

ARTICLE PROCESSING SYSTEM AND METHOD

Field of Invention

The present invention generally relates to processing of articles. In particular, the
5 present invention relates to processing articles using a combination of ozone, heating
and cooling.

Background

Timber and wood products are articles that are susceptible to infestation problems,
10 for example, infestation by insects and other pests. These problems become more
severe when the articles are kept in enclosures over an extended period of time for
storage or transportation. In addition, many countries have also put in place
quarantine regulations to protect their native forests from the introduction of wood
pests. The International Plant Protection Convention (IPPC) Secretariat, part of the
15 Food and Agriculture Organization (FAO) of the United Nations, issued ISPM 15
(International Standards for Phytosanitary Measures) guidelines for regulating wood
packaging material in international trade.

Currently, many processing methods are available for processing these articles prior
20 to storage or transportation. The main objectives of these processing methods are to
prevent insect infestation and growth and to remove or retard growth of algae and
fungi in these articles. Processing methods approved by IPPC for such use are
methyl bromide (MB) fumigation and heat treatment (HT).

25 MB fumigation was previously in wide spread use for fumigating articles such as
timber, package materials and pallets. However, as some of these articles are
subsequently used for containing or transporting food items and methyl bromide that
settles on these articles are toxic, this processing method is generally unsafe.
Additionally, MB fumigation only lasts a few weeks and does not prevent re-
30 infestation by insects. This is undesirable as these articles may be transported in
containers over air, land and/or sea for extended durations during which re-
infestation will definitely occur.

In accordance with the HT processing method, the articles are heated in accordance with a specific time-temperature schedule to achieve a minimum article core temperature of 56°C for at least 30 minutes. Kiln drying is one example of a HT processing method. In kiln drying, the articles, for example wood furniture, are subjected to constant high temperatures within an enclosure with constant airflow out of the enclosure for expelling moisture from the enclosure. The articles are then loaded onto transportation after kiln drying. Similar to the use of MB fumigation, although the high temperature kiln drying is able to kill pest and insects in the articles, it does not prevent re-infestation from occurring.

There is therefore a need for effective processing of articles for keeping them substantially pest free during transportation or prolonged storage.

Summary

The present embodiment of the invention disclosed herein provides a system and a method for processing articles using a combination of ozone, heating and cooling.

In accordance with a first aspect of the invention, there is disclosed a processing system comprising an enclosure, a temperature conditioning system and an ozonator.

The enclosure defines a processing space and an opening to the processing space. The enclosure also disposes at least one article in the processing space through the opening. The temperature conditioning system conditions temperature within the processing space for one of heating and cooling the at least one article disposed in the processing space. The ozonator generates and discharges ozone (O₃) into the processing space for exposing the at least one article disposed in the processing space to ozone. Lastly, by substantially exposing the at least one article in the processing space to ozone and one of heating and cooling the at least one article in the processing space over a predetermined duration substantially at least one of repels pest from, eradicate pest from and disinfect the at least one article disposed in the processing space.

In accordance with a second aspect of the invention, there is disclosed a processing method comprising providing an enclosure, a temperature conditioning system and

an ozonator. The enclosure defines a processing space and an opening to the processing space. The enclosure also disposes at least one article in the processing space through the opening. The temperature control system conditions temperature within the processing space for one of heating and cooling the at least one article
5 disposed in the processing space. The ozonator generates and discharges ozone (O_3) into the processing space for exposing the at least one article disposed in the processing space to ozone. Lastly, by substantially exposing the at least one article in the processing space to ozone and one of heating and cooling the at least one article in the processing space over a predetermined duration substantially at least
10 one of repels pest from, eradicate pest from and disinfect the at least one article disposed in the processing space.

Brief Description Of The Drawings

Embodiments of the invention are disclosed hereinafter with reference to the
15 drawings, in which:

FIG. 1 is a system representation of a processing system according to an embodiment of the invention;

20 FIG. 2 shows a first process flow diagram of a processing method for utilising the processing system of FIG.1;

FIG. 3 shows a second process flow diagram of a processing method for utilising the processing system of FIG.1; and

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FIG. 4 shows a third process flow diagram of a processing method for utilising the processing system of FIG.1.

Detailed Description

30 A system and a method for processing articles using a combination of ozone, heating and cooling are described hereinafter for addressing the foregoing problems.

For purposes of brevity and clarity, the description of the invention is limited hereinafter for treating articles using a combination of ozone, heating and cooling. This however does not preclude various embodiments of the invention from other implementations, uses and applications. The fundamental operational and functional principles of the embodiments of the invention remain common throughout the various embodiments.

Embodiments of the invention described hereinafter are in accordance with FIGs. 1 to 4 of the drawings, in which like elements are numbered with like reference numerals.

An embodiment of the invention, a processing system 20, is described with reference to FIG. 1. The processing system 20 comprises an enclosure 22, a barrier 24, an ozonator 26 and a temperature conditioning system 27. The enclosure 22 defines a processing space 28 and an opening 30 to the processing space 28. The processing space 28 is used for disposing articles 32 for processing by ozone, heating and cooling. The enclosure 22 is preferably a steel shipping container being shaped for carriage and transportation by air or sea or land transport. Alternatively, the enclosure 22 is a tent-like structure constructed from flexible panels, for example fabric panels or plastic panels. The tent-like structure enables the enclosure 22 to be collapsible for facilitating portability of the tent-like structure. Further alternatively, the enclosure 22 forms part of a fixed structure, for example, a building, a warehouse or a silo.

The barrier 24 is preferably coupled to the enclosure 22 for substantially covering the opening 30 of the enclosure 22. Preferably, the barrier 24 is a flexible panel for covering the opening 30 of the enclosure 22. Alternatively, the barrier 24 is a door pivotably or slidably coupled to the enclosure 22 and operable for covering the opening 30.

The ozonator 26 is preferably structurally integrated with the enclosure 22. Alternatively, the ozonator 26 is formed integral with the barrier 24 or is coupled to the barrier 24 for generating and discharging ozone into the processing space 28.

The ozonator 26 generates ozone (O₃) preferably by corona discharge. However, this does not preclude the ozonator 26 from generating ozone by ultraviolet irradiation, electrolysis or plasma generation.

5 To enable the operation of the ozonator 26, the processing system 20 further comprises a first controller (not shown) and a first sensor (also not shown) coupled to the first controller. The first controller controls the amount of ozone generated by the ozonator 26. The first sensor is preferably disposed within the processing space 28 for detecting and for providing as data input to the first controller the level of
10 ozone in the processing space 28. The first sensor can be for example a sensor array which consists of multiple sensors that are deployed in the processing space 28 in order to ensure that ozone is uniformly circulated throughout the processing space 28 during processing of the articles 32. The data input received from the first sensor allows the first controller to determine and control the amount of ozone generated by
15 the ozonator 26 based on measurements of the level of ozone in the processing space 28. Additionally, the first sensor is preferably connected to a computer (not shown) in order for data collation to be performed.

The temperature conditioning system 27 performs either heating or cooling of the
20 articles 32 within the processing space 28. The temperature conditioning system 27 preferably contains either heating elements or refrigeration condenser units for respectively heating or cooling the articles 32. However, the processing system 20 preferably uses heat for processing the articles 32. The articles 32 are preferably heated by using of at least one of dry heat, steam, thermal radiation and hot water.
25 The processing system 20 then preferably uses a HT processing method such as kiln drying for heating the articles 32. Further, the temperature conditioning system 27 is also preferably structurally integrated with the enclosure 22. Alternatively, the temperature conditioning system 27 is formed integral with the barrier 24 or is coupled to the barrier 24 for controlling the temperature within the processing space
30 28.

Alternatively, if the processing system 20 uses cooling for processing the articles 32, the temperature conditioning system 27 then preferably uses refrigeration for cooling the articles 32.

- 5 The temperature conditioning system 27 is preferably controlled through the use of a second controller (not shown) and a second sensor (not shown) coupled to the processing system 20. The second sensor is coupled to the second controller, in which the second controller controls the temperature within the processing space 28. The second sensor is preferably disposed within the processing space 28 for
10 detecting and for providing as data input to the second controller the temperature within the processing space 28. The second sensor can be for example a sensor array which consists of multiple sensors that are deployed in the processing space 28 in order to sense temperature at different parts of the processing space 28 during processing of the articles 32. The data input received from the second sensor then
15 allows the second controller to determine and control the temperature within the processing space 28 based on measured temperature of the processing space 28. Additionally, the second sensor is preferably connected to the computer in order for data collation to be performed.
- 20 The articles 32 to be processed are preferably of appropriate size and shape for disposing in the processing space 28. The articles 32 are, for example, timber, wooden furniture or food products. The processing system 20 further comprises an air mover 34 coupled to the enclosure 22 for circulating ozone discharged into the processing space 28. The air mover 34 is preferably an air blower or a fan.
25 Alternatively, the air mover 34 is formed integral with the ozonator 26.

- When kept in an enclosed space over a period of time during transportation, the articles 32 are exposed to further infestation by insects and other bio-forms. By circulating ozone within the processing space 28 and heating or cooling the articles
30 32 in the processing space 28 over a predetermined duration, insects and other bio-forms are eradicated from the articles 32. Further re-infestation of the articles 32 by insects and other bio-forms is also substantially prevented. In addition, exposing the articles 32 to ozone in the processing space 28 also substantially disinfects the

articles 32 and retards growth of algae and fungus on the articles 32. The articles 32 are preferably placed on pallets 36 when placed in the processing space 28 to enable the articles 32 to be substantially exposed to ozone and when subjected to heating or cooling.

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The processing system 20 also further comprises an air filter 40 for filtering air in the processing space 28 when the air in the processing space 28 is displaced through the air filter 40. Preferably, the air filter 40 also enables insects and other bio-forms that have been repelled from the articles 32 and into the air to be trapped by the air filter

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Preferably, the enclosure 22 further comprises vents (not shown) for facilitating exhaust of air and escape of insects carried in the air out of the processing space 28. The vents are preferably conduit-coupled to an exhaust location or system (not

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shown) for delivery of insects to a predefined location away from the enclosure 22.

The ozonator 26, the temperature conditioning system 27, the air mover 34, the first controller, the second controller and the air filter 40 are preferably electrically or solar powered by a mobile power source, for example, a portable battery array or a generator set (all not shown). This further facilitates transportability of the processing system 20 between locations and facilitates carriage of the processing system 20 by sea, air or land transport vehicles. Alternatively, the ozonator 26, the temperature conditioning system 27, the air mover 34, the first controller, the second controller and the air filter 40 are coupled to a manifold (not shown), for example an electrical socket cluster, coupled to the enclosure 22 which in turn, is coupled to an external electrical power source.

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The processing system 20 is configurable for performing either a first processing method 200, a second processing method 300 or a third processing method 400 for processing the articles 32. With reference to the first processing method 200 as shown in FIG. 2, the articles 32 are placed within the processing space 28 via the opening 30 in a step 202. The opening 30 is then covered using the barrier 24 in a step 204. In a step 206, the ozonator 26 generates and discharges ozone into the

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processing space 28. The ozone in the processing space 28 is maintained at a predetermined level by the first controller. The articles 32 are then left in the processing space 28 for a predetermined duration in a step 208. During the predetermined duration, air within the enclosure 22 is circulated which consequently
5 circulates the ozone therein.

Preferably, the ozone used for processing the articles 32 during the predetermined duration is recycled by recycling the air in the enclosure 22. During recycling of the air in the enclosure 22, moisture present in the air is removed by a moisture-removal
10 system (not shown). The ozone is then re-circulated into the processing space 28 for processing the articles 32. This enables the ozone in the air to be recycled without re-introducing moisture into the processing space 28 for processing the articles 32. Further, recycling the ozone in the air for processing the articles 32 also serves to maintain the concentration of ozone in the processing space 28 at a substantially high
15 level for eradicating any insects in the articles 32. Additionally, the air filter 40 further functions to trap airborne insects that have emerged from the articles 32.

After being exposed to ozone for the pre-determined duration, the articles 32 are subjected to either heating or cooling to further eradicate any remaining insects left
20 in the articles 32. In a step 210, the temperature conditioning system 27 heats or cools the articles 32 in the processing space 28. The temperature in the processing space 28 is maintained at a predetermined level by the second controller. Heating or cooling is performed for a pre-determined duration in order to allow the articles 32 to be substantially processed. The air mover 34 may optionally be used to enable the
25 articles 32 to be more uniformly heated or cooled when heating or cooling is performed. After the predetermined duration, the opening 30 is uncovered and the articles 32 are removed from the processing space 28 in a step 212. Optionally, before the articles 32 are removed from the processing space 28, the ozone in the processing space 28 is broken down into oxygen by an ozone processing system (not
30 shown) before being released into the atmosphere.

Alternatively, as shown in FIG. 3, the processing system 20 performs the second processing method 300 for processing the articles 32. The steps 202 and 204 for the

second processing method 300 are similar to the first processing method 200 of FIG.

2. The difference between the first processing method 200 and the second processing method 300 is that the second processing method 300 first heats or cools the articles 32 before later exposing the articles 32 to ozone. After performing the step 204, the temperature conditioning system 27 heats or cools the articles 32 in the processing space 28 in a step 302. The temperature within the processing space 28 is maintained at a predetermined level by the second controller. Heating or cooling is performed for a pre-determined duration in order to eradicate any insects in the articles 32.

Next then in a step 304, the ozonator 26 generates and discharges ozone into the processing space 28. The ozone in the processing space 28 is maintained at a predetermined level by the first controller. The articles 32 are then left in the processing space 28 for a predetermined duration in a step 306. During the predetermined duration, air within the enclosure 22 is circulated which consequently circulates the ozone therein. Preferably, the ozone used for processing the articles 32 during the predetermined duration is recycled by recycling the air in the enclosure 22. During recycling of the air in the enclosure 22, moisture present in the air is removed by the moisture-removal system. The ozone is then re-circulated into the processing space 28 for processing the articles 32. This enables the ozone in the air to be recycled without re-introducing moisture into the processing space 28 for processing the articles 32. Further, recycling the ozone in the air for processing the articles 32 also serves to maintain the concentration of ozone in the processing space 28 at a substantially high level for eradicating any insects in the articles 32. After the predetermined duration, the opening 30 is uncovered and the articles 32 are removed from the processing space 28 in the step 212. Optionally, before the articles 32 are removed from the processing space 28, the ozone in the processing space 28 is broken down into oxygen by the ozone processing system before being released into the atmosphere.

Further alternatively, the processing system 20 performs the third processing method 400 for processing the articles 32. The steps 202 and 204 are similar as in the first processing method 200 of FIG. 2 and the second processing method 300 of FIG. 3.

In the third processing method 400, the articles 32 are first subjected to heating or cooling within the processing space 28 in a step 402. When the articles 32 are undergoing heating or cooling, ozone is then generated by the ozonator 26 for exposing the articles 32 to the ozone in the step 402. Then in a step 404, the ozone is further circulated around the processing space 28 for a predetermined duration when heating or cooling of the articles 32 is being performed. The combination of using ozone, heating or cooling simultaneously enables any insects in the articles 32 to be eradicated.

Preferably, the ozone used for processing the articles 32 during the predetermined duration is recycled by recycling the air in the enclosure 22. During recycling of the air in the enclosure 22, moisture present in the air is removed by the moisture-removal system. The ozone is then re-circulated into the processing space 28 for processing the articles 32. This enables the ozone in the air to be recycled without re-introducing moisture into the processing space 28 for processing the articles 32. Further, recycling the ozone in the air for processing the articles 32 also serves to maintain the concentration of ozone in the processing space 28 at a substantially high level for eradicating any insects in the articles 32. After the predetermined duration, the opening 30 is uncovered and the articles 32 are removed from the processing space 28 in the step 212. Optionally, before the articles 32 are removed from the processing space 28, the ozone in the processing space 28 is broken down into oxygen by the ozone processing system before being released into the atmosphere.

The enclosure 22 enables the steps of one of the first processing method 200, the second processing method 300 and the third processing method 400 to be performed even during transportation of the enclosure 22 by a vehicle between locations.

In the foregoing manner, a system and a method is described according to one embodiment of the invention for addressing the foregoing disadvantages of conventional fumigation methods. Although only one embodiment of the invention is disclosed, it will be apparent to one skilled in the art in view of this disclosure that numerous changes and/or modification can be made without departing from the scope and spirit of the invention.

Claims

1. A processing system comprising:
 - an enclosure for defining a processing space and an opening to the processing space, the enclosure for disposing at least one article in the processing space through the opening;
 - a temperature conditioning system for conditioning temperature within the processing space for one of heating and cooling the at least one article disposed in the processing space; and
 - an ozonator for generating and discharging ozone (O₃) into the processing space for exposing the at least one article disposed in the processing space to ozone,
- whereby substantially exposing the at least one article in the processing space to ozone and one of heating and cooling the at least one article in the processing space over a predetermined duration substantially at least one of repels pest from, eradicate pest from and disinfect the at least one article disposed in the processing space.
2. The processing system as in claim 1, further comprising:
 - an air mover for circulating ozone discharged into the processing space.
3. The processing system as in claim 2, the air mover being formed integral with the ozonator.
4. The processing system as in claim 1, the ozonator being integrated with the enclosure.
5. The processing system as in claim 1, the ozonator being coupled to the enclosure.
6. The processing system as in claim 1, further comprising:

a controller for controlling the amount of ozone at least one of generated by the ozonator and discharged into the processing space by the ozonator.

- 5 7. The processing system as in claim 6, further comprising:
 a sensor for detecting and for providing as data input to the controller
 the level of ozone in the processing space, the controller controlling the
 amount of ozone discharged into the processing space based on the data input.
- 10 8. The processing system as in claim 1, the enclosure being a container.
9. The processing system as in claim 8, further comprising:
 a barrier for substantially impeding escape of ozone discharged.
- 15 10. The processing system as in claim 9, the barrier being one of at least one door
 coupled to the container and a panel being couplable to the opening of the
 container.
11. The processing system as in claim 8, the container being shaped for transport
 20 by a vehicle.
12. The processing system as in claim 1, the enclosure being a tent, the tent
 comprising a plurality of panels for defining the processing space, at least one
 of the plurality of panels being the barrier.
- 25 13. The processing system as in claim 1, wherein ozone is generated by the
 ozonator by at least one of corona discharge, ultraviolet irradiation, plasma
 generation and electrolysis.
- 30 14. The processing system as in claim 1, the at least one article being at least one
 of furniture, timber and food items.

15. The processing system as in claim 1, the temperature conditioning system being integrated with the enclosure.
16. The processing system as in claim 1, the temperature conditioning system being coupled to the enclosure.
17. The processing system as in claim 1, wherein the temperature conditioning system uses kiln drying for heating the at least one article.
18. The processing system as in claim 1, wherein the at least one article is heated using at least one of steam, hot water, thermal radiation and dry heat.
19. The processing system as in claim 1, wherein the temperature conditioning system uses refrigeration for cooling the at least one article.
20. The processing system as in claim 1, further comprising:
a controller for controlling the temperature within the processing space.
21. The processing system as in claim 20, further comprising:
a sensor for detecting and for providing as data input to the controller the temperature within the processing space, the controller controlling the temperature within the processing space based on the data input.
22. A processing method comprising:
providing an enclosure for defining a processing space and an opening to the processing space, the enclosure for disposing at least one article in the processing space through the opening;
providing a temperature conditioning system for conditioning temperature within the processing space for one of heating and cooling the at least one article disposed in the processing space; and

providing an ozonator for generating and discharging ozone (O₃) into the processing space for exposing the at least one article disposed in the processing space to ozone,

whereby substantially exposing the at least one article in the processing space to ozone and one of heating and cooling the at least one article in the processing space over a predetermined duration substantially at least one of repels pest from, eradicate pest from and disinfect the at least one article disposed in the processing space.

23. The processing method as in claim 22, further comprising:
circulating ozone discharged into the processing space by an air mover.
24. The processing method as in claim 23, the air mover being formed integral with the ozonator.
25. The processing method as in claim 22, the ozonator being integrated with the enclosure.
26. The processing method as in claim 22, the ozonator being coupled to the enclosure.
27. The processing method as in claim 22, further comprising:
controlling the amount of ozone by a controller at least one of generated by the ozonator and discharged into the processing space by the ozonator.
28. The processing method as in claim 27, further comprising:
detecting and providing as data input by a sensor to the controller the level of ozone in the processing space, the controller controlling the amount of ozone discharged into the processing space based on the data input.
29. The processing method as in claim 22, the enclosure being a container.

30. The processing method as in claim 29, further comprising:
providing a barrier for substantially impeding escape of ozone discharged.
- 5 31. The processing method as in claim 30, the barrier being one of at least one door coupled to the container and a panel being couplable to the opening of the container.
32. The processing method as in claim 29, the container being shaped for
10 transport by a vehicle.
33. The processing method as in claim 22, the enclosure being a tent, the tent comprising a plurality of panels for defining the processing space, at least one of the plurality of panels being the barrier.
- 15 34. The processing method as in claim 22, wherein ozone is generated by the ozonator by at least one of corona discharge, ultraviolet irradiation, plasma generation and electrolysis.
- 20 35. The processing method as in claim 22, the at least one article being at least one of furniture, timber and food items.
36. The processing method as in claim 22, integrating the temperature conditioning system with the enclosure.
- 25 37. The processing method as in claim 22, coupling the temperature conditioning system to the enclosure.
38. The processing method as in claim 22, wherein heating the at least one article
30 using kiln drying.
39. The processing method as in claim 22, wherein heating the at least one article using at least one of steam, hot water, thermal radiation and dry heat.

40. The processing method as in claim 22, wherein cooling the at least one article using refrigeration.
41. The processing method as in claim 22, further comprising:
5 controlling the temperature within the processing space by a controller.
42. The processing method as in claim 41, further comprising:
10 detecting and providing as data input by a sensor to the controller the temperature within the processing space, the controller controlling the temperature within the processing space based on the data input.