

Description

This invention is directed toward the art of effectively operating variable air volume delivery systems, and particularly toward the control of static pressure in the supply ducts of said variable air volume delivery systems during the delivery of air irrespective of the amount of air delivered in such systems.

One example of a variable air volume delivery system includes rooftop air conditioners in the 78-907 (20-100 ton) operational range, which include extensive ductwork to the rooms and spaces subject to air delivery. Such air conditioners frequently face the problem of controlling static pressure in their ductwork during variable air volume applications, because of the need to continually modify the amounts and quantities of air needed to be delivered in order to establish effective building temperature control with regard to conditioned and conditionable rooms and spaces therein.

The problem of static pressure control can be usefully understood and illustrated by the following example. As the need for cooling a room or space to be conditioned decreases, the air terminals in the rooms and spaces addressed begin to modulate between open and closed states, to reduce the amount of air delivered to the region being conditioned. This of course increases the static pressure delivered by the blower of the variable air volume delivery system driving the air in direct relationship to the reduction in the amount of air delivered.

In other words, as the amount of air is reduced with diminished need, the system itself requires only a reduced level of static pressure. Instead, the level of static pressure is in fact increased, because less amounts of air are actually lost during operation under reduced air flow conditions.

Significantly, not only are static pressure levels at their maximum just when they are clearly least needed, but the excessive level of static pressure applied at repeated intervals can indeed increase energy costs and additionally cause damage to the ductwork of the air volume delivery system being operated and also to the room terminals delivering the air to the spaces being conditioned.

It would thus be advantageous to regulate, or reduce, the static pressures present during system operation for many reasons relating both to energy savings and to the structural integrity and mechanical maintenance of the system. Beyond that, it is of course clear that solving the static pressure problem indicated would tend to promote energy savings for the user and to reduce the work done by the air volume delivery system blower which bears in substantial part the burden of producing such excessive static pressure levels.

In the prior art this effect has been achieved by controlling the blower motor to maintain the static pressure in the supply duct generally constant. Such a prior art system according to the precharacterizing portion of claim 1 enabling regulation of the static pressure is disclosed in "Taschenbuch für Heizung und Klimatechnik", vol 61, 1981, R. Oldenbourg München Wien, page 886. In the known system the supplied air volume is continuously variable. This requires an expensive infinitely variable speed motor.

To avoid this disadvantage there is provided in accordance with the invention a method of supplying variable amounts of air to an air volume delivery system including a blower, a motor for driving said blower, a motor controller for controlling the speed of said motor, an inlet duct bringing air to the blower, and a supply duct including room terminals, for moving variable quantities of air from the blower to selected rooms through corresponding room terminals, said blower being effective for blowing air from said inlet duct into said supply duct and through selected ones of said room terminals, said room terminals being adjustable thereby causing static pressure variation in said supply duct, said method comprising the steps of controlling the blower motor speed to regulate the static air pressure in said supply duct, characterized by controlling the blower motor speed stepwise by switching between two or more discrete speed stages; establishing a predetermined static pressure operating range wherein the static pressure is allowed to vary between an upper and a lower limit during operation of said blower motor, and preventing, for all discrete speed stages of said motor, the static pressure from exceeding said upper limit and from falling below said lower limit, and when the static pressure reaches the upper limit of said static pressure operating range, switching to a lower motor speed stage with an associated lower static pressure which is sufficiently above said lower limit to prevent the static pressure from decreasing below the lower limit caused by opening of the room terminals to compensate for the reduction in air flow rate due to the switching to the lower motor speed stage.

In one embodiment, when duct static pressure rises to an excessive level, the fan motor is switched to a next lower speed by action of the motor controller in response to a pressure detector in the supply duct of the air volume delivery system, which pressure detector is effective for delivering a signal indicative of pressure levels detected therein. The blower fan speed is controlled under direction of a multi-speed motor in turn controlled by a motor controller, capable of operation at two or more discrete speeds. The speed change of the fan motor and its connected blower arrange-

ment in turn is effective for producing a reduction in static pressure for example proportional to the square of the ratio of initial and final revolutions per second, as will be seen. Concurrently therewith, the quantity of air delivered in cubic meter per minute for example, will be reduced in direct proportion to the ratio of initial and final revolutions per second.

The method of supplying variable amounts of air to an air volume delivery system will now be described in greater detail with reference to the accompanying drawings, wherein :

Figure 1 is a schematic illustration of a typical centrifugal blower system used for air conditioning and variable air volume delivery, and employing supply and return ducts leading to and from the rooms and spaces to be conditioned.

Figure 2 is a graph displaying the operating characteristics of the air volume delivery system, according to Figure 1, in particular indicating external static pressure in millimeters of water as a function of air flow rate in cubic meter per minute.

Figure 1 shows a variable air volume delivery system 130 including an outer cabinet 140 containing filters 150 for receiving air from an inlet or return duct 160, an evaporator coil 170 for conditioning the air received from filters 150, a condenser arrangement 175, and a motor 180 for driving a centrifugal blower 190 subject to the direction of motor controls 200, the centrifugal blower 190 being effective for blowing the air passing through the evaporator coils 170 out of cabinet 140 into supply duct 210 and then in turn into the rooms and spaces 215 to be conditioned by way of respective room terminals 220. Such a system 130 further includes a conventional and well known closed loop refrigerant system and a compressor (not shown) for circulating refrigerant between condenser 175 and evaporator coil 170. It is however not an object herein to address the features and operation of the refrigerant system which operates in conjunction with the air delivery objectives of direct interest herein. The outer cabinet 140 is moreover supported on a substantial roof structure 300 as suggested in Figure 1. Supply duct 210 is further subject to measurement by a static pressure sensor 310, which communicates along line 320 with motor controller 200 to provide an indication of pressure levels detected by sensor 310.

The operation of the blower system 130 of Figure 1 proceeds according to the invention herein, in accordance with the scheme set forth in Figure 2, which scheme is programmed into motor controls or controller 200 according to well known techniques. In particular, point 1 on the characteristic curves of Figure 2 suggests the condition of operation by system 130 at highest revolutions per second with the room terminals 220 delivering a

maximum load in cubic meter per minute, as per system curve "A", which shows how the air volume delivery system 130 operates for a given setting of air terminals 220.

Further, point 2 of the operational graph set forth in Figure 2 suggests operation according to system curve A' with reduced air flow, at which time the room terminals 220 will have been throttled into a slightly closed condition to somewhat restrict air flow into the rooms or spaces to be conditioned.

Point 3 shown in Figure 2 suggests a condition of even greater throttled operation as per indicated system curve A". Point 4 of the Figure in turn sets forth the condition at which the room terminals 220 have been closed sufficiently to cause the level of static pressure to reach an upper limit setting for motor controls 200 for the given level of revolutions per minute. At said limit, the fan motor 180 is, according to the invention, switched to a next lower speed, represented by "RPM2".

At point 5 of the operational characteristic, system operation is repeated according to the outer section of system curve B for a new level "2" of revolutions per minutes as indicated on Figure 2, at which time the fan effect of centrifugal blower 190 slows down and the air flow rebalances at a new state of operation. Point 6 accordingly is suggestive of the operating point of system 130 with the room terminals 220 opened slightly to compensate for the reduction in flow rate (in cubic meter per minute) caused by the change in fan speed. Points in turn 7-12 are the operating points of system 130 which are analogous to points 1-6 discussed above, but which represent the operational transition between motor states "2" and "3", whereas points 1-6 describe the transition between motor states "1" to "2" as described immediately above.

Claims

1. Method of supplying variable amounts of air to an air volume delivery system including a blower (190), a motor (180) for driving said blower (190), a motor controller (200) for controlling the speed of said motor (180), an inlet duct (160) bringing air to the blower (190), and a supply duct (210) including room terminals (220), for moving variable quantities of air from the blower (190) to selected rooms through corresponding room terminals (220), said blower (190) being effective for blowing air from said inlet duct (160) into said supply duct (210) and through selected ones of said room terminals (220), said room terminals (220) being adjustable thereby causing static pressure variation in said supply duct (210), said method comprising the steps of:



ment in turn is effective for producing a reduction in static pressure for example proportional to the square of the ratio of initial and final revolutions per second, as will be seen. Concurrently therewith, the quantity of air delivered in cubic meter per minute for example, will be reduced in direct proportion to the ratio of initial and final revolutions per second.

The method of supplying variable amounts of air to an air volume delivery system will now be described in greater detail with reference to the accompanying drawings, wherein :

Figure 1 is a schematic illustration of a typical centrifugal blower system used for air conditioning and variable air volume delivery, and employing supply and return ducts leading to and from the rooms and spaces to be conditioned.

Figure 2 is a graph displaying the operating characteristics of the air volume delivery system, according to Figure 1, in particular indicating external static pressure in millimeters of water as a function of air flow rate in cubic meter per minute.

Figure 1 shows a variable air volume delivery system 130 including an outer cabinet 140 containing filters 150 for receiving air from an inlet or return duct 160, an evaporator coil 170 for conditioning the air received from filters 150, a condenser arrangement 175, and a motor 180 for driving a centrifugal blower 190 subject to the direction of motor controls 200, the centrifugal blower 190 being effective for blowing the air passing through the evaporator coils 170 out of cabinet 140 into supply duct 210 and then in turn into the rooms and spaces 215 to be conditioned by way of respective room terminals 220. Such a system 130 further includes a conventional and well known closed loop refrigerant system and a compressor (not shown) for circulating refrigerant between condenser 175 and evaporator coil 170. It is however not an object herein to address the features and operation of the refrigerant system which operates in conjunction with the air delivery objectives of direct interest herein. The outer cabinet 140 is moreover supported on a substantial roof structure 300 as suggested in Figure 1. Supply duct 210 is further subject to measurement by a static pressure sensor 310, which communicates along line 320 with motor controller 200 to provide an indication of pressure levels detected by sensor 310.

The operation of the blower system 130 of Figure 1 proceeds according to the invention herein, in accordance with the scheme set forth in Figure 2, which scheme is programmed into motor controls or controller 200 according to well known techniques. In particular, point 1 on the characteristic curves of Figure 2 suggests the condition of operation by system 130 at highest revolutions per second with the room terminals 220 delivering a

maximum load in cubic meter per minute, as per system curve "A", which shows how the air volume delivery system 130 operates for a given setting of air terminals 220.

Further, point 2 of the operational graph set forth in Figure 2 suggests operation according to system curve A' with reduced air flow, at which time the room terminals 220 will have been throttled into a slightly closed condition to somewhat restrict air flow into the rooms or spaces to be conditioned.

Point 3 shown in Figure 2 suggests a condition of even greater throttled operation as per indicated system curve A". Point 4 of the Figure in turn sets forth the condition at which the room terminals 220 have been closed sufficiently to cause the level of static pressure to reach an upper limit setting for motor controls 200 for the given level of revolutions per minute. At said limit, the fan motor 180 is, according to the invention, switched to a next lower speed, represented by "RPM2".

At point 5 of the operational characteristic, system operation is repeated according to the outer section of system curve B for a new level "2" of revolutions per minutes as indicated on Figure 2, at which time the fan effect of centrifugal blower 190 slows down and the air flow rebalances at a new state of operation. Point 6 accordingly is suggestive of the operating point of system 130 with the room terminals 220 opened slightly to compensate for the reduction in flow rate (in cubic meter per minute) caused by the change in fan speed. Points in turn 7-12 are the operating points of system 130 which are analogous to points 1-6 discussed above, but which represent the operational transition between motor states "2" and "3", whereas points 1-6 describe the transition between motor states "1" to "2" as described immediately above.

Claims

1. Method of supplying variable amounts of air to an air volume delivery system including a blower (190), a motor (180) for driving said blower (190), a motor controller (200) for controlling the speed of said motor (180), an inlet duct (160) bringing air to the blower (190), and a supply duct (210) including room terminals (220), for moving variable quantities of air from the blower (190) to selected rooms through corresponding room terminals (220), said blower (190) being effective for blowing air from said inlet duct (160) into said supply duct (210) and through selected ones of said room terminals (220), said room terminals (220) being adjustable thereby causing static pressure variation in said supply duct (210), said method comprising the steps of:



controlling the blower motor speed to regulate the static air pressure in said supply duct (210).

characterized by:

controlling the blower motor speed stepwise by switching between two or more discrete speed stages:

establishing a predetermined static pressure operating range wherein the static pressure is allowed to vary between an upper and a lower limit during operation of said blower motor (180), and preventing, for all discrete speed stages of said motor (180), the static pressure from exceeding said upper limit and from falling below said lower limit, and

when the static pressure reaches the upper limit of said static pressure operating range, switching to a lower motor speed stage with an associated lower static pressure which is sufficiently above said lower limit to prevent the static pressure from decreasing below the lower limit caused by opening of the room terminals (220) to compensate for the reduction in air flow rate due to the switching to the lower motor speed stage.

2. Method according to claim 1, characterized in that said motor (180) is a multi-speed motor providing at least two different rates of air volume corresponding to respective ones of selected motor speeds.

3. Method according to claim 1, characterized by the step of detecting static pressure in said supply duct (210).

4. Method according to claim 3, characterized by the step of providing an indication of detected static pressure to said motor controller (200).

Revendications

1. Procédé de distribution de quantités variables d'air à un système de distribution d'un volume d'air comprenant un ventilateur de soufflage (190), un moteur (180) pour entraîner ledit ventilateur (190), un régulateur du moteur (200) pour réguler la vitesse dudit moteur (180), une gaine d'admission (160) amenant l'air au ventilateur de soufflage (190), et une gaine d'alimentation (210) avec ses bouches de sortie (220), pour déplacer des quantités variables d'air du ventilateur de soufflage (190) vers les locaux choisis au travers des bouches de sortie correspondantes (220), ledit ventilateur de soufflage (190) étant efficace pour souffler l'air provenant de ladite gaine d'admission (160) vers ladite gaine d'alimentation (210) et au

travers de certaines desdites bouches de sortie (220) sélectionnées, lesdites bouches (220) étant réglables, provoquant ainsi une variation de la pression statique dans ladite gaine d'alimentation (210), ledit procédé comprenant les étapes consistant à :

contrôler la vitesse du moteur du ventilateur de soufflage pour réguler la pression d'air statique dans ladite gaine d'alimentation (210).

caractérisé par :

le contrôle pas-à-pas de la vitesse du moteur du ventilateur de soufflage par commutation entre deux ou plus paliers de vitesse distincts;

l'établissement d'une plage opératoire prédéterminée pour la pression statique pour laquelle la pression statique est autorisée à varier entre une limite supérieure et une limite inférieure pendant le fonctionnement dudit moteur (180) du ventilateur de soufflage, et l'empêchement mis, pour tous les divers paliers de vitesse dudit moteur (180), à ce que la pression statique n'excède ladite limite supérieure et ne tombe en dessous de ladite limite inférieure, et

lorsque la pression statique atteint la limite supérieure de ladite plage opératoire de pression statique, la commutation à un palier de vitesse du moteur inférieur associée à une pression statique inférieure qui est suffisamment supérieure à ladite limite inférieure pour empêcher la pression statique de tomber en dessous de la limite inférieure provoquée par l'ouverture des bouches de sortie (220) pour compenser la réduction de la vitesse d'écoulement de l'air due à la commutation à un palier de vitesse du moteur inférieur.

2. Procédé selon la revendication 1, **caractérisé par le fait que** ledit moteur (180) est un moteur à plusieurs vitesses fournissant au moins deux vitesses d'écoulement de l'air correspondant aux vitesses sélectionnées du moteur.

3. Procédé selon la revendication 1, **caractérisé par l'étape** consistant à détecter la pression statique dans ladite gaine d'alimentation (210).

4. Procédé selon la revendication 3, **caractérisé par l'étape** consistant à fournir une indication de la pression statique détectée audit régulateur (200) du moteur.

Patentansprüche

1. Verfahren zum Abgeben von variablen Luftmengen an ein Luftmengenfördersystem mit



- einem Gebläse (190), einem Motor (180) zum Antreiben des Gebläses (190), einem Motorregler (200) zum Regeln der Drehzahl des Motors (180), einem Einlaßkanal (160), der die Luft zu dem Gebläse (190) bringt, und einem Auslaßkanal (210), welcher Rauman-schlüsse (220) aufweist, zum Abgeben von variablen Luftmengen von dem Gebläse (190) an aus-
gewählte Räume über entsprechende Rauman-
schlüsse (220), wobei das Gebläse (190) be-
wirkt, daß Luft aus dem Einlaßkanal (160) in
den Auslaßkanal (210) und durch ausgewählte
Rauman-schlüsse (220) geblasen wird, wobei
die Rauman-schlüsse (220) einstellbar sind und
dadurch eine Veränderung des statischen
Drucks in dem Auslaßkanal (210) hervorrufen,
wobei das Verfahren die Schritte beinhaltet:
Regeln der Gebläsemotordrehzahl, um den
statischen Luftdruck in dem Auslaßkanal (210)
zu regeln,
gekennzeichnet durch:
schrittweises Regeln der Gebläsemotordreh-
zahl durch Umschalten zwischen zwei oder
mehr als zwei diskreten Drehzahlstufen;
Festlegen eines vorbestimmten Arbeitsberei-
ches des statischen Druckes, in welchem dem
statischen Druck gestattet wird, sich während
des Betriebes des Gebläsemotors (180) zwi-
schen einem oberen und einem unteren
Grenzwert zu verändern, und Verhindern, daß
bei allen diskreten Drehzahlstufen des Motors
(180) der statische Druck den oberen Grenz-
wert übersteigt und unter den unteren Grenz-
wert absinkt, und
wenn der statische Druck den oberen Grenz-
wert des Arbeitsbereiches des statischen Druk-
kes erreicht, Umschalten auf eine niedrigere
Motordrehzahlstufe, wobei ein zugehöriger
niedrigerer statischer Druck, der ausreichend
über dem unteren Grenzwert liegt, um zu ver-
hindern, daß der statische Druck unter den
unteren Grenzwert absinkt, durch Öffnen der
Rauman-schlüsse (220) bewirkt wird, um die
Verringerung des Luftdurchsatzes aufgrund
des Umschaltens auf die niedrigere Motordreh-
zahlstufe zu kompensieren.
4. Verfahren nach Anspruch 3, gekennzeichnet
durch den Schritt des Versorgens des Motorre-
glers (200) mit einer Anzeige des erfaßten sta-
tischen Druckes.
2. Verfahren nach Anspruch 1, dadurch gekenn-
zeichnet, daß der Motor (180) ein Motor mit
mehreren Drehzahlen ist, der für wenigstens
zwei verschiedene Luftmengenleistungen
sorgt, die ausgewählten Motordrehzahlen ent-
sprechen.
3. Verfahren nach Anspruch 1, gekennzeichnet
durch den Schritt des Erfassens des statischen
Druckes in dem Auslaßkanal (210).