On the basis of the results obtained from the first project activities, the grinding conditions on a larger scale were determined.

As regards the sintering, an adjustment has been made to the roller furnaces for sintering, taking into account the specification that emerged not to exceed 1200 °C.

A ceramic laboratory was built-up to be able to do the forming and firing tests, in order to find the best powder mix and processing conditions. It was known that forming by pressing requires the addition of clays or plasticizers. Were obtained and tested 110x55x10 mm samples containing up to 90% of Micropowder by weight using a 110 bar forming pressure. The samples were fired in air atmosphere at 1050-1150°C, with a shrinkage value that depends from the Micropowder content.

Acceptable mechanical properties (like 300 kg/cm²) were obtained.

Regarding thermo-mechanical properties, it was found that a sufficiently homogeneous irradiation by microwave is required to assure the absence of breakage effect due to differential thermal stresses.

Different powder mixes and different forming/firing specifications were so defined for each research topic: microwave absorbing tiles, microwaveable containers for food cooking, electric heating resistances.

The pilot line has so been used to produce sintered and molten elements which, after machining and application of electrical contacts or supporting refractory, were ready for testing and presentation to stakeholders.

**Microwave absorbing tiles:**

The slag content is up to 90%wt. They have maximum dimension 400x400x10 mm and they are excellent microwaves attenuators. Installed at the ends of tunnel microwave ovens, they provide shielding against microwave leakage. They are thermally resistant but quite heavy and not flexible. To match this two requirements, also rubbery tiles containing 60% of slag, that are flexible and lightweight, were realized by moulding and vulcanizing rubber at 160°C for 15 minutes. Then microwave absorber tiles were tested in lab conditions and an insertion loss around 6 dB/cm at 2.45 GHz was measured.
These samples demonstrated to be useful as microwave leakage attenuators and absorbers in industrial microwave plants. They have high mechanical resistance (>250 kg/cm²) and are easy to cut and drill to be mounted on oven walls and different substrates.

Ceramic absorbers with 60%wt. slag content were so prepared with the pilot plant to be installed on microwave conveyor oven walls. A drastic reduction of microwave leakage was measured. Their performance are equal or better than current shielding/attenuation solutions (water, silicon carbide, ferrite tiles), which are less versatile and much more expansive.

**Microwaveable plates and pirofila:**
It was produced a prototype of pirofila for new approach in microwave cooking. Unlike conventional ceramic/pirex/plastic containers that are transparent to radiation, this container heats up to 250°C in a microwave oven, heating food with a traditional heat transfer process, while microwaves heat the food from the internal. It contains up to 45% of slag.

The processing steps for this product are the followings: wet-pressing to assure homogeneity of the mixture, drying, firing at 1100°C, internal metallization by thermal spraying, enamelling with glazes and last firing at 970°C.
Plates were prepared in different sizes and shapes.

Microwave heating properties and cooking performances of microwave plates were tested in common microwave home appliances. Thanks to the hybrid absorbent/transmissive characteristics of the slag/ceramic composite, the position of the microwave inlet only slightly affects the heating pattern. Therefore this technology is very adaptable because the plate fits well with several ovens from different manufacturers with replicable results. To achieve sufficient cooking results the container should be preheated for 2-3 minutes at 900W to reach 150°C. In comparison to Crisp Plate this preheating times are quite longer because the ceramic plate weighs more (1000 g) than a conventional metallic Crisp Plate (600 g). On the other hand, the high thermal mass and thermal retention of ceramic allows the plate to remain warm for a double time than a Crisp Plate after cooking. Furthermore some cooking advantages were evidenced: slag-activated plates show a level of browning/crisping that is comparable or better than Crisp Plate. In addition, slag plates provide strong heat generation also on the lateral sides, while Crisp Plate don’t.
The final products realized:

- **Ceramic glazes**
- **Sol-gel coatings** (low-temperature process)

**Heating resistances:**
Micropowder has a semiconductor behaviour. At room temperature it has very high resistivity (MΩ·cm) which decreases exponentially with raising temperature. To fabricate heating resistance it has been stated that Micropowder must be doped or mixed with high-conductive elements or alloys. Several tests have been made using different conductive powders (carbon, aluminium, steel, silicon, copper, nichel) at 5-15% by weight. From the earlier tests appears that a reducing atmosphere during firing was necessary to avoid the oxidation of the conductive phase. Firing in controlled combustion atmosphere (CO, CO2) elements with 5-10% copper was an effective way to obtain 20-cm samples with resistance between 30 Ω and 100 Ω. This results becomes highly reproducible with the use of a small amount (<5%) of an industrial salt-based flux. The heating elements can be heated up to 1000°C by Joule effect applying conventional voltages (0-100 V).
The only problem that occurred regard the worsening of the performances of the heating elements after a few working cycles, probably due to the oxidation under working. A protective coating or a passivation method (adding different fluxes) were tested to avoid this problem, as well as finding a method to decrease the porosity using low-firing ceramics or increasing the homogeneity of the mixture, for example using an extrusion forming method. This problem, however, was not totally solved: XRD/SEM tests performed by Trento University show a dramatic decrease of the conductive phase with operation. This fact, which is probably due to oxidation reactions within the bulk, is responsible of the decay of heating properties after 5-10 uses. The situation was slightly improved by the application of a protective coating, but the number of working cycles never exceeded 15 cycles.

Some added tests proved to be necessary also to find the correct formulation for the waterproof ceramic container production, using an appropriate enamel formulation and an appropriate way of application of the enamel. It was known that a very low bulk porosity is crucial to obtain a correct enamel application and adhesion. Therefore, the firing step was tuned to reach a measured porosity of 3% (water absorption in wt.). This lowers the importance of an ad-hoc enamel formulation: many standard ceramic glaze were tested with good adhesion results. Furthermore, sol-gel coatings were tested on the substrates, leading to encouraging results, but heating resistance are not performant enough, since it is possible to obtain the resistances, they work, but they have too few activity cycles for applications.