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BRICK FURNANCES – HOFFMAN TYPE: TECHNICAL FEASIBILITY OF INCINERATING MUNICIPAL SOLID WASTES (MSW)

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BIOENERGY - I

From Concept to Commercial Processes

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- Faculty of Engineering - Universidad de los Andes - Bogotá – Colombia
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- COLCIENCIAS
- INAMCO LTDA

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VIEW OF TIPICAL DISPOSAL GARBAGE PLACE IN MANY ZONES IN COLOMBIA

Some cities In Colombia use landfills to waste disposal but is necesary become to use other options.

TIPICAL TREATMENT OPTIONS TO MUNICIPA SOLID WASTES (MSW)

Alternative	*Descriptión*	*Advantages*	*Disadvantages*
Aerobic/Anaerobic Digestion	Is efficient to allow the natural degradation of organic wastes	▪ Gas generation and/or fertilize material are produced	▪ Its aplication is only possible to organic material.
Landfills	Is a controlled form de un terreno para el depósito de desechos clasificados	▪ Can be used in many kinds of wastes within previous treatment.	▪ Larger terrain areas is demmand. ▪ Gases and leaching control is mandatory. ▪ Operation is expensive.
Incineration	Is a termic destruction of wastes in oxigen presence and high temperature.	▪ Drastic volume reduction. ▪ Convenient to medical and industrial wastes. ▪ Recovery Energy is possible. ▪ No need larger areas.	▪ High initial investments. ▪ High Emission control efficiencies are necesary. ▪ Uncontrolled emisions are high risk. ▪ Operation and monitoring are expensive.
3R	Reduce, Reuse and/or Recycling of wastes.	▪ Environmentally Friendly.	▪ Limited to some kind of wastes. ▪ Economically could be unpractical and expensive.

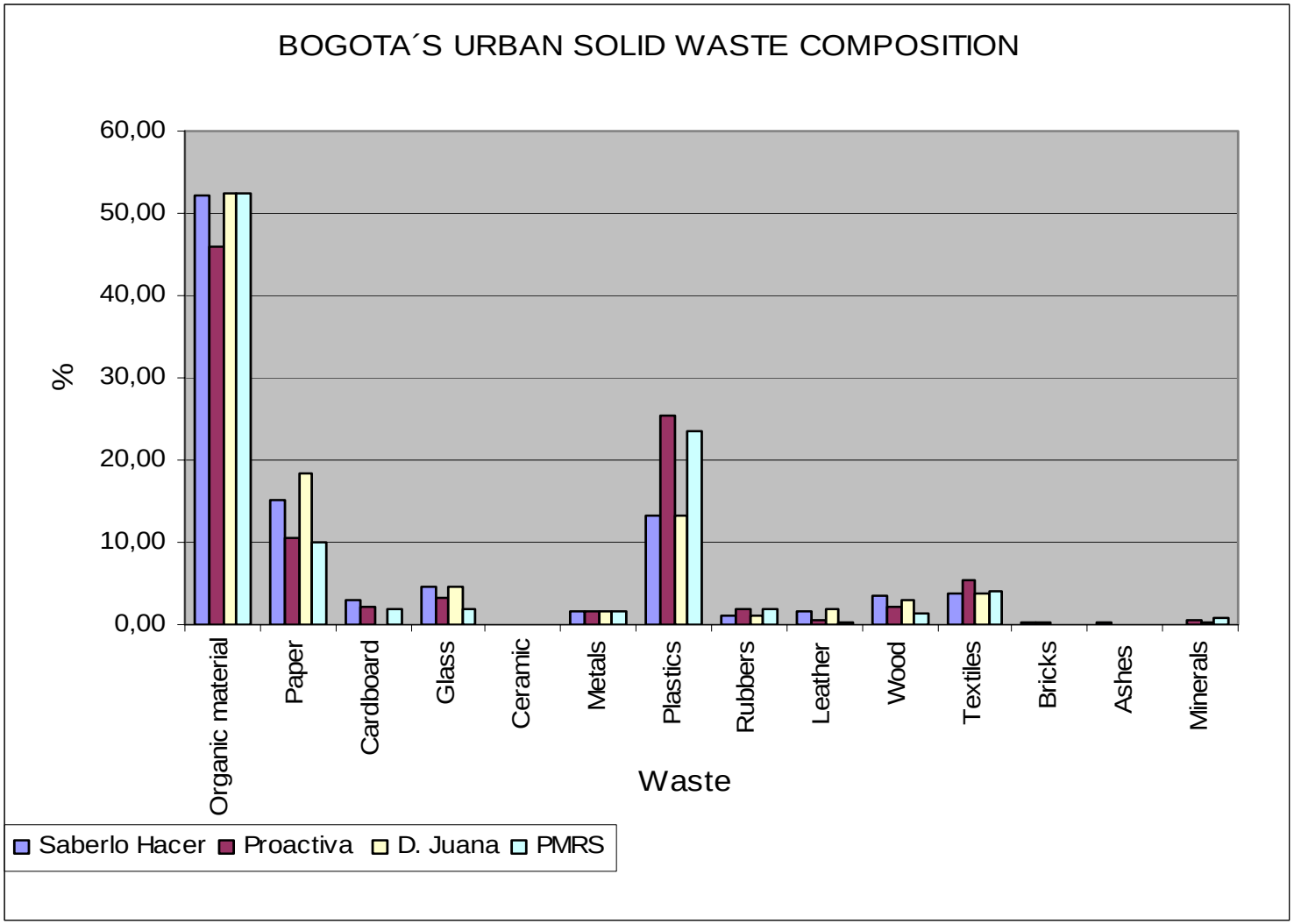
Perhaphs theirs disadvantages, the MSWI, could be the best option to MSW treatment because destroy and minimize the waste to disposal.

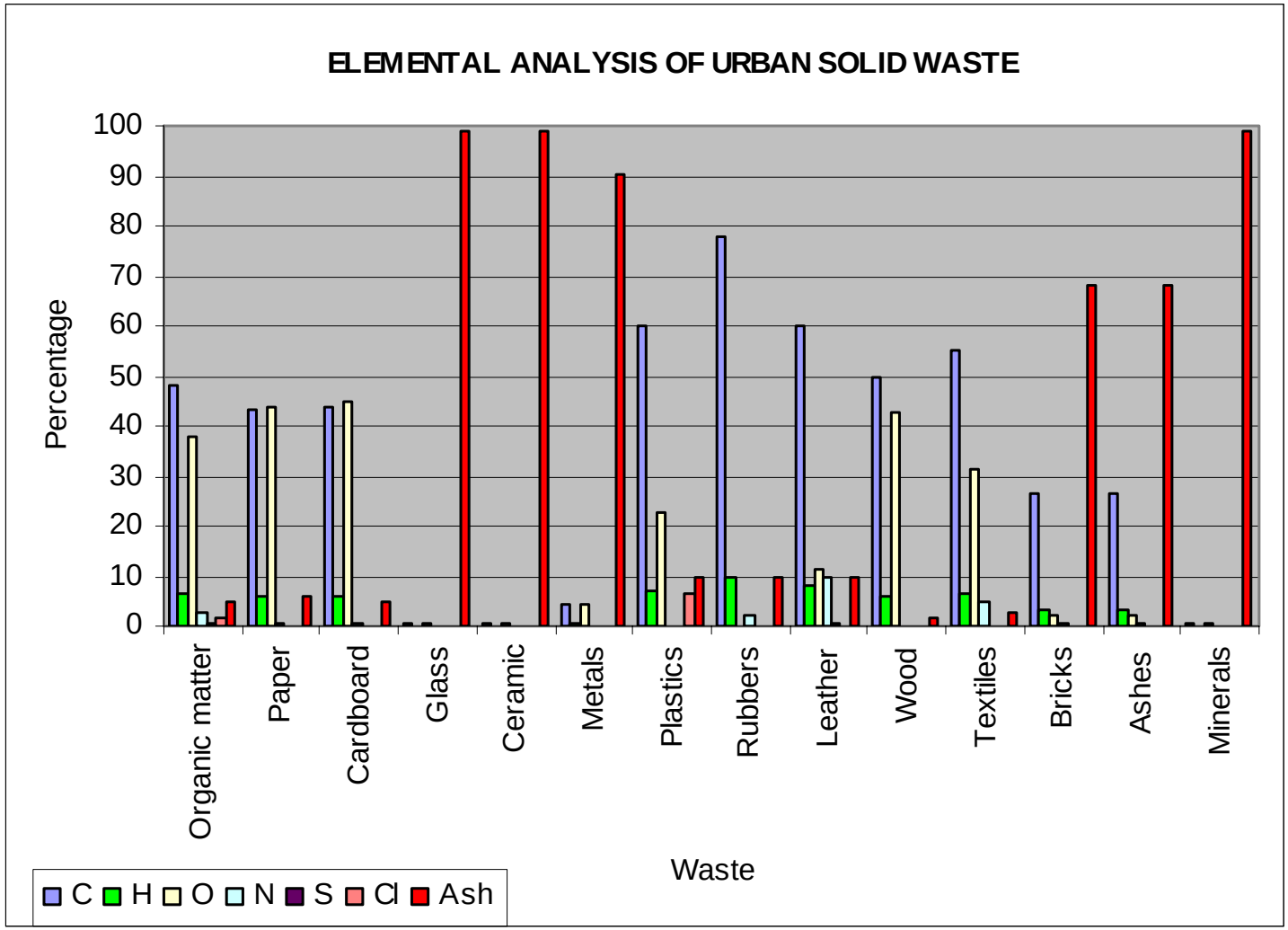
URBAN SOLID WASTE CHARACTERISTICS IN BOGOTA COLOMBIA

(Per each 100 kg)

Characteristic	E MINISTRY	LANDFILL OPERATOR	OTHER	UNIANDES	Average
Volatile material (kg)	44.54	50.87	44.42	48.23	**47.02**
Moisture (kg)	39.20	34.62	39.32	38.76	**37.98**
Dry weight (kg)	60.79	65.38	60.68	61.22	**62.02**
Fixed carbon (kg)	5.12	4.65	4.97	4.43	**4.79**
No Combustible (kg)	10.43	9.60	10.73	8.50	**9.82**
Heat Power (kcal/kg)	2,775.60	3,448.38	2,770.62	3,238.69	**2,933.32**

Characterization of MSW composition




ELEMENTAL ANALYSIS OF URBAN SOLID WASTE
Percentage
100
90
80
70
60
50
40
30
20
10
0
Organic matter
Paper
Cardboard
Glass
Ceramic
Metals
Plastics
Rubbers
Leather
Wood
Textiles
Bricks
Ashes
Minerals
Waste
C
H
O
N
S
Cl
Ash

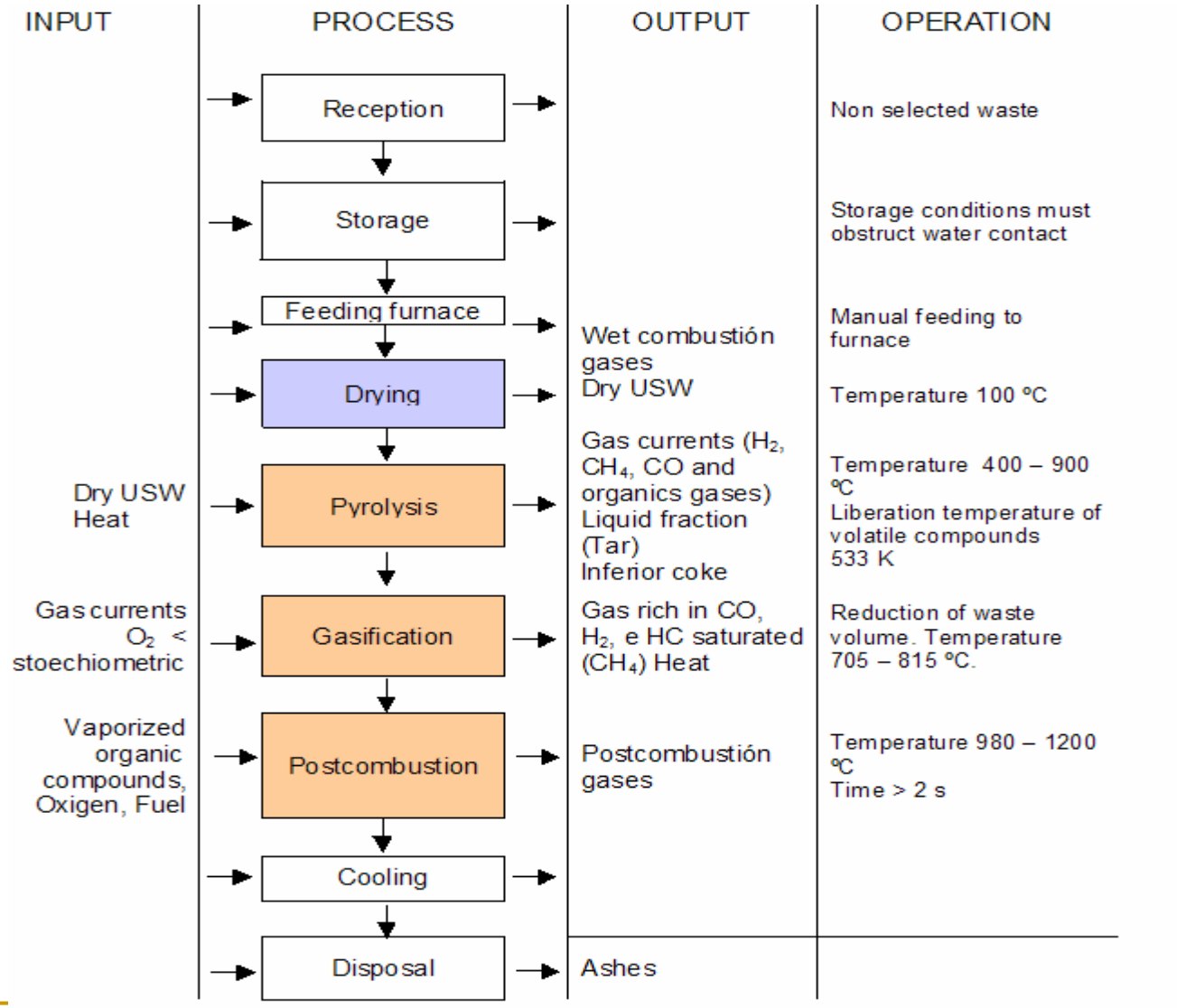
PROPOSED PROBLEM

- High moisture waste incineration is a technological challenge, due to the great fuel requirements for making the process viable.

- The problems to be solved are:
  - High costs of fuel
  - High levels of pollutant emissions
  - Adequate final disposal of ashes
  - To obtain reliable and representative information about wastes

The combustion process carried out in brick manufacturing furnaces is similar to the incineration process and it allows heat reuse.

CHARACTERISTICS OF SOLID WASTE INCINERATION PROCESS



TECHNICAL REQUIREMENTS OR CONTROL VARIABLES NEEDED TO DESTROY WASTES IN AN INCINERATOR

(*Brunner 1993, Mckay 2001*)

Temperature:	In combustion chamber 850 ºC, In postcombustion chamber 1200 ºC.
Time:	Residence postcombustion chamber 2 seconds
Turbulence:	Expresed as Reynolds number **Re** > 10000 (50000); (Re = v*De/υ)
% O_2:	>6 % v/v

INCINERATION PROCESS RESIDUES

EMISSIONS	• **Particulate Matter**	**PM**
	• **Sulfur oxides**	**SOx**
	• **Carbon monoxide**	**CO**
	• **Nitrogen oxides**	**NOx**
	• **Heavy metals**	**HM**
	• **Dioxins and furans**	**PCDD/Fs**
	• **Halogenated acids**	**HA**
	• **Incomplete combustion products**	**ICP's**
	• **Volatile organic compounds VOCs**	**VOC's**

SOLID WASTE

- **Bottom ashes**
- **Volatile ashes**

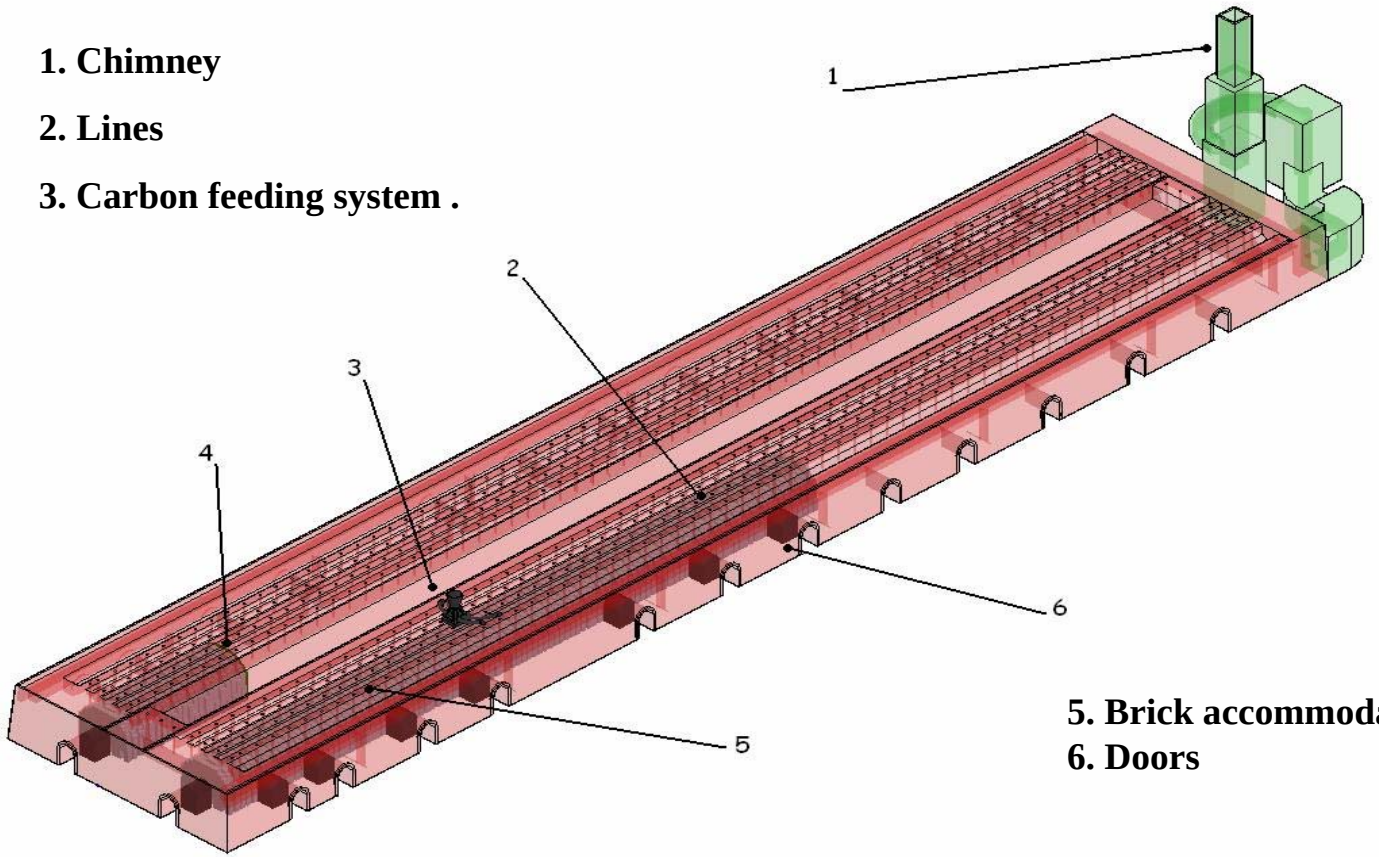
Waste incineration requires a technology with appropiate conditions of temperature, oxidant fluxes and residence times to eliminate toxic compounds. Also, it should have an emissions control system.

CHARACTERISTICS OF A HOFFMAN FURNACE

1. Chimney

2. Lines

3. Carbon feeding system .

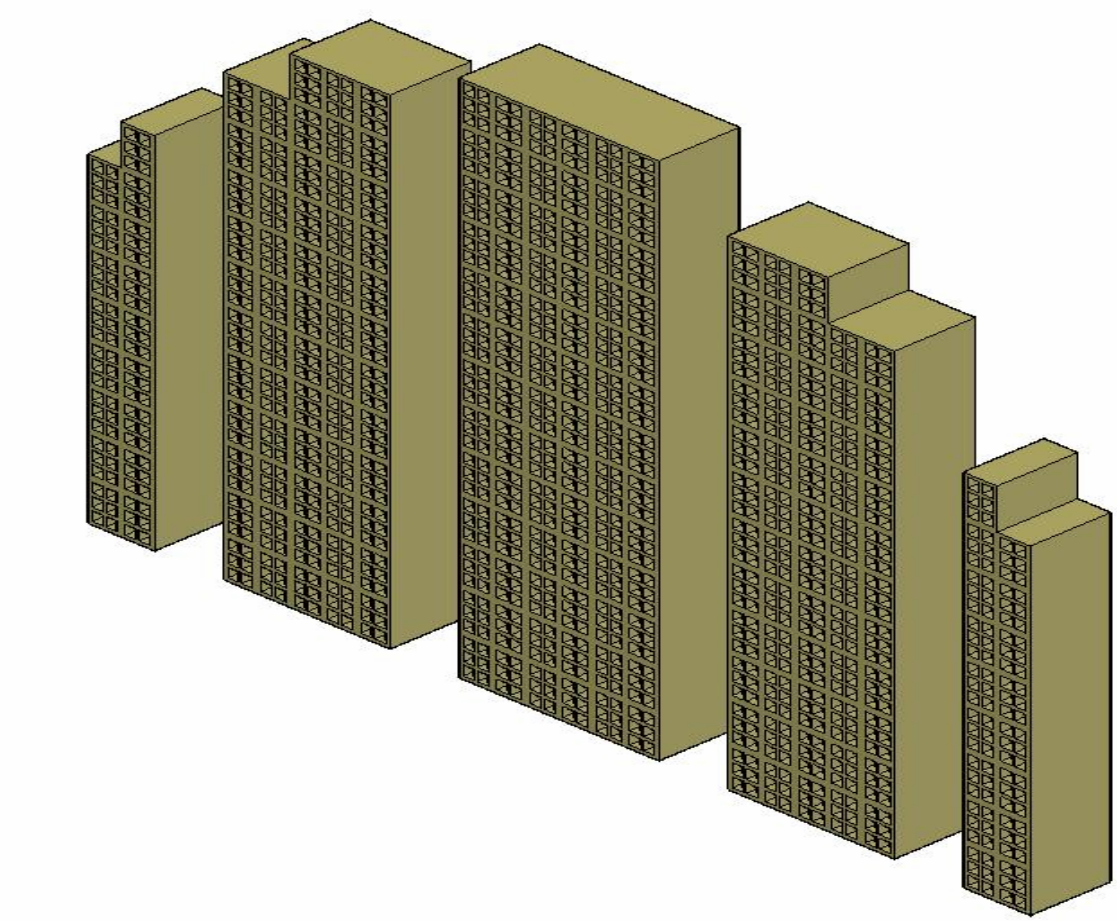


5. Brick accommodation

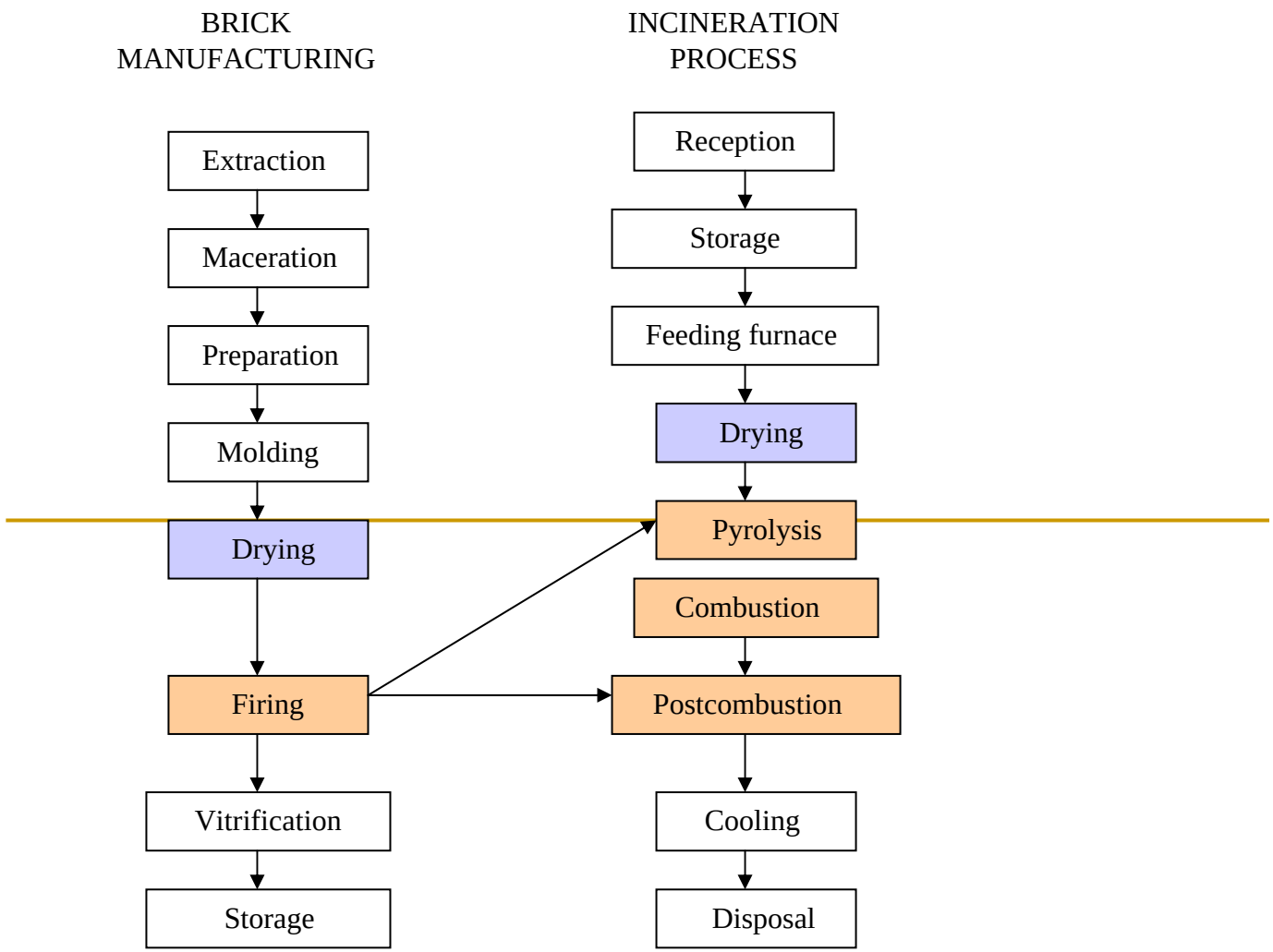
6. Doors

Basic compounds of a Hoffman Furnace adapted for waste incineration

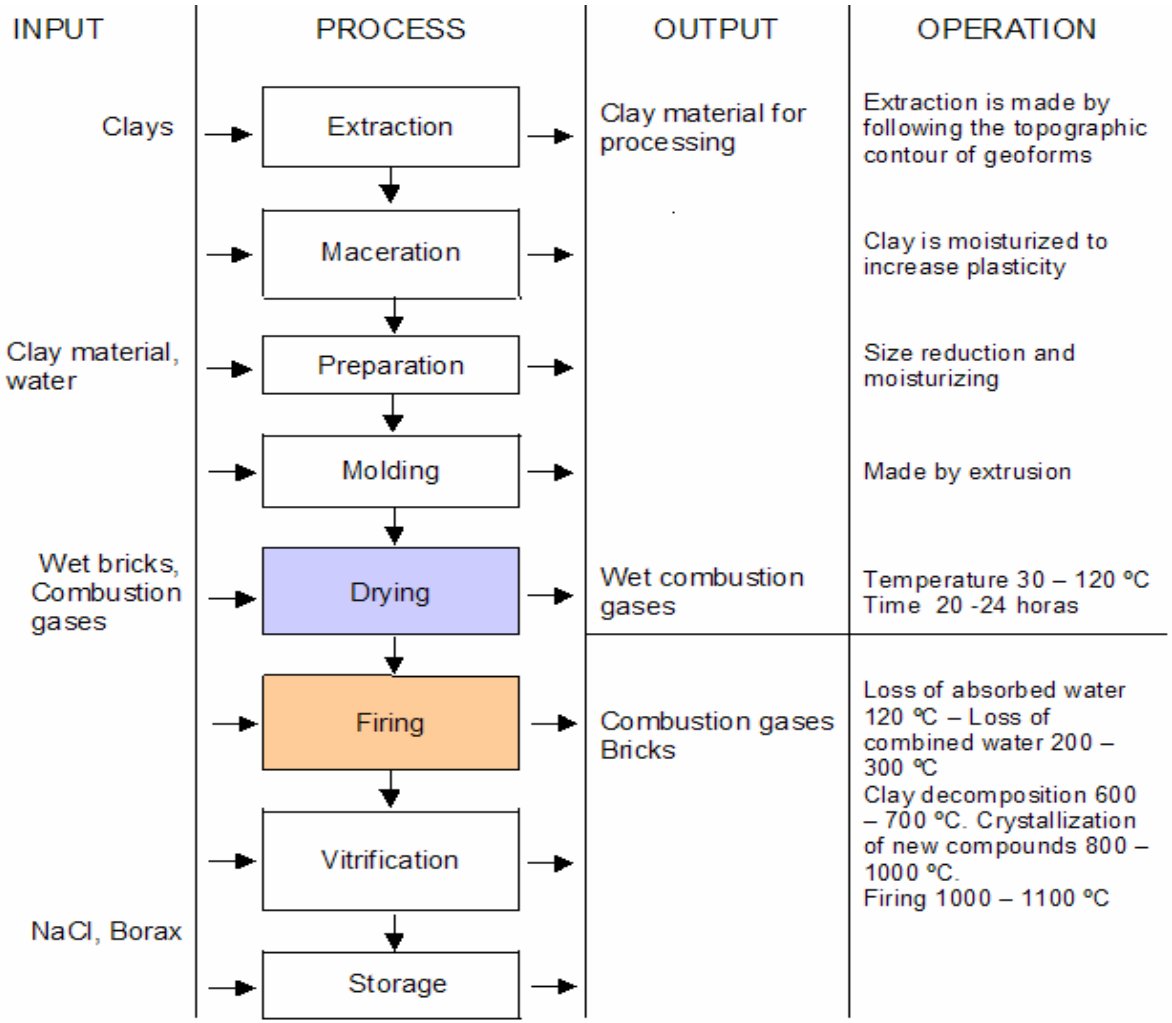
TIPICAL BRICKS ACOMODATION INTO THE FURNANCE



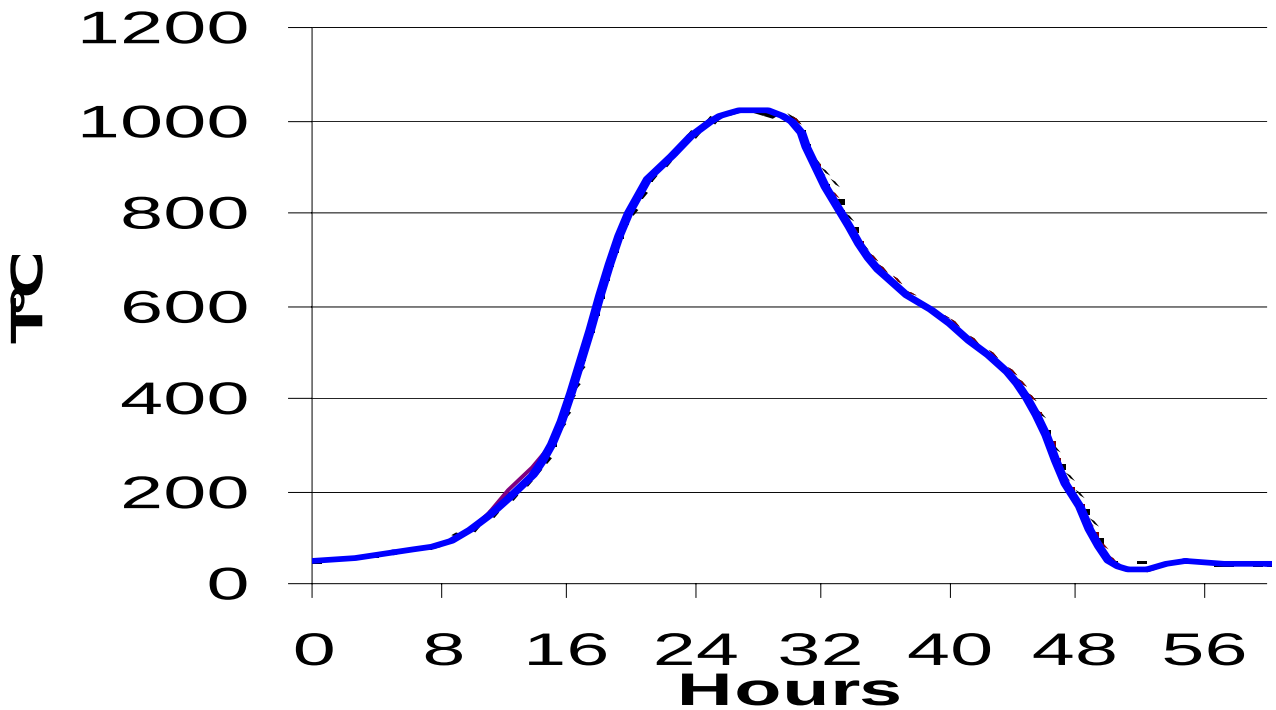
COMPARISON BETWEEN THE BRICK MANUFACTURING PROCESS AND WASTE INCINERATION



CHARACTERISTICS OF BRICKS MANUFACTURE PROCESS IN A HOFFMAN FURNACE



TYPICAL TEMPERATURE CURVE IN A HOFFMAN FURNACE



FAVORABLE ASPECTS OF A HOFFMAN FURNACE AS WASTE INCINERATOR

- Waste coincineration by mineral carbon firing without adittional fuel.
- Suitable combustion conditions such as high temperatures in combustion chamber (1100 ºC), gas residence time (4-6 second), and oxigen excess (12-16%).
- Possibility to adapt postcombustion chamber.
- Inhibiton of PCDD/Fs formation during coincineration process due to 1% sulfur content in mineral carbon. (*Tuppurainen y otros 1997*).
- Inhibiton of the catalytic action of metal ions caused by the bricks in the firing process.
- Ashes and clay compatibility (Ellias, 2002).

AIR POLLUTION CONTROL SYSTEM SELECTED

ESPECIFICACIONES TÉCNICAS DE LAVADOR DE GASES

ANEXO Nº 1

Cali, Abril 7 de 2003
Señores: INAMCO
Att: Ing. Cesar Augusto Garcia
E-Mail: inamco@empresario.com.co
Tel:
Fax: 071-2631394
Ciudad Bogota

ITEM # 4 CANT: 1
S/REF: lavador de gases
N/REF: 03-134
COTIZACIÓN ☑ REV 0 1 2 3
PEDIDO ☐
FECHA DEL PEDIDO

COIN
Cra 34 No. 10-445 ACOPI
Tel: 57-2-6644703 / 6914444
Fax: 57-2-6648036
E-MAIL: coinltda@emcali.net.co
Cali-Colombia

Pg. 3.

PARÁMETROS DE FUNCIONAMIENTO SOLICITADOS

Caudal	4704	CFM
Temperatura	122	°F (50 °C)
Material de Colectar	Cenizas de Carbon	

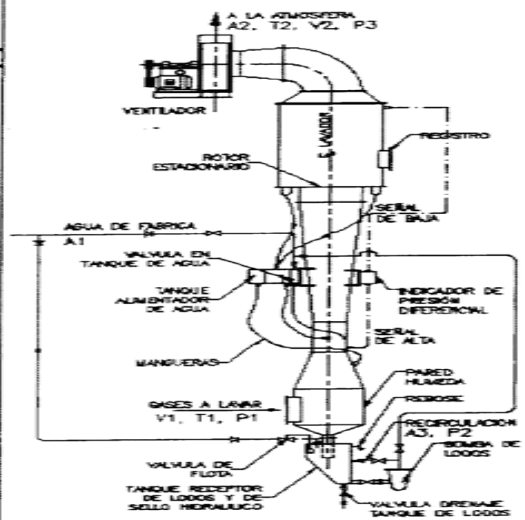
CARACTERISTICAS DEL LAVADOR OFRECIDO

Tamaño	270	
Volumen de Gases (V1)	4704	ACFM
Temp. De Gases (T1)	122	° F
Volumen de Gases (V2)	4704	ACFM
Temp. De Gases (T2)	122	° F
Caida Presión Lav. (SP)	6	" H_2O
Agua de Fábrica (A1)	0.5	GPM
Agua a la Atmósfera (A2)	0	GPM
Agua con Contaminante (A3)	0.5	GPM
Particulas contaminantes entrando (P1)	14	Lbs/Hr
Particulas contaminantes retenidas (P2)	13.86	Lbs/Hr
Particulas contaminantes no retenidas (P3)	0.14	Lbs/Hr
Eficiencia para particulas > 1,0 µ	99%	
Bomba de lodos	☑ POR COIN ☐ POR CLIENTE	
Marca	GOULDS PUMPS	
Capacidad	0.6	GPM
Cabeza	10	Pies

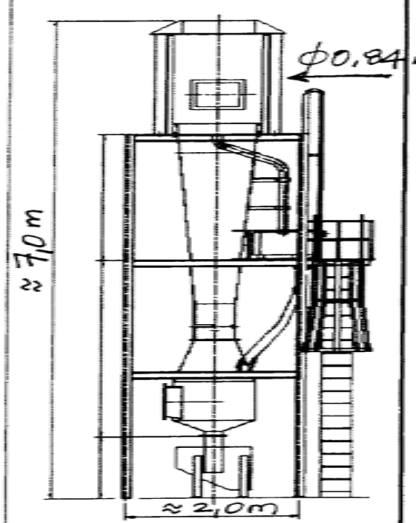
ACCESORIOS

Estructura de Soporte	☑
Mangueras	☑
Indicador de Presión sin Trans. de Señal (0 a 15" H_2O)	☑
Válvula Manual en Tanque de agua	☐
Indicador de Presión con Trans. de Señal (4 a 20 mA.)	☐
Válvula Solenoide en Tanque de agua	☐
Válvula de Flota en Tanque de Lodos	☐
Válvula de Drenaje Tanque de Lodos	☑

ESQUEMA DE CONEXIONES



DIMENSIONES GENERALES



MATERIALES PARA CONSTRUCCIÓN DEL LAVADOR

Cuerpo:	ACERO ASTM A-36	☑	ACERO INOX	☐	OTROS:
Estructura:	ACERO ASTM A-36	☑	ACERO INOX	☐	OTROS:
Tanque de Lodos:	ACERO ASTM A-36	☑	ACERO INOX	☐	OTROS:
Tanque Suministro:	ACERO ASTM A-36	☑	ACERO INOX	☐	OTROS:

FACTORES DE CONVERSIÓN

1" H_2O	=	25,4 mm H_2O
1 Psi	=	27,7" H_2O
1 CFM	=	1,7 m^3/h
°F	=	9/5 °C+32

ACLARACIONES TÉCNICAS:
1- la bomba de lodos que suministra Coin ltda es para recircular el agua desde el tanque de lodos al tanque de agua. La disposicion final de los lodos que se acumulan en la parte inferiror del tanque de lodos sera por cuenta de INAMCO

AIR POLLUTION EMISSION LEVELS & ENVIRONMENTAL FEASIBILITY

POLLUTANT	EMISSION LEVEL (mg/m^3)	STANDARD (mg/m^3)	FEASIBILIYT
PM	36.7	40	OK
SOx	147.2	250	OK
NOx	104.7	200	OK
CO	82.4	100	OK
HCl	32.1	60	OK
HF	1.4	6	OK
PCDD/Fs	$4.2*10^{-6}$	$20*10^{-6}$	OK
VOC's	17.4	30	OK

Incineration of MSW in Hoffman ovens is possible, but is necessary an air pollution control system to install.

TEST ILUSTRATION AND PROCESS

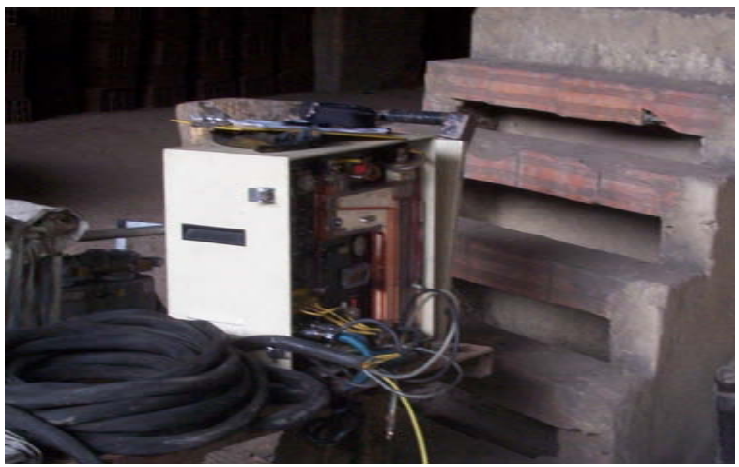
MSW ACOMODATION IN THE OVEN

MSW ACOMODATION IN THE OVEN

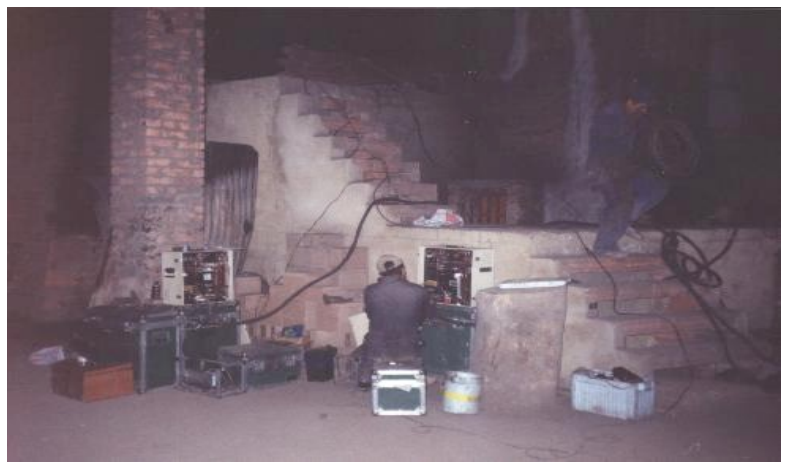
ASHES AFTER COINCINERATION PROCESS

TEST ILUSTRATION AND PROCESS

Air Pollution Control System and stack monitoring



Emission Stack Sampler



Stack Sampler and Emission Test

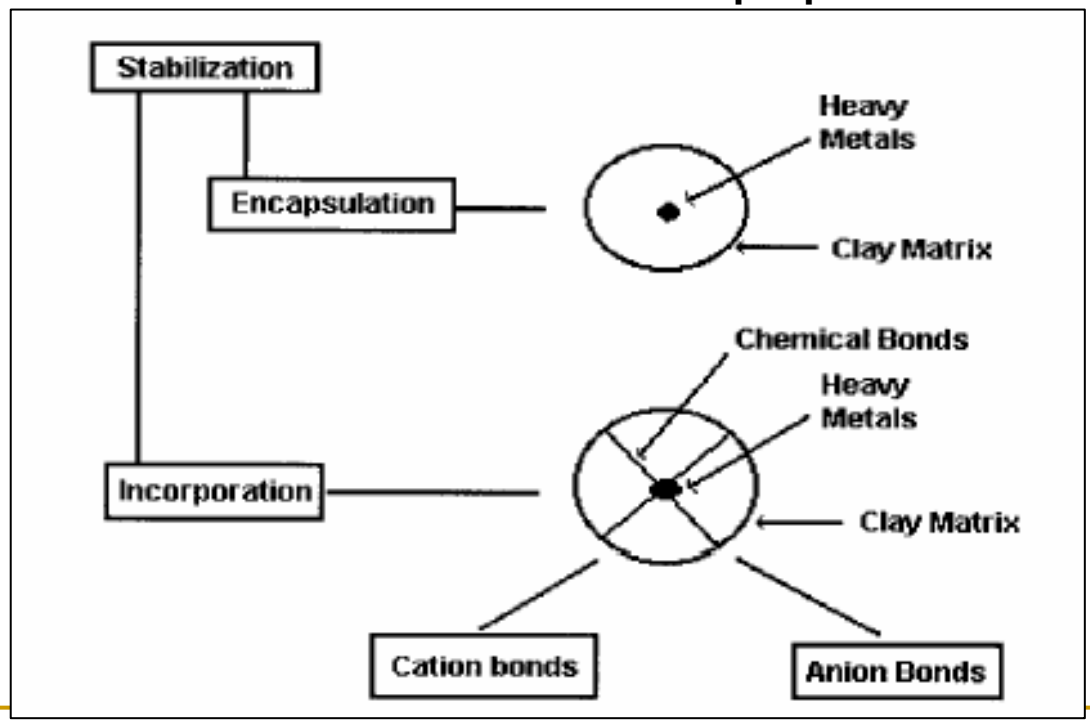
TREATMENT AND DISPOSAL OF ASHES BY ENCAPSULATION IN CLAYS

BACKGROUND: Stabilization–Solidificación processes (**SS**).

Sun, Chang (2001, 2003)

Treatment of heavy metals contained in catalytic craking waste of petroleoum refination processs using clays. The obtained material was used to produce bricks.

Stabilization mechanisms proposed



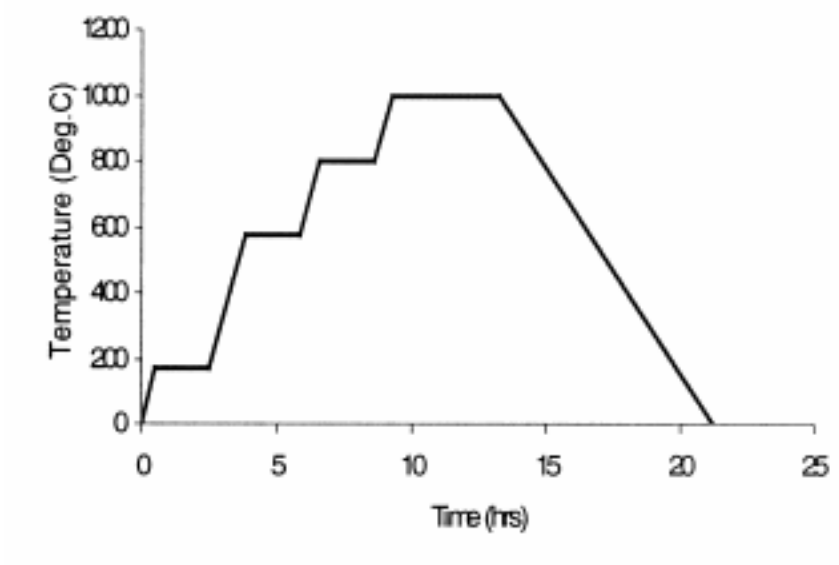
ASH TREATMENT AND DISPOSAL BY ENCAPSULATION IN PROCESS CLAYS

The proposed mechanism establishes two stages:

Adsortion-Ionic exchange: Temperatures below 600 ºC

Final incorporation: Temperatures above 1000 ºC

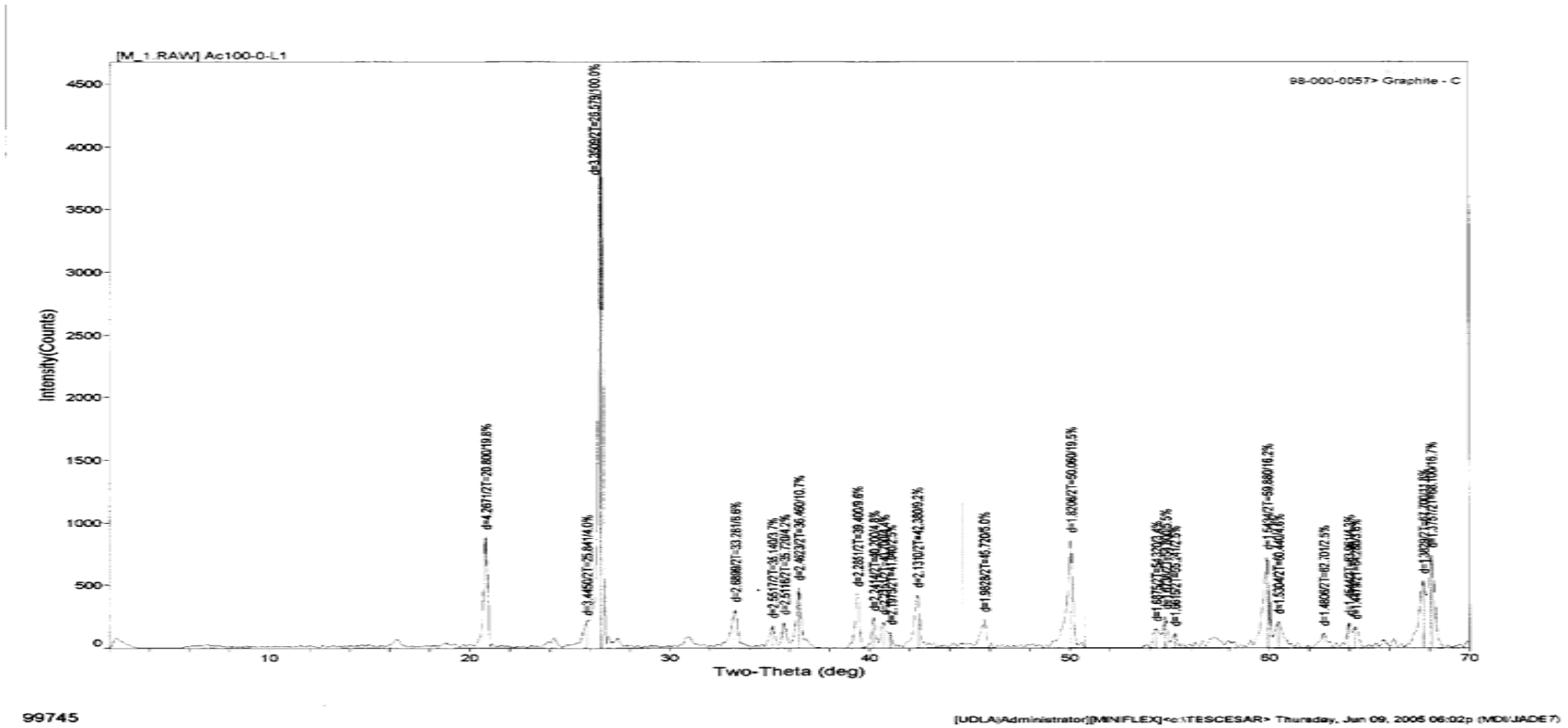
Typical temperature profile – Sun (2003)



CHARACTERISTICS OF COLOMBIAN CLAYS USED IN BRICK MANUFACTURING

Composition according to XRD,

- Quartz
- Kaolinite
- Illite
- Montmorillonite

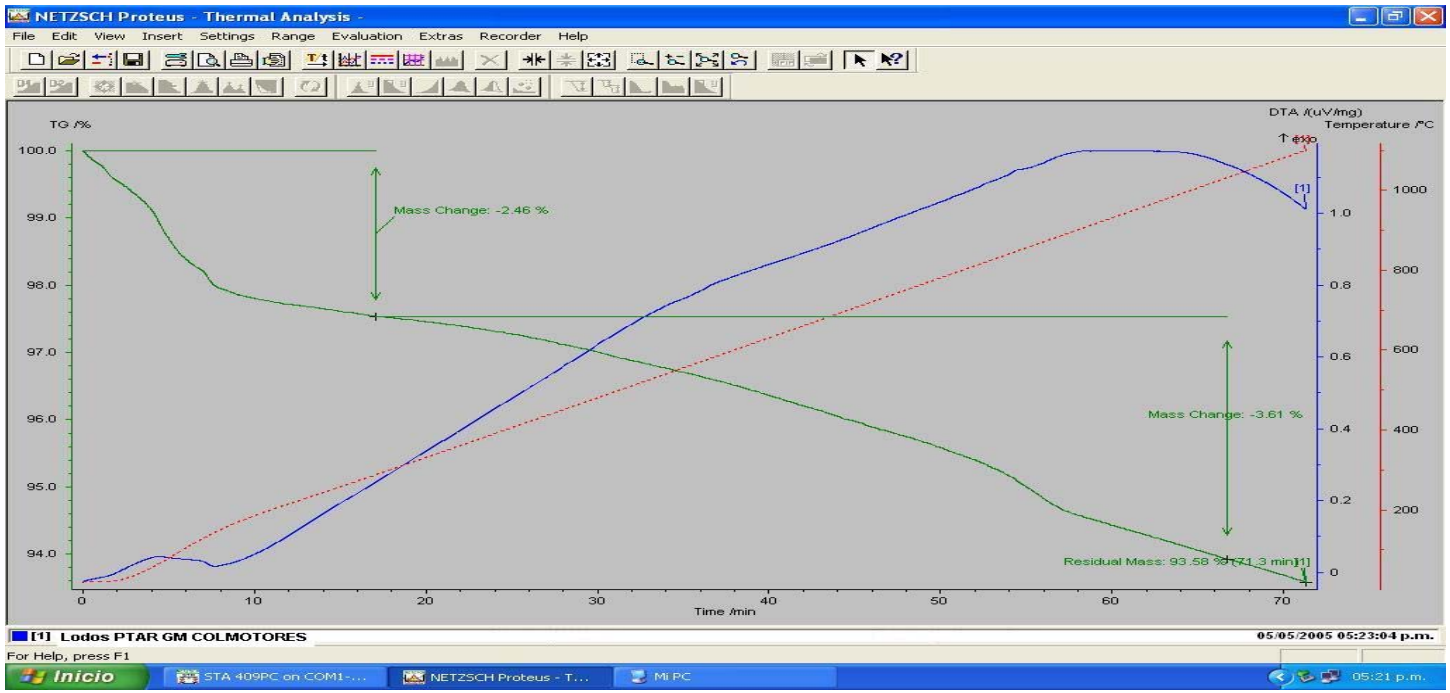


Colombian clays diffractogram

CHARACTERISTICS OF ASHES FROM URBAN SOLID WASTE INCINERATION

Composition according to XRD, IRS, TG, DTA

PH	6.5
Moisture	3.2 %
Organic Matter (Volatil solids)	42.3 %
Inorganic Material (SiO_2 Al_2O_3, CaO, Fe_2O_3)	48.0 %



TG – ATD Ashes from incineration

CONTENT OF HEAVY METALS IN ASHES FROM COLOMBIAN URBAN SOLID WASTE INCINERATION IN ACCORDING TO TCLP - AAS (mg/Kg)

Arsenic (As)	1.120
Barium (Ba)	2.260
Cadmium (Cd)	0.430
Total Chromium(Cr)	3.450
Copper (Cu)	1.560
Mercury (Hg)	0.023
Magnesium (Mg)	4.720
Nickel (Ni)	3.370
Lead (Pb)	1.230
Silver (Ag)	0.083
Selenium(Se)	0.221
Zinc (Zn)	2.270

HEAVY METAL CONTENT IN TCLP TEST BRICKS MANUFACTURED WITH CLAY AND ASH MIXTURES (CA) FROM THE INCINERATION OF URBAN SOLID WASTES IN COLOMBIA IN mg/L

METAL	ASH	CA 99-1	CA 95-5	CA 90-10	CA 80-20	CA 60-40	STANDARD	REDUCTION (%)
As	1.120	0.001	0.001	0.003	0.008	0.012	5.00	92-99
Cd	0.435	0.020	0.029	0.031	0.035	0.057	1.00	84-99
Cr	3.452	0.035	0.048	0.054	0.074	0.104	5.00	89-98
Hg	0.024	ND	ND	ND	ND	ND	0.20	>70%
Ni	3.457	0.025	0.042	0.063	0.076	0.098	5.00	94-99
Pb	1.238	0.020	0.023	0.042	0.047	0.052	5.00	95-99
Se	0.364	0.002	0.003	0.008	0.012	0.018	1.00	82-96
Zn	3.375	0.008	0.024	0.035	0.058	0.092	-	95-99

ND=Non Detectable

RESULT ANALYSIS

According to published results, physical and chemical interaction between clays and ashes, may additionaly occur in the **SS** process. It can be explained by similarities between the sludges inorganic components (SiO_2, Al_2O_3, CaO, Fe_2O_3) and the principal compounds of clays: SiO_2, Al_2O_3 y Fe_2O_3. The mixture of this two susbtances and their firing above 1000ºC, eliminates any organic content and inhibits another possible formation. At the same time, the final material is solidified making it physically and chemically inert.

FABRICATION PROCESS BRICKS OF CLAY-ASHES MIXTURES

Stages of Clay–Ash mixture and water addition in extrision machine

Bricks exite from the extrusion machine and storage previously to introduce in the oven

CONCLUSIONS

1. **According to results, the use of Hoffman type ovens to co-incinerate MSW and produce bricks, could be possible with air pollution control adaptation, but is necesary specific studies that include MSW from other places and ovens to confirm and validate these conclusions.**
2. **The leaching tests results in the clay-ashes mixtures, show reductions on heavy metal concentrations in test bricks. The heavy metal concentration in lechates of encapsulated ashes was 70% to 99% lower than nontreated ashes.**
3. **Although the first leaching tests provide no conclusion about the optimum mixture of clay and ashes, a greater percentage of reduction is observed in mixtures with 99-1, 95-5 and 90-10 clay-ash proportions respectively.**

THANK YOU VERY MUCH…!