Microwave Based Detection, Quantification and Non-Destructive Evaluation of Materials and Compounds

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Abstract: -The current tendency in most of the instruments is the one of developing its function without intervening in the activity of the means. This new technology with base in the microwaves has a strong application in the inspection of new dielectric materials or compound insulating. The non destructive technology of microwaves penetrates easily the insulating ones. The penetration depth depends on its factor of lost of the same dielectric material and of the operation frequency. The possibility exists of measuring in direct contact or not with the sample, technologies of Reflection and / or Transmission. The experience that we have had inside the laboratory is centered in the application in near field of signals of microwaves in the X band, (8.2 GHz at 12.4 GHz.) modulated at 1 KHz. By means of the use of this frequency it is possible to detect the presence of water in a mixture, those like cement and water, cement and sand without an specific arrangement of the samples under analysis we always consider the samples as we take, ready for their analysis, that means you doesn't pulverize neither you accommodation in the Carrier samples. It was possible to detect water by means of the measurement of the amplitude of the reflection of the applied signal. The equipment has couplers that guide the signal toward the sample, and a detector coupled to a meter that presents us readings in milivolts.

Key-words: Non-Destructive systems, Microwave measurements, Cement characterization

1.-Introduction

The microwaves technology arises like a useful tool for the detection and evaluation of certain characteristics in mixtures and compound [1]. Still when it can seem unusual this valuable tool that has their origin and main application in the telecommunications, it has demonstrated certain easiness to be used in Non-destructive technology.
The use of microwaves in the so much different fields of the industry like searching to determine state of mixtures or composed, is hardly being accepted, the first applications have them in certain areas of the industry of the cement, where determining the degree of humidity is necessary in some mixtures.

2.0 Development of the work

Analysis of the properties of the concrete

Any comment that we can make regarding the cement in anyone of its possible mixtures begins around one of the most important parameters, associated with the concrete, its strength, the compression strength. The concrete is a heterogeneous mixture made up of water, powdered cement, sand, stones of several sizes (or it burdens) and air that gives him certain porosity. [2]
The strength of compression of the concrete is strongly influenced by its relationship water-cement (w/c) as well as its relationship of hard attached (coarse) to cement (Ca/c).

Traditionally to detect how like is compound the concrete a sample of the same one is used that is taken directly of the drain that gives it, it stops then to pass a series of tests in specialized laboratories that take a certain time and they should also have to be careful in marking each one of the taken sample and then later, we have to associate them with each column or part of the building of which we suppose it is part. The other one is to take directly a piece of the construction, breaking the column (making a hole in one face of the column to observe how is made it) when it is already finished. In both cases it is considered destruction.

For that situation is suggested the instrumentation used with base in non-destructive technical, to characterize concrete samples using energy of microwaves with the direct application of the open wave guide to the sample or the entire column *in situ*.

A quick and non-destructive determination of the cured state and the relationship dilutes cement; in fresh cement Portland is important. The traditional techniques are not reliable and they require a priori of tests with samples for calibration for later tests. The microwaves (as an inherent) non-destructive technique had received attention, for their potential to determine relationships like (W/c) water-cement; (S/c) sand-cement; (Ca/c) gravel-cement, in cement cured mortar and concrete.

As traditional technical we have the next one:

1. - First we have to formed a cylinder of concrete as sample and next their strength is determined, pushing until crash it.

2. - A portion of the center of the structure is extracted to be analyzed.

Both methods are considered destructive.

In a calibration process, samples are used some of them whose constitution is known. Samples that can be formed containing a specific ratio.

Examples of ratio:

Sand to cement (S/C) =1.0

Coarse to cement (Ca/C) =1.0; 1.5; 2.0

We are experiencing too, with some techniques to be able to determine in a reliable way the presence and place of the bars of steel of reinforcements in ribs and chains of concrete.

2.1 compound insulators.

In the generation rubber compound, it is necessary to determine the presence of black coal; it is achieved applying to the samples of the compound of rubber, the energy of a microwaves signal. The relationship that is known is that, when the content of black coal increase the dielectric constant of the sample is also increased [3]. There is the importance of knowing dielectric constant.

The presence of ¨cure ¨elements in rubber samples also can be detected, not for itself but for the effect that takes place in the sample, that indicates us the sensitive of microwaves signals to the chemical reaction shot by the curators. These elements cause changes in the dielectric properties of the rubber, at ambient temperature. It is of great relevance the potential that these signals have for monitoring chemical reactions associated with the formation of molecular crossed connections nets.

2.2 techniques

The microwaves as a non destructive technology have characteristic that make them ideal for such tasks since are clean imperceptible and quick. [4] Inside the application of the microwaves there are different techniques that serve for the development of appropriate instrumentation. The techniques in those that we are centering our interest are those that only use the near field [6] for the determination of the values or levels of the variable of interest. Some of them are applied directly on the sample, other more have a certain separation among the source of the energy the sample to analyze and the receiving end.

In both situations use of properties that are well-known is already made, as the Reflection and the Transmission or the energy through the sample. When the element of interest is the water, the transmission is generally used for low concentrations of water and the reflection for high concentrations of the same one.

Transmission. Through the sample.

Inside this technique we have the direct application from the source to the sample. Through an opened end rectangular wave-guide again, (fig.1), there will be some that have a direct contact with the sample and those that don't have any contact (fig.2).

a) For the first one, we have that a direct contact exists on the sample, because the guide is coupled her, the wave guide finishes in the sample. The element of couple or antenna has a double application because first, the energy that goes through the sample is conducted by it, and second the energy reflected return toward the source by the same way.

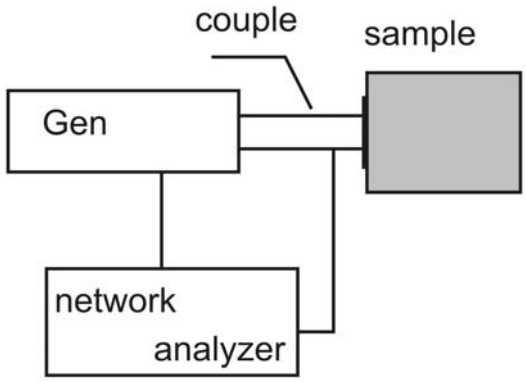

Fig. 1 Draw of the block diagram of the arrangement sample-equipment.

b) For the second (method of free space) we have that the energy launched crosses the sample without contact of the antenna, or device of couple, with her. One can research to a great variety of structures like those that have cement as a base with different contents and dimensions, and different relationships of components with water.

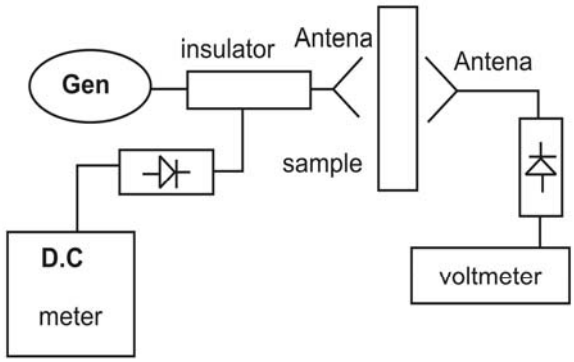

Fig. 2 Block diagram of an arrangement for measuring.

Reflection in the sample.
Technique used in this first phase.
This technique has like base the different tests that are carried out in compound as the coal, the idea is to detect or measure the humidity in samples of coal, while it is driven by a carrier band, without being selected or crushed (fig.3). The water absorbs the radiations of microwaves strongly in certain frequency bands, commonly two or three orders of much higher magnitude than the material bases and this has been used to determine the humidity contained in an interval of powdered or granular materials [5]

The energy is applied on the sample without a previous process (nothing has been made to the sample), it is not pulverized neither makes it in one way or form, that means not moved to a standard form.

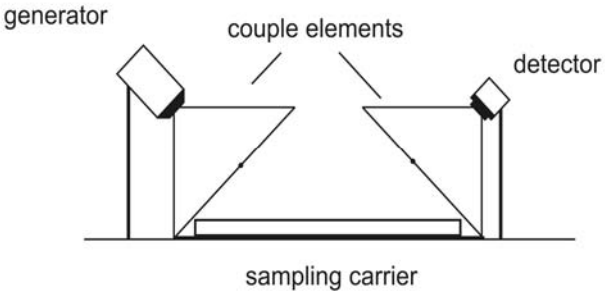

Fig.3 D*raw that shows the disposition of the sample and the elements of couple. As part of the arrangement proposed for the non-destructive detection of the component characteristic of a sample.*

The sampling carrier in the previous drawing has an aluminum base; trying the former experience of the methods that only use the reflection, we take advantage of those phenomena, as we can see in some similar works [6]. In fact having metallic material as a base allows us to achieve a calibration point, since we can take the reading when material doesn't exist and to fix it as the maximum value to measure.

The phase of the reflected signal is not detecting, the amplitude of the same one is only determined.

3. Results

What we exposed in this work is the result of tests initials on a simple mixture of common lands and attached of water and cement in certain proportions, achieving as first goal to detect the presence of liquid in the same one [7].
Later we proceeded with second step, to associate the content of water with the mass of the mixture.
It is indispensable to emphasize the fact that the instruments used in these first tests were developed almost in 90% in the Centro de Ciencias Aplicadas y Desarrollo Tecnologico (CCADET).

Table of results.

Samples	mVolts	Mass gr.
M _0	330	6
M_1	168	10
M_1_T	180	
M_A	98	64,1
M_B	78	115,
M_C	50	170,6

Table 1.

The samples A B and C of the table 1, they were used like initial test, and their weight was only obtained in grams, like additional reference. The answer obtained in the equipment is represented by the reading in mVolts. Each sample has different level of humidity; almost beginning with humidity zero (M_A) water is added in a smaller quantity at the 10 ml. The second sample (M_B) was added a superior dose of water. In third case, their content surpasses the 20ml.

We're using specific frequency of 9.66 GHz instead of use all the range of frequencies of the band, as we can see in other works [5]

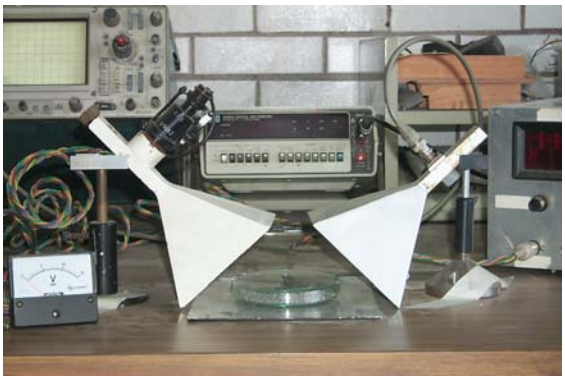

Fig. 4 Photograph of the equipment

5. - Conclusions.

We can be able to develop the necessary instrumentation for detection level humidity of a mixture, and with it impel analysis of mixtures by means of the use of the microwaves.

An important factor is that we can do similar proofs in samples containing water as the proofs made with Lab equipments that means, if we have an specific frequency to apply in certain kind of samples we just have to design the arrange to work in that frequency not in all the range.

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