United States Patent Application Publication	20250264228
Kind Code	A1
Publication Date	August 21, 2025
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AIR FLOW CONTROL TECHNOLOGY FOR OVENS

Abstract

A system and apparatus for controlling airflow in large industrial forced-convection ovens that are used for cooking, smoking, drying, and processing meat and food products. The system and apparatus reduce temperature, color, and yield variation within the ovens, and also reduce cooking times and power requirements. The system and apparatus use variable-width supply-air slots and dual, side-mounted return ducts to precisely control the airflow within the oven so that the air can be directed to the slowest cooking areas in the oven.

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Family ID: **1000008576599**

Appl. No.: **19/198593**

Filed: **May 05, 2025**

Related U.S. Application Data

parent US continuation 17357846 20210624 parent-grant-document US 12292201 child US 19198593
us-provisional-application US 63043553 20200624

Publication Classification

Int. Cl.: **F24C15/32** (20060101); **A21B1/24** (20060101); **F27D7/02** (20060101); **F27D7/04** (20060101); **G05D7/06** (20060101)

U.S. Cl.:

CPC **F24C15/322** (20130101); **F27D7/04** (20130101); **G05D7/0682** (20130101); A21B1/24 (20130101); F27D2007/026 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. nonprovisional patent application Ser. No. 17/357,846, filed 24 Jun. 2021, now U.S. Pat. No. 12,292,201, entitled “Air Flow Control Technology For Ovens,” which claimed the benefit of U.S. provisional patent application Ser. No. 63/043,553, filed 24 Jun. 2020, both of which are incorporated herein by reference in their entireties.

37 C.F.R. § 1.71(e) AUTHORIZATION
[0002] A portion of the disclosure of this patent document contains material, which is subject to copyright protection. The copyright owner has no objection to the facsimile reproduction by anyone of the patent document or the patent disclosure, as it appears in the US Patent and Trademark Office patent file or records, but otherwise reserves all copyright rights whatsoever.
STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT
[0003] Not applicable.
REFERENCE TO A MICROFICHE APPENDIX, IF ANY
[0004] Not applicable.
1. FIELD OF THE INVENTION
[0005] The present invention relates, generally, to air flow control systems, apparatus, and methods. Particularly, the invention relates to air flow control systems in ovens. Most particularly, the invention relates to air flow control systems in large, commercial ovens used to cook, smoke, dry, and otherwise process meats and meat products.
2. BACKGROUND INFORMATION
[0006] Existing technology in this field is believed to have significant limitations and shortcomings. For this and other reasons, a need exists for the present invention.
[0007] Industrial ovens have been used in the meat industry to cook, smoke, dry, or otherwise process meats. Conventional ovens, or smokehouses, typically have two supply-air ducts located on opposing sides of an oven cabinet, usually in the upper corners thereof. These supply-air ducts have either fixed-width supply slots or fixed-diameter orifice cones. A single recirculation fan forces air through the air supply slots or cones into a processing chamber of the cabinet. The two opposing air streams from the side mounted supply ducts meet at a turbulent-air interface known in the trade as the “breakpoint.” The conventional designs use either a diverter vane or a linked tandem rotating-damper vane assembly to continuously vary the air velocities from the opposing supply ducts, causing the breakpoint to sweep or oscillate from side-to-side in the processing chamber like a pendulum. These oscillating airflow systems are generally single-speed systems that continuously sweep the air from side-to-side without varying the speed. Some oscillating airflow systems, however, include what is known in the trade as “pause timers,” which stop or “pause” the breakpoint in two or more locations in the oven.
[0008] A primary purpose of sweeping process air from side-to-side in the oven is to minimize color and temperature variation inherent when large loads of meat products are cooked in the ovens. Oscillating airflow systems have many designs and names in the trade, including rotating dampers, wig-wag dampers, boat-rudder dampers, and the like. However, all of the oscillating airflow systems serve the same function, to sweep the hot air back-and-forth in the oven during cooking.
[0009] Referring to FIGS. **1** A-C and **2** A-C, one common design uses dual-vane rotary diverter dampers that divert the air from one supply duct to the other. Another design is a rotating damper

system that uses two shaft/damper assemblies located in the opposing supply ducts that are connected using a chain drive assembly (FIG. **1**) or shaft linkage assembly (FIG. **2**). A motor drive rotates the damper blades during cooking, thus diverting the air from one supply duct to the other and sweeping the air from side-to-side in the oven.

[0010] Another design uses twin-fans, shown for example in FIGS. **3** A-C. Each fan supplies air to one supply duct. Two independent electric motors are connected to electronic variable speed drives that are used to drive the two independent centrifugal fans. The variable speed drives are used to vary the fan speeds, thus sweeping the breakpoint from side to side in the oven. For example, if both fans are set to run at 100%, the two opposing airstreams will meet at the breakpoint at the bottom dead-center of the oven. However, if one fan is set at 100% while the other is set at 45%, these settings will direct the air to the upper-corner of the oven. If one fan is set at 100% and the other set to 55 or 65%, these settings will direct the air to the middle-side, or if the fan is set to 75 or 85%, the air will be directed to the bottom corner.

[0011] Regardless of the variation in design, all conventional ovens have one similar shortcoming, namely that a single Return Duct disposed in the center of the oven ceiling creates a “Cold Zone” at the upper-center of the product load. Referring to FIGS. **4** and **5**, the centrally-located return duct sucks the air through the product to the top-center of the oven, which creates airflow patterns that produce one or more Cold Zones, and sometimes one or more corresponding “Hot Zones.” Regardless of what air-handling system is used to sweep the air from side-to-side int eh oven, the hot air from the supply ducts still cools as it flows through the product from the supply ducts to the central return duct. This leaves the product at the top-center of the oven continuously exposed to the coldest air in the oven. Oven designs that use conventional damper systems (FIGS. **1** and **2**) have an additional disadvantage in that the dampers in the air stream block the airflow, resulting in a build-up of static pressure that wastes motor power.

[0012] All US patents and patent applications, and all other published documents mentioned anywhere in this application are incorporated by reference in their entirety.

BRIEF SUMMARY OF THE INVENTION

[0013] The invention provides an air moving system, apparatus, and method, which are practical, reliable, and efficient, and which are believed to fulfill a need and to constitute an improvement over the background technology. The invention also provides an oven that control airflow patterns, including variable-width supply slots to control air velocity and airflow volume through a forced-air industrial batch and continuous ovens. The invention further provides an oven including independent or linked control of the variable supply slot position and width of supply gap. The invention still further provides an oven including independent or linked control of supply slot rate of change position, and resulting change in width of variable-width supply slots. The invention yet also provides an oven including dual, side-mounted return ducts equipped with return-air dampers to control the airflow through the cold zones to speed cooking and reduce temperature and color variation. And the invention provides an oven including dual, side-mounted return ducts equipped with dual, independent main fans and variable speed drives, with or without dampers, to control the airflow through the cold zones to speed cooking and reduce temperature and color variation.

[0014] In one aspect, the invention provides an oven apparatus, including: [0015] a processing chamber adapted to contain food product to be processed; [0016] at least one fan disposed above the processing chamber; [0017] at least two air supply slots, separated a predetermined distance from each other, for transmitting air generated by the at least one fan to the processing chamber, each air supply slot having a predetermined air flow area; [0018] a blade disposed proximate each air supply slot for controlling the size of the air flow area; and [0019] at least one air return slot for returning air from the processing chamber to the fan.

[0020] In another aspect, the invention provides an oven apparatus, including: [0021] a processing chamber adapted to contain food product to be processed; [0022] at least one fan disposed above the processing chamber; [0023] two air supply slots, separated a predetermined distance from each

other, for transmitting air generated by the at least one fan to the processing chamber, each air supply slot having a predetermined supply air flow area; [0024] a supply damper disposed proximate each air supply slot for controlling the size of the supply air flow area of the air supply slot; [0025] at least two air return slots for returning air from the processing chamber to the fan, the at least two air return slots being disposed between the two air supply slots, each air return damper having a predetermined return air flow area; and [0026] a return damper disposed proximate each air return slot for controlling the size of the return air flow area of the respective air return slot.
[0027] And in yet another aspect, the invention provides an oven apparatus, including: [0028] a processing chamber adapted to contain food product to be processed; [0029] at least two fans disposed above the processing chamber, each fan being independently controllable; [0030] an air supply slot disposed generally below each fan for transmitting air generated by the fan to the processing chamber, each air supply slot having a fixed predetermined supply air flow area; and [0031] an air return slot disposed generally below each for returning air from the processing chamber to the fan, each air return slot being disposed between the two air supply slots, each air return damper having a predetermined return air flow area.
[0032] The aspects, features, advantages, benefits, and objects of the invention will become clear to those skilled in the art by reference to the following description, claims, and drawings.

Description

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING
[0033] FIGS. **1**A-C are diagrams showing a conventional chain-driven rotating-damper assembly that uses two perpendicular damper blades operating in tandem to sweep the air from a single fan in a side-to-side pattern in an oven.
[0034] FIGS. **2** A-C are diagrams showing a conventional shaft-driven rotating-damper that uses two perpendicular damper blades operating in tandem to sweep the air from the single fan in a side-to-side manner in the oven.
[0035] FIGS. **3**A-C are diagrams showing a conventional twin-fan airflow design that varies the speeds of the two fans to sweep the air from side to side using variable fan speeds instead of dampers.
[0036] FIG. **4** is a diagram showing temperature patterns showing locations of one or more “Cold Zones” that are typical when using the conventional air-handling systems with a single return duct that is center-mounted on the ceiling of an oven, as shown in FIGS. **1**-**3**.
[0037] FIGS. **5** A-C are side, bottom perspective, and top perspective views, respectively, of a first, basic embodiment of a variable-width supply duct and system of the present invention, with a single fan.
[0038] FIGS. **6** A-C are diagrammatic views of airflow patterns created using the variable-width supply duct arrangement of FIGS. **5** A-C.
[0039] FIG. **7** is a diagram of a second embodiment of the system of the invention, including dual, side-mounted return ducts with damper-controlled airflow, again with a single fan.
[0040] FIGS. **8** A-C are diagrammatic views of airflow patterns created using the dual, side-mounted return ducts design of FIG. **7**.
[0041] FIG. **9** is a diagram of a third embodiment of the system, including dual main fans mounted on dual, side-mounted return ducts.
[0042] FIGS. **10** A-C are diagrammatic views of airflow patterns created using the dual fans equipped with variable speed drives and dual, side-mounted return ducts.
[0043] FIG. **11** is a diagram of a fourth embodiment of the system of the invention, including dual main fans mounted on dual, side-mounted return ducts, and also including independently operable dampers on the side-mounted return ducts.

[0044] FIGS. **12** A-C are diagrammatic views of airflow patterns created using the dual fans equipped with variable speed drives and the independently dampered dual return ducts.
[0045] FIG. **13** is a first perspective view of an oven constructed and arranged with the aspects of the design of FIGS. **7** and **8**.
[0046] FIG. **14** is a first end view of the oven of FIG. **13**.
[0047] FIG. **15** shows the interior of the oven, including movable racks for holding product to be processed by the oven.
[0048] FIG. **16** is a top view of the oven.
[0049] FIG. **17** is a second perspective view of the oven.
[0050] FIG. **18** is an elevation view of the oven.
[0051] FIG. **19** is a second end view of the oven.
[0052] FIG. **20** is a detailed view of the interior of the oven shown in FIG. **15**.
[0053] FIGS. **21** A-C are a diagrammatic view of a fifth embodiment of the system of the invention, including dual air supply fans and independently dampered dual return ducts coupled to a common return plenum, and airflow patterns generated thereby.

DETAILED DESCRIPTION

1. Introduction

[0054] The present invention provides systems and apparatus for controlling airflow in ovens for processing meat and other food products, particularly in large, industrial, forced air convection ovens used for cooking, smoking, drying, or otherwise processing meats. The system and apparatus reduce temperature, color, and yield variation within the ovens, and also reduce cooking times and power requirements. The system and apparatus of the invention use variable-width supply-air slots technology and dual, side-mounted return duct technology to precisely control the airflow within the oven so that the air can be directed to the slowest cooking areas in the oven.

2. Example Embodiments

[0055] Details and features of the embodiments of the invention, including its parts, their interconnection, and the expected behavior and functions of the invention will be apparent by viewing the drawings in light of the following descriptions. Methods of making and using the embodiments will also be apparent to those skilled in the art from this disclosure.
[0056] FIGS. **1-5** show, again, conventional devices. FIGS. **1** A-C are diagrams showing a conventional chain-driven rotating-damper type oven **10** that uses two perpendicular damper blades **18** A and B located at fixed width openings **17** disposed at opposing top corners of a processing chamber **12**. The damper blades **18** operate in tandem to sweep the air **22** from side to side, through product loads **20** A and B, in the processing chamber **12** of the oven **10** having a single air fan **14**. The dampers **18** are controlled by a chain drive assembly **16**. Air is returned via a single, open, uncontrolled return duct **19** disposed centrally, in the top of the chamber **12**. In FIG. **1**A, damper **18**A is fully open and damper **18**B is fully closed, whereby breakpoint air is shifted to the right side of the chamber **12**. In FIG. **1**B, both dampers **18** are in a half open mode, whereby breakpoint air is centered in the chamber **12**. In FIG. **1**C, damper **18**A is fully closed and damper **18**B is fully open, whereby breakpoint air is shifted to the left side of the chamber **12**.
[0057] FIG. **2** A-C are diagrams showing a conventional shaft-driven rotating-damper type oven **30** that uses two perpendicular damper blades **38** A and B located at fixed width openings **37** disposed at opposing top corners of a processing chamber **32**. The damper blades **38** operate in tandem to sweep the air **32** from side to side, through product loads **40** A and B, in the processing chamber **32** of the oven **30** having a single air fan **34**. The dampers **38** are controlled by a shaft drive assembly **36**. Air is returned via a single return duct **39** disposed centrally in the top of the chamber **32**. In FIG. **2**A, damper **38**A is fully open and damper **38**B is fully closed, whereby breakpoint air is shifted to the right side of the chamber **32**. In FIG. **2**B, both dampers **38** are in a half open mode, whereby breakpoint air is centered in the chamber **32**. In FIG. **2**C, damper **38**A is fully closed and damper **38**B is fully open, whereby breakpoint air is shifted to the left side of the chamber **32**.

[0058] FIGS. **3** A-C are diagrams showing a conventional twin-fan airflow oven **50** that varies the speeds of the two fans **54** A and B to sweep the air from side to side using variable fan speeds instead of dampers. The fans **54** are located above fixed width openings **57** disposed at opposing top corners of a processing chamber **52**. Air is returned via a single, open, uncontrolled return duct **59** disposed centrally, in the top of the chamber **52**. In FIG. **3**A, fan **54**B is fully powered and fan **54**A is reduced power, whereby breakpoint air is shifted to the left side of the chamber **52**. In FIG. **3**B, both fans **54** are fully powered, whereby breakpoint air is centered in the chamber **52**. In FIG. **3**C, fan **54**A is fully powered and fan **54**B is reduced powered, whereby breakpoint air is shifted to the right side of the chamber **52**.
[0059] FIG. **4** is a diagram showing temperature patterns showing locations of one or more “Cold Zones” **60** A and B that are typical due to center air flow **68** when using the conventional air-handling systems with a single return duct **62** that is center-mounted on the ceiling. The cold zones **60** may overlap with the food product **64**, thus resulting in temperature and quality variation. One or more corresponding “Hot Zones” **66** A and B may also develop as a result of such air flow **68**.
[0060] FIGS. **5** A-C are perspective views of a first embodiment of a variable-width supply duct and system **70** of the present invention for use in an industrial oven, smokehouse, or the like. The system **70** is disposed in a processing chamber having opposing side walls **72**A and B and a single, centrally disposed fan (**82** in FIGS. **6**A-C). The system **70** includes a central housing **74** that preferably has a curvilinear upper member **76** and a rectilinear lower member **78**. The lower member has a central return duct **79**. Precision blade assemblies **80** A and B are connected to the housing **74** and extend a predetermined distance toward the side walls **72** A and B, respectively. The blade assemblies **80** are communicatively connected to independent actuators (shown in FIG. **7**), which may be mechanical, electrical, or pneumatic type. The actuators control the width of the supply-air slots, thus controlling the velocity and volume of the incoming air from each supply duct (formed between the terminal end of the blade assembly **80** and the associated wall **72**). The independent actuators vary the width of the supply slots independently to deliver either full velocity or restricted velocity out of each slot. This independent blade **80** control can be used to optimize the air velocities through the oven **70** for a particular product **84** (see FIG. **6**) or process. For example, both slots can be fully opened for maximum airflow and faster drying. Alternatively, one slot can be opened and one partially or fully closed to direct the air to a particular part of the load **84**.
[0061] Adjusting the width of the supply slot will change the air velocity and the air-delivery volume from each slot, allowing for control of the airflow patterns through the product. In contrast to the crude dampers to divert the air in conventional devices, the precision-controlled blades **80** are used on the supply ducts that vary the width of the supply-slot openings to control air volume, thus more precisely controlling the airflow out of each supply slot. These variable-width supply-air slots can be either linked in tandem or controlled independently so that the air velocities within the process chamber **70** are precisely controlled. Independent control of the slot width allows for one slot to remain fully open while the other one modulates closed and open, thus reducing wasteful static pressure build up and increasing the average velocity across the product surfaces. The speed of the independent drives can also be precision controlled, thus allowing the airflow and air velocities within the cabinet **70** to be tailored to individual product loads. For some products, it may be optimal for the airflow to dwell underneath the load, and for others it may be optimal for the airflow to dwell at the lower or upper corners of the load. For still other products or processes, it may be optimal to speed the breakpoint rapidly past some areas and go slowly past others. The precision-controlled independent supply-slot system would be capable of infinite control of these speeds and rates, and so could deliver any combination of airflows that might be found optimal for drying, cooking, or smoking in an oven. The precise control of the supply-air velocities allows the airflow to be diverted to the slower cooking areas in the oven, thus reducing temperature, color, and yield variation within the oven, while accelerating the heating rate and color development of the

slowest-cooking products.
[0062] FIGS. **6** A-C are diagrammatic views of airflow patterns created using the variable-width supply duct design oven **70**. In FIG. **6**A, the right slot formed between the wall **72**B and the blade **80**B is fully closed and the left slot between the wall **72**A and the blade **80**A is fully open. In FIG. **6**B, both slots are equally open. In FIG. **6**C, the left slot is fully closed and the right slot is fully open. Moving through this exemplary sequence of input air slot openings via the precision blades **80** avoids cold zones in product **84** A and B.
[0063] FIG. **7** is a diagrammatic view of a second embodiment of a system **90** of the invention, including dual, side-mounted return ducts with damper-controlled airflow. The system **90** utilizes a single, main recirculation fan **92** in an oven **94** with an interior processing chamber **96**. The oven **90** utilizes conventional fixed-width supply air ducts **98** A and B. Significantly, at least two side-mounted return ducts **100** A and B that are disposed to the sides of a centerline **102** the ceiling **104** of the oven **94** instead of conventional single return duct located in the center **102** of the ceiling **104**. These side-mounted return ducts **100** A/B are equipped with independently operable dampers **106** (connected to actuators **107** A and B) to control the airflow rate, location, and direction through each side of the oven **94**. The oven **94** is shown to have supply air control members **108** A and B connected to independent actuators **109** A and B. Actuators **107** and **109** are communicatively connected to an electronic controller **111**. The system **90** may include a housing **110**.
[0064] FIGS. **8** A-C are diagrams of airflow patterns created using the oven design **90** of FIG. **7**, with dual, side-mounted return ducts **100**. In FIG. **8**A, the right return ducts damper **106**B is fully closed and the left side damper **106**A is fully open. In FIG. **8**B, both return dampers **106** are equally and fully open. In FIG. **8**C, the left return duct damper **106**A is fully closed and the right side damper **106**B is fully open. Moving through this sequence of return air duct openings **100** A/B via dampers **106**, particularly when combined with input air slot **98** openings via controllers **108**, avoids cold and hot zones in product **112** A and B.
[0065] FIGS. **13-20** illustrate a specific embodiment of the system **90** of FIGS. **7** and **8**. The apparatus **190** includes an oven housing **194** enclosing a processing chamber, which is adapted to enclose a plurality of loads of product **212**, for example, on movable carts. A single recirculating fan assembly **192** is disposed at the top of the oven **190** and includes an electric motor, a fan element coupled to the motor, and a housing. Return air ducts **200** are disposed to the sides of the chamber **196**. Dampers **206** are arranged in the air ducts **200**. In the embodiment shown, the oven **190** is ten feet (10 ft) wide, four feet (4 ft) deep, and ten feet (10 ft) tall. However, it is within the purview of the invention that ovens may be built or modified up to fifty feet (50 ft) wide with corresponding increases in height and depth.
[0066] FIG. **9** is a diagrammatic view of a third embodiment of the system **120** of the invention, including dual main fans mounted on dual, side-mounted, damper-less return ducts. The system **120** utilizes at least two recirculation fans **122** A and B in an oven **124** with an interior processing chamber **126**. The oven **124** utilizes conventional fixed-width supply air ducts **128** A and B. Significantly, at least two side-mounted return ducts **130** A and B that are disposed to the sides of a centerline **132** of the ceiling **134** of the oven **124** instead of conventional single return duct located in the center **132** of the ceiling **134**. The system **120** may include a housing **140**. As shown, the dual main fans **122** both run at 100% speed. This system embodiment **120** has conventional fixed-width supply ducts **128**, but has the unique side-mounted return ducts **130**. The two recirculation fans **122** are speed controlled using variable speed drives. The variable speed drives independently control the airflow through the supply slots **128** from each fan **122**. This embodiment of the system has no dampers in the return ducts.
[0067] FIGS. **10** A-C are views of airflow patterns created using the oven design **120** of FIG. **9**, including dual fans **122** equipped with variable speed drives and dual, side-mounted return ducts **130**. In FIG. **10**A, the left fan **122**A is running at 100% speed and right fan **122**B is running at 50%. In FIG. **10**B, both fans **122** A and B are running at full speed. In FIG. **10**C, the left fan **122**A is

running at 50% speed and right fan **122**B is running at 100%. Moving through this sequence of fan **122** speeds, when combined with dual, side-mounted return ducts **130**, avoids cold and hot zones in product **132** A and B.

[0068] FIG. **11** is a diagrammatic view of a fourth embodiment of the system of the invention, including dual main fans and dual, independently dampered, side-mounted return ducts. The system **150** utilizes at least two recirculation fans **152** A and B in an oven **154** with an interior processing chamber **156**. The oven **154** utilizes conventional fixed-width supply air ducts **158** A and B. Significantly, this system embodiment **150** also has at least two side-mounted return ducts **160** A and B that are disposed to the sides of a centerline **162** of the oven **154**. Of still further significance, the side-mounted return ducts **160** have dampers **161** A and B to further control the flow of process air through the process chamber **156**. In this Figure, the dual main fans **152** both run at 100% speed. The two recirculation fans **152** are speed controlled using variable speed drives. The variable speed drives independently control the airflow through the supply slots **158** from each fan **152**, and the dampers **161** in the side-mounted return ducts **160** control the direction of the air through the process chamber **156**.

[0069] The return-air dampers **161** can be independently controlled or linked together using a chain, shaft, or other linkage. The position of the return-air alternating dampers **161** can be synchronized by using direct mechanical linkage or by independently controlling the position of actuators. Synchronization can be accomplished with a simple chain-and-sprocket arrangement or with linkage arms or shafts, or electronically controlled. The damper **161** position, open/close speed, rotation speed, and rate of change can all be controlled using variable speed drives, actuators, or controllers. The damper **161** position, open/close speed, rotation speed, and rate of change can all be controlled using precision positioning devices such as servo motors, linear-controlled actuators, or rotational actuators.

[0070] FIGS. **12** A-C are views of airflow patterns created using the oven design **150** of FIG. **11**, including the dual fans **152** equipped with variable speed drives and dual, off center, return ducts **160** including independently operated return dampers **161**. In FIG. **12**A, the right return-duct damper **161**B is fully closed and left side damper **161**A is fully open. The left fan **152**A is running at 100% speed and right fan **152**B is running at 50%, causing the airflow to shift to the right side of the oven. In FIG. **12**B, both return dampers **161** A and B are fully open and both fans **152** A and B are running at full speed. In FIG. **12**C, the left side return-duct damper **131**A is fully closed and right side damper **131**B is fully open. The left fan **152**A is running at 50% speed and right fan **152**B is running at 100%, causing the airflow to shift to the left side of the oven. Moving through this sequence of fan **152** speeds, when combined with dual, damper **151** controlled, side return ducts **150**, avoids cold zones in product **162** A and B.

[0071] FIGS. **21** A-C are diagrammatic views of a fifth embodiment of the system of the invention, including dual air supply fans and dual, independently dampered, return ducts coupled to a common return plenum. The system **250** utilizes at least two recirculation fans **252** A and B in an oven **254** with an interior processing chamber **256**. The oven **254** utilizes conventional fixed-width supply air ducts **258** A and B. This embodiment **250** also has two return ducts **260** A and B communicatively connected to a common return plenum **259**. The return ducts **160** have dampers **261** A and B to further control the flow of process air through the process chamber **256**. The two recirculation fans **252** are speed controlled using variable speed drives. The variable speed drives independently control the airflow through the supply slots **258** from each fan **252**, and the dampers **261** in the return ducts **260** control the direction of the air through the process chamber **256**.

[0072] In FIG. **21**A, both fans **252** are running at full speed and the return dampers **261** are both fully open. In FIG. **21**B, the left fan **252**A is running at 100%, while the right fan **252**B is running at 50%. The left return damper **261**A is fully open and the right return damper **261**B is fully closed. In FIG. **21**C, the left fan **252**A is running at 50% while the right fan **252**B is running at 100%. The left return damper **261**A is fully closed, while the right return damper **261**B is fully open Moving

through this sequence of fan **252** speeds, when combined with dual, damper **261** controlled, return ducts **260**, avoids cold and hot zones in product **262** A and B.
[0073] Although the invention has been shown and described in the context of newly constructed ovens, it is within the purview of the invention that the systems of the invention may be applied and retrofitted to existing ovens.
[0074] The embodiments above are chosen, described, and illustrated so that persons skilled in the art will be able to understand the invention and the manner and process of making and using it. The descriptions and the accompanying drawings should be interpreted in the illustrative and not the exhaustive or limited sense. The invention is not intended to be limited to the exact forms disclosed. While the application attempts to disclose all of the embodiments of the invention that are reasonably foreseeable, there may be unforeseeable insubstantial modifications that remain as equivalents. It should be understood by persons skilled in the art that there may be other embodiments than those disclosed which fall within the scope of the invention as defined by the claims. Where a claim, if any, is expressed as a means or step for performing a specified function it is intended that such claim be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof, including both structural equivalents and equivalent structures, material-based equivalents and equivalent materials, and act-based equivalents and equivalent acts.

Claims

1. A system, comprising: a processing chamber adapted to receive food products; a first air supply port configured to directly deliver a first forced airflow in a first direction to the processing chamber; a second air supply port configured to directly deliver a second forced airflow at least substantially in the first direction to the processing chamber; at least one fan configured to supply the first airflow and the second airflow; a first air return port configured to selectively receive a third airflow from the processing chamber in a second direction; a second air return port configured to selectively receive a fourth airflow from the processing chamber at least substantially in the second direction; the first air return port being disposed closer to the first air supply port than to the second air supply port and closer to the first air supply port than to the second air return port; the second air return port being disposed closer to the second air supply port than to the first air supply port and closer to the second air supply port than to the first air return port; a first return damper configured to selectively prevent or allow the third airflow from the first return port to a first return duct, between and including a first predetermined minimum airflow and a first predetermined maximum airflow; and a second return damper configured to selectively prevent or allow the fourth airflow from the second return port to a second return duct, between and including a second predetermined minimum airflow and a second predetermined maximum airflow.
2. The system of claim 1, further comprising at least one actuator operative coupled to the return dampers.
3. The system of claim 2, wherein the at least one actuator comprises a first actuator operative coupled to the first return damper and a second actuator coupled to the second return damper, the first and second actuators being operable independently of each other.
4. The system of claim 3, further comprising an electronic controller, the electronic controller being communicatively connected to each actuator.
5. The system of claim 1, wherein the third airflow is greater than the fourth airflow.
6. The system of claim 5, the processing chamber comprising a ceiling and two opposing walls, wherein the first air supply port is positioned to direct the first airflow between one of the vertical walls and the first air return port, wherein the second air supply port is positioned to direct the second airflow between the other of the vertical walls and the second air return port, wherein the processing chamber extends along a central longitudinal axis disposed at least generally parallel to

the two opposing vertical walls, the first air return port being disposed closer to the first air supply port than the longitudinal axis and the second air return port being disposed closer to the second air supply port than to the longitudinal axis.

7. The system of claim 6, wherein at least one of the air return ports is disposed in the ceiling.

8. The system of claim 7, wherein the first direction and second direction are substantially opposite.

9. The system of claim 1, the system comprising a first fan configured to supply the first airflow and a second fan configured to supply the second airflow.

10. A method comprising the steps of: placing a food product in a processing chamber; after the placing step, providing a first airflow to the processing chamber through a first air supply port; after the placing step, providing a second airflow to the processing chamber through a second air supply port simultaneously with the first airflow; during at least a portion of a time period during which the first airflow and the second airflows are provided to the processing chamber, selectively at least partially closing at least one of a first air return port and a second air return port which are configured to receive respective third and fourth airflows from the processing chamber, the third and fourth airflows comprising a mixture of the first and second airflows.

11. The method of claim 10, wherein the selective at least partially closing step reduces formation of cold and hot zones in food product disposed within the processing chamber.

12. The system of claim 10, the processing chamber having a vertical height, wherein the selective at least partially closing step causes at least one of the steps selected from the group consisting of: dwelling airflow in the processing chamber around a first portion of the food product located in a lower portion of the process chamber height, dwelling airflow in the processing chamber around a second portion of the food product located in an upper portion of the process chamber height, moving an airflow breakpoint within the processing chamber, and increasing average velocity of air flow across an outer surface of the food product.

13. The method of claim 10, the processing chamber comprising a ceiling and two opposing walls, wherein the first air supply port is positioned to direct the first airflow between one of the vertical walls and the first air return port, wherein the second air supply port is positioned to direct the second airflow between the other of the vertical walls and the second air return port, wherein the processing chamber extends along a central longitudinal axis disposed at least generally parallel to the two opposing vertical walls, the first air return port being disposed closer to the first air supply port than the longitudinal axis and the second air return port being disposed closer to the second air supply port than to the longitudinal axis.

14. The method of claim 10, wherein the first airflow and the second airflow are provided by a single fan.

15. The method of claim 10, wherein the first airflow is provided by a first fan and the second airflow is provided by a second fan.