the flue gases.

Several components of the waste cause formation of hydrochlorines in the flue gases, whereas a low sulphur content will only result in low levels of sulphur oxides. The emission of acid components will always be less per unit of energy produced by waste than when produced by oil or coal.

The acid components can be removed in several ways, mainly by neutralization by water, calcium solutions, or other base solutions. Today, several acid removal plants are in operation and a constantly increasing level of experience regarding availability, effectiveness, and economy is being built-up.

ANSALDO VØLUND can demonstrate reference plants incorporating various methods all integrated into the design concept of System Vølund.

Wet Flue Gas Cleaning Process

The most common method is the scrubber method, either operating by water or using a slurry of water and calcium. The temperature drops below the dew point of water. To avoid a visible plume, reheating of the flue gases in necessary. The residue from the scrubbing process is an acid liquid containing solids that has to undergo extensive treatment and solidification before being finally discharged to sewers and controlled landfills. The consumption of calcium is slightly above that of stoichiometric consumption.

Semi-dry Flue Gas Cleaning Process

In recent years the semi-dry method has been utilized more often. The calcium compound is suspended in limited amounts of water, allowing for full evaporation of the water, leaving only a solid residue in the flue gases mixed with fly ash. The remaining solids and fly ash are precipitated in an electrostatic precipitator or a baghouse filter. The consumption of calcium is slightly higher than with the scrubber method. The temperature level after treatment is 130 to 140EC, eliminating the necessity of reheating the flue gases.

Dry Flue Gas Cleaning Process

The dry process sprays calcium compounds in dry form into a reactor where they react with the acid gases to form solid reaction products. The precipitation of the solids takes place in the electrostatic precipitator or a baghouse filter.

This system operates with a small temperature drop, and no reheating of flue gases is necessary. The small drop in temperature allows for a better overall energy efficiency, which could compensate for the considerably higher consumption of calcium.

Flue Gas Fan

Immediately after the flue gas cleaning system an induced draught fan connects the flue gas cleaning system to the succeeding chimney.

The task of the I.D. fan is to draw the produced flue gases through the system, and to maintain a negative pressure in the combustion chamber.

Clinker and Ash Handling (Residue)

Today 3 different systems for discharge of clinker are used.

Dry Clinker Discharge

"Dry" clinker discharge by means of clinker pusher. In this system the clinker in the chute forms a seal to the furnace room. The clinker is then transported into a container by means of a pusher or into a conveying system which is humidified by means of water nozzles and then disposed of.

When this system operates with dry clinker instead of wet clinker in the pusher it is because of the fact that the wearing of the bottom plate is considerably less than by wet clinker which wears much at the bottom plate.

The clinker pusher cannot be used in a rotary kiln plant, as the clinker from the rotary kiln has a higher temperature, 800-900EC and a melting together of the clinker in the chute cannot be avoided.

Please note that the burnout is still going on in the clinker chute. This improves the degree of burnout.

Apron Conveyor

ANSALDO VØLUND has its own construction which is tested, i.e. used in both grate plants and rotary kilns. The system consists of an apron conveyor submerged into a water trough. Thus sealing to the furnace room is secured.

The system is very reliable and the maintenance and the expenses are very low.

With this construction the apron conveyors have been in operation for more than ten years and no lamellas and chains have been changed.

The system is suited for feeding on apron or vibrating conveyor.

As conveying system vibrating conveyors are preferred, as these have no waste of water and clinker. This means that the floors are easy to keep clean.

Removal of Clinker

For removal of clinker a container could be a solution, as 2 or 3 containers can be placed at the outlet of the conveying system and filled one by one, as a discharge conveyor can be swung from one container to another. Besides, it is possible with an adjustable conveyor or a vibrating conveyor to have an even filling of the container, as the conveyor can be swung into different positions over the container.

Clinker silo with clinker crane is the commonly used solution in large plants. Here the clinker can easily be stored during holidays and the silo can be equipped with clinker sorting systems.

Chimney

The clean flue gas is led out into the open through a high-insulated steel chimney.

The height of the chimney ensures that a proper emission value is obtained.

Control of Operation

From the control room all parts of the plant can be operated by remote control, and all operational data of importance can be monitored and recorded according to requirements. During the start-up or shut-down of the plant, all components are activated according to a system of interlockings in order to ensure the safest possible operation and to protect each component against damage.

Control System

The combustion process is automatically regulated and controlled to achieve a constant and optimal burn-out of both residue and flue gases. Through automatic control of the amount and the distribution of combustion air, the plant operates with the lowest possible surplus of air.

The varying compositions and heat values of the waste call for special attention to the control system. Depending on the demands on each facility, various levels of automatic control systems can be applied.

Remote visual control of feeding, combustion, and other plant functions takes place through TV-cameras placed at key points with monitors in the control room.

Speed of the rotary kiln and the grate movement is controlled simultaneously by continuously variable regulation of the hydraulic oil flow.

For the complete combustion of any combustible particle, three parameters must be met: Time, Temperature, and Turbulence. Waste-to-energy plants must meet these conditions in order to obtain complete combustion.

Computer Control

Computer-based regulation, control and recording systems allow for automatic printing of operation and alarm reports; performance of analyses and calculations to give the operational management a proper basis for optimization of the plant operation; along with an up-to-date picture of the important operational, such as:

- total amount of waste treated
- produced power
- total electricity consumption
- thermal efficiency
- calorific values
- etc.

The computer-based system furthermore gives access to rapid changes or adaptation in the controlling parameters, minimizing the effect of major changes in the waste composition. The possibility of combining corresponding trend curves and process pictures on a colour screen draws a clear picture of the operation in any phase of operation, allowing resolute actions to be taken in accordance with any unexpected conditions of operation.