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(54) Apparatus for drying sugar cubes with microwave radiation

(57) The present invention relates to a sugar cube production- and drying apparatus comprising:
- a press for shaping a sugar mass in sugar cubes,
- a heating apparatus for heating and dehumidifying the sugar cubes,
- a conditioning apparatus for cooling and dehumidifying the sugar cubes and
- transportation means for transporting the sugar cubes from the press to the heating apparatus and from there to the conditioning apparatus,

whereas the heating apparatus comprises a multitude of heating devices, each heating device having a microwave source emitting microwave radiation and a wave guide to guide the microwave radiation from the microwave source to a drying chamber in which the sugar cubes are heated.

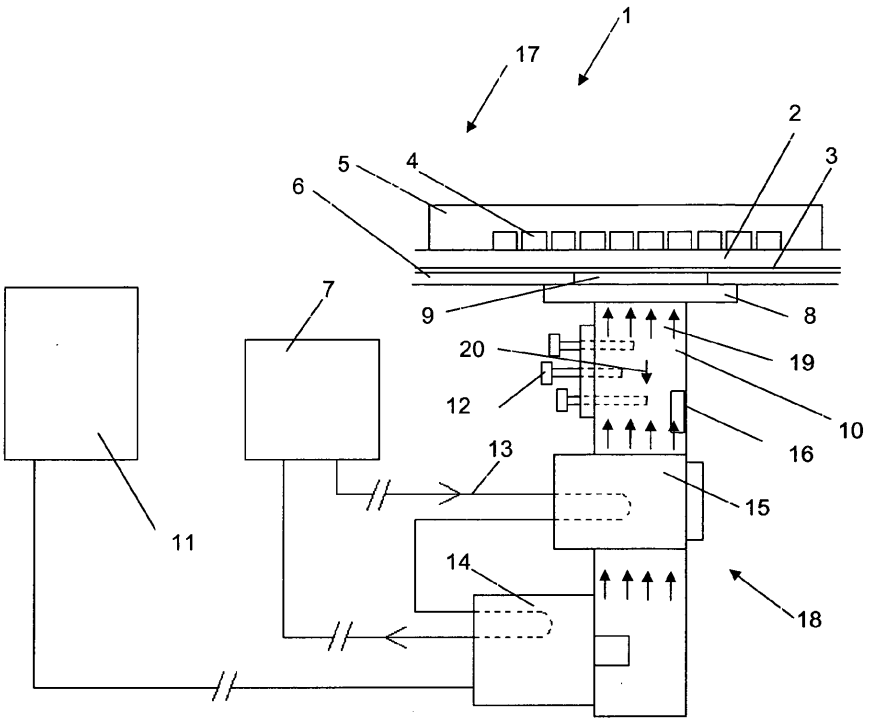

Fig. 1

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Description

[0001] The present invention relates to a sugar cube production- and drying apparatus comprising:

- a press for shaping a sugar mass in sugar cubes,
- a heating apparatus for heating and dehumidifying the sugar cubes,
- a conditioning apparatus for cooling and dehumidifying the sugar cubes and
- transportation means for transporting the sugar cubes from the press to the heating apparatus and from there to the conditioning apparatus,

whereas the heating apparatus comprises a multitude of heating devices, each heating device having a microwave source emitting microwave radiation and a wave guide to guide the microwave radiation from the microwave source to a drying chamber in which the sugar cubes are heated.

[0002] Such an apparatus is for example known from EP0894871 B1. The apparatus described in this patent has however the deficiency, that the amount of sugar cubes which are produced per time unit, has to be relatively constant.

[0003] It was therefore the objective of the present invention to provide a sugar cube production-and drying apparatus which does not comprise the deficiencies according to the state of the art.

[0004] This problem is attained by a sugar cube production- and drying apparatus comprising:

- a press for shaping a sugar mass in sugar cubes,
- a heating apparatus for heating and dehumidifying the sugar cubes,
- a conditioning apparatus for cooling and dehumidifying the sugar cubes,
- transportation means for transporting the sugar cubes from the press to the heating apparatus and from there to the conditioning apparatus,

whereas the heating apparatus comprises a multitude of heating devices, each heating device having a microwave source emitting microwave radiation and a wave guide to guide the microwave radiation from the microwave source to a drying chamber in which the sugar cubes are heated, whereas each heating device comprises an isolator located in the wave guide that allows the transmission of radiation only in the direction from the source to the drying chamber.

[0005] The present invention relates to a sugar cube production- and drying apparatus. In this apparatus, sugar particles are mixed with water and this sugar mass is then formed in a press in sugar cubes. These sugar cubes are subsequently discharged on a transportation means, for example a transportation belt, which transports the sugar cubes to a heating apparatus for heating the sugar cubes in a drying chamber, in order to evaporated the water content of the sugar cubes at least partially. The water vapor is removed from the drying chamber, for example, by ventilation of the drying chamber. Downstream from the heating apparatus a conditioning apparatus is positioned for cooling and dehumidifying the sugar cubes. Finally, the sugar cubes are packaged for example in boxes.

[0006] The heating apparatus according to the present invention comprises a multitude of heating devices, whereas each heating device has a microwave source, a magnetron, which emits microwave radiation. In a wave guide preferably a rectangular wave guide, the microwave radiation is guided from the microwave source to the drying chamber in which the sugar cubes are heated and consequently, in which the water content of the sugar cubes vaporizes at least partially. The water vapor is intermittently or continuously removed from the drying chamber.

[0007] In most cases, the microwave radiation is not absorbed entirely by the water molecules in the sugar cubes, but reflected, at least partially, back into the wave guide. The amount reflected depends on the amount of radiation and the amount of water introduced into the drying chamber per time unit.

[0008] According to the present invention, the inventive apparatus comprises an isolator in the wave guide that allows the transmission of the radiation only in the direction from the source to the drying chamber. Thus, back radiation will not be guided beyond this isolator in the wave guide. Consequently, even if the load of sugar cubes to be dried and thus the back radiation alters, this does not influence the inventive apparatus, which is consequently much more flexible than the apparatus according to the state of the art. Furthermore the lifetime of the microwave source can be increased.

[0009] Preferably, the isolator is connected to a water cooling, preferably a water cooling circuit, whereas the isolator redirects back radiation reflected from the drying chamber into the water cooling, preferably the water cooling circuit, where the back radiation is absorbed by the water. More preferably, the inventive apparatus comprises a heat sink in the water cooling circuit, where the heat, transferred to the water circuit, is removed and the water is then circulated to the isolator. The heat that is removed from the water circuit in the heat sink is preferably reused for example in the inventive process to heat air that flows, for example, through the drying chamber. Additionally or alternatively, the heat can be used in a different process and/or in order to heat for example a building or to drive a generator.

[0010] In another preferred embodiment, the cooling circuit also cools the microwave source, whereas the microwave source is located in the cooling circuit, preferably upstream from the isolator.

[0011] Preferably, the inventive apparatus comprises in the wave guide, preferably between the isolator and the drying chamber, means to neutralize the back radiation at least partially, so that the back radiation load,

which has to be absorbed in the isolator is reduced. In a preferred embodiment, the neutralization of the back radiation is achieved by modulating the oscillation of the back radiation, so that the generated radiation at least partially neutralizes the energy of the back radiation.

[0012] In a preferred embodiment the inventive apparatus comprises measurement means to measure the amount of back radiation. This signal is preferably used to adjust the neutralization means.

[0013] Preferably the means to neutralize the back radiation is a multitude, preferably three metal rods, which extend into the wave guide, whereas their extension into the wave guide is adjustable. By adjusting the extension of the rods into the wave guide, the wave's length and/or preferably the phase of the back radiation can be altered.

[0014] According to a preferred or to another inventive embodiment of the present invention the inventive apparatus comprises one energy supply for each microwave source, whereas the power supplies are located separate from the inventive apparatus. This embodiment of the present invention has the advantage, that the microwave sources and/or the wave guides are accessible more easily and that an additional heat source, the power supply, is removed from the microwave sources, which increases the lifetime of the microwave sources.

[0015] The present invention is now explained according to figures 1 and 2.

Figure 1 shows a side view of the inventive apparatus.

Figure 2 shows a top view of the inventive apparatus.

[0016] Figure 1 shows the heating apparatus 17, which is part of the inventive apparatus 1 to produce sugar cubes. In this apparatus 1, sugar and water are supplied in the usual way to a press, in which the sugar and the water are mixed and in which the sugar cubes are pressed into the correct shape, size and weight. From the press the sugar cubes are conveyed by transportation means 2 to the heating apparatus 17. The heating apparatus 17 contains a multimode heating devices 18 (compare figure 2). The conveying apparatus 2 conveys the wet sugar cubes 4 through a drying chamber, where the sugar cubes 4 are heated by microwave energy to a temperature of approximately 75 °C and most of the humidity in the sugar cubes 4 is evaporated. Thus, the sugar cubes 4 absorb enough latent energy to arrive at the desired final humidity content in a conditioning apparatus. After the sugar cubes have been conveyed through the conditioning apparatus 4, they are conveyed to a usual packaging apparatus by the transportation means 2, where the sugar cubes are packed in boxes or the like. The press, the transportation means 2 and the packaging apparatus are electrically driven in the known manner, the drives being adapted to one another. In order to lose as little microwave energy as possible, the transportation means 2 is preferably a conveyor belt made of synthetic material, the dielectric characteristics of which being such, that the conveyor belt takes up as little energy as possible.

[0017] The heating apparatus 17 of the inventive apparatus 1 comprises a multitude of heating devices 18 (compare figure 2), whereas only one heating device is depicted in figure 1. The heating device 18 comprises a wave guide 10 which is connected to a support 6, here a stainless steel plate, which is, for example, part of the frame of the apparatus 1, by, for example, a flange 8. The support 6 comprises an opening 9 through which the microwave radiation 19 can be transferred into the drying chamber 5. At the bottom of the wave guide a microwave source 14, a magnetron, is located, which emits microwave radiation into the wave guide 10. This wave guide 10 then directs the radiation, as depicted by the arrows 19, in the direction of the drying chamber 5. Relative to the radiation direction 19, upstream of the microwave source 14, an isolator 15 is located, which allows only the transmission of microwaves as indicated by the arrows 19. Back radiation 20 cannot get passed this isolator. This isolator is for example a device that transfers the back radiation 20 into a water load 13 where it is absorbed. The isolator, for example, comprises a permanent magnet to redirect the back radiation 20 into the water load 13.

[0018] Further upstream from the isolator 15 in the wave guide 10 or on the isolator, a measurement device 16 islocated, which measures the amount of back radiation 20. The signal of this measurement is preferably used to adjust or control back radiation neutralization means 12, which are also located upstream to the isolator. These back radiation neutralization means 12 are, in the present case, a multitude, here three rods 12, whose extension into the wave guide 10 can be adjusted. By adjusting the extension of these rods, the bandwidth and/or the phase of the back radiation 20 can be altered such, that its energy is neutralized by the radiation 19, while the radiation 19 remains as emitted.

[0019] The inventive heating apparatus 17 further comprises a water cooling circuit 13, which is connected to the isolator 15 to provide a continuous or intermittent water flow, which absorbs the back radiation energy directed from the isolator into the water cooling circuit 13. The water circuit 13 coming from the isolator 15 preferably also cools the microwave source 14, whereas, preferably, the microwave source is located upstream from the isolator. The heated water is then cooled in a heat sink 7 and the cooled water is then recirculated to the isolator and/or the microwave source 14. The heat removed from the water circuit 13 in the heat sink 7 can be utilized by the inventive apparatus for example for heating air ventilated through the drying chamber 5 and/or to preheat the sugar. Additionally or alternatively the heat can be used to heat a building or to generate electricity.

[0020] As can be also seen from figure 1, there is one individual energy source 11 for each microwave source 14. Furthermore, it can be seen, that this energy source

11 is located removed from the inventive apparatus.

[0021] Figure 2 shows a top view of the heating apparatus. It can be clearly seen, that below the drying chamber 5, a multitude of heating devices 18 are located. Here, always five heating devices 18 are arranged in a recurrent pattern. Each of the heating devices 18 is designed as described according to figure 1, whereas one individual energy supply, which each located removed from the inventive apparatus, provides the power to one microwave source 14. The cooling circuit comprises preferably one branch per heating device 18, whereas the branches are operated in parallel. All branches are connected to one heat sink 7.

List of reference signs:

[0022]

1 apparatus to produce sugar cubes

2 transportation means, transportation belt

3 anti friction means

4 sugar cube

5 drying chamber

6 support, stainless steel plate

7 heat sink

8 flange

9 opening in the support

10 wave guide

11 power supply

12 back radiation neutralization means to influence oscillation of the back radiation

13 water cooling, water cooling circuit

14 magnetron, microwave source

15 isolator

16 measurement device, preferably located on the isolator 15

17 heating apparatus

18 heating device

19 radiation

20 back radiation

Claims

1. Sugar cube production- and drying apparatus (1) comprising:

- a press for shaping a sugar mass in sugar cubes (4),
- a heating apparatus (17) for heating and dehumidifying the sugar cubes (4),
- a conditioning apparatus for cooling and dehumidifying the sugar cubes (4)
- transportation means (2) for transporting the sugar cubes (4) from the press to the heating apparatus (17) and from there to the conditioning apparatus,

whereas the heating apparatus (17) comprises a multitude of heating devices (18), each heating device (18) having a microwave source (14) emitting microwave radiation and a wave guide (10) to guide the microwave radiation (19) from the microwave source (14) to a drying chamber (5) in which the sugar cubes are heated, **characterized in, that** each heating device (18) comprises an isolator (15) located in the wave guide (10) that allows the transmission of radiation only in the direction from the source (14) to the drying chamber (5).

2. Sugar cube production- and drying apparatus (1), according to claim 1, **characterized in, that** isolator (15) is connected to a water cooling (13), preferably a water cooling circuit , whereas the isolator (15) redirects back radiation (20), reflected from the drying chamber (5), into the water cooling (13), preferably the water cooling circuit (13), where the back radiation is absorbed.

3. Sugar cube production- and drying apparatus (1) according to claim 2, **characterized in, that** a heat sink (7) is part of the water cooling circuit (13).

4. Sugar cube production- and drying apparatus (1) according to claim 3, **characterized in, that** the heat that is recovered in the heat sink (7) is reused.

5. Sugar cube production- and drying apparatus (1) according to one of claims 2 — 4, **characterized in, that** the water cooling circuit (13) cools the microwave source (14).

6. Sugar cube production- and drying apparatus (1) according to one of the preceding claims, **characterized in, that** it comprises in the wave guide (10) downstream from the isolator (15) means (12) to neutralize the back radiation (20) at least partially,

preferably by modulating the oscillation of the back radiation (20).

7. Sugar cube production- and drying apparatus (1) according to claim 6, **characterized in, that** it comprises measurement means (16) to measure the back radiation (20) and that means (12) are adjusted based on a signal from the measurement means (16).

8. Sugar cube production- and drying apparatus (1) according to claims 6 or 7, **characterized in, that** the means (12) is a multitude of metal rods which extend into the wave guide (10), whereas their extension into the wave guide (10) is adjustable.

9. Sugar cube production- and drying apparatus (1), preferably according to one of the preceding claims, **characterized in, that** it comprises multiple central power supplies (11), which is separated from the sugar cube production- and drying apparatus (1).

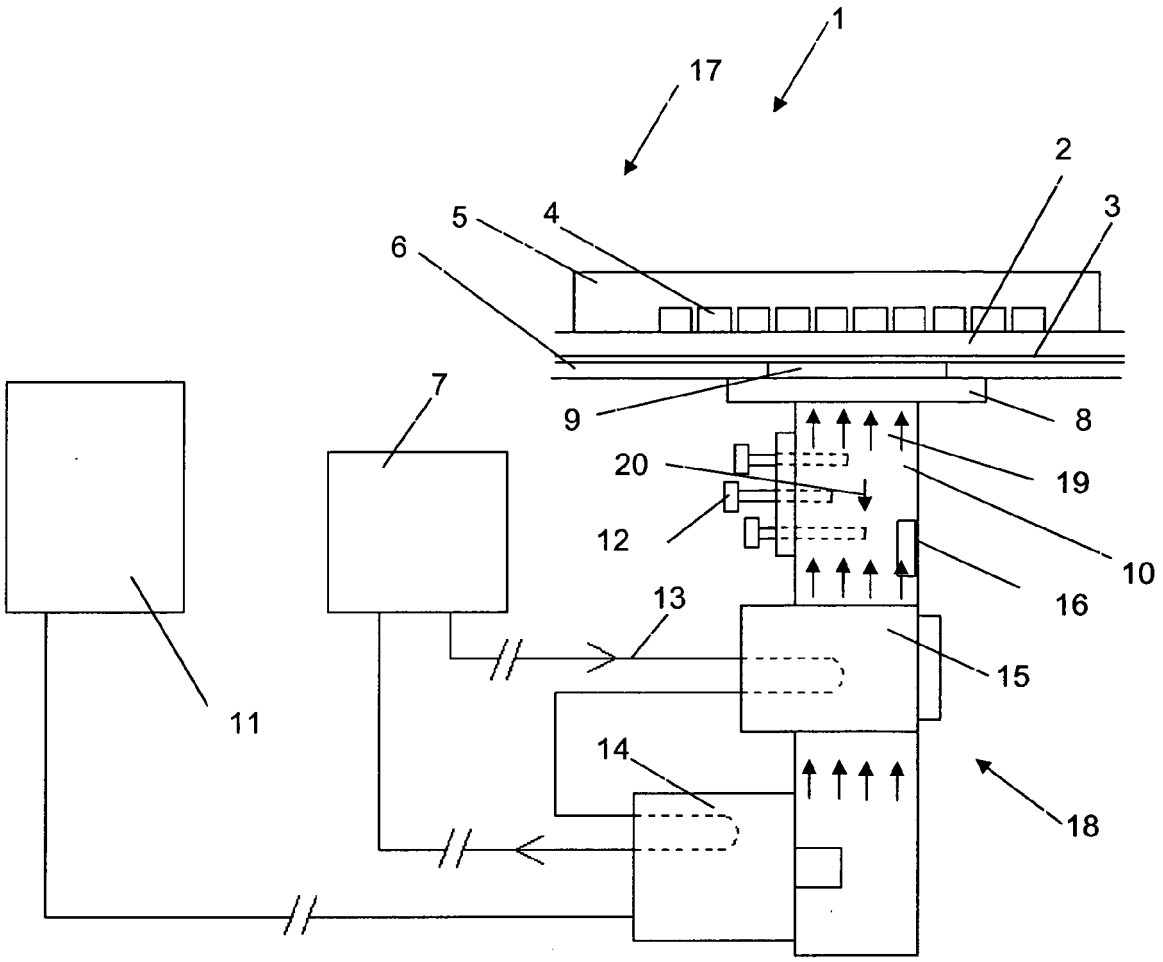

Fig. 1

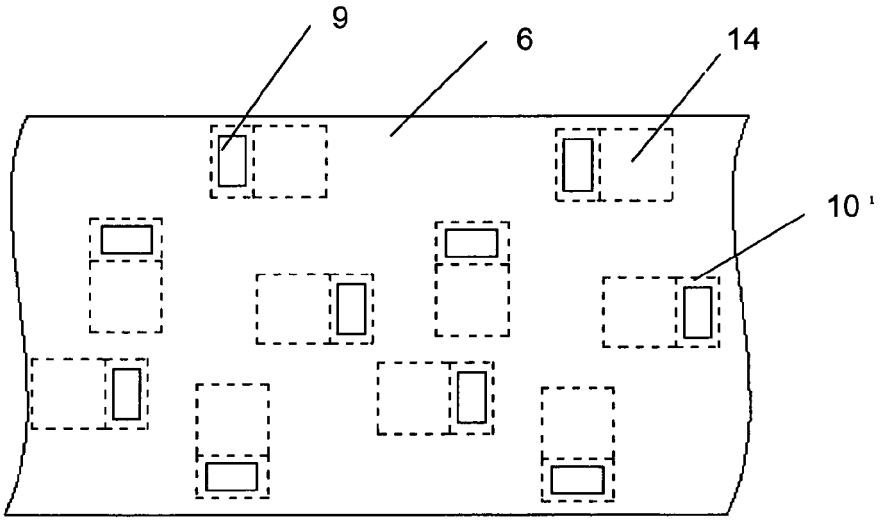

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 11 00 0703

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 0 036 241 A1 (STORK BEPAK BV [NL]) 23 September 1981 (1981-09-23) * claims 1-10 * -----	1-9	INV. C13B40/00
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TECHNICAL FIELDS SEARCHED (IPC)

C13B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 July 2011	Picout, David

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 00 0703

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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