DRYING OF FOOD IN A MICROWAVE TUNNEL OVEN

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Abstract: GIGATHERM developed a new microwave tunnel oven based on the established HERA patent. It works with a hybrid mode which brings in the energy homogeneously in the material to avoid hot and cold spots. To reach this homogeneity the magnetrons are arranged in a staggered and optimized position. Another positive aspect of this arrangement is the fact of negligible cross coupling of microwave power between the applicators. Due to this the heating process is under control and very efficient. The high efficiency of the magnetrons, the lossless waveguides and applicators complete the equipment.

Keywords: microwave, drying, continuous, HERA, industrial

INTRODUCTION

Microwave is one way to dry goods but due to many experiences in the past it is said to create uneven and unpredictable heating patterns.

Cold and hot spots are the keywords that people always talk about. Those result in bad drying results, to wet on one hand and to dry or burnt on the other hand. For some reasons people accept these restrictions but there is a solution which solved these negative aspects.

Microwave units can mainly be separated in three groups:

- Single mode applications
- Multimode applications
- Hybrid mode applications

The report will show the differences between the different modes and explain the reason why the hybrid mode is the best solution in the field of food applications.

WHICH MODE FOR WHICH APPLICATION?

**Single mode applications**

With single mode units small volumes can be heated in a short time with a high energy input. It is used to sinter small parts but due this physical phenomenon it is not possible to use it for food applications.

**Multimode applications**

Multimode microwave units are characterized by the following facts:

- the tunnel has a big ratio between tunnel volume and used volume
- the tunnel is feed from different sides with microwaves (preferred from the top and/or the bottom)

Those facts cause a high number of microwave patterns which overlap and interfere, it is impossible to get repeatable temperature profiles. They get out of the control of the user, especially during start-up and shutdown.

Tests showed that the heating profile in the product depends very strong on the product itself. Influencing factors are e.g. type, shape, size, arrangement in the oven and water and salt content.

**Hybrid mode applications**

The hybrid mode application is based on a polarized and directed wave. Due to special construction there are also under-heating waves penetrating the product even though the feeding is only from the top.
The tunnel itself is much more compact than that of a comparable multimode unit, the whole process is optimized for a low tunnel height, which makes it less flexible but more efficient.

The special polarization of the hybrid mode waves inducts the heat by a strong magnetic field which reduces the edge overheating effect significantly. The resulting heating pattern (influenced by the arrangement of the applicators which is also fixed in the patent) causes a minor dependence of the product itself in terms of type, size, shape etc.

Of course this process is also limited, limited by the laws of nature and physics, but in the end it is much easier to optimize the process because the influence of the mentioned factors is much lower than in a multimode process.

Another positive aspect is that the lifetime of the components will be increased due to the low cross coupling, which ends up in lower cost for the process.

The directed waves cause a repeatable field and due to this the process can handle repeatable temperature profiles.

To sum it up, one can say:

- Due to the polarization the process is much more flexible regarding the selection of the containers for the good to be dried.
- High efficiency and long lifetime of the used components.
- It is possible to run a process with a repeatable temperature profile

COMPARISON OF MULTI AND HYBRID MODE

Test with IEC standard batter

Both units have been tested with standard IEC batter to get an impression of the efficiency, pros and cons of each unit.

The main intention when developing this unit was to use it for the pasteurization of ready-made meals, but of course it can be used for any thermal process where heating is needed.

The test showed the following results which are a perfect match with the theory described before:

- The trays which have been heated in the multi mode tunnel oven show dry areas at the edges, the edge overheating effect can be detected.
- Even though the trays have a very low height the tests showed that there is a big cold spot in the middle of the tray. This goes along with the theory of pronounced cold spots.
- All of the three trays gave good results in the hybrid mode tunnel oven, even though they are not all optimized for a microwave process. The difference in the temperature between hot and cold spot during this test was much lower which will end up in a better result and a high quality for the product.

Boundary conditions to optimize the process

The hybrid mode depends less on the boundary conditions than the multimode, but in the end it is all about process time and – of course – money.

To make the process as effective as possible in regards to quality and cost, it makes sense to have a look on some aspects:

- How is the good arranged on the conveyor belt?
- Is it put directly on the belt? Is it in trays?
- Is it paste-like or solid?
- How much water has to be removed?
- Is it a sensitive product?
The arrangement of the good is important, especially in case of using the hybrid mode. As mentioned before the special construction helps to bring the waves into the good from the bottom without having an active inlet at the bottom. Due to this there must be free spaces to let the waves pass to the bottom part below the conveyor belt where they will be guided back by the use of rails. The layer height can be higher than in a multimode oven because of the penetration from two sides but it has also to be considered that the humidity has to be brought to the surface that it can be removed.

If the product is placed in containers, e.g. the packing in which it will be sold later, the edge overheating effect has to be taken into account, also the effect of the cold areas which normally occur in the middle of those containers if a multimode unit is used. As described before those effects are less critical when using the hybrid mode, but they are also not negligible.

Depending on the consistency of the product it might be necessary to run a defined temperature profile in the tunnel. This will be nearly impossible with a multimode.

Another aspect is the amount of water that has to be removed. The big advantage of microwave is that it heats up only dipolar liquids like water or solvents. This means that the heating process itself is very efficient, but if there is a lot of water to be removed it might be better to remove the main part in a conventional way and dry the rest to the needed resident moisture by using a microwave process. Another aspect is the gentle way of drying, because of the fact that only the water is heated up the rest of the material gets less heat impact than in other kind of processes.

CONCLUSIONS
Drying with microwave, especially using the hybrid mode, has some major advantages in comparison to other methods.

The drying process is very gentle, the microwave only heats dipoles. If the material itself does not absorb the microwave very well there will be only a very low heating of the material itself.

The process time is much faster than using a conventional drying process. Microwave has no influence on the mass transfer itself (but you have to reconsider that mass and heat transfer go in the same direction, from inside to outside), this is limited by the physics but the due to the fact that it only heats the water and not the surrounding material there can be a lot of saving in time. Depending on the good to be dried it’s between app. 20 and 60 %.

In comparison to multimode units the hybrid mode gives repeatable temperature profiles which also result in a homogeneous heating and drying of the product.

Last but not least it is also worth to mention the efficiency of the power/energy transferred into the material:

- Hot air: 10 … 40 %
- Infrared: 20 … 60 %
- Microwave: 60 … 98 %

It is obvious that microwave gives the best efficiency compared to other applications (depending on material properties and water content), this should be kept in mind when talking about the efficiency of the whole process.

REFERENCES