1. Introduction

Waste incineration is a widely used solution for simultaneously reduce the waste final disposal problem and at the same time create added value in the form of energy, normally steam and/or electricity. This business model is one type of what nowadays is known as “waste valorization”.

The process consists typically in feeding mixed waste on a burning chamber which consists of movable parts from underneath so that as new waste comes in from one side the burned residues can be rejected on the other side. These movable parts can be grates made of alternate sliding perforated devices or cylindrical rolls, arranged either in horizontal position, sloped or even other forms depending on the design. There also hospital waste incinerators, which need to be enclosed due to hazardous materials. One possible design is a rotating drum slightly sloped.

The main air supply, named primary air, is responsible to supply oxygen for the first combustion zone, where the burning mass lays. Right above the flame area, a second stream of air – secondary air – is injected in order to burn to completion hazardous by-products of the first rough combustion section, as well as in order to control excess oxygen and keep CO emissions under control. Unlikely in gas or oil combustion processes, where excess oxygen is low, in waste incinerators the excess oxygen is kept between 6.5-9.0% mainly in order to ensure total combustion of undesired by-products.

The storage time on the incinerators sites favours waste decomposition reactions, water evaporation and it also changes the apparent density of the waste due to compression caused by its own weight. These effects are visible during weekend and public holidays operation when most of the domestic waste collection stops. All those factors affects the combustion process in a predictable way, however barely not possible to be quantified.

It is interesting to note that, unlikely nearly all other combustion processes where efficiency is the key to minimize costs with fuel, waste incinerators are typically paid to process waste.

The hot flue gases are used as heat source in steam coils to generate high-pressure steam, which is either exported to other industrial customers in the area and/or used to move a steam turbine and generate electricity. Given the current revenues for electrical power sales and the amount of investment needed both in equipment and fuel on clients side in order for them to have their own steam generator, steam customers currently offer a better financial return to waste incinerators. For this reason, nowadays the steam turbines typically levels out the steam mass and energy balances, producing electricity with the supplementary steam not taken by steam clients.

As a result of the various components present on mixed waste, the flue gas treatment section in waste incinerators is remarkable when compared to the whole process. Right after exchanging heat with steam generator and economizers, flue gases are subjected to a particle removal system consisting of an electrostatic filter followed by a bag filter with sodium bicarbonate injection in between for SOx, HCl and fluoride abatement. Free of particles, the flue gases passes through a de-NOx module with NH_3 in order to convert NOx components into H_2O and N_2. Due to the high pressure drop through all these systems, typically a draft fan finally takes the treated flue gases out at the stack.

The solid residues collected right after the incineration are normally used as filling material for pavements after being separated of valuable metals. Ashes from the electrolytic filter are current not recyclable and are disposed in landfill sites after treatment. The fine ashes contains several inorganic salts in reasonable amounts and are sent to recovery in specialized companies.

A general overview of a waste incinerator plant is shown in Figure 1.

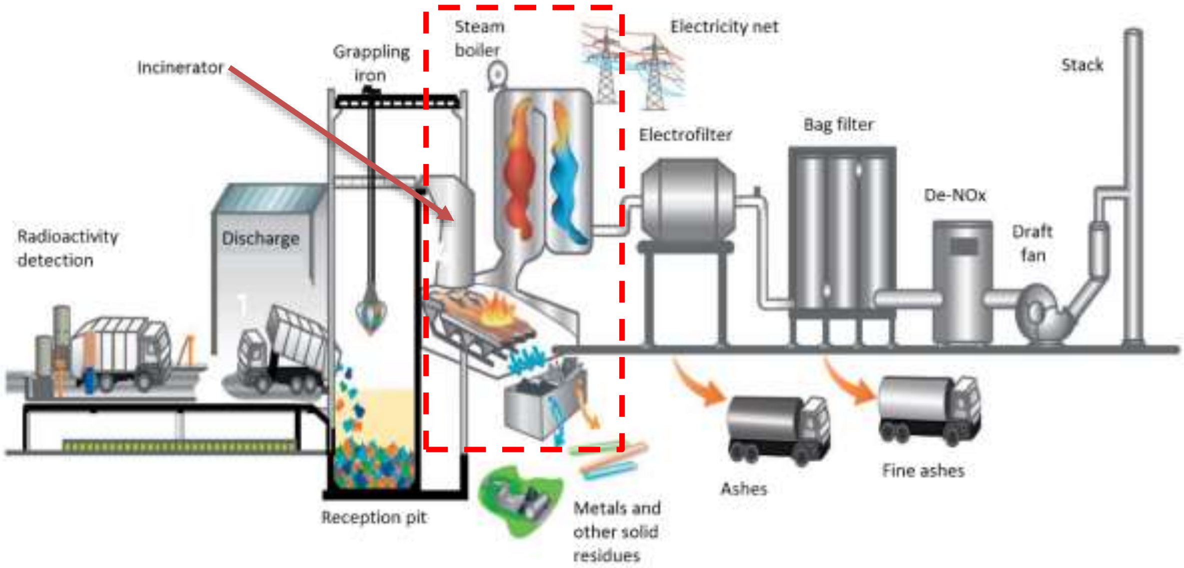

Figure 1 – Waste incineration plant overview

2. The Control Challenge

The main problem in the waste incineration process is related to uncertainty and variations on the quality of the waste to be burned. Not only intrinsic factors such as type of materials can significantly change the calorific power of the waste mass but also external factors such as weather conditions can cause the waste to change dramatically – wet waste when there are long events of rain, for instance. In one incinerator located in the north of France, the calorific power is expected to be around 2000 kcal/kg with expected variations up to ±30%.

In order to achieve stable and smooth combustion, it is important to control waste feeding speed and the pace of the moving burning mass so that an uniform cushion of burning material is kept along the burning path. Adjusting the feeding and the pace typically involves numerous PID controllers and several adjustable parameters related to cyclic moves of the movable parts of an incinerators such as their displacement speed, position at begin and end of the sliding course, cycle pauses, sequence order, and so forth.

Stable differential pressure through the burning material layer is one indication that the cushion is uniform, although other parameters such as primary and secondary air have also an influence on this pressure drop threshold. Also different drop pressure measurement points along the combustion layer can indicate how uniform this layer is.

Due to the typical high excess of air and considering the nominal air to waste ratio defined by design, reducing air inflow to the incinerator tends to bring combustion temperature up due to the reduction of low enthalpy streams to the system. However, if the burning material layer is too packed, eventually there will be lack of oxygen and in this case air flow needs to be increased instead to keep the combustion temperature. At the same time, eventually a too packed burning waste bed will create so much pressure drop that air will no longer flow through the bed but around it. In this case excess oxygen will suggest that there is too much air, but in fact it can be due to excessive feeding.

For all of these reasons, but not limited to them, steam production in a waste incinerator boiler suffers of typical flow variations which easily exceeds 10% (Figure 2):

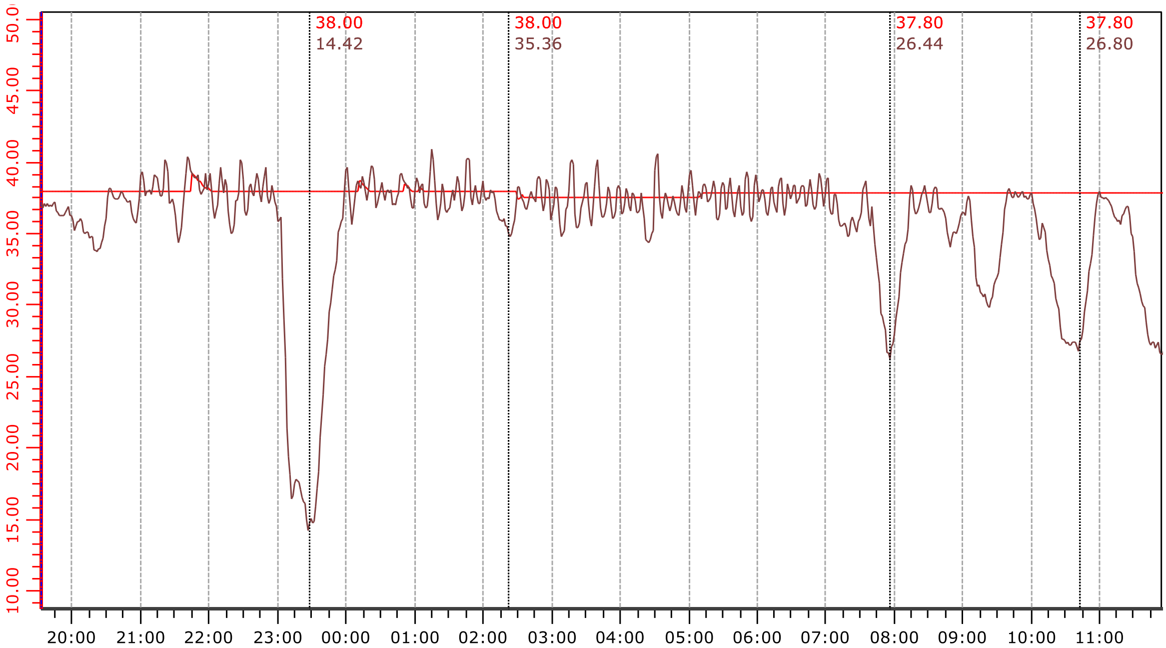

Figure 2 – Typical steam production variation on a waste incinerator boiler compared to the steam flow set-point

3. Baselayer Assessment Initial Results

To the date of publication of this case study, the baselayer assessment and control strategy studies were still ongoing on this client's site. Up to this moment, a full PID tuning assessment has already been carried over on the feeding and grates speed controllers. Moreover, the trimming air coefficient control strategy has been changed and feeders speed are used as a function of combustion conditions. Although on this specific client site there are 2 identical trains, IPCOS has assessed only one of them in order to validate results of all implemented tuning and changes. Figure 3 shows the line performance of the two trains together by meaning of steam production: the red set-point and steam flow curves corresponds to the train assessed by IPCOS whereas the blue curves represent the other identical train.

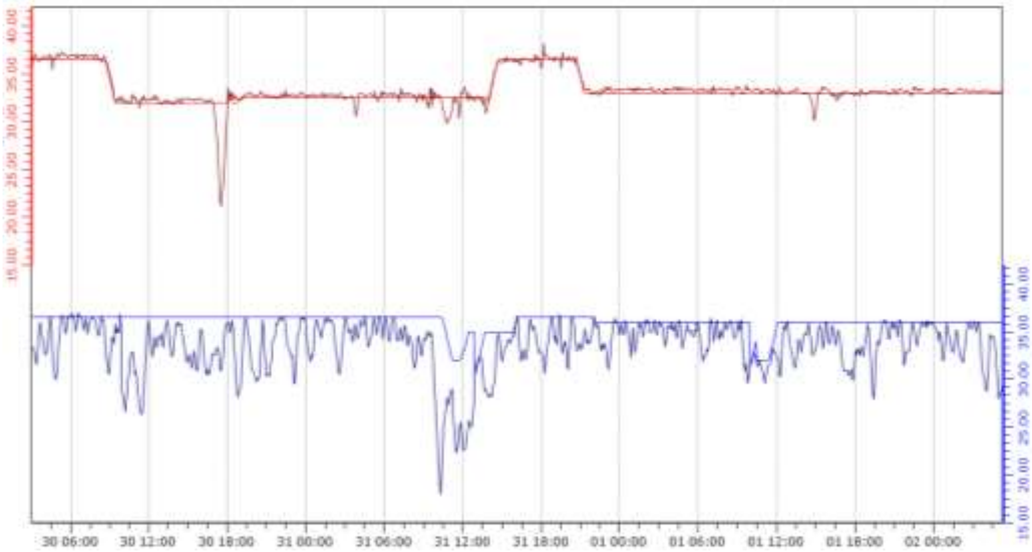

Figure 3 – Steam production after IPCOS assessment on waste incinerator (red) vs. identical boiler not yet assessed (blue)

4. Conclusion

Waste incineration is a widely used solution for simultaneously reduce the waste final disposal problem and at the same time create added value in the form of energy, normally steam and/or electricity. This business model is one type of what nowadays is known as waste valorization.

The main problem in the waste incineration process is related to uncertainty and variations on the quality of the waste to be burned, not only due to intrinsic factors but also external factors such as weather conditions and logistic factors as storage time before incineration.

As a control problem, the principle challenge is early detection and correct reaction to the disturbances introduced in the combustion process by the waste changeable quality. Tight control of feeding and waste displacement devices within the combustion are fundamental.

The base-layer control assessment carried out by IPCOS to the current stage already allowed the client to operate the steam generator more stably, which not only increase steam delivery at a higher rate but also saves treatment chemicals and reduces material stress due to large variations on the combustion side.

--- Images and source data gently supplied by Suez Environment Oréade site ---