Experimental elimination of moulds by EMW

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Abstract **This report describes different ways and efficiency of mould elimination with microwave radiation (further referred to as EMW). It describes the efficiency of EMW regarding different mould kinds with particular respect to the intensity of radiation and the length of the radiation cycle the mould samples are subjected to.**

Keywords - **Moulds, Microwave radiation, Damp, Masonry.**

I. INTRODUCTION

A frequent problem in building objects is higher relative air humidity in the interior. As a result, due to thermal bridges and/or other problems the masonry becomes damp. Damp masonry is then a cultivating medium for the growth of moulds. Moulds have a very negative impact on the health of people who live in objects afftected this way. Being so harmful, timely and succesful elimination of moulds is essential. Since elimination of moulds using common preparations does not prove to be very efficient, experimental elimination of moulds with microwave radiation has been tested instead.

II. MOULD

Samples of plaster and masonry were collected in objects affected by humidity where the masonry showed considerable amount of moulds. Samples were collected in sterile plastic ampoules and evaluated, i.e. the specific kinds of biotic pests were determined. Then, the samples and the moulds alone were subject to a more specific analysis and the most frequently occurring moulds were determined.

The most frequently occurring pure mould cultures include the following:

- Alternaria alternata,
- Aspergillus versicolor,
- Cladosporium cladosporioides,
- Penicillium brevicompactum,
- Penicillium chrysogenum,
- Stachybotrys chartarum.

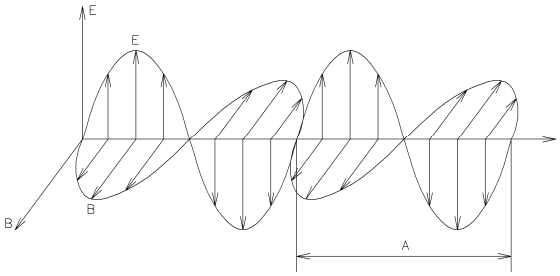
Generally, moulds are microorganisms which significantly influence building substances and materials and the microclimate of an object. To be able to grow, microorganisms need humidity and relatively stable temperature around 25°C. Unfortunately, this kind of environment is nowadays very often created in modern and in principle low-energy houses. In order to save considerable amount of money on energy, the inhabitants of such houses usually do not ventilate the interior spaces sufficiently. This leads to the increase in relative humidity of the interior and consequently to the increase in moisture by weight of the building materials which enclose the respective area. This creates suitable microclimate for the growth of microorganisms.

Microorganisms such as moulds have a significant impact on the quality of the interior microclimate. They retain excessive humidity in the masonry and release their spores into the surrounding area. Spores are in fact a carcinogenic substance which endangers people's health to a certain extent.

On the basis of the above-mentioned, construction survey, particularly moisture and microbiological surveys, were carried out in the objects and samples of moulds which occur most frequently in objects of this type were determined.

III. MICROWAVE RADIATION

Microwaves are electromagnetic waves which lie between infrared radiation and radio waves in the electromagnetic spectrum. Their frequency ranges from 300 MHz to 300 GHz which corresponds to the wave length 1-1000 mm. [1-2]



Graph. 1 Electromagnetic wave with wavelength λ – electric (E) and magnetic component (B) of the wave

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$$\lambda = \frac{c_\lambda}{f} \qquad [m] \qquad (1),$$

where λ ….. wavelength [m],
c_λ …. speed of propagation [m.s^{-1}],
f …..microwave radiation frequency [Hz] (2450 MHz). [1-2]

When applying microwaves to remove moisture from masonry, the so-called industrial frequency 2450 MHz is used which corresponds to the wavelength 122 mm. [1-2]

A. Microwave heating

Microwave heating is characterized as quick and economical and it is based on electromagnetic induction. Heating takes place directly in the structure of the material and not from the surface. The mechanism of changing microwave energy to heat is expressed by this formula:

$$P=2.\pi.f.\varepsilon'.\varepsilon''.E^2 \qquad [W.m^{-1}], \qquad (2)$$

where P ….. energy absorbed in a volume unit [W.m^{-1}],
f ……frequency of the microwave field [2450 MHz],
ε´….. permittivity [F.m^{-1}],
ε´´…. dielectric material loss factor,
E …..intensity of an electric field inside the material [V.m^{-1}]. [1-2]

B. Biological effects of microwave radiation

Numerous technical, biological and medical experiments proved that when in contacts with the living matter, electromagnetic waves are biologically active in the whole width of its spectrum, given the wave intensity reaches a sufficient effective value. The following applies to frequencies ranging from zero to approximately 1011 Hz:

$$W = h.f \qquad [J] \qquad (3)$$

where h ……. the Planck constant (6,625 . 10^{-34}) [J.s],
f ..... wave frequency [s^{-1}]. [1-2]

The above-stated relation shows that the radiation does not have ionizing effect as the effective quantum of energy is too small on these frequencies. Therefore, microwave radiation is called non-ionizing radiation. [1-2]

C. Device for microwave elimination of moulds

A certified device MWD 2000 GMR 1200 (10-1200 W) by the company Plazmatronika is used to eliminate moulds with microwave radiation (EMW). It is a device with variable output ranging from 0 to 1200 W. The device was fitted with an auxiliary horn antenna..[1-2]

Fig. 1 A schematic picture and a photo of the EMW device[1-3]

The so-called Industrial frequency 2,45 GHz is used for microwave radiation in the given cases.

IV. THE PROCEDURE OF THE EXPERIMENTS

The samples were inoculated in cultivating medium and samples of mixed mould cultures were grown from the samples. Cultivated varieties of mould samples were performed on glass Petri dishes. Then, separation and cultivation of pure cultures was done, again on Petri dishes.

A. Example of a simplified process of cultivation

- cultivation in a thermostat at 27 °C
- cultivation of land -wort agar with chloroamfetamine,
  - CDA (Czapek-Dox agar) with 20% sucrose.

To suppress the growth of undesirable bacteria was necessary to add to the samples some antibiotics, thereby should be ensured the growth of fungi without unwanted bacteria.

B. Cultivation of selected pure fungal cultures

With regards to wide range of tested biotic pests (fungi), it was necessary to proceed to partial elimination of these factors. That is why we separated each fungal culture right from grown mixed cultures in laboratory.

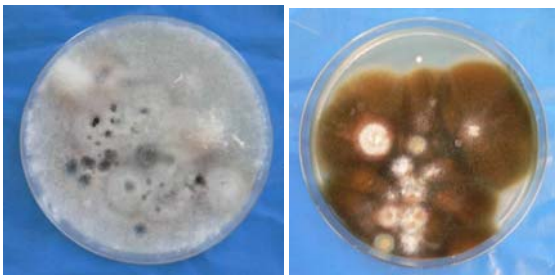


Fig. 2 Mould samples on Petri dishes [3]

C. Microwave irradiation

Irradiation of the mould samples on Petri dishes was commenced. For the experiments, according to previous experiences with EMW radiation, was chosen:

- 400 W,
- 700 W,
- 1200 W.

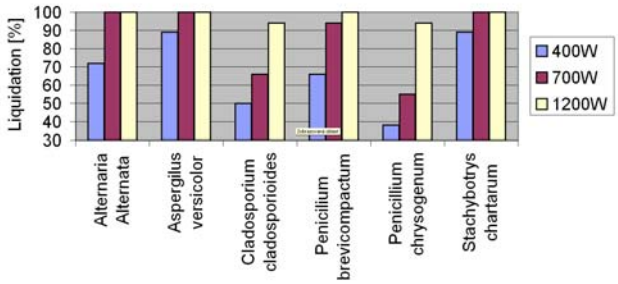
The period of each radiation of location was 240 minutes. The period of radiation is based on years of experience – in chosen period is relatively slow increase in temperature in wall, thus is not threatened its mechanical characteristic.

Fig. 3 Application of EMW radiation on the mould samples

There is an effort to keep the EMW device output as low as possible with regard to the efficiency of biotic pest elimination. The reason is a relatively slow increase of temperature in the masonry which does not affect the strength of the masonry. Radiation was carried out cyclically. The total length of radiation was 8 cycles lasting 30 minutes. The radiation time is based on years of experience – there is just a relatively small increase of the temperature in the masonry in the selected period (the temperature in the masonry is app. 90°C) so its mechanical characteristics are not affected.

V. Results of the Experiments

The efficiency of elimination in this case is expressed by the percentage of efficiency of elimination of the different mould samples and the corresponding EMW radiation intensity. The results are showed in Graph 2.



Graph 2 Efficiency of elimination on pure cultures

The graph shows that the higher the intensity of EMW radiation is, the more efficient the elimination of biotic pest becomes. EMW radiation with lower intensity suffices to eliminate simpler mould forms, i.e. moulds with a thinner cell wall. EMW radiation with higher intensity or longer exposure to the radiation, as the case may be, is necessary to eliminate moulds with a thicker cell wall.

VI. Conclusions

It is apparent that eliminitation of moulds and biotic agents, particularly moulds, with EMW radiation is very efficient. The point is to determine suitable intensity and time of radiation.

Before redevelopment begins it is suitable to do microbiological survey in order to determine different kinds of moulds. Then it is possible to establish the intensity of EMW radiation, the number of irradiation cycles and their length.

With regard to the previous experiments, the experimental analysis should be extended and an analysis and measuring related to the intensity and the length of irradiation should be included in it. Considering that EMW is harmful to health, operation by a trained person is necessary. Furthermore, no people must be present in the in the area under redevelopment in the course of irradiation. Therefore, there is a tendency to lower the intensity of radiation and to raise the number of cycles or the length of cycles. This issue is being experimentally resolved these days.

Acknowledgement

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References

[1] Suhajda, K. Use of rod antenna during microwave pre-drying of injection holes. Thesis syllabus. Brno: 2004.

[2] Suhajda, K. Rehabilitation of moist masonry structures - Use of rod antenna during microwave pre-drying of injection holes. Thesis. Brno: 2006

[3] Suhajda, K., Novotny, M., Hanulakova, D., The occurrence of fungi in the military facilities and its disposal options, strana, vydal, konference. Brno: 2011

[4] Skramlik, J., Novotny, M., Moisture transfer in building materials. 1st International Conference on Protection of Historical Buildings (PROHITEC 09). Rome, Italy, 2009. ISBN 978-0-415-55803-7. vol. 887-891.