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(54) **METHOD FOR OPERATING CONVECTIONAL OVEN PROVIDED WITH ENERGY SAVINGS AND INCREASED CLEANING EFFICIENCY IN PYROLYTIC CYCLE**

VERFAHREN ZUM BETRIEB VON KONVEKTIONSOFEN MIT ENERGIEEINSPARUNG UND ERHÖHTER REINIGUNGSEFFIZIENZ IM PYROLYTISCHEN KREISLAUF

PROCÉDÉ DE FONCTIONNEMENT D'UN FOUR À CONVECTION MUNI D'ÉCONOMIES D'ÉNERGIE ET D'UNE EFFICACITÉ DE NETTOYAGE ACCRUE DANS UN CYCLE PYROLYTIQUE

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EP 3 470 740 B1

Description

Technical Field

[0001] The invention is related to a convectional oven with pyrolytic heating system, which is provided with higher self-cleaning efficiency and lower energy consumption, during pyrolytic cycle.

State of the Art

[0002] Energy generation and consumption is one of the parameters which affects international competitive capacity and is used in determining the development level and economical independency of countries. Importance of renewable energy sources are getting greater so as to prevent use of excessive energy sources and thus global warming, and also a higher level of efficiency with minimum energy is tried to be obtained. In order to achieve this, studies on thermal energy and consumption thereof have been carried out nowadays.

[0003] It is one of the main objectives to obtain hygiene and maximum efficiency on the ovens employed in cooker devices sector. Oven walls and interior portions thereof become permeated with scent of foods in the course of cooking which make cleaning process an obligation. It is ensured to burn grease and dirt without using any chemical substances in pyrolytic and catalytic ovens that are developed upon the appearance of need for the oven which facilitates cleaning process and is provided with self-cleaning property. In case the catalytic enamel coating, which ensures acceleration of grease dispersion, is present in ovens, grease residuals are burnt at cooking temperature by absorbing it by means of said coating. Carrying out cleaning process in the course of cooking saves energy in terms of energy consumption and its cost are less compared to those self-cleaning ovens because of the catalytic coating. In state of the art, the patent application numbered UA93961 discloses the enamel-glass catalytic coating with the self-cleaning property that can be applied on interior surfaces of oven, wherein the coating comprises frit, MnO as oxidation catalyst, catalyst disintegrating greases and AlO used as heat-resistant filler. However, enamel coatings lose their efficiencies in two or three years and therefore, it is necessary to replace them periodically. Further, manual cleaning process is needed because the coating is not applied on the bottom of oven and the interior surface of door.

[0004] Yet, there exists a pyrolytic coating allowing pyrolysis process, which is known as thermal degradation process of substances in anaerobic environment, in pyrolytic ovens. Gas being rich in hydrocarbon, a liquid in a greasy form and solid outputs (char) being rich in carbon can be obtained as a result of pyrolysis. Pyrolysis reactions vary according to substances, wherein in general, it starts between 150°C-250°C and here, mass loss occurs swiftly. Sudden mass loss ends between the temperatures of 350-400°C. Mass loss slows down after this temperature and it stays almost stable about 500-600°C. That mass loss stays stable at those temperatures is resulted from the fact that there exists no compound to depart from the structure, and just remaining ash and solid articles (char). However, advanced isolation system, cooling designs and safety requirements are needed in these ovens because of the temperature, which increases costs. Further, because amount of energy consumed during pyrolytic cycle is considerably high, studies how to decrease energy consumption have been carried out.

[0005] A perfect cleaning efficiency cannot be achieved in the course of pyrolytic cycle. Achieving a complete cleaning efficiency is possible for ovens in a longer cycle during at almost impossible temperatures. Therefore, for the purpose of achieving energy savings and increasing cleaning efficiency in the course of pyrolytic cleaning process, it is necessary to check out the parameters such as temperature and pyrolysis period, and oven chamber variables. It is stated in state of the art that the most suitable cycle period is 120 minutes, and sensor systems comprising temperature, light, volatile gas or oxygen sensors should be integrated with pyrolytic ovens. The patent application numbered US5534678 discloses an oven comprising an upper grid member and lower oven member that can be cleaned pyrolytically. Further, the control system allowing cycle that is coupled to heating element and temperature sensor provides grid member with power until oven reaches up to triggering temperature. the utility model application numbered CN205635489 discloses a pyrolytic oven comprising an automatic control system, wherein said oven comprises temperature and pressure sensors. However, a limited area could be sensed inside the oven by way of sensor and thus, all dirty regions could not be detected. Furthermore, it is important to select the sensor type that is suitable for ambient conditions and provides continuous and accurate date. In addition, although various system can be integrated with pyrolytic ovens, consuming considerable amount of energy still constitutes a problem, and it is necessary to determine minimum pyrolysis temperature and optimum pyrolysis duration.

[0006] Further relevant prior art is given in EP 1 837 599 A2 and DE 197 06 186 A1.

Problems Intended to be Solved with the Present Invention

[0007] Objective of the invention is to develop a convectional oven provided with lower energy consumption in the pyrolytic cycle, and a pyrolytic heating system that can be integrated with said oven.

[0008] Another objective of the invention is to increase the self-cleaning efficiency by means of increasing mass loss of oven chamber dirtiness in the course of pyrolytic cycle through pyrolytic heating system (algorithm).

[0009] Further objective of the invention is to determine minimum pyrolysis temperature and optimum pyrolysis duration and to achieve energy savings by means of pyrolytic heating system (algorithm).

Description of the Figures

[0010]

Figure 1a. Temperature-time graph comprised by the present heating system

Figure 1b. Temperature-time graph comprised by the heating system 1 (algorithm 1)

Figure 1c Temperature-time graph comprised by the heating system 2 (algorithm 2)

Figure 2 View of a convectional oven with pyrolytic heating system

Description of the references in the figures

[0011] The parts in the figures are enumerated, their descriptions are given below:

1 : Reservoir

2 : Pump

3 : Nozzle

4 : Hotspot

5 : Oven body

Description of the Invention

[0012] The invention relates to a convectional oven with pyrolytic heating system, which is provided with higher self-cleaning efficiency and lower energy consumption, during pyrolytic cycle, and a pyrolytic heating system that can be integrated with said oven.

[0013] The convectional oven that is subject matter of the invention comprises a nozzle (3) having a pyrolytic heating system allowing volatiles occurred due to adding of waiting-period in intermediate steps during degradation to be removed in a slower manner from the environment and based on this, to increase mass loss in the course of pyrolytic cycle, also increasing the total of mass loss and discharging water and/or steam from water and/or steam reservoir (1) inside hotspot (4) by means of water and/or steam reservoir (1) and pump (2) positioned in the oven body (5) and outside the oven hotspot (4). Pyrolysis atmosphere is one of the most important factors affecting pyrolysis, and in case there exists water and/or water steam in the atmosphere, total mass loss increases and accordingly, cleaning efficiency increases as well. Figure 2 illustrates a convectional oven with pyrolytic heating system.

[0014] The pyrolytic heating system that is subject matter of the invention, which comprises hotspot body resistant to pyrolysis temperatures, whose door is locked automatically during pyrolysis process and which can be applied to convectional ovens in which Pyrolysis cycle is carried out through a capillary thermostat or electronic card; comprises the process steps of removing volatiles occurred during degradation from environment in a controlled manner and increasing mass loss throughout pyrolysis cycle by way of keeping water and/or water steam in pyrolysis atmosphere and accordingly achieving a higher cleaning efficiency,

- increasing temperature of inside of hotspot (4) up to 200-250°C, which is the temperature in which pyrolysis reactions are started, while oven is cool,
- increasing oven temperature gradually between 5-20°C starting from 200-250°C and keeping it at this temperature for at least 1 minute,
- after gradual temperature increase, increasing temperature of inside of hotspot (4) up to 350-500°C,

- keeping the oven at this temperature such that the total pyrolytic cycle is at least 80 minutes.

[0015] The pyrolytic heating system that can be applied to convectional ovens is heated gradually between 5-20°C starting from 200-250°C and is kept at such temperatures for at least 1 minute, and there exist at least two stages in this process step.

[0016] Firstly, mixture of margarine and beef broth is prepared in accordance with Standard EN 60335-2-6 in the pyrolytic heating system and is applied on inside of the oven, including its door. Subsequently, the oven is operated on the maximum temperature adjustment in the static position for 3 hours and thus, dirtiness can be obtained in the oven wall. The oven chamber dirtiness is employed as raw material in the course of pyrolytic cycle and it is subjected to thermal analysis in thermogravimetric analysis (TGA) device so as to examine its thermal degradation behavior. dTG values are achieved by means of calculating the derivative of date obtained through as a result of characterization dirtiness with TGA and thus, percent of the total mass loss by weight and maximum degradation temperature achieved.

[0017] Effects of different heating speed, pyrolytic cycle duration or waiting period on mass loss of dirtiness and energy consumption are examined so as to provide energy savings, and it is compared to the present heating system. Accordingly, the minimum pyrolysis temperature and optimum pyrolysis period are determined. A new pyrolytic heating system is developed by forming a pyrolytic cycle algorithm for the purpose of in a controlled manner removing volatiles appeared in the course of degradation of oven chamber dirt from the chamber and also, increasing the mass loss in the same cycle duration. It is ensured in the new developed heating system that waiting durations are added to intermediate steps along with removing slower manner volatiles appeared during degradation from the chamber and accordingly, in the same cycle duration there is an increased mass loss. Cleaning efficiency also increases along with increase of the total mass loss.

[0018] Pyrolysis process is carried out in the following cycle duration, for example in the heating system 1 and 2 so as to compare the total mass loss and energy saving in the pyrolytic heating system that is subject matter of the invention.

[0019] The pyrolytic cycle duration, temperature values and details applied to heating system 1 and 2 are given on the Table 1.

[0020] Temperature-time graphs of the present heating system, heating system 1 and heating system 2 are respectively illustrated on the Figure 1a, 1b and 1c.

Table 1. Pyrolytic cycle duration applied to heating system 1 and 2

Heating system 1		Heating system 2	
Time (min.)	Temperature (°C)	Time (min.)	Temperature (°C)
0	25	0	25
10-35	25-250	10-35	25-250
36-45	250-270	36-45	250-270
45-80	270-500	45-60	270-500
80-140	500	60-110	500

[0021] The total mass loss and maximum degradation temperature obtained as a result of TGA data of pyrolytic heating system, which is present and subject matter of invention, is given on the Table 2.

Table 2. The total mass loss and maximum degradation temperature in different heating systems

	Pyrolysis duration (min.)	**Total mass loss (by weight %)**	**Maximum degradation temperature (°C)**
Present heating system (10°C/min.)	120	29,19	388
Heating system 1 (Algorithm 1)	120	41,33	380
Heating system 2 (Algorithm 2)	90	36,50	380

[0022] As it can be seen in the Figure 2, oven cleaning efficiency is achieved respectively as 41,33% and 36,50% in heating system 1 and 2 According to the present heating system; the total mass loss is increased 41,6 % by weight in

the heating system 1 and 25,0 % by weight in the heating system 2. It can be seen that mass loss is considerably increased because there is a waiting period in intermediate steps in the pyrolytic heating system that is subject matter of the invention and it also decreases the maximum degradation temperature.

[0023] In order to compare energy amounts consumed in the course of pyrolytic cycle, the present heating system and the pyrolytic heating system that is subject matter of the invention are applied in a controlled manner to oven prototypes by means of an electronic device and energy consumption of these systems are given on Table 3.

Table 3. Amount of energy consumption of heating system 1 and 2 and the present heating system during pyrolytic cycle

	Energy consumption (Wh)
The present heating system	4461,0
Heating system 1 (Algorithm 1)	4291,5
Heating system 2 (Algorithm 2)	3247,1

[0024] As can be understood from Table 3, energy consumption is decreased by means of the pyrolytic heating system that is subject matter of the invention, to which waiting period is added. According to the present heating system, energy saving is achieved respectively %3,8 and %27,2 in heating system 1 and 2.

[0025] Pyrolytic heating system that consumes less energy, of which cleaning efficiency is increased during pyrolytic cycle is particularly in a such form that it can be applied to both built-in ovens and heater/cooker devices that require cleaning process.

The industrial practice of the invention:

[0026] The pyrolytic heating system that is subject matter of the invention and can be integrated with convectional oven and oven chamber exhibits superior properties compared to ovens provided with self-cleaning property by means of increasing self-cleaning efficiency thanks to adding waiting periods at different temperatures during pyrolytic cycle, increasing pyrolytic cycle efficiency by using water and/or steam in hotspot (4) during cycle and achieving energy saving.

Claims

1. A method for removing volatiles occurred during degradation from environment in a controlled manner, increasing mass loss throughout pyrolysis cycle and accordingly achieving a higher cleaning efficiency in convectional ovens with pyrolytic cycle which comprises hotspot body resistant to pyrolysis temperatures, of which door is locked automatically during pyrolysis process and which can be applied to convectional ovens in which pyrolysis cycle is carried out through a capillary thermostat or electronic card and which has self-cleaning properties, comprising below process steps

    • increasing temperature of inside of hotspot (4) up to 200-250°C, which is the temperature in which pyrolysis reactions are started, while oven is cool, **characterized by** that the method further comprises the steps of
    • increasing oven temperature gradually between 5-20°C starting from 200-250°C and keeping it at this temperature for at least 1 minute,
    • after gradual temperature increase, increasing temperature of inside of hotspot (4) up to 350-500°C,
    • keeping the oven at this temperature such that the total pyrolytic cycle is at least 80 minutes.

2. A method according to Claim 1, **characterized by** continuously or discontinuously ejecting steam by means of pump (2) and nozzle (3) into hotspot (4) during pyrolytic cycle in the stage of process steps to increase cleaning efficiency.

Patentansprüche

1. Verfahren zur Entfernung der flüchtigen Stoffen auf eine kontrollierte Weise, die während des Abbau von Umgebung auftreten, zur Erhöhung des Massenverlust mittels des Pyrolysevorgangs und dementsprechend des Erreichen einer hohen Reinigungseffizienz in konventionellen Öfen mit Pyrolysevorgang, der einen gegen Pyrolysetemperaturen beständigen Heißpunktskörper umfasst, dessen Tür während des Pyrolysevorgangs automatisch verschlossen ist und der auf die konventionellen Öfen angewandt werden kann, wobei der Pyrolysevorgang mittels eines Kapil-

larthermostat oder einer elektronischen Karte und der selbstreinigenden Eigenschaften aufweist, umfassend die folgenden Prozessschritte;

• Erhöhung der Temperatur innerhalb des Heißpunkt (4) bis auf 200-250°C, die die Temperatur ist, in der die Pyrolysesreaktionen beginnen, während der Ofen kühl ist, **dadurch gekennzeichnet, dass** das Verfahren ferner die folgenden Schritte umfasst;
• Erhöhung der Ofentemperatur auf eine graduelle Wiese zwischen 5-20°C ausgehend von 200-250°C und Beibehaltung davon auf dieser Temperatur für mindestens 1 Minute,
• Erhöhung die Temperatur innerhalb des Heißpunkt (4) bis auf 350-500°C nach der graduellen Erhöhung der Temperatur,
• Beibehaltung des Ofens auf dieser Temperatur derart, dass der ganze Pyrolysevorgang mindestens 80 Minuten dauert.

2. Verfahren gemäß Anspruch 1, **gekennzeichnet durch** kontinuierlichen oder nicht kontinuierlichen Ausstoß vom Dampf mittels Pumpe (2) und Düse (3) in den Heißpunkt (4) während des Pyrolysevorgang in der Phase der Prozessschritte, um die Reinigungseffizient zu erhöhen.

Revendications

1. Une méthode pour éliminer de l'environnement, d'une manière contrôlée, les substances volatiles produites lors de la dégradation augmentant la perte de masse durant le cycle de pyrolyse et atteindre, par conséquent, une efficacité de nettoyage plus élevée dans les fours à convection au cycle pyrolytique qui comprend un corps avec des points chauds résistant aux températures de la pyrolyse, dont la porte est verrouillée automatiquement pendant le procédé de pyrolyse et qui peut être appliqué aux fours à convection dans lesquels le cycle de pyrolyse est effectué au travers d'un thermostat capillaire ou d'une carte électronique et qui est de qualités d'auto-nettoyage, comprenant les étapes du procédé suivantes:

• augmenter la température à l'intérieur du point chaud (4) jusqu'à 200-250°C, qui est la température de départ des réactions de pyrolyse, quand ledit four est froid, **caractérisé en ce que** la méthode comprend en outre les étapes suivantes:
• augmenter la température du four progressivement entre 5-20°C à partir de 200-250°C et le maintenir à cette température pendant au moins 1 minute,
• après l'augmentation progressive de la température, augmenter la température à l'intérieur du point chaud (4) jusqu'à 350-500°C,
• maintenir ledit four à cette température de sorte que le cycle pyrolytique soit d'au moins 80 minutes.

2. Une méthode selon la revendication 1, **caractérisée en ce que**, éjecter de la vapeur, continûment ou discontinûment, au moyen d'une pompe (2) et d'une buse (3) dans le point chaud (4) pendant le cycle pyrolytique en cours des étapes du procédé pour augmenter l'efficacité du nettoyage.

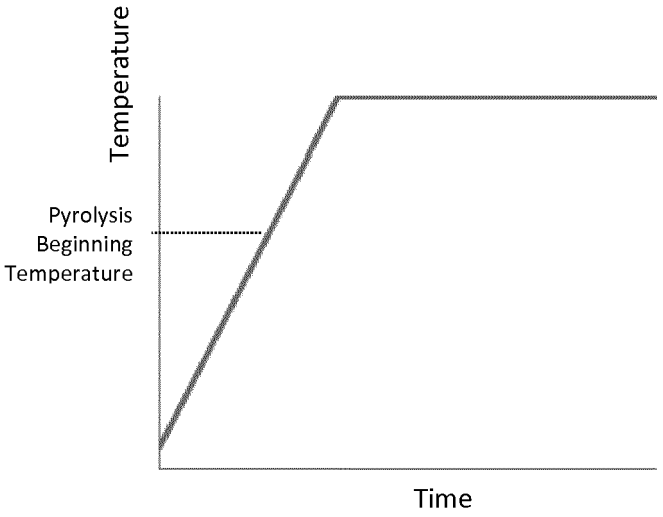

Figure 1A

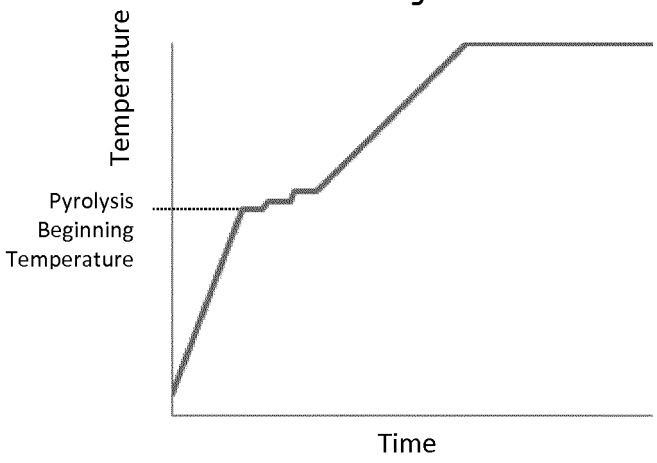

Figure 1B.

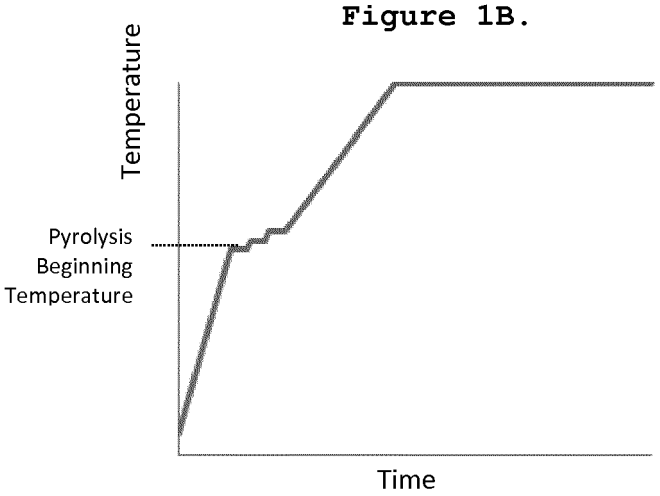

Figure 1C.

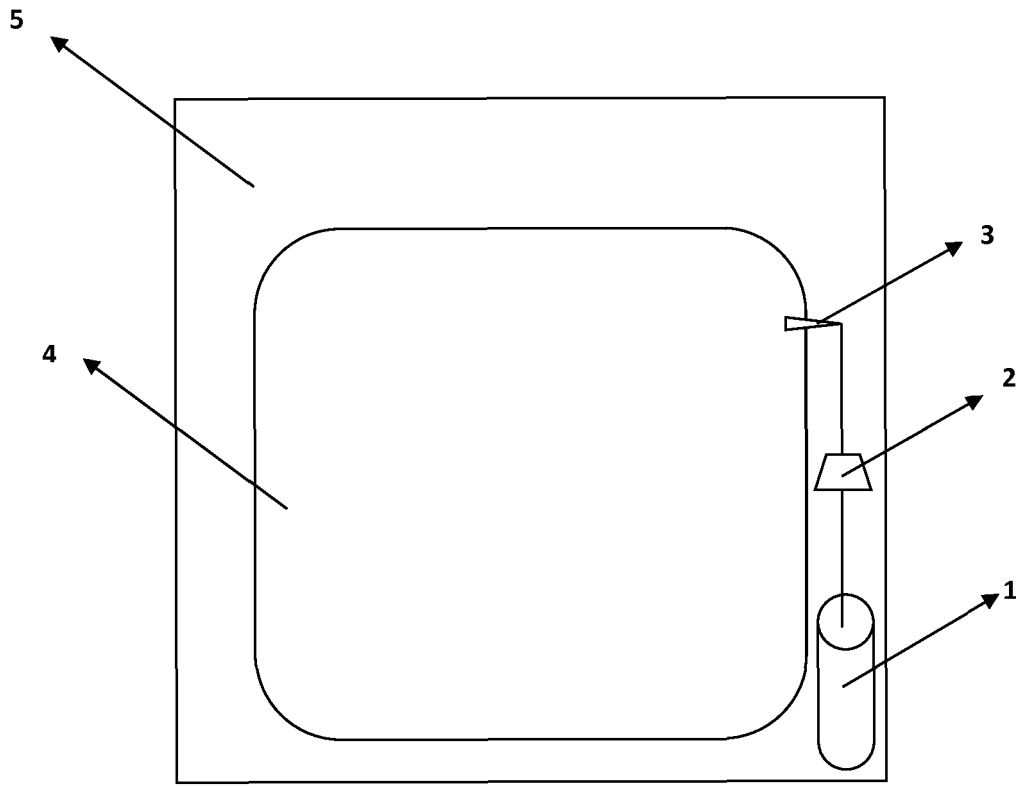

Figure 2

REFERENCES CITED IN THE DESCRIPTION

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- DE 19706186 A1 **[0006]**