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APLICATION OF THE THREE PHASE TESLA COIL FOR REMOVAL OF SO2 AND NOx FROM FLUE GASES BY HIGH FREQUENCY DISCHARGE

PRIMENA TROFAZNOG TESLINOG TRANSFORMATORA ZA ČIŠĆENJE SO2 I NOx IZ DIMNIH GASOVA POMOĆU VISOKOFREKVENTNOG KORONA PRAŽNJENJA

Abstract

The new original electronic filtering technology (ELFI) using a plasma chemistry method is developed in "VINCA" Institute of Nuclear Sciences, on the basis of fundamental research of the original type of high frequency corona discharge energized by the new type of high-frequency and high voltage generator - "Three-phase Tesla Coil".
The ELFI module can be added to an existing plant as a by-pass, so it does not obstruct its function. SO2 and NOx are simultaneously removed from the flue gases by the ELFI technology and are converted into a useful artificial fertilizer. Waste materials are not produced by this technology, and the problem of permanent storage of undesired products does not exist.

Key words: SO2, NOx, flue gas treatment

1. INTRODUCTION

The emission of toxic gas, sulphur oxides and nitrogen oxides from industrial plants has become a serious problem in the World. SO2 and NOx are known to be converted to "acid rain" in the atmosphere and cause the environmental pollution. – Fig. 1

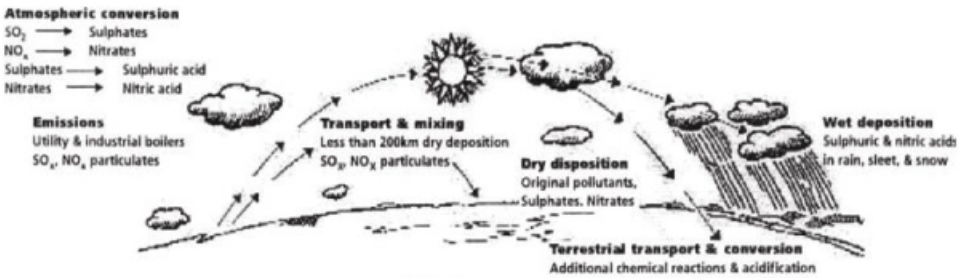

Fig. 1

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2. TECHNOLOGIES FOR CLEANING SO2 AND NOx FROM FLUE GASES

E-beam technology has the disadvantages of high capital cost and the need to shield potentially hazardous X-rays which are produced in the process. One possible alternative technology is the corona discharge, a comparatively recent entrant to the field of non-thermal waste treatment. The principle behind the corona discharge is the creation of plasma filaments – small bursts of plasma – generated when a high voltage is applied between a wire filament and a metal plate. High electric fields are created in the heads of those filaments, which produces largenumbers of free electrons, as in e-beam reactors.

Results so far have been encouraging, although the gas volumes treated to date have been considerably smaller than those using e-beams. Corona disharges have the potential advantages that fitting costs may be greatly reduced, since they use the same wire-plate electrode configuration as in the electric percipitators used in convetional "wet scrubbers" for flue gas control. If either of these methods is to replace conventional technology, they will need to use less than 3% of the total electrical power of the generator.

One of the major problems for both technologies is "scale-up" for application to the modern large power plants [1] .

3. IMPULSE CORONA DISCHARGE

Theoretical investigation of the phenomenon impulse corona energization of flue gases led to the assumption that the most suitable electron energy for producing the chemical radicals which are responsible for the oxidations of the sulphur and nitrogen oxides is in the range 5 to 20 eV and that a pulse corona discharge can provide a number of such electrons : Table 1 and Table 2 [3] .

Table I - Main reactions of the process

$e^*(5.1eV) + H_2O \longrightarrow H + OH^-$

$e^*(7eV) + O_2 \longrightarrow O + O^-$

$e^*(>15,7eV) + N_2 \longrightarrow N_2^+; e; N^+; N; N_2^*$

$e^*(>12,1eV) + O_2 \longrightarrow O_2^+; e; O^+; O; O_2^*$

$e(<5eV) + O_2 \longrightarrow O_2^-$

$O_2^+ + O_2^- \longrightarrow O_3 + O$

$O_2^+ + H_2O \longrightarrow O_2^+ H_2O$

$O_2^+ H_2O + H_2O \longrightarrow H_3O^+ OH + O_2$

$H_3O^+ OH + n\,H_2O \longrightarrow H_3O^+ (H_2O)_n + OH$

$H_3O^+ (H_2O)_n + O_2^- \longrightarrow (n+1)H_2O + HO_2$

$NO + HO_2 \longrightarrow NO_2 + OH$
$NO + O \longrightarrow NO_2$
$NO_2 + OH \longrightarrow HNO_3$

$NO_2 + O \longrightarrow NO_3$
$NO_2 + NO_3 \longrightarrow N_2O_5$
$N_2O_5 + H_2O \longrightarrow 2HNO_3$

$SO_2 + OH \longrightarrow HSO_3$
$HSO_3 + OH \longrightarrow H_2SO_4$

$SO_2 + O \longrightarrow SO_3$
$SO_3 + H_2O \longrightarrow H_2SO_4$

$HNO_3 + NH_3 \longrightarrow NH_4NO_3$

$H_2SO_4 + 2NH_3 \longrightarrow (NH_4)_2SO_4$

Table 1

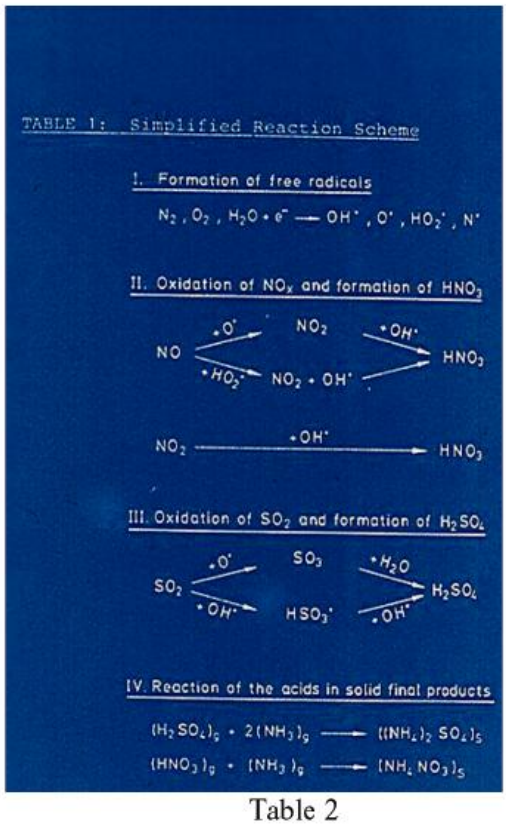


Table 2

4. HIGH FREQUENCY CORONA DISCHARGE BY THREE PHASE TESLA COIL

4.1. Double-Sided High-Frequency Corona Brush Discharge

Corona Brush Discharge (CBD) represents a new type of a high-frequency corona discharge . One of the principal characteristics of this discharge is that corona occupies a whole volume between a special brush-shaped electrodes in a discharge chamber .

The results of the study of the double-sided high-frequency corona brush discharge (DSCBD) when a new type of Tesla coil is used as a power supply – the Three-Phase Tesla coil (3PTC), which gives uniform output voltage in each operating pulse – are presented in this paper.

When 3PTC is energized, corona discharge is established and it completely occupies the space between the all electrodes and emits uniform light from the whole volume of double-sided corona brush discharge (DSCBD). So, for example, second positive system of N_2^* 337.1 nm and 357,7 nm are obtained [4] .

4.2. ELFI Technology Principal Characteristics

The ELFI technology is based on a new type of the high frequency corona discharge. As a consequence, the principal advantages of ELFI technology over other existing technologies for cleaning of flue gases (e.g. the electron beam technology) are:

- Plasma is created in the whole volume of a plasma chemical reactor (PCR);
- It is possible to scale-up a plasma chemical reactor, so that a large flow of flue gases from a thermal plant can be processed, which is significant for industrial application of the ELFI technology.

One may find about other existing methods for cleaning of flue gases from SO2 and NOx in the article: "Plasmas join the fight against acid rain "by Graeme Lister, Physics World, December 1992, p. 19.

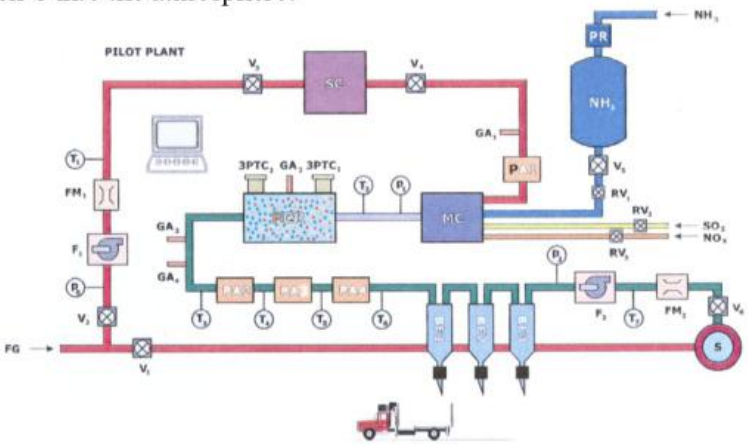
Some properties of the ELFI technology:

- this new, original technology using a plasma chemistry method is developed in the "VINCA" Institute of Nuclear Sciences on the basis of fundamental research of the original type of high frequency corona discharge.
- it is realized in the form of a special ELFI module which makes a part of a plant that burns fossil fuel.
- ELFI modules can be added to existing plants as a by-pass, so that it does not obstruct their function.
- SO2 and NOx are simultaneously removed from flue gas and by ammonia addition, converted into a useful, high quality and commercially valuable artificial fertilizer.
- waste materials are not produced by this technology, and the problem of permanent storage of undesired products does not exist.
- it consumes less electric energy for its functioning than other technologies.
- it is the only commercially efficient technology of this kind in the world.
- Removal of SO2 and NOx from flue gases contributes to the protection of human environment from these pollutants, and therefore directly improves health of human population ; it also prevents creation of acid rains, and protects buildings and metal constructions

- It can be used (installed) in all plants that burn fossil fuels: electric power plants, mills, chemical industry, oil industry, thermal plants, and other plants.

Principle of operation

A flue gas of known characteristics (temperature, gas flow rate, humidity) enters the plasma chemical reactor PCR, in which SO2 and NOx are being removed with addition of ammonia (NH3) in stoichiometric ratio and converted into artificial fertilizer.
Fertilizer is collected in bag filters BF1 – BF3, and flue gas without SO2 and NOx is passed through the stack S into the atmosphere.



S	– stack	MC	– gasmixing chamber
FG	– flue gas	PCR	– plasma chemical reactor
V	– valve	GA	– gas analyzer
F	– fan	PA	– particle analyzer
P	– pressure gauge	3PTC	– 3 Phase Tesla coil
T	– thermometer	BF	– bag filter
SC	– spray cooler	RV	– regulation valve
FM	– flow meter	PR	– pressure regulator

Results achieved:

- New technology is the result of fundamental research on which ELFI is based and is presented on international scientific meetings.
- Laboratory studies show completely fulfilled foreseen expectations for flue gas filtering and gave numerous data necessary to project a pilot plant [6] .
- The patents for ELFI technology were granted in : United States of America [7], following countries of the European Patent Union - Austria, Belgium, Switzerland and Luxemburg, France, Great Britain, Ireland, Italy, Holland, Germany and Sweden.[8] , Japan [9], and Serbia [10].

4.3. V. Miljevic, ELFI – New original technology for simultaneous removal of sulphur dioxide (SO2) and nitrogen oxides (NOx) from flue gases in plants which burn fossil fuel - Fig. 3

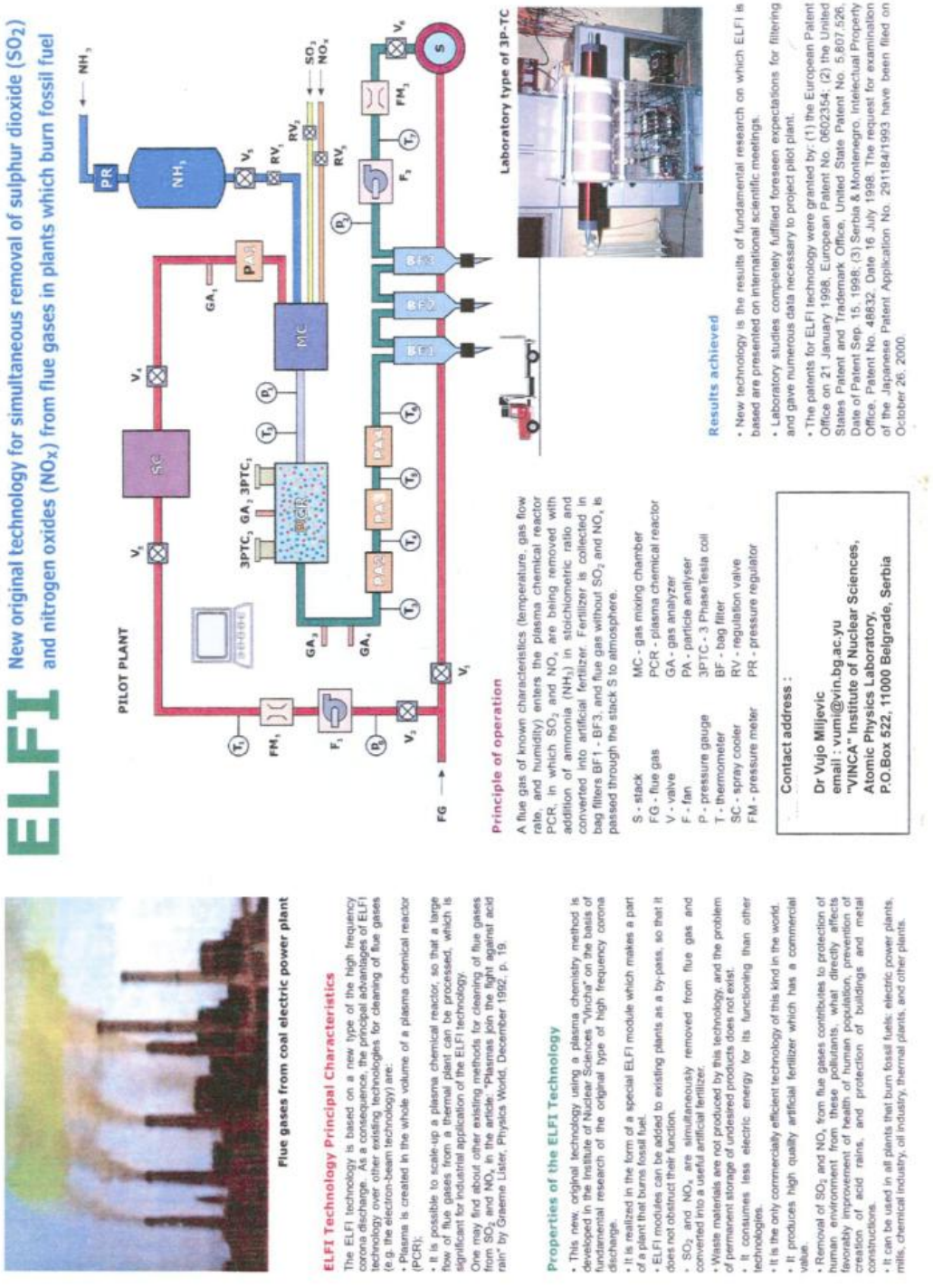


Fig. 3

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