EXPERIMENTAL RESULTS OF FLAMELESS TECHNOLOGY FOR ZERO RESETTING OF DIOXINS IN THE PRODUCTS OF COMBUSTION ITEA - ISOTHERM PROCESS

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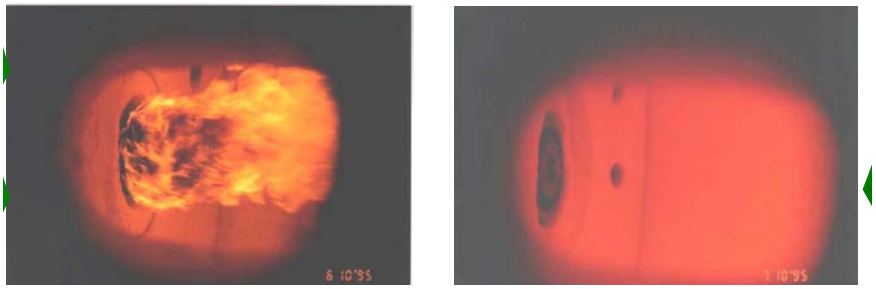
Abstract
The flameless technology realized by Itea on the Isotherm plant of Gioia del Colle (Bari) concerns a process of flameless oxidation with oxygen at elevated temperatures (1600-1700°C), in a pressurized reactor, with more than 2 second of residence time, aimed at guaranteeing uniform temperature conditions in the whole reactor. The process is expected to realize the complete oxidation of the waste organic substances, assuring the absence of TOC (Total organic carbon), dioxins, furans, PAH, fine particulate. The whole waste inorganic substances (incombustible) are liquefied directly in the reactor and solidified in glassy phase before being drawn out from the plant. The process is expected to assure energetic recovery from different typologies of residues, dangerous and not, as, for example, petrochemical and pharmaceutical by-products.

Introduction
A novel [1] [2] combustion process, performing flameless oxy-combustion of any kind of combustible (gaseous, liquid, solid) in a pressurized reactor, is expected to bring down to the analytical limit both PCDDs/PCDFs, HPA, and particulate, releasing a CO_2 concentrated offgas only. . The process has been implemented at 5 MW thermal demonstration scale, with fully automated control, in a simple and ultra-compact (30m x 30m) hardware. The industrial application is in progress (15 MWth unit onstream January 2008, at Jurong Island-Singapore)

Materials and Methods
The ISOTHERM technology is expected to realize the treatment of special wastes with or without organic contents. The treatment of wastes occurs in an iso-thermal reactor in which an extremely fast chemical reaction of oxidation of the fuels (wastes) takes place, with oxygen, at temperatures of 1600 - 1700° C (temperature of the gases in the reactor) and 4 bar absolute pressure.
The isotermicity in the reactor is obtained by the massive presence of triatomic gases, as CO_2 and H_2O, recycled pressurized in to reactor as thermal regulator. In fact , Isotherm PWR® takes advantage of the characteristic behaviour of these triatomic gases to be strong absorber and emitter in the infrared field, thus letting the heat of combustion being almost entirely transmitted into the reaction chamber by irradiation. It is assumed to determine a homogeneous temperature profile in entire reactor. Therefore, in the aforesaid combustion, there is no forehead flame. The distribution of the fuel and the others components is uniform and the reaction spreads uniformly in the whole reactor what occurs is the so-called volume reaction, that represents the optimal condition to prevent the formation of the dioxins and the furans precursors.
This peculiarity, combined to the thermal level of exercise of the reactor, characterizes a type of combustion named "flameless."
The difference among a standard combustion and a flameless combustion is shown in Figure 1.

Figure 1: Comparison between Standard Combustion and flameless Oxidation



Among the positive effects of the flameless combustion are to be expected: the absence of temperature differences inside the combustion room chamber, the complete combustion of all the combustible substances that are present in the combustion room chamber thanks to residence times higher than 2 seconds (HPA<1ppm), the liquefaction of large quantities of incombustible (from the reactor only small quantities of dusts escape together with the products of combustion) and the absence of nano dusts.
In the ISOTHERM plant, the temperature differences that are the principal cause of the formation of precursors of dioxins and furans in the traditional combustion reactions are not expected.
In the ISOTHERM plant the constant profile of temperature (1600- 1700°C) in the whole room chamber of reaction and the combustion without flame is expected to determine:

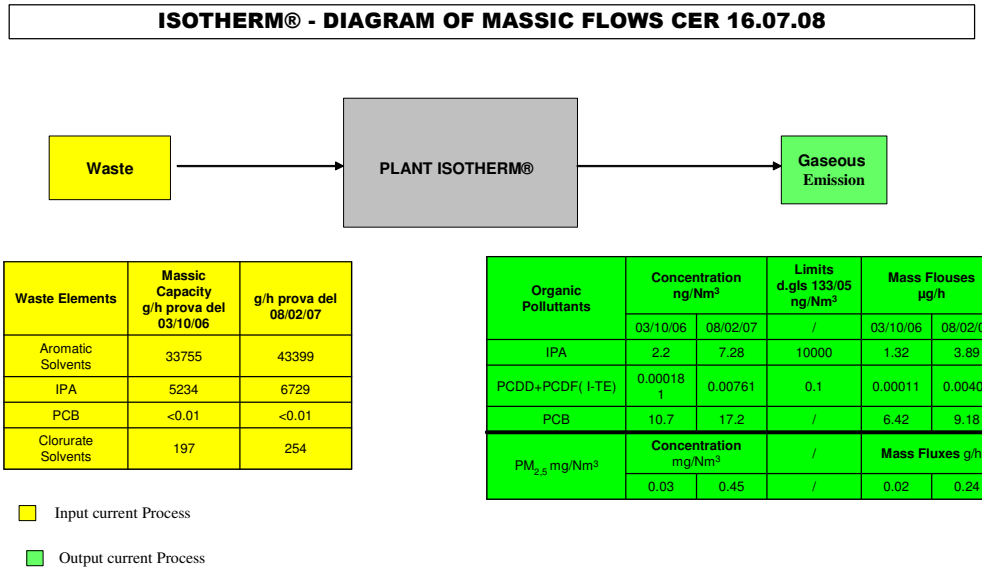
1. the complete destruction of precursors of dioxins, furans and PAH, all the organic fuels are brought back to simple and inactive compound as the carbonic anhydride and the water, without toxic by-products;
2. the possible presence of ashes is exclusively due to the contained incombustible substances the waste. The ashes are processed by a quantitative liquefaction and deposit at the fund of the reactor, and are extracted already in vetrified form (inactive);
3. nano dusts are minimized, on the contrary they are present in all the combustions with flame.

Currently the experimentation is in progress on a prototype plant installed inside the Ansaldo Caldaie establishment of Gioia del Colle (BA) - Italy, patented by the society ITEA S.p.A. of the Sofinter group. Said plant has a potentiality of 5 thermal MW.
Another important peculiarity of this technology lies in the elevated output of the energetic recovery, the 30% threshold is overcome, compared to 12-15% of traditional technologies, with the same quantiy of treated waste with presence of organic substances.

Results and Discussion

After having tested the plant with traditional combustibles (gas-oil, fuel oil, coal and olive-derived heavy oil), two experimental sessions are performed on special waste containing dangerous organic substances.
The monitoring of the emissions, during the execution of the experimental tests, has been performed as foreseen by the method UNI EN 1948/1999 part 1.
In the following schemes, represented in Figure 2 and 3, data related to the plant pollutants in input and output monitored during the two experimental sessions are reported.

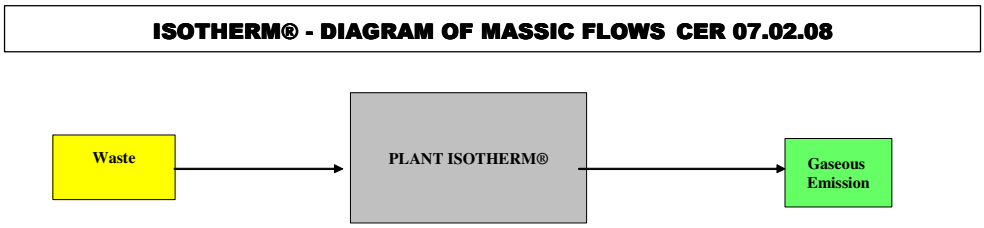
Figure 2: Scheme of the Flows of Mass. test with Refusal CER 16.07.08



Waste Elements	Massic Capacity g/h prova del 03/10/06	g/h prova del 08/02/07
Aromatic Solvents	33755	43399
IPA	5234	6729
PCB	<0.01	<0.01
Clorurate Solvents	197	254

Organic Polluttants	Concentration ng/Nm³		Limits d.gls 133/05 ng/Nm³	Mass Flouses µg/h	
	03/10/06	08/02/07	/	03/10/06	08/02/07
IPA	2.2	7.28	10000	1.32	3.89
PCDD+PCDF(I-TE)	0.000181	0.00761	0.1	0.00011	0.00401
PCB	10.7	17.2	/	6.42	9.18
$PM_{2.5}$ mg/Nm³	Concentration mg/Nm³		/	Mass Fluxes g/h	
	0.03	0.45	/	0.02	0.24

Figure 3: Scheme of the Flows of Mass. test with Refusal CER 07.02.08



Waste Elements	Massic Capacity g/h prova del 06/02/07	Massic Capacity g/h prova del 07/02/07
Aromatic Solvents	15326	19157
IPA	0.7	0.8
PCB	<0.01	<0.01
Solventi clorurati	1371	1702

Input current Process

Output current Process

Organic Polluttants	Concentration ng/Nm³		Limits d.gls 133/05 ng/Nm³	Massic Flouxes µg/h	
	06/02/07	07/02/07	/	06/02/07	07/02/07
IPA	1.19	3.28	10000	0.47	1.67
PCDD+PCDF(I-TE)	0.00069	0.00059	0.1	0.00027	0.00030
PCB	4.62	13.1	/	1.82	7.07
$PM_{2.5}$ mg/Nm³	Concentrazione in mg/Nm³		/	Flussi di massa in g/h	
	0.35	0.34	/	0.14	0.18

From the examination of the analytical results it can be concluded that the Isotherm process minimizes the emission of PCDDs/PCDFs, POAHs and HAP.

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