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Air filter with deployment mechanism and control for HVAC applications

Abstract

A heating, ventilation, and air conditioning (HVAC) system includes an air handling unit, a supply airflow damper to direct a supply airflow from the air handling unit to a conditioned space, and one or more filters selectively deployable across a flowpath of the air handling unit to remove one or more contaminants from the supply airflow prior to the supply airflow passing through the supply airflow damper. A control system is operably connected to the one or more filters to direct movement of the one or more filters between a deployed position and a stowed position.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) This application is a National Stage application of PCT/US2019/046297, filed Aug. 13, 2019, which claims the benefit of Provisional Application No. 62/720,627 filed Aug. 21, 2018, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND
(1) Exemplary embodiments pertain to the art of heating, ventilation and air conditioning (HVAC) systems. In particular, the present disclosure relates to assessment and control of indoor air quality (IAQ) in a conditioned space.
(2) Maintaining indoor air quality (IAQ) in spaces served by HVAC systems is a major concern, with maximum levels of contaminants such as particulates, CO.sub.2, and volatile organic compounds (VOCs). Such contaminant levels are typically managed by filters located across a flowpath of the HVAC system to remove the contaminants from the airflow. The filters, which may include particulate filters, VOC filters and CO.sub.2 scrubbers, fixed in an air handling unit of the HVAC system.
BRIEF DESCRIPTION
(3) In one embodiment, a heating, ventilation, and air conditioning (HVAC) system includes an air handling unit, a supply airflow damper to direct a supply airflow from the air handling unit to a conditioned space, and one or more filters selectively deployable across a flowpath of the air handling unit to remove one or more contaminants from the supply airflow prior to the supply airflow passing through the supply airflow damper. A control system is operably connected to the one or more filters to direct movement of the one or more filters between a deployed position and a stowed position.
(4) Additionally or alternatively, in this or other embodiments the one or more filters include a particulate filter, a volatile organic compound filter, or a CO.sub.2 scrubber.

(5) Additionally or alternatively, in this or other embodiments a plurality of sensors are located at the air handling unit and operably connected to the control system, the control system directing movement of the one or more filters based on conditions sensed by the plurality of sensors.
(6) Additionally or alternatively, in this or other embodiments a return airflow damper directs a return airflow from the conditioned space into the air handling unit, wherein the plurality of sensors includes a plurality of return airflow sensors located at the return airflow damper.
(7) Additionally or alternatively, in this or other embodiments the plurality of return airflow sensors include one or more of a return particulate matter sensor, a return volatile organic compound sensor, and a return CO.sub.2 sensor.
(8) Additionally or alternatively, in this or other embodiments the control system signals for deployment of one or more filters when a condition sensed by a return airflow sensor of the plurality of return airflow sensors exceeds a selected threshold.
(9) Additionally or alternatively, in this or other embodiments the return airflow damper is moved between an opened position and a closed position in response to a return airflow condition detected by the plurality of return airflow sensors.
(10) Additionally or alternatively, in this or other embodiments an outdoor airflow damper is located at the air handling unit configured to selectably admit an outside airflow into the air handling unit, wherein the plurality of sensors includes a plurality of outside airflow sensors located at the outdoor airflow damper.
(11) Additionally or alternatively, in this or other embodiments the plurality of outdoor airflow sensors includes an outdoor airflow particulate matter sensor.
(12) Additionally or alternatively, in this or other embodiments the control system signals for deployment of one or more filters when a condition sensed by an outside airflow sensor of the plurality of outside airflow sensors exceeds a selected threshold.
(13) Additionally or alternatively, in this or other embodiments the outdoor airflow damper is moved between a minimum opened position and a maximum opened position in response to an outdoor airflow condition detected by the plurality of outside airflow sensors.
(14) Additionally or alternatively, in this or other embodiments the one or more filters are configured to rotate about a pivot to move between a deployed position and a stowed position.
(15) Additionally or alternatively, in this or other embodiments one or more of a heating coil and a cooling cool is located in the air handling unit to condition the supply airflow.
(16) Additionally or alternatively, in this or other embodiments one or more fans are located in the air handling unit to direct airflow through the air handling unit.
(17) In another embodiment, a method of operating a heating, ventilation and air conditioning (HVAC) system includes sensing one or more contaminant levels in an airflow of the HVAC system via one or more sensors located at the HVAC system, comparing the one or more contaminant levels to one or more threshold values, and selectively deploying one or more filters across an airflow of the HVAC system if the one or more contaminant levels exceed the one or more threshold values.
(18) Additionally or alternatively, in this or other embodiments the one or more sensors includes one or more of a particulate matter sensor, a volatile organic compound sensor and a CO.sub.2 sensor.
(19) Additionally or alternatively, in this or other embodiments the one or more filters are one of more of a particulate matter filter, a volatile organic compound filter and a CO.sub.2 scrubber.
(20) Additionally or alternatively, in this or other embodiments selectably deploying the one or more filters comprises rotating the one or more filters about a filter pivot between a deployed position and a stowed position.
(21) Additionally or alternatively, in this or other embodiments selectably opening and or closing one or more dampers of the HVAC system is based on a result of the comparison.

(22) Additionally or alternatively, in this or other embodiments the one or more dampers include one or more of a return air damper, an outside air damper and an exhaust air damper.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:
(2) FIG. **1** is a schematic illustration of an embodiment of a heating, ventilation, and air conditioning system;
(3) FIG. **2** is a schematic illustration of an embodiment of a filter deployment mechanism;
(4) FIG. **3** is a schematic illustration of an embodiment of a filter deployment mechanism;
(5) FIG. **4** illustrates a method of operation of an HVAC system; and
(6) FIG. **5** illustrates another method of operation of an HVAC system.
DETAILED DESCRIPTION
(7) A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the figures.
(8) The use of filters in an HVAC system increases air flow resistance. The increased air flow resistance correspondingly increases energy consumption by, for example, fans urging the airflow through the HVAC system to overcome the increased air flow resistance and provide the required airflow to condition the space to a set point temperature.
(9) FIG. **1** is a schematic illustration of an embodiment of a heating, ventilation, and air conditioning (HVAC) system **10**. The HVAC system **10** is provided to circulate a supply airflow **12** into a conditioned space **14** to maintain the conditioned space **14** at a selected set point temperature. The HVAC system **10** utilizes one or more of a return airflow **16** returned to the HVAC system **10** from the conditioned space **14** and an outside airflow **18** introduced into the HVAC system **10** from outside of the conditioned space **14**. Outside airflow **18** is also referred to as fresh airflow.
(10) The HVAC system **10** includes an air handler **20**, which generally defines an air flowpath **22** through the air handler **20**. A cooling coil **24** and a heating coil **26** are disposed in the air handler **20**, extending across the air flowpath **22**. The cooling coil **24** is connected to a cooling valve **28**, which when opened circulates a cooling flow, for example, a refrigerant or chilled water, through the cooling coil **24**. Similarly, the heating coil **26** is connected to a heating valve **30** which when opened circulates a heating fluid, such as a heated liquid or air, through the heating coil **26**. In operation, the heating valve **30** or the cooling valve **28** is opened to heat or cool the airflow flowing through the air handler **20**, depending on whether heating or cooling of the supply airflow **12** is needed to achieve the set point temperature at the conditioned space **14**.
(11) To urge flow through the air handler **20**, a supply airflow fan **32** and a return airflow fan **34** are located in the air handler **20**. In some embodiments, the supply airflow fan **32** is located near a supply air damper **36**, through which the supply airflow **12** exits the air handler **20** toward the conditioned space **14**. In some embodiments, the supply airflow fan **32** is located downstream of the cooling coil **24** and the heating coil **26**. The return airflow fan **34** is located at an opposite end of the air handler **20** from the supply airflow fan **32**, and in some embodiments is located at a return air damper **38** through which the return airflow **16** is directed from the conditioned space **14** into the air handler **20**. The air handler **20** further includes an outside airflow damper **40** through which the outside airflow **18** is admitted into the air handler **20**. In some embodiments, the supply airflow damper **36**, the return airflow damper **38** and the outside airflow damper **40** are variable, such that the airflow through the dampers **36**, **38**, **40** may be regulated by opening or closing the dampers **36**, **38**, **40**.

(12) The air handler **20** further includes one or more filters to remove contaminants from the airflow in the air handler **20**. The filters are located, for example between the outside airflow damper **40** and the cooling coil **24** and the heating coil **26**, such that contaminants are removed from the airflow prior to heating or cooling the airflow. The filters may include a particulate filter **42**, a VOC filter **44**, and a CO.sub.2 scrubber **46**.
(13) The filters are movable into and out of the air flowpath **22** of the air handler **20**. The movement of the filters will be described below in the context of a particulate filter **42**, but one skilled in the art will readily appreciate that such deployment mechanisms may be similarly utilized with a VOC filter **44** and a CO.sub.2 scrubber **46**. Referring to FIG. **2**, a filter deployment mechanism **48** is utilized to move the particulate filter **42** into and/or out of the air flowpath **22**. The particulate filter **42** is connected to an actuator **50** via a pivot **52**. When the actuator **50** is activated, the actuator **50** rotates the particulate filter **42** about the pivot **42** between a deployed position where the filter **42** is substantially perpendicular to the direction of airflow through the air flowpath **22**, and a stowed position where the filter **42** is substantially parallel to the direction of airflow through the air flowpath **22**. In the embodiment of FIG. **2**, the pivot **52** is located at one end of the filter **42**, while in other embodiments the pivot may be at other location of the filter **42**, such as a center of the filter **42**.
(14) In an embodiment, shown in FIG. **3**, the actuator **50** is connected to the filter **42** via a linkage **54**. When the actuator **50** is activated, the filter **42** is moved laterally between the deployed position substantially across the air flowpath **22** and a stowed position substantially outside of the air flowpath **22**. In an embodiment, the filter is moved from a deployed position substantially across the air flowpath **22** and a stowed position substantially outside of the air flowpath **22** by rotation about a hinge wherein the filter **42** is disposed substantially flat against a duct wall in the stowed position. In any embodiment the actuator **50** can be connected to the filter **42** directly, or to a linkage member, for transferring and/or translating motion imparted by actuation of the actuator **50** to the filter **42**.
(15) Referring again to FIG. **1**, the HVAC system **10** includes a control system **56** connected to the fans **32**, **34**, the dampers **36**, **38**, **40**, and the coil valves **28**, **30**. Further, the control system **56** is operably connected to the filters **42**, **44**, **46**, in particular to the filter deployment mechanism **48** connected to each of the filters. The control system **56** controls the various components of the HVAC system **10** to provide conditioned supply airflow **12** to the conditioned space **14** at a selected temperature, while maintaining a selected IAQ in the conditioned space **14**. Further, it is desired to minimize energy consumption of the HVAC system **10**.
(16) The HVAC system **10** further includes a plurality of sensors operably connected to the control system **56** to provide data to the control system **56** such that the control system **56** can determine filter positions, damper positions, fan operation, valve position, and the like by utilizing the sensor data. A supply temperature sensor **58** and a supply pressure sensor **60** are located at the supply airflow damper **36**. The sensors at the supply airflow damper **36** detect the condition of the supply airflow **12** entering the conditioned space **14** to ensure the selected set point temperature is achieved in the conditioned space **14**.
(17) Further, a plurality of return air sensors are located in the air handler **20** upstream of the return air flow damper **38**. Such sensors detect the conditions of the return airflow **16** approaching the return airflow damper **38**. The sensors located upstream of the return airflow damper **38** include a return temperature sensor **62**, a return humidity sensor **64**, a return CO.sub.2 sensor **66**, a return particulate sensor **68** and a return VOC sensor **70**.
(18) Additionally, a plurality of outside air sensors are located upstream of the outside airflow damper **40**, including an outside temperature sensor **72**, an outside humidity sensor **74** and an outside particulate sensor **76**. The outside air sensors monitor conditions of the outside airflow **18** prior to the outside airflow **18** being admitted into the air handler **20** via the outside airflow damper **40**. Additionally, the air handler **20** may include other sensors, such as a mixing chamber

temperature sensor **80** located in a mixing chamber **82** of the air handler **20**, which is downstream of both the return airflow damper **38** and the outside airflow damper **40**, and upstream of the filters.

(19) Additional dampers may be utilized in the air handler **20**, such as an exhaust air damper **84** to exhaust return airflow **16** to ambient without the return airflow **16** proceeding across the filters. In effect, if the exhaust air damper **84** is opened and the return airflow damper **38** is closed, the return airflow **16** bypasses the filters and coils of the air handler **20** and is merely exhausted to ambient, not returned to the conditioned space **14**. Further, the air handler **20** may include a purge damper **86** downstream of the coils, but upstream of the supply airflow damper **36**. The purge damper **86** may be opened to, for example, purge excess CO.sub.2 from the air handler **20**.

(20) Referring now to FIG. **4**, a method **100** of operating the HVAC system **10** is illustrated. The method includes receiving a set point temperature at block **102**. Conditions of the return airflow **16** are sensed at block **104**. The conditions include return air temperature, return air humidity, return air CO.sub.2 level, return air particulate matter level, and return air VOC level. At block **106**, conditions of the outside airflow **18** are sensed, including outside airflow temperature, outside air humidity, and outside air particulate matter level. At block **108**, based on the sensed outside airflow temperature, return air temperature and the set point temperature, the cooling coil **24** or the heating coil **26** is activated. Further, at block **110**, the controller selectably deploys one or more of the filters **42**, **44**, **46** and/or selects one or more of the return airflow **16** or outside airflow **18** to be admitted into the air handler **20**.

(21) The decision is based on whether the return airflow **16** or the outside airflow **18** is sensed to exceed a threshold for one or more of the indoor air quality measures of CO.sub.2 level, VOC level, or particulate matter level. Further, the control system **56** takes into account energy required to bring the source air (either return airflow **16** or outside airflow **18**) to the temperature required to meet the set point temperature. If the energy required to condition the source airflow by heating or cooling exceeds the excess energy used when the filter is deployed (such as fan operation requirements, etc.) the control system **56** may signal to deploy the one or more filters **42**, **44**, **46**. On the other hand, if the source airflow can be selected such that the supply airflow **14** meets the indoor air quality measures and the additional energy required to condition the source airflow does not exceed the additional energy required due to filter deployment, the filters will not be deployed, and the source airflow will be appropriately selected.

(22) An embodiment of a method **200** is illustrated in FIG. **5**. In the method of FIG. **5**, one or more return airflow conditions, such as CO.sub.2, VOC or particulate matter concentration is sensed at block **202** and an outside airflow particulate matter concentration is sensed at block **204**. The return airflow conditions are compared to selected thresholds and the outside airflow particulate matter concentration is compared to a selected threshold at block **206**. If the return airflow conditions are below threshold, the method returns to block **202**. As shown in block **209**, if one or more of the return airflow conditions exceeds the selected threshold, and the outside airflow particulate matter concentration exceeds its threshold, the method proceeds to block **208**, where the minimum outside air damper setting is calculated, based on, for example, system load and ventilation requirements. The outside air damper is set to the calculated minimum outside air damper setting at block **210**. One or more of the filters **42**, **44**, **46** are deployed at block **212**.

(23) If, on the other hand, the outside airflow particulate matter concentration is below the selected threshold at block **206**, as shown in block **209** the method proceeds to block **214**, where the minimum outside air damper setting is calculated, based on, for example, system load and ventilation requirements. At block **216**, a predicted additional cooling power required to condition the outside airflow is compared to a predicted additional fan power required due to deployment of one or more filters. If the predicted cooling power required exceeds the predicted additional fan power required, the outside air damper is set to the minimum outside air damper setting at block **218**, and one or more filters are deployed at block **220**. If, on the other hand, the predicted cooling power required does not exceed the predicted additional fan power required, an outside air damper

maximum setting is calculated at block **222**. At block **224**, the outside air damper is actuated between the calculated maximum and minimum settings to achieve the selected temperature set point.
(24) The HVAC system **10** disclosed herein only deploys filters **42**, **44**, **46** when needed, thus can avoid additional energy consumption due to additional pressure drop which results from filter deployment across the flowpath **22**. Deployment of filters only as needed also has the technical effect of extending filter service life. Such effects will be notable in geographic locations where indoor and outdoor air quality issues arise intermittently.
(25) The term "about" is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.
(26) The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.
(27) While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

Claims

1. A heating, ventilation, and air conditioning (HVAC) system, comprising: an air handling unit; a supply airflow damper to direct a supply airflow from the air handling unit to a conditioned space; one or more filters selectively deployable across a flowpath of the air handling unit to remove one or more contaminants from the supply airflow prior to the supply airflow passing through the supply airflow damper; a control system operably connected to the one or more filters to direct movement of the one or more filters between a deployed position and a stowed position; an outdoor airflow damper disposed at the air handling unit configured to selectably admit an outside airflow into the air handling unit; and one or more of a heating coil and a cooling coil disposed in the air handling unit to condition the supply airflow; wherein the one or more filters are disposed along the flowpath between the outdoor airflow damper and the one or more of the heating coil and the cooling coil; and a plurality of sensors disposed at the air handling unit and operably connected to the control system, the control system directing movement of the one or more filters based on conditions sensed by the plurality of sensors; wherein the plurality of sensors includes a plurality of outside airflow sensors disposed upstream of the outdoor airflow damper; and a purge damper disposed downstream of the one or more of a heating coil and a cooling coil and upstream of the supply airflow damper to selectably purge excess CO.sub.2 from the air handler.
2. The HVAC system of claim 1, wherein the one or more filters include a particulate filter, a volatile organic compound filter, or a CO.sub.2 scrubber.
3. The HVAC system of claim 1, further comprising a return airflow damper to direct a return airflow from the conditioned space into the air handling unit, wherein the plurality of sensors includes a plurality of return airflow sensors disposed at the return airflow damper.
4. The HVAC system of claim 3, wherein the plurality of return airflow sensors include one or

more of a return particulate matter sensor, a return volatile organic compound sensor, and a return CO_2 sensor.
5. The HVAC system of claim 3, wherein the control system signals for deployment of one or more filters when a condition sensed by a return airflow sensor of the plurality of return airflow sensors exceeds a selected threshold.
6. The HVAC system of claim 3, wherein the return airflow damper is moved between an opened position and a closed position in response to a return airflow condition detected by the plurality of return airflow sensors.
7. The HVAC system of claim 1, wherein the plurality of outdoor airflow sensors includes an outdoor airflow particulate matter sensor.
8. The HVAC system of claim 1, wherein the control system signals for deployment of one or more filters when a condition sensed by an outside airflow sensor of the plurality of outside airflow sensors exceeds a selected threshold.
9. The HVAC system of claim 1, wherein the outdoor airflow damper is moved between a minimum opened position and a maximum opened position in response to an outdoor airflow condition detected by the plurality of outside airflow sensors.
10. The HVAC system of claim 1, wherein the one or more filters are configured to rotate about a pivot to move between a deployed position and a stowed position.
11. The HVAC system of claim 1, further comprising one or more fans disposed in the air handling unit to direct airflow through the air handling unit.