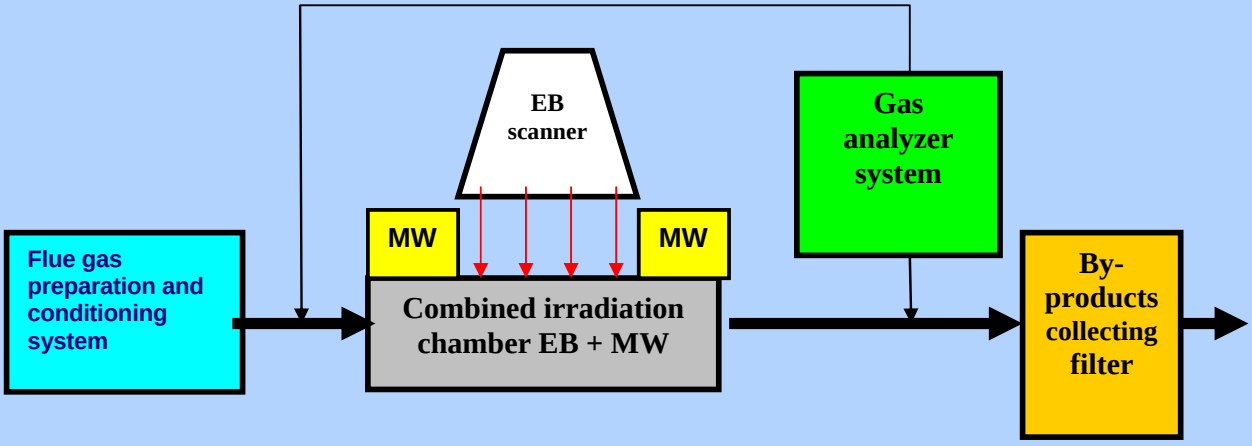
STAGE III: 15.05.2009

Elaboration, design and partial realization of an expertimental model for flue gases treatment with electron beam (EB) and microwave (MW) for a linear industrial accelerator

Activity III.1 Elaboration of an expertimental model for acid gases conversion with the simultaneous treatment EB+MW, for an industrial accelerator
Elaboration of the combined irradiation reactor
Elaboration of the experimental model for gas analyzing and conditioning
Activity III.2 Design of an expertimental model for acid gases conversion with the simultaneous treatment EB+MW, for an industrial accelerator
Design of the combined irradiation reactor
Design of the experimental model for gas analyzing and conditioning
Activity III.3 Partial realization of an expertimental model for acid gases conversion with the simultaneous treatment EB+MW, for an industrial accelerator
Partial realization of the combined irradiation reactor
Partial realization of the experimental model for gas analyzing and conditioning
Activity III.4 Elaboration and designing of the experimental model for the gases preparation for the industrial accelerator
Activity III.5 Realization of experimental versions for the operating conditions of the industrial accelerator

No. III phase objective was to develop, design and partial make an experimental model for the conversion of acid gas by *simultaneous* electron beam and microwave treatment for an *industrial* accelerator.
To this end, it was made a brief comparative analysis of separate interaction mechanisms of electron beams and microwaves with the substance. This study demonstrates that the accelerated electrons and microwaves are both able to induce, with high efficiency, plasmas in gaseous materials but by totally different physical and chemical mechanisms.
Also, we have shown that the geometry of irradiation combined reactors is imposed by the particularity of the interaction with the substance of each of the two physical systems. We concluded that the experimental model for treatment of industrial flue gas with the industrial accelerator should allow the *simultaneous* irradiation with electrons and microwave and must contain the following components: *A reaction chamber for combined irradiation* adapted to electromagnetic characteristics of microwaves and which present a geometry adapted to electric and geometric characteristics of accelerated electrons; *A system for generating microwave* attached to the combined irradiation chamber; *An experimental model for the combustion gases preparation and reaction products separation;* A conditioning and gas analysis system before and after irradiation; *An electron accelerator* as a source of electron beams.



General block diagram of the installation of production, conditioning, irradiation with electron beam and microwave and flue gas analysis

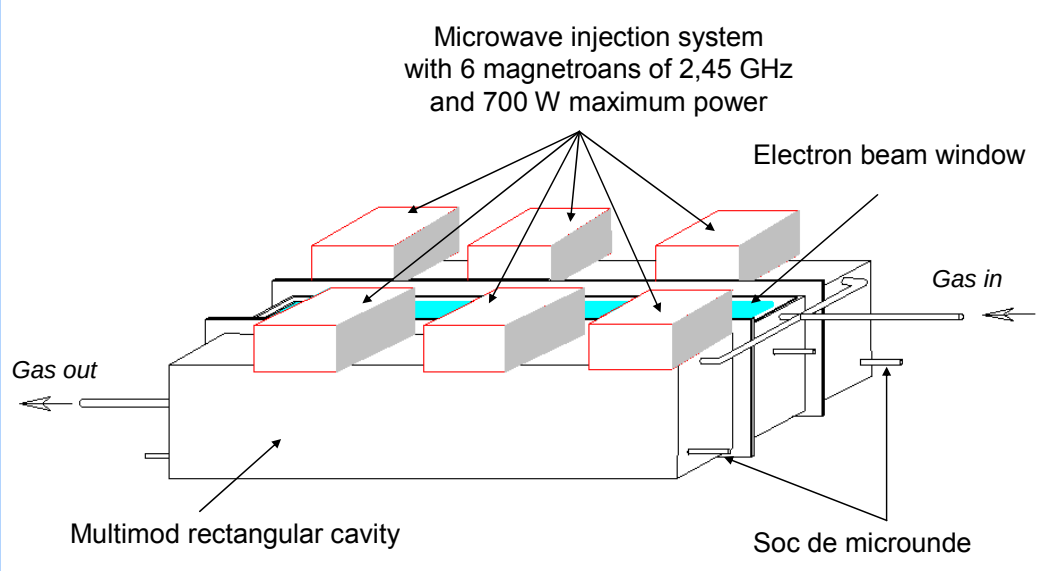
To achieve phase the following activities were carried out by partners in the project:

- *Elaboration, design and partial realization of the combined irradiation reactor*

The reactor is of rectangular form with the inner dimensions of 9λ x 6λ x 2λ, where λ is the wavelength corresponding frequency of 2.45 GHz, provided on top cover with a 40 μm thin aluminum window with surface of 6 cm x 100 cm, wherethrough enter the electron beam from the industrial accelerator. Microwave flow is introduced by 6 slits cut in the upper horizontal wall of the reactor, through six generators adapted from microwave ovens.
The flow gas enter through 3 griddle slots in one of the narrow side walls of the reactor with mesh large enough not to disrupt the movement of gas and small enough not to disrupt the current distributions of the cavity walls and reduce "microwave energy losses" outside the cavity.

- Elaboration and design of microwave injection system

To achieve microwave generation system, we used 6 household microwave ovens of 700 W. The six ovens were dismantled and 90% of components were re-used in the construction of microwave injection systems. The main changes made had considered the possibilities of: - continuous and widely adjustment, from zero to the maximum value, of the microwave power injected into the chamber and irradiation time; - continuous power measurement during microwave irradiation; - remote control regimes of microwave irradiation in order to synchronize them with electron radiation schemes in combined irradiation experiments.



- Elaboration of the experimental model for gas analyzing and conditioning

For the gas conditioning experimental model elaboration and design was performed mathematical modeling of gas treatment process with accelerated electrons considering a chemical reaction system and the experimental data obtained from a pilot plant. It was designed the flue gas conditioning and analyzing experimental model and made a preliminary model.
For the analysis of gaseous-products will be used a continuous analyzer for SO2, NOx, CO, CO2 and O2 formed by a conditioning unit, a unit of measurement and a mode selector for gas sampling and calibration. For solid reaction-products analysis will be done ion chromatography and thermo-gravimetric analysis. It were described the operation principles of these methods.

- Elaboration and designing of the experimental model for the gases preparation

The technical solution of the experimental model was developed to achieve two major objectives:
- To obtain flue gas with no dust with the necessary chemical composition and temperature for developing specific radiolysis reactions, with maximum efficiency - Retention of the by-products obtained after the combined irradiation with accelerated electrons and microwave.

- Realization of experimental versions for the operating conditions of the industrial accelerator

It was done a description of the industrial electron accelerators, after that being presented the ILU-6M industrial accelerator planned to perform experiments with combined irradiation chamber. This accelerator generates in current operating conditions 1.8 MeV accelerated electrons energy, 6 mA maximum average current and 10.8 kW power. This accelerator is equipped with a scanner having the output window of 130 cm length and 6.5 cm width. It was evaluated the dose rates for the operating modes of the accelerator. Also, there were set field dimensions of the accelerated electrons and their path and attenuation, being necessary in the designing of size of the gas reactor.