Fact Sheets – Waste Incineration

1 Co-combustion of MBM & Natural Gas

References used for the compilation of this fact sheet:

103 ***Co-combustion of meat and bone meal with natural gas***, N.O Knudsen, N. Henriksen, I. Hundebøl, K. Wieck-Hansen, VGB , November 2003

1.1 Short description of technology

The meat and bone meal (MBM) is produced by heat treatment (i.e. 133 °C for 20 minutes at 3 bars of pressure) followed by drying and milling. Compared to coal, the MBM can be characterised as a fuel with a low heating value, but with high ash, volatiles, potassium, sodium and chloride values. After processing and drying, the MBM is pulverised in a hammer mill to a grain size below 4 to 6 mm. MBM are usually burnt at power plants.

1.2 Technical aspects

1.2.1 Detailed description of technology

1.2.2 Implementation experience

In Denmark, Unit 3 at the Fynsvaerket power plant was originally a 285 MWe oil-fired boiler commissioned in 1974. The steam parameters are 18.2 MPa (182 bar)/535°C. In two steps the boiler has been converted to allow firing of an almost arbitrary combination of oil, coal and natural gas. The unit has been retrofitted with a baghouse filter, but lacks an efficient FGD installation. For environmental reasons the main fuel is natural gas, except in cold winter periods where there is a shortage of natural gas. In such periods low-sulphur coal is used.

The test plants consisted of a 75 m³ silo and two root blowers and tubular screw feeders for MBM dosing. The MBM was pneumatically transported nearly 100 metres to the central tubes of a modified pulverised coal burner. The capacity in the test period was around 7 to 8 tonnes per hour.

1.2.3 Stage of development

Table 1: Stage of development

	current	2010	2015	2020	2030
bench/laboratory					
pilot/demonstration plant					
commercial					

1.2.4 Reference installation

1.2.5 Operational experience

1.2.6 Advantages of technology

The co-combustion of MBM with natural gas is a promising and straightforward operation for the incineration of MBM with residual product recovery.

1.2.7 Drawbacks of technology

The combination of a high fat content and high air temperatures involves a risk of clogging in the transport pipes, especially in hot periods. Generally, when the MBM is dry there is only a slight, but distinct smell from meat and bone meal. However, wet, accidentally, split MBM smells unpleasant and should be avoided.

Corrosion at nominal steam date (>480°C) is severe, and this problem can only be solved either by a reduction of the steam parameters or by the addition of efficient additives to the fuel.

Continued operation of the co-combustion plant will require considerable investments in NO_x reduction systems. Recycling of the residual phosphate ash is hampered by the chloride content in the ash and by legislative and psychological obstacles.

1.3 Environmental aspects

1.3.1 Emission factors

Remarks : to reduce emissions even further, a hydrated system lime injection in front of the baghouse filter has been installed. The operation has been partial success. At a stoichiometric ratio of 2 to 3 we reduced HCl by around 90%, but the SO_2 by only 25 %.

Table 2: Emission factors

Importance	Pollutant	Emission factor or reduction
important	SOx	SO_2 60 mg/m³
	NOx	
	NMVOC	HCl 40 mg/m³
	PM (TSP, PM10, PM2.5)	
	CO2	
	Energy	
less important	CO	
	NH3	
	N2O	
	POPs (e.g. dioxins, furans)	dioxins : far below the limits of 0.1 ng/m³
	Heavy metals (e.g. As, Cd, Cr, Cu, Ni, Pb, Zn)	

1.3.2 Trans-media effects

1.4 Economical aspects

1.5 Diffusion, expected relevance

1.5.1 Activity of sector[1]

Table 3: Activity of sector

area	2005	2010	2015	2020	2025	2030

1.5.2 Applicability[2]

Table 4: Applicability of the technology

area	2005	2010	2015	2020	2025	2030

[1] from RAINS- model

[2] theoretical maximum application rate (only technical restrictions)

1.5.3 Application rate (market share)[3]

Table 5: Application rate of the technology

area	2005	2010	2015	2020	2025	2030

1.6 References

103 ***Co-combustion of meat and bone meal with natural gas***, N.O Knudsen, N. Henriksen, I. Hundebøl, K. Wieck-Hansen, VGB , November 2003

[3] effective application rate

2 Plasma Discharge / Plasma Gasification Microwave Plasma

References used for the compilation of this fact sheet:

29 ***Overview of New and Emerging Technologies for Solid Waste Management***, www.city.toronto.on.ca, Toronto City, January 2003

30 ***First Draft Reference Document on Best Available Techniques for Waste Incineration***, Integrated Pollution Prevention and Control, European IPPC Bureau, Sevilla, 2003

2.1 Short description of technology

Plasma Discharge Technology / Plasma Gasification :

Plasma discharge uses extremely high temperatures in an oxygen-starved environment to completely decompose input waste material into very simple molecules in a process similar to pyrolysis. Products include combustible gas and a vitrified solid residue.

Microwave plasma :

A mixture of CFCs with water vapour is fed to the plasma and is broken down at temperatures exceeding 6000°K into the dissociated state, after which HCl, HF, CO and CO_2 are formed. The acid gases are scrubbed in a tower with a slaked lime slurry and the process gas is combusted with air to convert the CO to CO_2. The destruction removal efficiency (DRE) for the microwave plasma process is reported to exceed 99.99% while destroying CFC-12 at a rate of 2 kg/h.

2.2 Technical aspects

2.2.1 Detailed description of technology

Plasma Discharge Technology/Plasma Gasification

The heat source is a plasma discharge torch, a device that produces a very high temperature plasma gas. Plasma is an electrically neutral, highly ionized gas composed of ions, electrons, and neutral particles. It is a phase of matter distinct from solids, liquids, and normal gases. Plasma is very common and is found in the sun, fire, fluorescent and neon lights. A plasma gas is the hottest, sustainable heat source available and results in a temperature profile of between 3,000 and 8,000 degrees Celsius

Microwave plasma:

This process feeds microwave energy at 2.45 GHz into a specially designed coaxial cavity to generate a thermal plasma under atmospheric pressure. The coaxial design is claimed to promote plasma stability. Argon is used to initiate the plasma but otherwise the process requires no gas to sustain the plasma. The flue gas volume has been estimated at 32 Nm^3/h based on the process description and flue-gas compositions reported.

2.2.2 Implementation experience

Microwave plasma : The microwave plasma process was developed in Japan. The development of the process was started in 1997 and was launched in the market in 2000. The plasma approach was selected to provide a very compact design that could be applied at the many sites where CFCs were recovered. The CFC feed rate of 2 kg/h was determined by market research.

2.2.3 Stage of development

Table 1: Stage of development

	current	2010	2015	2020	2030
bench/laboratory					
pilot/demonstration plant					
commercial					

2.2.4 Reference installation

2.2.5 Operational experience

2.2.6 Advantages of technology

Microwave plasma : Key advantage of the process are the high destruction efficiency. The process is reported to be capable of achieving the high operating temperatures in a very short time, thus providing operating flexibility and reduced downtime. There is no need an inert gas to operate the process, which improves the power efficiency, reduces operating cost, as well as and minimising the volume of flue-gas produced.

2.2.7 Drawbacks of technology

Microwave plasma: A disadvantage of the process is that halide salts produced by neutralisation of the acid gases must be discharged to the environment. Another disadvantage is the high energy consumption required for the plasma generation.

2.3 Environmental aspects

2.3.1 Emission factors

Table 2: Emission factors

Importance	Pollutant	Emission factor or reduction
important	SOx	
	NOx	
	NMVOC	HCl/ Cl2 0.45 mg/Nm³ (concentration); 78 mg/h (mass emission) HF 0.74 mg/Nm³ (mass concentration) ; 24 mg/h (mass emission)
	PM (TSP, PM10, PM2.5)	10.6 mg/ Nm³ (concentration); 340 mg/h (mass emission)
	CO2	
	Energy	
less important	CO	4.3 mg/Nm³ (concentration) ; 136 mg/h (mass emission)
	NH3	
	N2O	
	POPs (e.g. dioxins, furans)	0.0011 ng-ITEQ/Nm³ (concentration); 0.03 ng-ITEQ/h (mass emission)
	Heavy metals (e.g. As, Cd, Cr, Cu, Ni, Pb, Zn)	

2.3.2 Trans-media effects

2.4 Economical aspects

2.4.1 Investments

Capital costs were reported at about $US 60000 for a 2kg/h system, although it is not clear what such a system would include.

2.5 Diffusion, expected relevance

2.5.1 Activity of sector[4]

Table 3: Activity of sector

area	2005	2010	2015	2020	2025	2030

2.5.2 Applicability[5]

Table 4: Applicability of the technology

area	2005	2010	2015	2020	2025	2030

2.5.3 Application rate (market share)[6]

Table 5: Application rate of the technology

area	2005	2010	2015	2020	2025	2030

2.6 References

29 ***Overview of New and Emerging Technologies for Solid Waste Management***, www.city.toronto.on.ca, Toronto City, January 2003

30 ***First Draft Reference Document on Best Available Techniques for Waste Incineration***, Integrated Pollution Prevention and Control, European IPPC Bureau, Sevilla, 2003

[4] from RAINS- model

[5] theoretical maximum application rate (only technical restrictions)

[6] effective application rate

3 Electrox™

References used for the compilation of this fact sheet:

190 ***Electrox - Questionnaire "Assessment of Emerging Technologies"***, Personal Communication, 2004

3.1 Short description of technology

Oxidation of air pollutants using plasma treatment.

3.2 Technical aspects

3.2.1 Detailed description of technology

The system is for the pulsed corona plasma treatment of industrial off gases. The plasma is produced between two electrodes by high voltage pulses. The pollutants are oxidised and NO_x, SO_x give acids which are scrubbed and organic materials are oxidised to carbon dioxide and water.

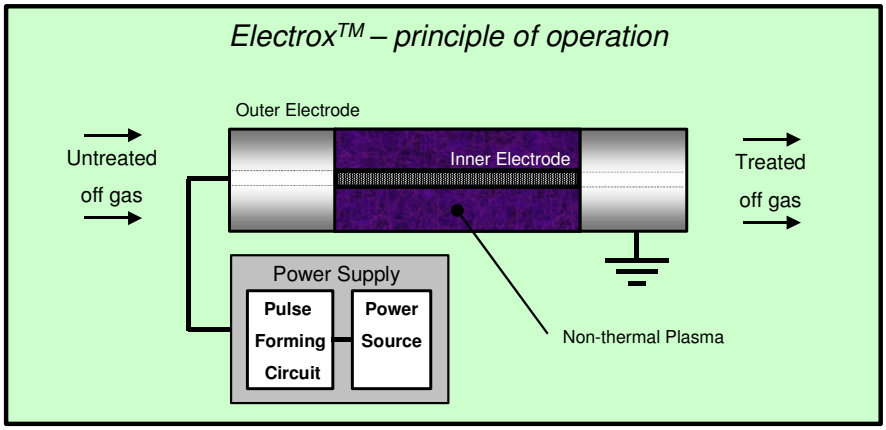

Figure 1: Principle of Electrox™

3.2.2 Implementation experience

Table A: Implementation experience of Electrox™

scale (e.g. pilot)	area of use	location	producer	references
~1000 m³/hr	Waste incinerator (NOx, SOx, dioxins and furans, organics)	SELHP, Chineham (UK)	Accentus	R McAdams et al. Proceedings of the Second International Symposium on Incineration and Flue-Gas Treatment Technologies, Sheffield, UK 1999
300-400 m³/hr	Odour removal (toluene, ammonia, hydrogen sulphide, actealdehyde)	Culham (UK)	Accentus	R McAdams J. Phys. D. Appl. Phys. **34**, 2810 (2001)

3.2.3 Stage of development

We are now seeking the development funding to produce a industrialised pilot plant. The system is effectively at the size of what would be a typical module (treating up ~ 1000m³/hr) but it is not industrialised. Once the industrial plant is operational we would expect the product to breakthrough.

Table 1: Stage of development

	2005	2010	2015	2020	2025	2030
bench/laboratory	X					
pilot plant	X					
demonstration plant	X					
commercial		X				

3.2.4 Reference installation

3.2.5 Operational experience

Limits for operation:
Works at any concentration/flow simply by adding enough modules.
Economically it is more feasible at lower concentration.
Operational performance of the installation :
Present large non-industrialised system is operated occasionally.

3.2.6 Advantages of technology

3.2.7 Drawbacks of technology

Obstacles that hinder the commercial application : Development of power supply technology
These obstacles can be overcome in future : The obstacle to find the development funding.

3.3 Environmental aspects

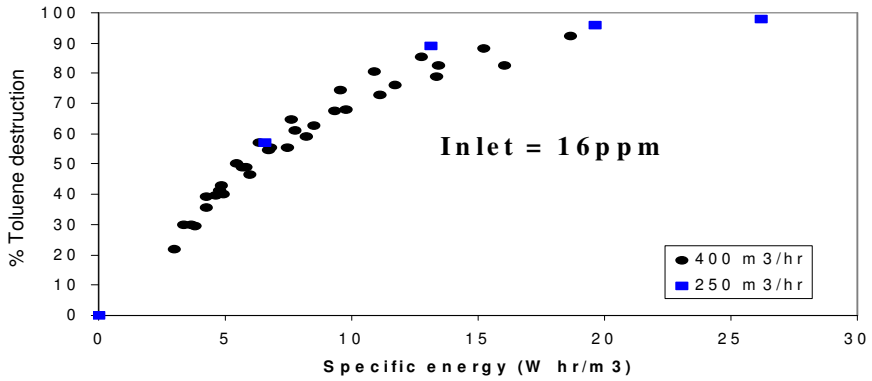

Figure 2: Destruction of toluene at different flow rates as a function of specific energy (power/flow rate). Varying power varies destruction level.

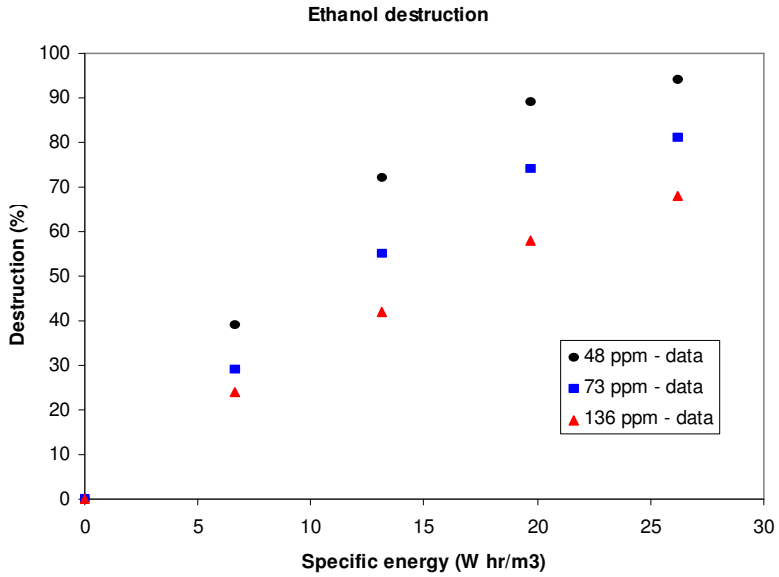

Figure 3: Example of the destruction of ethanol as a function of specific energy (power/flow rate) for different ethanol concentrations.

3.3.1 Emission factors

Table 2: Emission factors

Importance	Pollutant	Emission factor or reduction
important	SOx	
	NOx	
	NMVOC	
	PM (TSP, PM10, PM2.5)	
	CO2	
	Energy	
less important	CO	
	NH3	
	N2O	
	POPs (e.g. dioxins, furans)	
	Heavy metals (e.g. As, Cd, Cr, Cu, Ni, Pb, Zn)	

3.3.2 Trans-media effects

3.4 Economical aspects

3.4.1 Investments

Table B: Investments

	2005	2015	2025
	Module	Module	
investment costs	Approx £20-30k After non recurring development costs	Approx £10-15k	

3.4.2 Fix costs

3.4.3 Variable costs

System size (number of modules) depends on the flow rate and inlet concentrations and require outlet concentrations. Example below is for 1 module only operating 90% of time.

Table C: Variable costs

operational costs	2005	2015	2025
energy consumption	£0.05/kWh (£2760/year/module)	N/a	N/a
consumption of materials	~£3k/year/module	N/a	N/a
extra demand of manpower	some		

3.4.4 Lifetime

Expect a lifetime of many years with power supply refurbishment every 1-2 years.

3.5 Diffusion, expected relevance

3.5.1 Activity of sector[7]

Table 3: Activity of sector

area	2005	2010	2015	2020	2025	2030

3.5.2 Applicability[8]

Table 4: Applicability of the technology

	2005	2010	2015	2020	2025	2030
Chance	low	medium				

3.5.3 Application rate (market share)[9]

Table 5: Application rate of the technology

area	2005	2010	2015	2020	2025	2030

3.6 References

R McAdams (2001): Prospects for non-thermal atmospheric plasmas for pollution abatement. Invited paper at The Future of Technological Plasmas, Institute of Physics Congress, Brighton, 2001. J. Phys. D. Appl. Phys. **34**, 2810 (2001)

[7] from RAINS- model
[8] theoretical maximum application rate (only technical restrictions)
[9] effective application rate

J Carlow, R King, and R McAdams (1996): The removal of gaseous pollutants in the flue-gas from the Chineham U.K. Municipal Solid Waste Incinerator using pulsed corona technology. Invited paper at the 3rd International Conference on Advanced Oxidation Technologies, Cincinnati, USA, October 1996.

R McAdams, J Carlow, R Gillespie, M Greenough, M Harte, N Jorgensen, R King, J Stedman, F Winterbottom and J Wilman (1999): The removal of gaseous pollutants in the flue gas from solid waste incinerators using pulsed corona technology. Proceedings of the Second International Symposium on Incineration and Flue-Gas Treatment Technologies, Sheffield, UK 1999

J Carlow, R King and R McAdams (1997): The removal of gaseous pollutants in the flue-gas from the Chineham , UK, Municipal Solid Waste Incinerator using pulsed corona technology. Proceedings of the First International Symposium on Incineration and Flue-Gas Treatment Technologies, Sheffield, UK 1997

J. Carlow, R. King and R. McAdams (1997): The use of pulsed corona technology to destroy VOCs, dioxins and furans at a Municipal Solid Waste Incinerator. Proceedings of the VI’th international Conference on Electrostatic Precipitation, Budapest, Hungary, June 1996.

4 High-Efficient Centrifugal Gas Deduster with Closed Helical Channel

References used for the compilation of this fact sheet:

179 ***High- efficient centrifugal gas deduster with closed helical channel – Questionnaire for EU-Project "Assessment of the air emissions impact of emerging technologies"***, Robert Kubica, Personal Communication, 2004

4.1 Short description of technology

Gas dedusting by using a high-efficient centrifuge.

4.2 Technical aspects

4.2.1 Detailed description of technology

The apparatus was manufactured in its original design which is characterised by a compact construction of single modules with the possibility of extension into a multi-element unit (Figure 1). The method of process realisation was applied for patent. The lab researches were carried out with the use of TiO_2 dust obtained straight from the production line of Police Chemical Plant (100% of particles diameters under 2,4 μm), Figure 4. Researches proved that with the use of proposed apparatus a dedusting efficiency of 100% for particles of diameter about 1 μm (Figure 4) can be obtained. Pressure drop observed under test conditions is about 2000 Pa, and water consumption about 1 $dm^3_{(water)}/m^3_{(dedusted\ gas)}$.

Analysis of carried out studies allows formulation of following conclusions considering centrifugal dedusting process carried on by means of closed helical channel:

1. Proposed device makes possible realisation of dedusting process under conditions enabling intensification of phenomena responsible for aerosol separation. It characterises itself with short path of separation (distance to the separation surface) and well defined shape of swirl. Introduction of additional forces causing hold-up of particles on the separation surface prevents dust reemission.
2. Computationally forecasted high dedusting efficiency was experimentally proved (Figure 2 and Figure 3).
3. Computationally forecasted low pressure drop at high gas velocities was experimentally proved.
4. Parameters of multi-element device were evaluated to enable future scale-up of apparatus (Figure 4 and Figure 5). Improved design gives better hydraulic characteristics (Figure 4) which enables the use of higher gas velocities leading to the increase of dedusting efficiency (Figure 5).
5. Computer programs, enabling design of deduster with closed, helical channel, were developed with the use of Delphi Enterprise 6.0 environment.
6. Presented apparatus can be listed among high-efficient dedusters when analysing its parameters against the background of not only centrifugal dedusters (Figure 6).

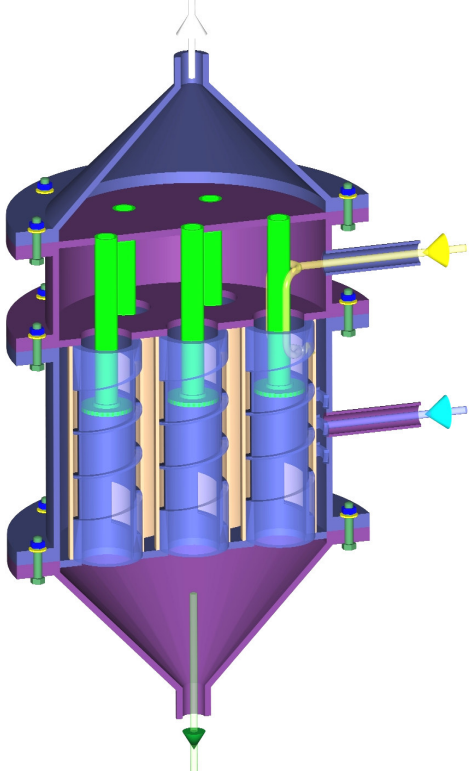

Figure 1: Multi-element device (technical scale)

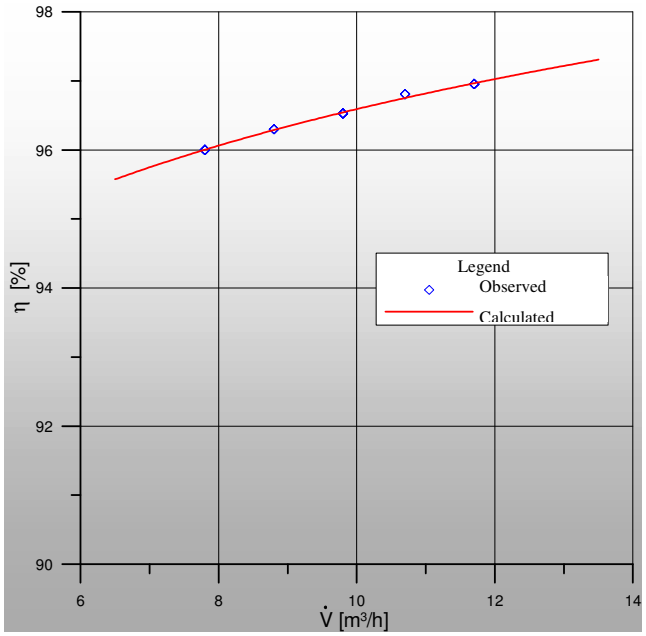

Figure 2: Dedusting overall efficiency (100% of particles diameters under 2,4µm)

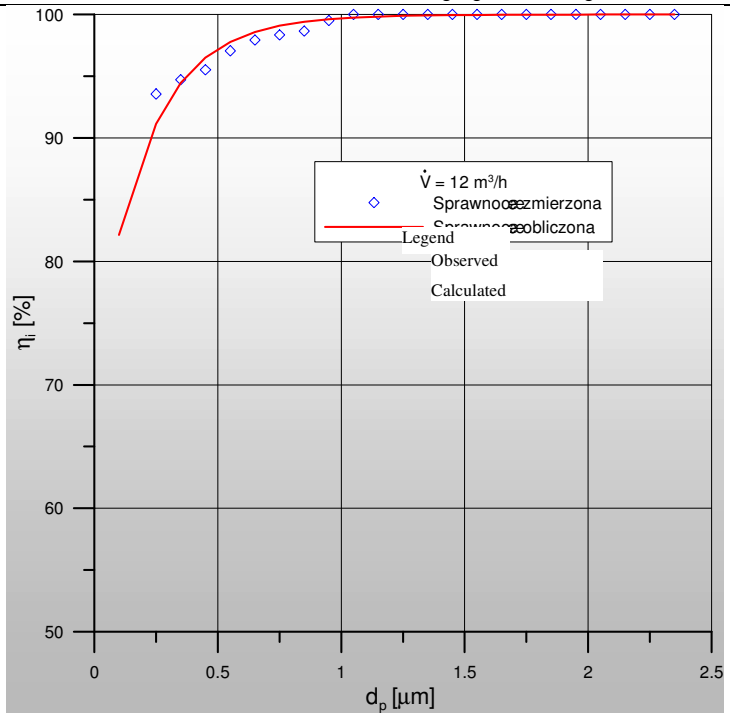

Figure 3: Dedusting efficiency at gas velocity of 22 m/s (inside helical channel)

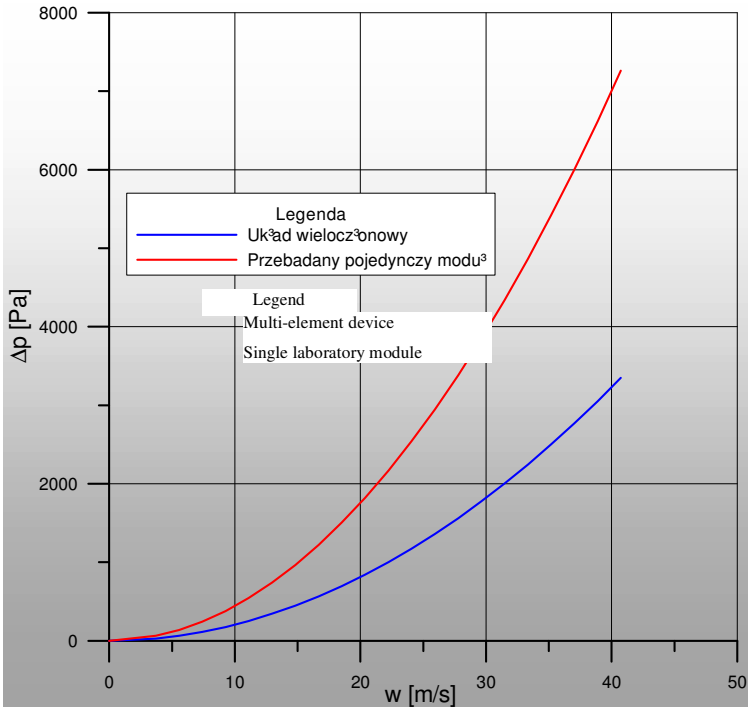

Figure 4: Predicted pressure drop for multi-element device (industrial application), in comparison to observed pressure drop for laboratory apparatus

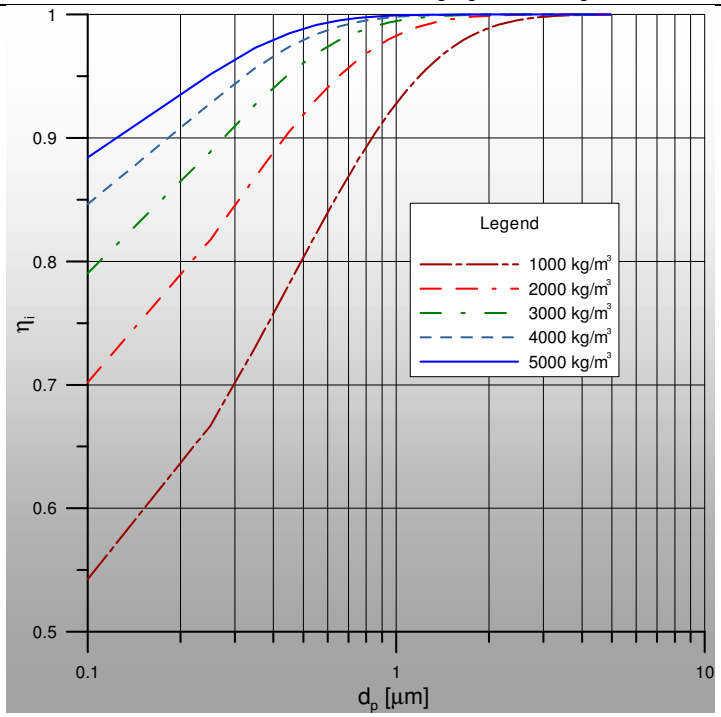

Figure 5: Predicted dedusting efficiency for multi-element device (industrial application), for different dust densities at gas velocity of 40 m/s (inside helical channel).

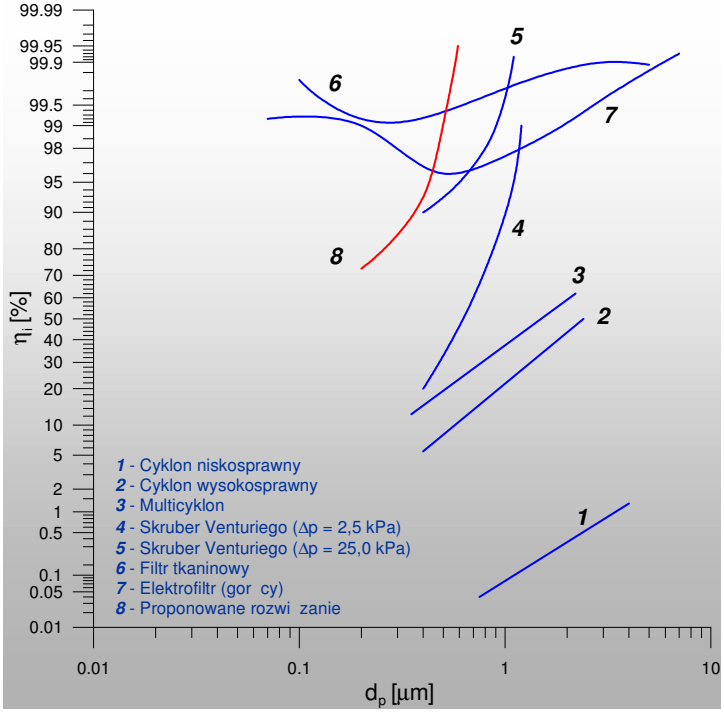

Figure 6: Dedusting efficiency of laboratory single module in comparison to dedusting efficiencies of chosen dedusters

4.2.2 Implementation experience

4.2.3 Stage of development

Table 1: Stage of development

	current	2010	2015	2020	2030
bench/laboratory	x (lab phase accomplished in 2003)				
pilot/demonstration plant		x			
commercial			x		

Expected break-through about 2010.

4.2.4 Reference installation

4.2.5 Operational experience

Limits for operation:
Capacities of single module between 5 and 24 m^3/h where the increase of overall apparatus capacity is achieved through the multiple modules use (similarly to multicyclones). Apparatus of diameter equal to 1000 mm and 600 mm high enables dedusting of about 4000 m^3/h of gas.

Operational performance of the installation:
Continuous operation.

4.2.6 Advantages of technology

High separation efficiencies observed for very fine particles give the possibility of smokes, odours and bacteria removal intensified by means of chemical agents addition to liquid (wetting separation surfaces).

4.2.7 Drawbacks of technology

Air moistening is not always desired.

4.3 Environmental aspects

4.3.1 Emission factors

Table 2: Emission factors

Importance	Pollutant	Emission factor or reduction
important	SO_x	
	NO_x	
	NMVOC	
	PM (TSP, PM_{10}, $PM_{2.5}$)	100% for particles of diameter about 1 μm
	CO_2	
	Energy	
less important	CO	
	NH_3	
	N_2O	
	POPs (e.g. dioxins, furans)	
	Heavy metals (e.g. As, Cd, Cr, Cu, Ni, Pb, Zn)	

4.3.2 Trans-media effects

TSP is removed from the apparatus with the stream of liquid (very small flow rates in comparison to present solution of wet dedusting).

4.4 Economical aspects

4.4.1 Investments

2005: 100 Euro/m^3 of cleaned gas
2015: 95 Euro/m^3 of cleaned gas
2025: 100 Euro/m^3 of cleaned gas

4.4.2 Fix costs

4.4.3 Variable costs

energy consumption: small if needed at all (only to provide gas flow – by means of fans if necessary)
consumption of materials: <1 litre of water /m^3 of cleaned gas

4.4.4 Lifetime

Lifetime depends on operational conditions. Wear-out of some steel parts is possible (only partial replacement needed – expenses not exceeding 5% of investment costs).

4.5 Diffusion, expected relevance

There are no real obstacles that hinder the commercial application of the product and no specific measures that could promote the diffusion process. However, there is a lack of financial support enabling pilot scale application and successive technical scale implementation.

The technology can be retrofitted to existing installations.

No geographical differences in the diffusion process are expected in EU25.

4.5.1 Activity of sector[10]

Table 3: Activity of sector

area	2005	2010	2015	2020	2025	2030

4.5.2 Applicability[11]

Applicable for:

- combustion for energy and steam production (plants of low and medium capacities (low emission))
- waste incineration (plants of low and medium capacities (low emission))
- air conditioning

Table 4: Applicability of the technology

area	2005	2010	2015	2020	2025	2030

[10] from RAINS- model
[11] theoretical maximum application rate (only technical restrictions)

4.5.3 Application rate (market share)[12]

Table 5: Application rate of the technology

area	2005	2010	2015	2020	2025	2030
chance	low	medium	high			
combustion for energy and steam production				<5%		<10%
renewable/alternative energy production				<2%		<5%
waste incineration				<2%		<5%
Air-conditioning				<5%		<10%

4.6 References

1. A.Bryczkowski, R.Kubica: „The study of dedusting process in centrifugal forces field carried on by means of closed helical channel", Inż. & Ap. Chem. Special Edition 2000.
2. A.Bryczkowski, R.Kubica: „High-efficient, centrifugal gas deduster with closed helical channel Chem. Eng. and Proc. 22, 289 (2001).
3. A.Bryczkowski, R.Kubica: „High-efficient, centrifugal gas deduster with closed helical channel – dedusting efficiency forecast – alternative models", Inż. & Ap. Chem. III/2002.
4. A.Bryczkowski, R.Kubica: „The study of hydraulics of gas deduster with closed, helical channel", Inż. & Ap. Chem. VII/2002.
5. A.Bryczkowski, R.Kubica: High-efficient, centrifugal gas deduster with closed helical channel – experimental results" Inż & Ap. Chem. Spec.ed./2003

[12] effective application rate

5 Microbiological removal of sulphur, nitrogen oxides and heavy metals from flue gases

References used for the compilation of this fact sheet:

257 Jan Gasiorek, Institute of Natural Fibres in Poznan (PL), ***Microbiological removal of sulphur, nitrogen oxides and heavy metals from flue gases - Questionnaire for EU-Project "Assessment of the air emissions impact of emerging technologies"***, Personal Communication, 2004

5.1 Short description of technology

The application of micro-organisms in removal of nitrogen oxides from the gas streams is possible. This is a new technology.

5.2 Technical aspects

5.2.1 Detailed description of technology

Interactions of the sulphur and nitrogen natural cycles are applied in the proposal project. The removal of $(NO)_x$ from flue gases is achieved by chemical reaction between reduced inorganic sulphur compounds e.g. H_2S; SO_2 and oxidized nitrogen forms as nitrite and nitrate to nitrogen free with simultaneous oxidation reduced sulphur compounds to sulphates. The sources of the reduced sulphur compounds are products of the microbiological reduction of sulphates with *Desulfovibrio desulfuricans* strain. The desulphurisation process will be carried out together with autotrophic sulphur oxidizing bacteria *Thiobacillus denitrificans* in circulation tank perform role of the bio-reactor in the system of the absorption tower of the flue gasses. The described processes can be expressed by following reactions;

$$SO_2 + NO + CO_2 + \text{molasses (10 g /dm}^3) \xrightarrow{\textit{Desulfovibrio}} H_2S + CO_2 + NO \xrightarrow{\textit{Th. denitrificans}} SO_4^{2-} + N_2$$

$$S^{2-} + Me^{2+} \rightarrow MeS$$

In the method one of the pollutant e.g. SO_2 will be used to the removing of nitrogen oxides and heavy metals (Me^{+2}) from a gas stream in absorption tower. Besides the heavy metals will removed from a gas stream in sulphide forms as the results of the chemical reactions between S^{2-} ions and heavy metals. The available carbon source for feeding of the *Desulfovibrio* bacteria will be applied molasses. The proposed project can be the new technological solution to application for cleaning of flue gases with the well-known microbiological processes in different industry.

5.2.2 Implementation experience

The break-through of the technology is expected after carried out studies and obtained good results in the pilot plant study (2010).

5.2.3 Stage of development

Table 1: Stage of development

	current	2010	2015	2020	2030
bench/laboratory	X				
pilot/demonstration plant		X			
commercial			X		

5.2.4 Reference installation

In years 2003-2005 we have studied the chemical interaction between natural sulphur (reduced inorganic sulphur compounds) and nitrogen cycles on nitrate and nitrite removal in aqueous solution like to the proposal project in pilot plant at the central treatment plant of municipal waste water in Koziegłowy near Poznan (PL).

5.2.5 Operational experience

The operational performance of the installation will be determined after finished pilot plant study.

5.2.6 Advantages of technology

The advantageous of the proposal project will be determined after pilot plant scale.

5.2.7 Drawbacks of technology

In the proposal project we do not foresight disadvantageous effects of the technology.

5.3 Environmental aspects

5.3.1 Emission factors

Table 2: Emission factors

Importance	Pollutant	Emission factor or reduction
important	SOx	70%
	NOx	80%
	NMVOC	
	PM (TSP, PM10, PM2.5)	
	CO2	
	Energy	
less important	CO	
	NH3	
	N2O	99%
	POPs (e.g. dioxins, furans)	
	Heavy metals (e.g. As, Cd, Cr, Cu, Ni, Pb, Zn)	60%

In the Table above publication data are shown that have been obtained in laboratory scale in aqueous solutions during a study in laboratory scale in the course of framework domestic grant (2003-2005).

5.3.2 Trans-media effects

5.4 Economical aspects

The costs will be determined after finished pilot plant study

5.4.1 Investments

5.4.2 Fix costs

5.4.3 Variable costs

5.4.4 Lifetime

The expected lifetime will be determined after finished pilot plant study.

5.5 Diffusion, expected relevance

5.5.1 Activity of sector[13]

Table 3: Activity of sector

area	2005	2010	2015	2020	2025	2030

5.5.2 Applicability[14]

Practical application of the proposal project can be applied in whole sectors. In the laboratory scale investigation we did not find limits for different operation. The technology can be retrofitted to existing installations. The investment costs will be determined after finished pilot plant study.

Table 4: Applicability of the technology

area	2005	2010	2015	2020	2025	2030

5.5.3 Application rate (market share)[15]

Table 5: Application rate of the technology

Area	2005	2010	2015	2020	2025	2030
Chemical industry		X				
Energetic industry			X			

There will not be differences in the diffusion process in EU25 plus Norway and Switzerland.
We did not foresee obstacles in development the proposal technology.
There are no specific measures that could promote the diffusion process.

5.6 References

(1) Gąsiorek, J.A., "Waste pyritic coal as an energetic source", *Fuel Processing Technology* 1997,52,175

(2) Gąsiorek, J.A. et al., "EPR study and structural aspects of ferredoxins obtained from *Thiobacillus ferrooxidans*", *Appl. Microbiol. Biotechnol*. 1999,52,96

(3) Gąsiorek, J.A., Gąsiorek, P., Krystek, A., Kempny,Z., Tomaszewski, J., „Procedure for nutrient removal in wastewater treatment"., *Polish patent application*, P-340 359 (29 May 2000)

(4) J. Gąsiorek., „Removal of heavy metals from excess activated sludge" *Polish Jour.of Chem. Technol.*; rok 4 nr 3 (2002).

(5) J. Gąsiorek,. „Ekological barriers for management of sludge" Ekotechnika, wyd. Lektorium, nr 1 str.2 / 2002r /.

[13] from RAINS- model
[14] theoretical maximum application rate (only technical restrictions)
[15] effective application rate