Abstract.

Material heat processing systems using microwave energy have been used for more than 60 years. Design and implementation techniques have greatly evolved during this time, but a precise control in material temperature is still difficult to achieve due to theoretical and practical reasons.

This difficulty arises, in many cases, because a deep knowledge in several technical fields is needed in order to design the process properly, being microwave engineering only one of them. Usually it's necessary to combine knowledge in microwaves with material technology, chemistry, and other fields, in order to have a clear idea about how the process should be.

The main aim of this work is the development of experimental equipment that allows the heat treatment of material samples using microwave energy, while providing a great control over the sample temperature and the energy absorbed. Using such an equipment, very valuable data can be obtained for the process dynamics when using microwave technology.

With this objective in mind, in a first step different suitable types of microwave applicators have been studied, as well as several optimization techniques for the temperature distribution within the sample.

Advantages and disadvantages of multimodal applicators have been analyzed, and a detailed study about the effect of mode stirrers in the

field uniformity has been carried out, which is the more common technique for this aim.

A next step was the study of thermal effects in materials under high power electromagnetic fields. Heat transfer, convection and phase change phenomena have been studied in order to analyze their effect in the sample temperature.

The thermal runaway effect has a special importance in the processing of some materials, mainly when dielectric losses increase with temperature. This phenomenon has been analyzed, as well as some suitable techniques that can be used to avoid it, or at least to reduce its effects. Also, different types of temperature sensors have been reviewed to study its usability in microwave systems, and as a result infrared temperature sensors has been chosen as the more suitable technology.

In microwave heating systems the temperature increment in the sample is determined by the microwave power absorbed by the applicator, and for this reason an accurate control over this parameter is required for a good temperature control. It should be remarked that microwave heating processes are dynamic, evolving with the changes in material temperature and properties. For this reason, different procedures for absorbed power control has been analyzed, with highlight in the work carried out regarding the development of a dynamic impedance matching system.

Moreover, other strategies for absorbed power regulation have been studied, using different control parameters as the generated power, the cavity tuning or the frequency sweep span.

Two different systems have been developed. One is based on a tunable monomode cavity with a mechanic tuning system; the second is based on a non-tunable cavity and the use of a variable frequency generator. Both systems integrate temperature sensors and the equipment required to measure the power delivered to the sample. An automated process control algorithm based on PID has been implemented, allowing autonomous working during the experiments.

Both developed systems have been used in a high number of experiments with different nature of samples. Some of these results are presented in this work, showing the excellent performance of the systems and the valuable information that can be obtained for the studied materials.

As a final point, several future research lines are proposed in order to continue the work developed up to now.