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Heating apparatus and method of heating objects
Verfahren und Vorrichtung zum Heizen von Objekten
Appareil et méthode de chauffage d'objets

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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention is related to a heating apparatus and a method of heating objects inside an oven using microwaves in order to carry out drying, warming, thawing, cooking, roasting, sterilizing, concentrating and the like, according to the preambles of Claims 1 and 5.

DESCRIPTION OF THE PRIOR ART

[0002] In the case were objects are heated using microwaves, when microwaves emitted from a magnetron are passed through a waveguide and introduced inside a tank, a portion of such introduced microwaves form reflected waves which travel in the opposite direction and return to the magnetron, thereby creating an energy loss and damaging the magnetron due to the heat generated by such reflected microwaves. Prior art technology for preventing this includes mounting a matching device midway in the waveguide to match the microwaves in order to reduce reflected waves, and mounting an isolator near the microwave generator to absorb and eliminate reflected waves.

[0003] Further, a stirrer is generally mounted inside the oven to disperse the microwaves in order to achieve matching.

[0004] Further, in the case where a plurality of microwave introduction ports are provided in the oven, these microwave introduction ports are arranged away from mutually opposing positions to prevent increased reflected waves and mutual interference of the microwaves introduced through such introduction ports, and in the case of rectangular microwave introduction ports, if a horizontal arrangement is used on one side, a vertical arrangement can be used on the opposite side away from opposing positions.

[0005] However, the isolator and matching device used in the prior art are extremely expensive and form the main cause of high costs introduced when the microwave generator is to be used a lot for industrial applications, and for this reason the use of such high value-added energy microwaves has been limited.

[0006] Further, a stirrer is generally provided to disperse the microwaves inside the oven in order to achieve uniform heating, but because this requires a significant mounting space for holding the rotation axle for the rotor and the motor required for the stirrer, it is impossible to provide a large number of microwave introduction ports, and this makes it difficult to achieve uniform heating by means of a plurality of microwave introduction ports. Further, because the incident waves interfere with each other and become dispersed while the stirrer is rotating, a fluctuating increase and decrease in reflected waves normally appears, and this has made it difficult to achieve a stable reduction in reflected waves.

[0007] Further, in the case where a plurality of microwave introduction ports are provided in the oven, when these microwave introduction ports are arranged at positions away from opposing positions, minute changes in position can have subtle adverse effects on uniform heating and matching, and this has created problems for heating matching and made it impossible to achieve a sufficient reduction in reflected waves. In particular, this problem is striking in the case where the object being heated is fixed in place.

[0008] The generic US 5 961 871 A is directed to a microwave heating apparatus working at different frequencies. A directional coupler is provided to direct reflected microwaves away from the amplifier assembly. A tapered waveguide is arranged between the cavity and the directional coupler.

[0009] EP 0 967 841 A shows a microwave drying apparatus provided with a cone-shaped metal difusor in the cavity. The diffusor also serves as protection against back reflected microwave radiation.

[0010] DE 31 46 377 A presents a microwave based heating. Between a waveguide and the cavity a transmission part is arranged, the sectional area of which increases in form of a truncated pyramid from the waveguide towards the cavity to prevent back reflection of microwave radiation to the magnetron.

SUMMARY OF THE INVENTION

[0011] The invention provides the features of Claims 1 and 5, respectively.

[0012] First, the waveguide connected to the oven is shaped so to not hinder the propagation of microwaves incident toward the oven, namely, the waveguide is shaped so that the cross-sectional area of the port portion of the waveguide at the oven side is greater than the cross-sectional area at the microwave generator side. Namely, the cross-sectional area of the waveguide gradually expands from the microwave generator side toward the oven side to give the waveguide a horn shape, and a prescribed size cone-shaped, pyramid-shaped, bell-shaped or other similarly shaped reflector apparatus is provided at a prescribed position inside the waveguide with the bottom of the reflector apparatus facing the oven side to form a structure which does not hinder the propagation of incident microwaves from the microwave generator toward the oven. With this structure, most of the reflected microwaves heading toward the waveguide from the oven will be reflected again by the bottom of the reflector apparatus and returned to the inside of the oven, and this significantly reduces the reflected microwaves traveling back toward the microwave generator.

[0013] Further, if a straight tube made of metal is provided between the waveguide and the microwave introduction port of the oven, the incident microwaves passing through the straight tube will make it possible to improve the heating matching, and this further reduces the reflect-
ed microwaves. In this case, the straight tube has a prescribed length and both ports thereof have the same size and shape as the oven-side port portion of the waveguide.

[0014] Next, if the stirrer of the prior art is replaced with a fixed metal reflection diffusion apparatus provided in the oven at a position in front of the microwave introduction port of the oven at a prescribed distance from the microwave introduction port, the microwaves incident into the oven will undergo reflection diffusion, and this makes it possible to achieve highly uniform heating. Also, the use of an appropriately sized reflection diffusion apparatus at an appropriate position facilitates heating matching and reduces reflected waves. Further, because the reflection diffusion apparatus is compact, the use thereof makes it possible to provide many microwave introduction ports, thereby making it possible to improve heating matching. Moreover, the use of the reflection diffusion apparatus prevents the reflected energy fluctuations that occur for the rotational dispersion carried out by a stirrer, and this contributes to reducing reflected waves.

[0015] Further, by providing the oven with a plurality of microwave introduction ports arranged at opposing positions, it is possible to carry out fine matching and achieve highly accurate uniform heating. In the case where the microwave introduction ports are arranged at opposing positions, because the microwaves propagate toward opposing microwave introduction portions, there is generally an increase in reflected waves which results in a loss of heating matching.

[0016] Namely, the method of heating objects with microwaves according to the present invention involves passing microwaves emitted from a microwave generator toward an oven through a propagation path shaped so as to not hinder the propagation of microwaves incident toward the oven, and shaped so to make the cross-sectional area of the oven side port portion of the propagation path larger than the cross-sectional area of the microwave generator side port portion of the propagation path, with a microwave reflector apparatus being provided at a prescribed position inside the propagation path to reflect most of the reflected microwaves from the oven heading toward the microwave generator back into the oven in order to reduce reflected waves and facilitate heating matching.

[0017] Further, the microwave heating method of the present invention may further comprise the step of passing the microwaves incident toward the oven through a straight metal tube having a prescribed length and port portions having the same size and shape as the oven side port portion of the propagation path in order to reduce reflected waves and facilitate heating matching.

[0018] Another method of heating objects with microwaves according to the present invention involves passing microwaves emitted from a microwave generator through a microwave introduction port into an oven provided with a metal reflection diffusion apparatus arranged at a prescribed position in front of the microwave introduction port at a prescribed distance therefrom, whereby a prescribed ratio of the microwaves incident into the oven undergo reflection diffusion, wherein the major portion of the reflection diffused microwaves are directed away from the position of the reflection diffusion apparatus toward the inside of the oven in order to reduce reflected waves and facilitate heating matching.

[0019] In any of these methods, the oven may be provided with a plurality of microwave introduction ports arranged at opposing positions to enable uniform heating in order to reduce reflected waves and facilitate heating matching.

[0020] One apparatus for heating objects with microwaves according to the method of the present invention includes a microwave generator; an oven; a waveguide having one port portion connected to the microwave generator and one port portion connected to the oven, with the waveguide being shaped so as to not hinder the propagation of microwaves incident toward the oven, and shaped so to make the cross-sectional area of the oven side port portion of the waveguide larger than the cross-sectional area of the microwave generator side port portion of the waveguide; and a microwave reflector apparatus provided inside the waveguide at a prescribed position to reflect most of the reflected microwaves from the oven heading toward the microwave generator back into the oven, with the microwave reflector being shaped in the form of a prescribed size cone, pyramid, bell or other similar shape whose base is arranged to face the oven so as to not hinder the propagation of microwaves incident toward the oven.

[0021] Further, the microwave heating apparatus may further include a microwave introduction port formed in the oven; and a straight metal tube having a prescribed length and port portions having the same size and shape as the oven side port portion of the waveguide, with the straight metal tube being connected to the microwave introduction port of the oven.

[0022] Further, the straight metal tube of the microwave heating apparatus may be integrally formed with the microwave introduction port of the oven.

[0023] Another apparatus for heating objects with microwaves according to the method of the present invention includes a microwave generator an oven; a microwave introduction port formed in the oven; and a fixed metal reflection diffusion apparatus arranged in the oven at a prescribed position in front of the microwave introduction port at a prescribed distance therefrom, whereby a prescribed ratio of the microwaves incident into the oven undergo reflection diffusion, wherein the major portion of the reflection diffused microwaves are directed away from the position of the reflection diffusion apparatus toward the inside of the oven.

[0024] As one example, the fixed metal reflection diffusion apparatus may be formed with a plurality of V-shaped or U-shaped blades having a prescribed length and width radiating out from a central portion, with the
reflection diffusion apparatus being arranged so that the vertex line side of the blades faces the microwave introduction port of the oven.

[0025] As another example, the fixed metal reflection diffusion apparatus may be formed as a prescribed size cone, bell, pyramid or other similar shape, with the reflection diffusion apparatus being arranged so that the vertex side thereof faces the microwave introduction port of the oven.

[0026] Further, any of these microwave heating apparatuses may include a plurality of microwave introduction ports formed in the oven at opposing positions to produce uniform heating.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

Fig. 1(a) is an outline explanatory drawing showing an embodiment of the present invention for the case where a reflector apparatus is provided inside the waveguide, Fig. 1(b) and 1(c) show the case where the waveguide is provided with a straight tube, and Fig. 1(d) is an outline explanatory drawing showing the case where the straight tube is formed as an integral part of the oven.

Fig. 2(a) is a front view showing an example waveguide shape and an example arrangement of a reflector apparatus provided inside the waveguide, Fig. 2(b) is a cross-sectional side view of the example shown in Fig. 2(a), Fig. 2(c) is a front view showing another example waveguide shape and another example arrangement of a reflector apparatus provided inside the waveguide, and Fig. 2(d) is a cross-sectional side view of the example shown in Fig. 2(c).

Fig. 3(a) is a front outline view of an example shape of the reflector apparatus provided inside the waveguide, Fig. 3(b) is a side outline view of the example shown in Fig. 3(a), Fig. 3(c) is a front outline view of another example shape of the reflector apparatus provided inside the waveguide, and Fig. 3(d) is a side outline view of the example shown in Fig. 3(c).

Fig. 4 is an outline explanatory drawing showing an example arrangement of a fixed metal microwave reflection diffusion apparatus provided in the oven.

Fig. 5(a) is a front outline view showing one example of a blade-type reflection diffusion apparatus, Fig. 5(b) is a side outline view of the example shown in Fig. 5(a), and Fig. 5(c) is a partial perspective view of the blade-type reflection diffusion apparatus.

Fig. 6(a) is an outline explanatory drawing showing one example of a cone-type reflection diffusion apparatus, Fig. 6(b) is an outline explanatory drawing showing one example of a bell-type reflection diffusion apparatus, and Fig. 6(c) is an outline explanatory drawing showing one example of a pyramid-type reflection diffusion apparatus.

Fig. 7(a) is a front view showing an example arrangement in which a plurality of microwave introduction ports are provided at opposing positions in the oven, Fig. 7(b) is a side view of the example shown in Fig. 7(a), and Fig. 7(c) is a side view of the example shown in Fig. 7(a).

Fig. 8 is an outline explanatory drawing showing an example assembled structure.

Reference Numbers/Characters

[0028]

1 Oven
1a Oven including flange for introduction port
1b Oven including straight tube for introduction port
2 Fixed microwave reflection diffusion apparatus provided in oven
3 Microwave introduction port
4 Waveguide connected to microwave introduction port (or straight tube of Claim 9)
5 Microwave reflector apparatus provided at prescribed position inside waveguide
6 Waveguide
7 Microwave generator
8 Connection flange
9 Straight tube connected to microwave introduction port and waveguide

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

OPERATION

[0029] Most of the reflected waves which result in microwave energy loss are generated inside the waveguide or by microwaves introduced into the oven flowing back into the waveguide from a microwave introduction port. This problem arises when the waveguide connected to the oven has a structure that produces reflected waves or a structure that makes it easy for microwaves to flow back into the waveguide from the oven, or when the overall matching of the heating system is bad. Accordingly, to make it possible for roughly all the microwaves to be passed into the oven, the waveguide connected to the oven needs to at least have a structure that does not hinder the flow of microwaves into the oven. Further, a mechanism which includes a nonreturn valve function to prevent reflected microwaves in the oven from flowing back into the waveguide needs to be provided, and at the same time the heating matching which forms the most...
important factor needs to be significantly improved.

[0030] In has been determined by experiment that in order for most of the microwaves generated from the microwave generator to flow into the oven, it is important to prevent reflected waves from being generated inside the waveguide connected to the oven. Further, from examinations of the cross-sectional areas of the waveguide up to the microwave introduction port in the oven, a comparison of all points along the waveguide revealed that the cross-sectional area of the waveguide at positions toward the oven side must not be smaller than the cross-sectional area of the waveguide at positions toward the microwave generator side. Further, it was confirmed that so long as the cross-sectional area of the waveguide at positions toward the oven side are larger or the same size as the cross-sectional area of the waveguide at positions toward the microwave generator side, the shape of the waveguide will not cause reflected waves to be generated. Accordingly, the waveguide connected to the oven can have a shape which does not change from the microwave generator to the oven, or a shape which has an expanding cross-sectional area near the oven. However, this does not make it possible to prevent reflected microwaves from flowing back into the waveguide from the oven.

[0031] In response to this, the waveguide connected to the oven is shaped like a horn or the like by making the cross-sectional area of the port portion at the oven side greater than the cross-sectional area of the port portion at the microwave generator side, and a reflector apparatus made of metal and having a cone shape, pyramid shape, bell shape or other similar shape is provided inside the waveguide with the bottom of the reflector apparatus facing the oven side in order to function as a nonreturn valve which prevents reflected microwaves from entering the waveguide from the oven.

[0032] In order to avoid hindering the flow of microwaves into the oven from the microwave generator, the relationship between the reflector apparatus provided in the waveguide and the shape and size of the waveguide must be carefully considered because any inappropriate combination will make it impossible to reduce reflected waves. For example, in the case where the reflector apparatus has an inappropriate size, shape or mounting position, or in the case where the waveguide has an inappropriate size or shape with respect to the relationship with the reflector apparatus, a convergence will arise in the microwaves, and this will cause reflected waves to be generated in the area of the reflector apparatus.

[0033] On the other hand, when an appropriate size, shape and mounting position where selected for the reflector apparatus, it was confirmed by a power monitor that the reflector apparatus functioned as a nonreturn valve in preventing microwaves from flowing back into the waveguide from the oven. In this regard, even when the bottom of the reflector apparatus is flat or hollow, the reflected microwaves from the oven are sufficiently reflected, and so long as the bottom of the reflector apparatus is shaped so as to return microwaves for reaplication, there are no restrictions on shape.

[0034] From the results of conducted experiments, the preferred balance between the waveguide connected to the oven and the reflector apparatus provided inside the waveguide was obtained, and it was determined that is was possible to achieve a significant reduction in reflected waves. Further, from experiments comparing heating efficiencies, it was determined that the structure according to the present invention achieved a significant improvement in heating matching.

[0035] Further, for the case where a straight tube of a waveguide in the present invention was provided between the oven and the waveguide described in which is shaped so to make the cross sectional area of the oven side portion of the propagation path larger than the cross sectional area of the microwave generator side part portion of the propagation path, measurements of heating efficiency confirmed further improvement in heating matching. The reason for this is that the straight tube acts as a matching device, and this improves the matching of the microwaves flowing from the microwave generator through the waveguide into the oven and the reflected waves from the oven that have been reflected again by the reflector apparatus. The straight tube can be formed as an integral portion of the waveguide, or as an integral portion of the oven. In either case, the straight tube needs to be provided in the propagation path along which the microwaves from the microwave generator are propagat ed to the oven.

[0036] Now, in the prior art, a stirrer is generally used as a microwave dispersion apparatus, but such rotational dispersion does not necessarily achieve a sufficient improvement in heating matching. In particular, it has been determined from experiments that scorching can occur at specific locations even when a rotational dispersion is carried out with a stirrer, and this is due to the fact that such dispersion is not carried out at random. Namely, such rotational dispersion merely creates a fixed flow of microwaves. Further, fluctuations in the amount of energy of both the incident waves and the reflected waves were observed at the stirrer, and this had an effect on fine heating matching. Further, because the stirrer requires a lot of space inside the oven for holding a rotation apparatus, there are many cases where the use of a stirrer hinders the ability to achieve heating matching by the provision of many microwave introduction ports.

[0037] In this connection, a reflection diffusion apparatus was invented to replace the stirrer. The reflection diffusion apparatus is made of metal and is fixed. This reflection diffusion apparatus is shaped so as to make it possible for a prescribed ratio of microwaves incident into the oven to undergo reflection diffusion inside the oven. Further, because the reflection diffusion apparatus is shaped so as to make it possible for the major portion of the reflection diffused microwaves to be guided toward the inside of the oven from the position of the reflection diffusion apparatus in the oven, the reflection diffusion
apparatus is provided at a position in front of the microwave introduction port at a prescribed distance from the microwave introduction port. In this connection, experiments were repeatedly carried out to find the distance from the microwave introduction port, the ratio of incident microwaves diffused, and the shape of the reflection diffusion apparatus, and from the results of such experiments, reflection diffusion apparatuses were developed having a windmill shape, cone shape, bell shape, pyramid shape and other similar shapes.

[0038] Further, a fixed reflection diffusion apparatus having a prescribed reflection diffusion ratio with respect to the incident microwaves was provided in an oven at a prescribed appropriate distance from the microwave introduction port, and then from experiments with this arrangement, it was determined that there was a significant reduction in reflected waves and that the microwave heating caused no scorching of the object being heated. In other words, these experiments showed that the heating matching improvement achieved by the reflection diffusion apparatus according to the present invention was more significant than that obtained with a stirrer. Further, for the case of a fixed reflection diffusion apparatus, no fluctuations in the amount of energy of both the incident microwaves and the reflected waves were observed to occur, and this contributed to the improvement in heating matching.

[0039] Further, because the reflection diffusion apparatus is small, it does not become a hindrance in the case where heating matching is to be carried out by providing many microwave introduction ports.

[0040] Now, in the case where a plurality of microwave introduction ports are provided in the oven, even when they are provided at opposing positions, because a reflector apparatus is provided inside each waveguide connected to the oven, the interference created between mutually facing microwave introduction ports will prevent an increase in reflected waves. Also, as a comparison, it was confirmed that microwave introduction ports provided at opposing positions achieved a higher heating matching than the case where microwave introduction ports were provided at positions not facing each other.

[0041] Further, examinations of reflected waves and heating matching were carried out for a system incorporating the subject matter of the present invention, and the following results were obtained. First, from a heating experiment carried out using a stirrer in a prior art system, the occurrence of reflected microwaves was recorded at the high rate of 25% with respect to the incident waves. In contrast with this, experiments revealed that the systems of original claim 5 and original claim 14 recorded an 8% occurrence rate, and the systems of original claim 6 and original claim 15 recorded a 3% occurrence rate. Furthermore, the systems according to the present invention were able to reach a specific temperature within a shorter heating time, and this shows an improvement in heating matching. Moreover, in the case of heating for the purpose of drying, the present invention makes it possible to eliminate the scorching of the object being heated that occurs in prior art systems due to uneven heating, and in the case of heating for the purpose of thawing, the present invention makes it possible to prevent dripping that occurs in prior art thawing systems due to uneven heating.

SPECIFIC EMBODIMENT 1

[0042] Two ovens having a width of 500mm, a height of 500mm and a depth of 600mm were prepared, and then various comparisons were carried out without the use of a matching device for either oven. First, using a microwave power monitor to carry out measurements, a comparison was made between the reflected waves for the case where a square waveguide was connected to the oven without alteration, and the reflected waves for the case where the waveguide connected to the oven was given a horn shape and a conical metal reflector apparatus having a cone shape (with a base diameter of 75mm and a height of 80mm) that matched the shape inside the waveguide at the oven side was provided inside the waveguide at a position 8mm from the port portion at the oven side with the bottom of the cone shape facing the oven side. At that time, the square-shaped waveguide that was used had a port portion measuring 55mm X 110 mm, and the oven-side port portion of the horn-shaped waveguide was circular with a diameter of 130mm. Also at that time, the square-shaped waveguide described above was connected to the horn-shaped waveguide at the microwave generator side. In carrying out tests, a 1.5kW output was used for the microwave generator to operate the system as a drying apparatus, and 2kg of towels adjusted to have a water content of 75% were used as objects to be dried. In this case, a stirrer was provided inside both ovens. First, in the case where the square-shaped waveguide was connected without alteration to one of the ovens, reflected waves at a level of 0.40 to 0.45kW were measured for the 1.5kW microwave output. In contrast with this, in the case where the waveguide connected to the other oven was given a horn shape as described above, with a conical reflector apparatus being provided inside the horn-shaped waveguide, reflected waves at a level of 0.15 to 0.25kW were measured for the 1.5kW microwave output.

SPECIFIC EMBODIMENT 2

[0043] Next, under the same conditions described in Specific Embodiment 1, reflected waves were examined for the case where a straight tube was connected between the oven and the horn-shaped waveguide described in Specific Embodiment 1. The results of such examination confirmed a reduction of reflected waves to a level of 0.12 to 0.15kW. Further, an experiment was carried out for the case where the microwave introduction port of the oven was shaped as a regular octagon, where the oven-side port portion of the horn-shaped waveguide
had the same regular octagon shape as the octagonal microwave introduction port, and where a regular 8-sided pyramid reflector apparatus was provided inside the waveguide at the same position as that described in Specific Embodiment 1, and the measured reflected waves showed that roughly the same results as those described above were obtained.

SPECIFIC EMBODIMENT 3

[0044] Under the same conditions described in Specific Embodiment 2, a windmill-shaped reflection diffusion apparatus was provided in the oven in place of the stirrer. This windmill-shaped reflection diffusion apparatus had 8 vanes which were 240mm long and V-shaped, with the base of the V having a width of 20mm, the angle of the V being 90, and the vertex line of the V facing toward the microwave introduction port at a distance of 80mm therefrom. When measurements of reflected microwaves were carried out during heating, a reflection wave level of 0.05kW was recorded. This corresponds to a reflectance of approximately 3% for the case of an incident wave output level of 1.5kW. In this regard, because the reflectance can be called a microwave loss ratio, such results indicate that an extremely efficient heating matching was achieved. As a comparison, it should be noted that in the experiment where the horn-shaped waveguide of Specific Embodiment 1 was connected to the oven, the reflectance could not be reduced below 4% even in the case where a matching device was provided near the microwave generator. Next, under the same conditions, an experiment was carried out to measure the reflected microwaves for the case where a bell-shaped reflection diffusion apparatus was arranged in the oven with the vertex facing the microwave introduction port. This bell-shaped reflection diffusion apparatus had an 80mm diameter bottom and a height of 60mm, and measurements recorded reflected waves at a level of 0.07kW.

SPECIFIC EMBODIMENT 4

[0045] Under the same conditions described in Specific Embodiment 3, measurements of reflected waves were carried out for the case where two microwave introduction ports were provided at opposing positions in the oven. In this case, the reflected microwaves were further reduced to a level of 0.02kW. These results indicate that it is possible to achieve further improvements in heating matching with an arrangement in which microwaves at an output level of 1.5kW are divided by a branched waveguide for introduction into the oven via two microwave introduction ports. Further, the towel drying time was determined to be shorter for the case of two microwave introduction ports. Also, an examination of thermal readings taken at various points inside the drying objects recorded the highest error for the temperature attained by heating to be only 3°C. Accordingly, these results confirm that a highly accurate uniform heating can be carried out without the need for the provision of a matching device, and because there is a very low level of reflected waves, there is no need for the provision of an isolator.

EFFECT OF THE PRESENT INVENTION

[0046] Up to now, apparatuses that use microwaves have been slow to spread to industrial applications outside microwave ovens. One of the main reasons for this has been the huge cost of providing an isolator and a matching device. Namely, in the prior art, an isolator and a matching device are required to obtain a high heating efficiency without damaging the magnetron. In response to this problem, the present invention makes it possible to greatly reduce the construction cost of the apparatus, and at the same time, the high level of heating matching achieved by the present invention makes it possible to produce high quality products at low cost.

[0047] In the present invention, it is possible to start operations the instant the apparatus is turned ON and suspend operations the instant the apparatus is turned OFF, and because the inside of objects can be efficiently heated, such efficient use of energy makes it possible to apply the present invention to a wide variety of industrial fields, including the fields of drying, concentrating, sterilizing, roasting, thawing and the like.

Claims

1. A method of heating objects with microwaves, comprising the step of passing microwaves emitted from a microwave generator (7) toward an oven (1a, 1b) through a propagation path shaped so as to not hinder the propagation of microwaves incident toward the oven (1a, 1b), and shaped so as to make the cross-sectional area of the oven side port portion of the propagation path larger than the cross-sectional area of the microwave generator side port portion of the propagation path, characterized in that a microwave reflector apparatus (5) is provided at a prescribed position inside the propagation path to reflect most of the reflected microwaves from the oven (1a, 1b) back into the oven (1a, 1b) to reduce reflected waves and facilitate heating matching.

2. The microwave heating method of Claim 1, further comprising the step of passing the microwaves incident toward the oven (1a, 1b) through a straight metal tube (9) having a prescribed length and port portions having the same size and shape as the oven side port portion of the propagation path to reduce reflected waves and facilitate heating matching.

3. The microwave heating method of Claim 1 or Claim
2. further comprising the step of passing microwaves emitted from the microwave generator (7) through a microwave introduction port (3) into the oven (1, 1a, 1b) provided with a metal reflection diffusion apparatus (2) arranged at a prescribed position in front of the microwave introduction port (3) at a prescribed distance therefrom, whereby a prescribed ratio of the microwaves incident into the oven (1, 1a, 1b) undergo reflection diffusion, wherein the major portion of the reflection diffused microwaves are directed away from the position of the reflection diffusion apparatus (2) toward the inside of the oven (1, 1a, 1b) in order to reduce reflected waves and facilitate heating matching.

4. The microwave heating method of Claim 1, Claim 2 or Claim 3, wherein the oven (1, 1a, 1b) is provided with a plurality of microwave introduction ports (3) arranged at opposing positions to enable uniform heating in order to reduce reflected waves and facilitate heating matching.

5. An apparatus for heating objects with microwaves which uses the microwave heating method according to any of the preceding claims, comprising:

- a microwave generator (7);
- an oven (1, 1a, 1b); and
- a waveguide (4) having one port portion connected to the microwave generator (7) and one port portion connected to the oven (1, 1a, 1b), the waveguide (4) being shaped so as to not hinder the propagation of microwaves incident toward the oven (1, 1a, 2a), and shaped so to make the cross-sectional area of the oven side port portion of the waveguide (4) larger than the cross-sectional area of the microwave generator (7) side port portion of the waveguide (4),

characterized by

- a microwave reflector apparatus (5) provided inside the waveguide (4) at a prescribed position to reflect most of the reflected microwaves from the oven (1, 1a, 1b) heading toward the microwave generator (7) back into the oven (1, 1a, 1b), the microwave reflector (5) being shaped in the form of a prescribed size cone, pyramid, bell or other similar shape which base is arranged to face the oven (1, 1a, 1b) so as to not hinder the propagation of microwaves incident toward the oven (1, 1a, 1b).

6. The microwave heating apparatus of Claim 5, further comprising:

- a microwave introduction port (3) formed in the oven (1, 1a, 1b); and a straight metal tube (9) having a prescribed length and port portions having the same size and shape as the oven side port portion of the waveguide (4), the straight metal tube (9) being connected to the microwave introduction port (3) of the oven (1, 1a, 1b).

7. The microwave heating apparatus of Claim 6, wherein the straight metal tube (9) is integrally formed with the microwave introduction port (3) of the oven (1, 1a, 1b).

8. The microwave heating apparatus of Claim 5, 6 or 7, further comprising

- a fixed metal reflection diffusion apparatus (2) arranged in the oven (1, 1a, 1b) at a prescribed position in front of the microwave introduction port (3) at a prescribed distance therefrom, whereby a prescribed ratio of the microwaves incident into the oven (1, 1a, 1b) undergo reflection diffusion, wherein the major portion of the reflection diffused microwaves are directed away from the position of the reflection diffusion apparatus (2) toward the inside of the oven (1, 1a, 1b).

9. The microwave heating apparatus of Claim 8, wherein the straight metal tube (9) is integrally formed with the microwave introduction port (3) of the oven (1, 1a, 1b).

10. The microwave heating apparatus of Claim 5, 6 or 7, wherein the microwave reflector apparatus (5) is provided inside the waveguide (4) in the form of a prescribed size cone, bell, pyramid or other similar shape, and wherein the reflection diffusion apparatus (2) is arranged so that the vertex line side of the blades faces the microwave introduction port (3) of the oven (1, 1a, 1b).

11. The microwave heating apparatus of Claim 8, 9 or 10, further comprising a plurality of microwave introduction ports (3) formed in the oven (1, 1a, 1b) at opposing positions to produce uniform heating.

Patentansprüche

1. Verfahren zum Erwärmen von Gegenständen mit Mikrowellen, dem Schritt umfassend, von einem Mikrowellengenerator (7) ausgesendete Mikrowellen zu einem Herd (1, 1a, 1b) über einen Ausbreitungspfad zu leiten, der so geformt ist, dass die Ausbreitung von in Richtung auf den Herd (1, 1a, 1b) einfallenden Mikrowellen nicht behindert ist, und so geformt ist, dass die Querschnittsfläche des herseiti-
gen Anschlussabschnitts des Ausbreitungspfads größer ausgelegt ist als die Querschnittsfläche des auf der Seite des Mikrowellengenerators liegenden Anschlussabschnitts des Ausbreitungspfads, **durch gekennzeichnet, dass** eine Mikrowellenreflektorvorrichtung (5) an einer vorgeschriebenen Position innerhalb des Ausbreitungspfads vorgesehen ist, um einen Großteil der vom Herd (1, 1a, 1b) reflektierten Mikrowellen mit Richtung auf den Mikrowellengenerator (7) zurück in den Herd (1, 1a, 1b) zu reflektieren, um reflektierte Wellen zu reduzieren und eine Wärmeanpassung zu ermöglichen.

2. Mikrowellenenerwärmungsverfahren nach Anspruch 1, darüber hinaus den Schritt umfassend, die in Richtung auf den Herd (1, 1a, 1b) einfallenden Mikrowellen durch ein gerades Metallrohr (9) zu leiten, das eine vorgeschriebene Länge und Anschlussabschnitte mit derselben Größe und Form wie der herds seitige Anschlussabschnitt des Ausbreitungspfads hat, um reflektierte Wellen zu reduzieren und eine Wärmeanpassung zu ermöglichen.

3. Mikrowellenenerwärmungsverfahren nach Anspruch 1 oder Anspruch 2, darüber hinaus den Schritt umfassend, vom Mikrowellengenerator (7) ausgesendete Mikrowellen durch einen Mikrowellen-Einlassanschluss (3) in den Herd (1, 1a, 1b) zu leiten, der mit einer metallischen Reflexionsstreuungsvorrichtung (2) versehen ist, die an einer vorgeschriebenen Position vor dem Mikrowellen-Einlassanschluss (3) unter einem vorgeschriebenen Abstand zu diesem angeordnet ist, wodurch ein vorgeschriebener Anteil der in den Herd (1, 1a, 1b) einfallenden Mikrowellen eine Reflexionsstreuung durchmacht, wobei der Hauptanteil der durch Reflexion gestreuten Mikrowellen von der Position der Reflexionsstreuungsvorrichtung (2) weg zum Inneren des Herdes (1, 1a, 1b) gerichtet wird, um reflektierte Wellen zu reduzieren und eine Wärmeanpassung zu ermöglichen.

4. Mikrowellenenerwärmungsverfahren nach Anspruch 1, Anspruch 2 oder Anspruch 3, wobei der Herd (1, 1a, 1b) mit mehreren Mikrowellen-Einlassanschlüssen (3) versehen ist, die zur Ermöglichung einer gleichmäßigen Erwärmung an gegenüberliegenden Positionen angeordnet sind, um reflektierte Wellen zu reduzieren und eine Wärmeanpassung zu ermöglichen.

5. Vorrichtung zum Erwärmen von Gegenständen mit Mikrowellen, die das Mikrowellenenerwärmungsverfahren nach einem der vorhergehenden Ansprüche verwendet, Folgendes umfassend:

   einen Mikrowellengenerator (7);
   einen Herd (1, 1a, 1b); und
   einen Wellenleiter (4), von dem ein Anschlussabschnitt an den Mikrowellengenerator (7) und ein Anschlussabschnitt an den Herd (1, 1a, 1b) angeschlossen ist, wobei der Wellenleiter (4) so geformt ist, dass die Ausbreitung von in Richtung auf den Herd (1, 1a, 1b) einfallenden Mikrowellen nicht behindert ist, und so geformt ist, dass die Querschnittsfläche des herds seitigen Anschlussabschnitts des Wellenleiters (4) größer ausgelegt ist als die Querschnittsfläche des auf der Seite des Mikrowellengenerators (7) liegenden Anschlussabschnitts des Wellenleiters (4), **gekennzeichnet durch**

   eine Mikrowellenreflektorvorrichtung (5), die innerhalb des Wellenleiters (4) an einer vorgeschriebenen Position vorgesehen ist, um einen Großteil der von dem Mikrowellengenerator (7) zurück in den Herd (1, 1a, 1b) zu reflektieren, wobei der Mikrowellenreflektor (5) in Form eines Kegels, einer Pyramide, Glocke oder anderen ähnlichen Form mit vorgeschriebener Größe gebildet ist, dessen bzw. deren Basis dem Herd (1, 1a, 1b) zugewandt angeordnet ist, damit die Ausbreitung von in Richtung auf den Herd (1, 1a, 1b) einfallenden Mikrowellen nicht behindert ist.

6. Mikrowellenenerwärmungsvorrichtung nach Anspruch 5, darüber hinaus umfassend:

   einen im Herd (1, 1a, 1b) ausgebildeten Mikrowellen-Einlassanschluss (3); und ein gerades Metallrohr (9) mit einer vorgeschriebenen Länge und Anschlussabschnitt mit derselben Größe und Form wie der herds seitige Anschlussabschnitt des Wellenleiters (4), wobei das gerade Metallrohr (9) an den Mikrowellen-Einlassanschluss (3) des Herdes (1, 1a, 1b) angeschlossen ist.

7. Mikrowellenenerwärmungsvorrichtung nach Anspruch 6, wobei das gerade Metallrohr (9) einstückig mit dem Mikrowellen-Einlassanschluss (3) des Herdes (1, 1a, 1b) ausgebildet ist.

8. Mikrowellenenerwärmungsvorrichtung nach Anspruch 5, 6 oder 7, darüber hinaus umfassend:

   eine feststehende, metallische Reflexionsstreuungsvorrichtung (2), die im Herd (1, 1a, 1b) an einer vorgeschriebenen Position vor dem Mikrowellen-Einlassanschluss (3) unter einem vorgeschriebenen Abstand zu diesem angeordnet ist, wodurch ein vorgeschriebener Anteil der in den Herd (1, 1a, 1b) einfallenden Mikrowellen eine Reflexionsstreuung durchmacht, wobei der Hauptanteil der durch Reflexion gestreuten Mi-
Revendications

1. Procédé de chauffage d’objets à l’aide de micro-ondes, comprenant l’étape dans laquelle des micro-ondes émises par un générateur (7) de micro-ondes sont guidées vers un four (1, 1a, 1b) à travers un chemin de propagation formé de manière à ne pas entraver la propagation de micro-ondes incidentes en direction du four (1, 1a, 1b) et formé de manière à ce que la superficie de section du tronçon d’orifice du chemin de propagation côté four soit supérieure à la superficie de section du tronçon d’orifice du chemin de propagation côté générateur de micro-ondes, caractérisé en ce qu’il est prévu dans une position prédéterminée dans le chemin de propagation un dispositif réflecteur (5) de micro-ondes pour réfléchir la plupart des micro-ondes réfléchies par le four (1, 1a, 1b) et se dirigeant vers le générateur (7) de micro-ondes, de manière à les renvoyer dans le four (1, 1a, 1b) afin de réduire les ondes réfléchies et faciliter un ajustement de chauffage.

2. Procédé de chauffage par micro-ondes selon la revendication 1, comprenant en outre l’étape dans laquelle les micro-ondes incidentes en direction du four (1, 1a, 1b) sont guidées à travers un tube métallique (9) droit ayant une longueur prédéterminée et des tronçons d’orifice possédant la même taille et la même forme que le tronçon d’orifice du chemin de propagation côté four, afin de réduire les ondes réfléchies et faciliter un ajustement de chauffage.

3. Procédé de chauffage par micro-ondes selon la revendication 1 ou la revendication 2, comprenant en outre l’étape dans laquelle des micro-ondes émises par le générateur (7) de micro-ondes sont guidées à travers un orifice (3) d’admission de micro-ondes dans le four (1, 1a, 1b), qui est pourvu d’un dispositif métallique (2) de diffusion par réflexion agencé dans une position prédéterminée devant l’orifice (3) d’admission de micro-ondes à une distance prédéterminée de celle-ci, une part prédéterminée des micro-ondes incidentes dans le four (1, 1a, 1b) étant ainsi soumise à une diffusion par réflexion, la plus grande partie des micro-ondes diffusées par réflexion étant détournée de la position du dispositif (2) de diffusion par réflexion et dirigée vers l’intérieur du four (1, 1a, 1b) afin de réduire les ondes réfléchies et faciliter un ajustement de chauffage.

4. Procédé de chauffage par micro-ondes selon la revendication 1, la revendication 2 ou la revendication 3, dans lequel le four (1, 1a, 1b) est pourvu d’une pluralité d’orifices (3) d’admission de micro-ondes agencés dans des positions opposées afin de permettre un chauffage uniforme, de réduire les ondes réfléchies et de faciliter un ajustement de chauffage.

5. Dispositif pour le chauffage d’objets à l’aide de micro-ondes, utilisant le procédé de chauffage par micro-ondes selon l’une des revendications précédentes et comprenant :

un générateur de micro-ondes (7);
un four (1, 1a, 1b) ; et
un guide d’ondes (4) dont un tronçon d’orifice est raccordé au générateur (7) de micro-ondes et un tronçon d’orifice est raccordé au four (1, 1a, 1b), le guide d’ondes (4) étant formé de manière à ne pas entraver la propagation de micro-ondes incidentes en direction du four (1, 1a, 2a) et formé de manière à ce que la superficie de section du tronçon d’orifice du guide d’onde (4) côté four soit supérieure à la superficie de section du tronçon d’orifice du guide d’onde (4) côté générateur (7) de micro-ondes,

caractérisé par

un dispositif réflecteur (5) de micro-ondes prévu à l’intérieur du guide d’ondes (4) dans une position prédéterminée afin de réfléchir la plupart des micro-ondes réfléchies par le four (1, 1a, 1b) et se dirigeant vers le générateur (7) de micro-ondes, de manière à les renvoyer dans le four (1, 1a, 1b), le réflecteur
(5) de micro-ondes étant réalisé sous la forme d’un cône, d’une pyramide, d’une cloche ou une autre forme similaire de taille prédéterminée, dont la base est agencée de manière à faire face au four (1, 1a, 1b) afin de ne pas entraver la propagation de micro-ondes incidentes en direction du four (1, 1a, 1b).

6. Dispositif de chauffage par micro-ondes selon la revendication 5, comprenant en outre :

un orifice (3) d’admission de micro-ondes formé dans le four (1, 1a, 1b) ; et un tube métallique (9) droit ayant une longueur prédéterminée et des tronçons d’orifice possédant la même taille et la même forme que le tronçon d’orifice du guide d’ondes (4) côté four, le tube métallique (9) droit étant raccordé à l’orifice (3) d’admission de micro-ondes du four (1, 1a, 1b).

7. Dispositif de chauffage par micro-ondes selon la revendication 6, dans lequel le tube métallique (9) droit est formé d’un seul tenant avec l’orifice (3) d’admission de micro-ondes du four (1, 1a, 1b).

8. Dispositif de chauffage par micro-ondes selon la revendication 5, 6 ou 7, comprenant en outre :

un dispositif métallique (2) de diffusion par réflexion qui est fixe et agencé dans le four (1, 1a, 1b) dans une position prédéterminée devant l’orifice (3) d’admission de micro-ondes à une distance prédéterminée de celle-ci, une part prédéterminée des micro-ondes incidentes dans le four (1, 1a, 1b) étant ainsi soumise à une diffusion par réflexion, la plus grande partie des micro-ondes diffusées par réflexion étant détournée de la position du dispositif (2) de diffusion par réflexion et dirigée vers l’intérieur du four (1, 1a, 1b).

9. Dispositif de chauffage par micro-ondes selon la revendication 8, dans lequel le dispositif métallique fixe (2) de diffusion par réflexion a une pluralité de lames en forme de V ou de U ayant une longueur et une largeur prédéterminées et s’étendant en rayons à partir d’une portion centrale, et dans lequel le dispositif (2) de diffusion par réflexion est agencé de telle sorte que le côté de la ligne des sommets des lames fait face à l’orifice (3) d’admission de micro-ondes du four (1, 1a, 1b).

10. Dispositif de chauffage par micro-ondes selon la revendication 8 ou 9, dans lequel le dispositif métallique fixe (2) de diffusion par réflexion à la forme d’un cône, d’une cloche, d’une pyramide ou une autre forme similaire de taille prédéterminée, et dans lequel le dispositif (2) de diffusion par réflexion est agencé de telle sorte que son côté de sommet fait face à l’orifice (3) d’admission de micro-ondes du four (1, 1a, 1b).

11. Dispositif de chauffage par micro-ondes selon la revendication 8, 9 ou 10, comprenant en outre une pluralité d’orifices (3) d’admission de micro-ondes formés dans le four (1, 1a, 1b) dans des positions opposées afin de produire un chauffage uniforme.
FIG. 4
FIG. 5

(a)  

(b)  

(c)

Microwave
FIG. 6

(a)

(b)

(c)
FIG. 7

Microwave Introduction Port

(a)

oven door

Microwave Introduction Port

(b)

(c)