

## Chapter XIII

# Innovative Control Methods in Waste Management

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*Presently waste incineration is one of the most commonly used techniques for residual waste processing. It is an important step of making inert and compacting the waste before disposal. More strict legal regulations for the reduction of emissions requires the improvement of existing process control. This chapter presents several methods and approaches to improve the current status of process control systems, especially the application of machine intelligence methods. These methods comprise Neural Networks, Fuzzy Control and Machine Learning techniques.*

## WASTE MANAGEMENT BY THERMAL WASTE TREATMENT

Every manufacturing process affects the environment by consumption of resources and production of by-products and final products (waste). First approaches to tackle this by prescription of environmental laws were not sufficient with regard to an ecological point of view. Usually economical limits prevent a view beyond the production process. However, only comprehensive analysis of the stages of the lifecycle of a product leads to environmental impact statements.

In this context the notion of lifecycle suggests a complete recycling of by-products. In most cases this aim is not achievable and hence disposal of residuals is still inevitable.

Thermal waste treatment represents an important processing step for compacting of residuals before storage, or as a preprocessing step for recycling. The objectives of optimising the design and operation of solid waste incineration plants lie in the continuous generation of steam and heat, in minimum pollutant emissions, and optimum burnout.

Waste incineration inertizes the waste, and fluent pollutants rise as flue dust and flue gas. These pollutants have to be concentrated before disposal. This is linked with a high technical and financial effort.

*Table 1. Primary and Secondary Measures for NO<sub>x</sub> Reduction.*

<b>Primary Measures</b>		
Measures	Potential of improvement	Technical Progress
Homogenizing of the burning material	up to 20%	state of the art
Redirection of flue gas	up to 20%	state of the art
Sophisticated dosage of primary air	up to 20%	state of the art
<b>Secondary Measures</b>		
Measures	Potential of improvement	Technical Progress
Selective noncatalytic reduction (SCNR)	up to 80%	state of the art
Selective catalytic reduction (SCR)	up to 90%	state of the art
Charcoal treatment	up to 60%	test phase
Wet scrubbing	up to 70%	test phase

In addition to the so-called secondary measures of the cleaning of the flue gas, appropriate measures can reduce the arising of such pollutants (primary measures). Table 1 shows the potential of improvement of various primary and secondary measures for the reduction of NO<sub>x</sub> (Thome-Kozmiensky, 1994).

Most materials are very heterogeneous with respect to their calorific value, composition, and component size. This causes fluctuations in the ignition and combustion behaviour of solid waste, in furnace temperature, heat release, steam generation, and in pollutant concentrations in the untreated flue gas. The composition of the material to be incinerated cannot be measured. Consequently, control based on a detailed combustion technology model is not feasible, and the standard measurements obtained don't allow optimum control. The use of innovative information technologies of computational intelligence as described below, such as fuzzy control, neural networks, imaging processes, and machine learning, in controlling solid waste incineration plants greatly improve process management.

## **FUZZY CONTROL FOR OPTIMISING THE BURN OUT**

A video camera based control system for enhancement of burn out properties of waste was developed at the Institute for Applied Computer Science of the Forschungszentrum Karlsruhe (Keller and Albert, 1997; Kugele et al., 1993).

During the incineration process waste is moved on a grid and passes zones 1-2, the main combustion zone and zones 3-4, the burn out zone. These zones can be controlled individually by air supply and grid velocity. Each zone is divided into two segments horizontally.

The system's structure is shown in Figure 1. The camera monitors and produces a perspective image of the burn out zones for further evaluation. The evaluation tasks are performed on a standard personal computer. Within one evaluation cycle the following operations are performed:

- Image retrieval
- Image processing
- Computation of control values

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