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# ELFI PILOT PLANT FOR REMOVAL OF SO2 AND NOx FROM FLUE GASES IN THERMAL PLANTS

## 1. INTRODUCTION

With increase of industrialization in the world, demands for production of electric energy increase, particularly in developed countries. Presently, a largest amount of electric and thermal energy is produced in fossil fuel thermal plants. Burning of fossil fuels emits into atmosphere flue gases containing sulfur dioxide (SO2) and nitrogen oxides (NOx). These pollutants are very harmful for environment. For example, acid rains are caused by presence of SO2 and NOx in atmosphere. As a movement of pollutants in atmosphere depends on winds, the problems with them is a global problem of the whole world and mainly does not depend on the location of a pollution source.

With the increase of numbers of thermal plants, methods for removal of SO2 and NOx from flue gas (filtering of flue gas) has been developed. However, the existing methods for filtering of flue gases have its problems and even deficiencies. When using, for example, chemical methods for filtering of flue gases, the by-product of filtering from SO2 is gypsum which has limited commercial value. As gypsum is unstable it practically means that one kind of pollutant is turned into another kind, but a less harmful one. A land is sacrificed for disposal of filtering products (gypsum) and subterranean waters are polluted. The rate of efficiency of such a technology is about 50% for SO2. The installation has to be regenerated occasionally due to its saturation. A special methods are used for removal of NOx (selective catalytic
reduction - SCR).

Recently, method based on the electron beam irradiation of flue gas in the presence of ammonia (in stoichiometric amount) for simultaneous removal of CO and NOx has been developed - e-beam technology. This method has a high
efficiency rate; almost 100% for SO2 and about 80% - 90% for removal of NOx, and there is no saturation of the installation. The by-product is artificial fertilizer (ammonium sulfate and ammonium sulfonitrate) which has a commercial value. As it is used in agriculture there is no storage problems. One defect of this method of filtering is very expensive electron accelerator that operates in the regime of high power, i.e. 100 kW and more, as well as high consumption of electric energy for its operation. Pilot plants using this method and working under real conditions exist in the U.S.A., Japan, Germany, and Poland, with a purpose to obtain relevant data for construction of industrial installations. Thus, in Poland, using experience gained on one pilot plant, is recently made industrial 100 MW modular plant for removal of SO2 and NOx from flue gas, that operates under real conditions, and is commercialy available.

Another method for flue gas filtering is based on impulse corona discharge, and it is still in the experimental phase. Although the filter chamber is relatively simple, the impulse high power supply of rise time amounting to a few nanoseconds and of a repetition rate of 300 Hz is very expensive. The rate of efficiency of this method is about 50 to 60%, and is still in an experimental phase.

More about existing methods for cleaning of flue gases from SO2 and NOx is given in the article by G. Lister, Phisics World, December 2002, p.19. By our knowledge it is not developed a some new technology since the time the article by
G. Lister is published.

A new method for simultaneous removal of SO2 and NOx from flue gas, a plasma chemistry method called ELFI, which in great extent does not have defects of already mentioned methods, has been developed in the Atomic Physics
Laboratory of the Vinca Institute of Nuclear Sciences on the basis of fundamental research of the special type of high frequency corona discharge by the
Three Pase Tesla Coil (3PTC). The by-product of this method is also artificial fertilizer. The installation using this method costs less, consumption of energy for
its operation is lower, it is more reliable in operation, and it is simpler for servicing
than installations using previously mentioned methods. The process of cleaning of
flue gases would be completely self-contained by using such a technology: protection of human environment would be provided, and fossil fuels became also the source of other useful products besides their basic application to produce energy.

The results of fundamental research on which ELFI is based are presented on international scientific meetings. Laboratory studies completely fulfilled foreseen expectations for filtering and gave numerous data necessary to project pilot plant. The patents for ELFI technology were granted in 1998 by the European Patent Union, U.S.A., Japan, and Yugoslavia, .

## 2. COMPARISON OF E-BEAM AND ELFI TECHNOLOGIES

To see the advantage of the ELFI technology, let us compare it with the technology of electron beams:
- In the electron beam technology high-energy electrons (300 to 700 keV, and more) are used to produce secondary low-energy electrons in complex reactions with flue gas. Energies of secondary electrons are several thousands times smaller than energies of primary electrons. Just these secondary electrons take part in reactions which produce radicals and other constituents necessary for removal of SO2 and NOx from flue gases. That means that this is a two-

step process and a large part of energy given to flue gas by primary electrons is wasted, for instance, for heating of gas, for heating of system components (which must be cooled by forced air), and for other reactions that do not contribute to efficiency of filtering but represent a net loss of energy. That is why a filtering plant based on electron beam technology consumes even up to 15% of produced electric energy of thermo-electric power plant.
- In the case of ELFI technology primary low-energy electrons participate directly in reactions for filtering flue gases, i.e., without intermediate steps. Therefore, side effects are manifestly lower than in the case of the electron beam technology, and no additional cooling of system components is necessary. The efficiency of filtering is considerably increased in that way, and consumption of electric energy of ELFI plant is lower than for filtering by electron beam. For the same reasons ELFI plant production costs are considerably lower than those by electron beam.

The principal characteristics of ELFI technology are:
- Plasma is created in the whole volume of a plasma-chemistry reactor (PCR);
- It is possible to scale-up a plasma-chemistry reactor, so that a large flow of flue gases from thermal plants can be processed.
All this enables application of the ELFI technology to contemporary power plants.

## 3. ELFI PILOT PLANT

The basic aim of ELFI pilot plant is to obtain relevant data for construction of an industrial plant and its placement on the international and domestic markets. It is planned an industrial installation of modular type with basic modules of the power of 100 MW. In such a way it would be possible to ensure cleaning of flue gases from thermal plants and/or other plants of various powers emitting SO2 and NOx.

The pilot plant is designed for installation on thermal plant in VINCA Institute, of the
power of about 10 MW and with the capacity of flue gases of 10,000 m3 per hour.
A block diagram of the ELFI pilot plant is presented in attached figure. Heating plants of such characteristics are very suitable for operation of a pilot plant in realistic conditions and data obtained will be very useful for design and construction of industrial plants which will be placed on the international and domestic markets.

Eminent scientists, engineers, professionals, and technicians are engaged on the project. The project manager is Dr. V. Miljevic' who is the author of the new ELFI technology.

Completed phases of ELFI pilot plant project are as follows:
- Preliminary design.
- Complete technical documentation (contractor's design).
- All preparation for start of the construction of complete pilot plant and

choice of cooperators.

The ELFI pilot plant, as mentioned above, will give data which are going to be used for design and construction of industrial plants.

## 4. ECOLOGICAL EFFECTS OF ELFI PROCESS

It is usually thought that investment of financial resources is indispensable for protection of atmosphere, i.e. human environment. Therefore, a high stack is still the sole protection of atmosphere from SO2 and NOx in the majority of countries. By such "filtering" flue gases are ejected high in atmosphere - what is equivalent to dilution of harmful products but not to their removal.

The ELFI method promises a high grade of efficiency of filtering of flue gases from SO2 and NOx with addition of ammonia (NH ) in stoichiometric ratio, and their conversion into artificial fertilizers of a commercial value which are deficient goods in many countries in the world. In that way, for instance, a thermo-electric power plant ceases to be a pollutant, but, besides its basic purpose of production of electric energy, becomes a "factory" of fertilizers. The simple analysis has shown that the profit from artificial fertilizer is comparable (for domestic conditions) with the profit realized by the sale of electric energy.

It means that by using the ELFI technology, by which one produces artificial fertilizers besides the primary product, for example, electric power in the case of thermo-electric plant, pure air, without SO2 and NOx,
is a "by- product" , i.e. ecological problems of contamination of atmosphere by power plants disappear.

## 5. SUMMARY

The principal aim of an ELFI pilot plant is collecting of relevant data for construction and production of modular industrial plants of power of 100 MW for flue gas cleaning from a contemporary large power plants emitting SO2 and NOx. The ELFI technology is granted by patents in many developed countries that eneables an exclusive placement on domestic and international markets.

The raw materials for production of artificial fertilizers by ELFI technology are just SO2 and NOx in gas phase that are obtained by scrubbing of flue gases. The only component which has to be purchased for production of artificial fertilizers is ammonia.

Application of the ELFI technology to clean flue gases from SO2 and NOx, "by-product" is the clean air (without SO2 and NOx). In such a way one solves the
fundamental problem of pollution of the atmosphere with SO2 and NOx.