Claims

1. A method of controlling an HVAC system, the HVAC system comprising an air handling unit to produce a supply airflow and a cooling or heating capacity, the air handling unit being connected via a ducting system to a plurality of VAV diffuser units, each VAV diffuser unit influencing air temperature in a corresponding zone by delivering supply air to the corresponding zone, wherein

the air handling unit comprises at least one supply air fan or motorised supply air damper, and at least one heat exchanger; and

each diffuser unit comprises a diffuser, a motorised variable damper to alter a diffuser airflow rate of a diffuser airflow delivered by the corresponding diffuser unit into the corresponding zone, and a diffuser pressure sensor for determining a static pressure of the diffuser airflow; wherein

the HVAC system further comprises a plurality of zone temperature sensors;

the HVAC system further comprising at least one control unit connected to, optionally via a respective micro-controller corresponding to each diffuser unit, each diffuser unit motorised variable damper, each zone temperature sensor and each diffuser pressure sensor,

the control unit:

receiving at least one supply air temperature;

the method comprising determining a target constant thermal capacity and controlling the motorised variable damper of each diffuser unit with reference to a target diffuser airflow rate and a target diffuser temperature differential for each corresponding diffuser unit, and to provide the corresponding target constant thermal capacity to the corresponding zone as a substantially constant thermal capacity even if a supply air temperature or a supply air pressure to the corresponding diffuser unit changes, and further

determining, and controlling, for the HVAC system:

a supply air pressure setpoint in relation to an air handling unit supply air pressure sensor, or a fan speed of the at least one supply air fan, or a damper position of the motorised supply air damper, in each case with reference to a diffuser static pressure offset request from each diffuser unit; and

a supply air temperature setpoint for the air handling unit in relation to an air handling unit supply air temperature, or the cooling or heating

output of the at least one heat exchanger, in each case with reference to a diffuser temperature offset request from each diffuser unit.

2. The method of claim 1

comprising, for each diffuser unit:

determining a zone temperature setpoint;

determining a zone air temperature from the corresponding zone temperature sensor;

determining a diffuser unit control output in dependence on the zone temperature setpoint and the determined zone air temperature;

determining a diffuser design temperature differential and a diffuser design airflow rate; and

determining either:

a target diffuser airflow rate in dependence on a target diffuser air temperature differential, wherein the target diffuser air temperature differential is determined in dependence on the diffuser design temperature differential and the diffuser unit control output for the selected diffuser unit; or

a target diffuser air temperature differential in dependence on a target diffuser airflow rate, wherein the target diffuser airflow rate is determined in dependence on the diffuser design airflow rate and the diffuser unit control output for the selected diffuser unit; wherein

the design temperature differential may be determined in relation to a diffuser supply air temperature and the corresponding zone temperature; wherein

the diffuser supply air temperature may be determined by a sensor incorporated into the selected diffuser unit, or the diffuser supply air temperature may be determined by a sensor located remote from the selected diffuser unit; further wherein the target constant thermal capacity may be expressed according to the following formula:

C%D = D%SdTR * D%AR

where C%D is the target constant thermal capacity expressed as a percentage of maximum diffuser unit control output, D%SdTR is the target diffuser air temperature differential expressed as a percentage of the diffuser design temperature differential, and D%AR is the target diffuser airflow rate expressed as a percentage of the diffuser design airflow rate, wherein the target diffuser air temperature differential and the target diffuser airflow rate comprise a set of target variables, the product of which equals the target constant thermal capacity.

3. The method according to claim 1 or claim 2 further comprising determining a plurality of sets of control variables, each set of control variables comprising a target factored diffuser airflow rate and a target factored diffuser air temperature differential, in which each set of control variables satisfies the predetermined target constant thermal capacity for the selected diffuser unit, and wherein the plurality of sets of control variables are factored relative to the set of target variables; whereby,

the HVAC system may further comprise an economiser damper system for selectively mixing an air supply from outside the HVAC system with the supply air when the HVAC system is in an economiser mode, the method further comprising, when the HVAC system is in an economiser mode:

each set of control variables satisfies the predetermined target constant thermal capacity for the selected diffuser unit and additionally comprises

a target factored economiser deadband;

determining the target factored economiser deadband; and

controlling the economiser damper system with reference to said target factored economiser deadband.

4. The method of any preceding claim wherein the control unit further controls one or more of: a supply air temperature, a supply air static pressure, and the fan speed of the at least one supply air fan or the damper position of the motorised supply air damper; to alter or maintain a temperature of at least one zone wherein,

the control unit may control the supply static air pressure to alter or maintain a temperature of at least one zone when the motorised variable damper of the diffuser unit serving the at least one zone is fully open wherein,

the control unit may control the supply air temperature to alter or maintain a temperature of at least one zone when the motorised variable damper of the diffuser unit serving the at least one zone is fully open.

5. The method according to claim 4 when dependent on claim 3, further comprising selecting one of said plurality of sets of control variables to simultaneously change the supply air temperature and the diffuser airflow rate according to one or more criteria whilst maintaining delivery of the target constant thermal capacity, wherein,

the criteria may include one or more of humidity, zone over-cooling, zone over-heating, outdoor air temperature, energy conservation, indoor air quality, noise, and excess pressure.

6. The method of any preceding claim further comprising, for each diffuser unit, adjusting the motorised variable damper to deliver an adjusted target factored damper airflow rate.

7. The method of claim 6 when dependent on claim 3 wherein the adjusted target factored damper airflow rate is determined with reference to an actual temperature differential relative to a target factored diffuser air temperature differential for the corresponding diffuser unit, and an actual static pressure at the diffuser unit relative to a target factored diffuser static pressure wherein,

the method may further comprise, for a selected diffuser unit with fully open motorised variable damper, adjusting the target factored diffuser static pressure as a function of the target factored diffuser airflow rate.

8. The method according to any preceding claim further comprising, for each diffuser unit, determining the diffuser temperature offset request and the diffuser static pressure offset request.

9. The method according to claim 8, wherein, for each diffuser unit, the diffuser temperature offset request may be determined by subtracting the actual temperature differential from the target factored diffuser temperature differential, or if the actual static pressure is greater than the target factored diffuser static pressure then from the target factored diffuser temperature differential multiplied by the square root of the target factored diffuser static pressure divided by the square root of the actual static pressure wherein

the diffuser static pressure offset request may be determined by subtracting the actual static pressure from the target factored diffuser static pressure, or if the actual temperature differential is greater than the target factored diffuser temperature differential then from the target factored diffuser static pressure multiplied by the square of the target factored diffuser temperature differential divided by the square of the actual temperature differential.

10. The method according to claim 9 comprising realising, for each diffuser unit, a diffuser static pressure offset request of zero when the target factored diffuser static pressure is equal to the actual static pressure and the target factored diffuser temperature differential is greater than or equal to the actual temperature differential.

11. The method according to claim 9 comprising realising a diffuser temperature offset request of zero when the target factored diffuser temperature differential is equal to the actual temperature differential and the target factored diffuser static pressure is greater than or equal to the actual static pressure.

12. The method according to claims 9 to 11 comprising realising, for each diffuser unit, a diffuser static pressure offset request of zero when the target factored diffuser static pressure is greater than the actual static pressure and when the target factored diffuser static pressure divided by the actual static pressure is equal to the square of the actual temperature differential divided by the square of the target factored temperature differential wherein,

the method may further comprise realising a diffuser temperature offset request of zero when the target factored diffuser temperature differential is greater than the actual temperature differential and the target factored diffuser temperature differential divided by the actual temperature differential is equal to the square root of the actual static pressure divided by the square root of the target factored diffuser static pressure.

13. The method according to claim 8 or claim 9 further comprising determining system heating or system cooling by a vote of the diffuser units, and ranking each diffuser temperature offset request in a temperature rank and ranking each diffuser static pressure offset request in a pressure rank, wherein

the at least one control unit may further comprise an air supply controller and may further comprise a thermal capacity controller, in each case with the setpoint set to zero, and with the process value of the air supply controller designated as the highest diffuser static pressure offset request from the pressure rank, and where the direction of the thermal capacity control is set by a requirement for system cooling or system heating, with system cooling designating the process value to be the lowest diffuser temperature offset request from the temperature rank and system heating designating the process value to be the highest diffuser temperature offset request from the temperature rank, and wherein each controller may further provide proportional-integral (PI), proportional-integral-derivative (PID) or nudge-and-wait control.

14. The method according to claim 13 wherein the air supply controller further determines an air supply target , wherein the air supply target determines a supply air pressure setpoint for the air handling unit in relation to the air handling unit supply air pressures sensor, or directly determines the fan speed of the at least one supply air fan or the damper position of the

motorised supply air damper, and wherein the thermal capacity controller, if present, determines a cooling or heating capacity target, wherein the cooling or heating capacity target may determine the supply air temperature setpoint for the air handling unit in relation to the air handling unit supply air temperature sensor, or directly determines the cooling or heating output of the at least one heat exchanger.

15. The method according to claim 4 or any of claims 5 to 14 when dependent on claim 4, further comprising determining an economiser damper temperature setpoint with reference to a target economiser deadband for each diffuser unit, wherein when the method further comprises the design temperature differential being determined in relation to a diffuser supply air temperature, then the method may further comprise, for each diffuser unit, subtracting the actual temperature from the economiser damper temperature setpoint to determine an economiser offset request, wherein

the method may further comprise ranking each diffuser unit economiser offset request in an economiser rank, wherein

the HVAC system may further comprise an economiser controller with proportional-integral (PI), proportional-integral-derivative (PID) or nudge-and-wait control, and with the setpoint set to zero, and with the process value designated as the lowest economiser offset request from the economiser rank, wherein

the method may further comprise an economiser target from the economiser controller, wherein the economiser target determines an economiser supply air temperature setpoint for the economiser damper system in relation to the air handling unit supply air temperature sensor, or directly determines an economiser damper system output to directly modulate the economiser damper system.