

EXHAUST FAN AND METHOD

Technical Field

[0001] Embodiments described herein generally relate exhaust fans and methods. Specific examples may include redundant systems for exhaust fans and methods.

Background

[0002] Fan assemblies can be used in a number of applications. One example application includes exhausting fumes from a laboratory or other location where it is desired to remove an air entrained substance.

[0003] It is desirable to have redundant systems in case of failure of a primary system. It is further desirable to have low cost, high efficiency, low power and low noise systems. Example fan assemblies and methods described below address these, and other technical challenges.

Brief Description of the Drawings

[0004] FIG. 1 is a side cross section view of a fan assembly in accordance with some embodiments of the invention.

[0005] FIG. 2 is another side cross section view of the fan assembly from Figure 1 in accordance with some embodiments of the invention.

[0006] FIG. 3 is a comparison graph of fan assembly data in accordance with some embodiments of the invention.

[0007] FIG. 4 is a comparison table of fan assembly data in accordance with some embodiments of the invention.

[0008] FIG. 5 is a table of single fan assembly data in accordance with some embodiments of the invention.

[0009] FIG. 6 is a table of two fan assembly data in accordance with some embodiments of the invention.

[0010] FIG. 7A is an isometric view of a fan assembly in accordance with some embodiments of the invention.

[0011] FIG. 7B is a side view of the fan assembly from FIG 7A in accordance with some embodiments of the invention.

[0012] FIG. 8A is a cross section view of selected components of a fan assembly in accordance with some embodiments of the invention.

[0013] FIG. 8B is a cross section view of selected components of a fan assembly in accordance with some embodiments of the invention.

[0014] FIG. 9A is a side view of a fan assembly in accordance with some embodiments of the invention.

[0015] FIG. 9B is a top view of the fan assembly from FIG 9A in accordance with some embodiments of the invention.

Description of Embodiments

[0016] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0017] Figure 1 shows a fan assembly 100 according to one example. In Figure 1, the fan assembly includes a first fan 110, and a second fan 112. The first fan 110 includes a first inlet 111, and the second fan 112 includes a second inlet 113. The first fan 110 and the second fan 112 are shown commonly coupled to a single nozzle 114. In the example shown, the nozzle 114 is fitted with a windband 116, although the invention is not so limited.

[0018] In one example, a number of characteristics of the fan assembly 100 are improved by the use of multiple fans (110, 112) in place of a single fan. In one example, multiple fans may be run together, each at a lower speed, and produce the same characteristics or improved characteristics over a single fan. In one example, multiple fans are used to achieve a specified performance (pressure and flow), while other characteristics are improved. Improved characteristics include, but are not

limited to, power consumption, efficiency, noise, cost, etc. Although the example of Figure 1 shows two fans (110, 112) other examples may include a number of fans more than two.

[0019] A damper 118 is further illustrated in the fan assembly 100 of Figure 1. In one example, the damper 118 is a passive damper that is actuated by the operation of the one or more fans. In other examples, the damper 118 may include an active damper. Examples of active dampers may be activated by solenoids, hydraulics, pneumatics, electric motors, etc.

[0020] In one example, using multiple fans allows the fan assembly 100 to provide redundancy in the event of a fan failure. In the example of Figure 1, both fans are operating, and the damper 118 is shown in an central location, allowing flow indicated by arrows 120 from both the first fan 110 and the second fan 112, into the common nozzle 114. In the example of Figure 2, the second fan 112 is not operating, and the damper 118 is shown closing off the second fan from the nozzle 114. In the condition shown in Figure 2, the first fan 110 maintains operation, and provides all flow as indicated by arrows 120.

[0021] In the example illustrated in Figures 1 and 2, if either the first fan 110 or the second fan 112 fails, the remaining fan continues to operate, and maintains flow until the failed fan can be replaced or repaired. This feature may be of particular importance in a hazardous exhaust application, where flow must be maintained. In one example, under normal operating conditions, both fans operate at a first speed (RPM). In one example, in the event of failure of one fan, the remaining fan increases speed to a second RPM to achieve the necessary performance.

[0022] Figure 3 shows selected characteristics of a one fan assembly in comparison to a two fan assembly according to selected examples. Curve 304 illustrates a performance curve for a single fan operating a 2023 RPM, while curve 302 illustrates a performance curve for the two fan configuration similar illustrated in Figures 1 and 2. In Figure 3, the two fan curve 302 is shown at an operating speed of 1585 RPM. At point 306, the performance characteristics of both the single fan curve 304 and the two fan curve 302 are equal.

[0023] Other characteristics of both a single fan configuration and the two fan configuration shown in Figures 1 and 2 are also shown on the graph in Figure 3. The efficiency of the two fan configuration is shown to be higher as indicated along line 308. Additionally, the power consumption of the two fan configuration is shown to be lower. In addition to higher efficiency and lower power, the two fan configuration may be less expensive to manufacture. In one example, for a redundant fan system, only one nozzle is needed instead of two. The two fan configuration shown in Figures 1 and 2 saves in material cost. In selected examples, because the two fans used in the configuration shown in Figures 1 and 2 operate at a lower speed, a smaller, less expensive motor may be used to operate the fans (110, 112).

[0024] Figure 4 shows a table of selected data comparing a single fan example with the two fan example shown in Figures 1 and 2. In addition to the power savings and higher efficiency discussed with respect to Figure 3, the table in Figure 4 shows a lower operating noise level (68 dBA for two fans versus 76 dBA for a single fan configuration). In one example, the lower noise is a result of the two smaller fans running at a slower speed, in contrast to a single, larger fan running at a high speed. In addition to reduced noise, the lower speed on each of the smaller fans will improve bearing life and reduce wear on components.

[0025] Figure 5 shows detailed simulation data for a single fan assembly configuration, while Figure 6 shows detailed simulation data for the two fan assembly configuration shown in Figures 1 and 2. In particular, detailed noise information is shown at the bottom of Figures 5 and 6. It can be seen that the two fan assembly configuration shown in Figures 1 and 2 provides superior noise properties over the single fan assembly configuration.

[0026] Figures 7A and 7B show another example of a fan assembly 700. The fan assembly 700 includes a first fan 710, and a second fan 712. The first fan 710 is in communication with a first inlet 711, and the second fan 712 is in communication with a second inlet 713. In the example shown, the first inlet 711 and second inlet 713 are coupled to a manifold 720 that is in turn coupled to the first fan 710 and the second fan 712. In one example, the manifold and inlets 711, 713

may be routed to regions of an enclosure, such as a manufacturing facility or laboratory, where chemicals or other gasses may be present that are desired for removal.

[0027] The first fan 710 and the second fan 712 are shown commonly coupled to a single integrated nozzle 714. In the example shown, the nozzle 714 is fitted with a windband 716, although the invention is not so limited.

[0028] In the example of Figures 7A and 7B, the integrated nozzle 714 includes multiple inlets, and a single outlet. Figures 8A and 8B show a cross section view of the integrated nozzle 714 and illustrate its operation. In Figure 8A, a first inlet 810 and a second inlet 812 are shown. Within the integrated nozzle 714, the first inlet 810 and second inlet 812 converge to a single outlet 814.

[0029] A damper 818 is further illustrated in the integrated nozzle 714. Similar to examples described above, in one example, the damper 818 is a passive damper that is actuated by the operation of the one or more fans 710, 712. In other examples, the damper 818 may include an active damper. Examples of active dampers may be activated by solenoids, hydraulics, pneumatics, electric motors, etc.

[0030] In one example, the use of an integrated nozzle 714, in contrast to the example nozzle 114 of Figure 1, may reduce an overall cost of the fan assembly 700 by reducing a number of components in the assembly. In the example of Figures 7A and 7B, the windband 716 is coupled directly over the integrated nozzle 714, thereby eliminating the need for a separate nozzle 114 between the first fan 710 and the second fan 712, and the windband 716. In one example, the integrated nozzle 714 is geometrically, and aerodynamically configured to provide the necessary airflow without the need for a separate nozzle between the fans 710, 712, and the windband 716.

[0031] In one example, using multiple fans allows the fan assembly 100 to provide redundancy in the event of a fan failure. In the example of Figure 1, both fans are operating, and the damper 118 is shown in a central location, allowing flow indicated by arrows 120 from both the first fan 110 and the second fan 112, into the common nozzle 114. In the example of Figure 2, the second fan 112 is not

operating, and the damper 118 is shown closing off the second fan from the nozzle 114. In the condition shown in Figure 2, the first fan 110 maintains operation, and provides all flow as indicated by arrows 120.

[0032] Figures 9A and 9B show another example of a fan assembly 900. The fan assembly 900 includes a first fan 910, and a second fan 912. The first fan 910 is in communication with a first inlet 911, and the second fan 912 is in communication with a second inlet 913. In the example shown, the first inlet 911 and second inlet 913 are coupled to a manifold 940 that is in turn coupled to the first fan 910 and the second fan 912. As discussed in examples above, the manifold and inlets 911, 913 may be routed to regions of an enclosure, such as a manufacturing facility or laboratory, where chemicals or other gasses may be present that are desired for removal.

[0033] In the example of Figures 9A and 9B, an integrated nozzle 914 includes multiple inlets, and a single outlet. A damper 918 is further illustrated in the integrated nozzle 914. Similar to examples described above, in one example, the damper 918 is a passive damper that is actuated by the operation of the one or more fans 910, 912. In other examples, the damper 918 may include an active damper. Examples of active dampers may be activated by solenoids, hydraulics, pneumatics, electric motors, etc. A damper actuator 919 is illustrated in Figure 9B for optional inclusion in the fan assembly 900.

[0034] Additionally, in the example of Figures 9A and 9B, a windband 916 may be coupled directly over the integrated nozzle 914, thereby eliminating the need for a separate nozzle between the first fan 910 and the second fan 912, and the windband 916.

[0035] In one example, one or more fans 911, 912 are driven by a motor. Motor 920 illustrates a belt driven motor that drives fan 910 using pulleys 922 and 924. In another example, a direct drive motor 950 may be used without any belts or pulleys. In one example, use of a belt driven motor 920 may better facilitate a swing out configuration, described in more detail below.

[0036] A first hinge 928 may be coupled to belt driven motor 920 as shown in Figure 9B. A second hinge 934 is shown coupled to cover 930, and a second

motor (not shown). The belt driven motor 920 may be housed within a cover, similar to cover 930 illustrated covering portions of the second fan 912, and a corresponding motor. The cover 930 may provide sound attenuation and/or weather protection for the fan, motor, and belts, etc. In one example, it is desirable to have access to the motor, fan, belts, etc. for any needed repair or maintenance. A cover interface 932 is shown where the cover 903 meets a fan housing of the main body of the fan assembly 900. In one example a belt drive configuration better facilitates a swing out configuration due to the ability to easily remove and re-attach a belt when accessing the fan through the cover. In addition, the swingout construction, facilitates easier cleaning of the wheel and inlet cone during maintenance.

[0037] For certain operating conditions of fan assemblies described in the present disclosure, a dual fan/common nozzle system will be more efficient, quiet, last longer due to low speeds, and offer redundancy in the event of one fan failure over a single fan system. In addition, at $\frac{1}{2}$ flow through each fan, a full flow ‘jet’ plume height will be maintained through the common nozzle. This is unique in that for two independent fans in parallel, at $\frac{1}{2}$ flow, a weakened ‘pencil’ plume will result due to a variable area outlet nozzle required to maintain a certain windband outlet velocity.

[0038] Further, in the event of failure by one fan, the remaining fan can ramp up its speed from $\frac{1}{2}$ flow to full flow very quickly when compared to the time required to start a second redundant fan from a “0” rotational to full speed, from zero flow to full flow. In one example, the quicker response to the failure of one fan provides a safety benefit to the fume exhaust system, because flow never stops, and full flow is restored following failure much faster.

[0039] The above detailed description includes references to the accompanying drawings, which form a part of the detailed description. The drawings show, by way of illustration, specific embodiments in which the invention can be practiced. These embodiments are also referred to herein as “examples.” Such examples can include elements in addition to those shown or described. However, the present inventors also contemplate examples in which only those elements shown or described are provided. Moreover, the present inventors also

contemplate examples using any combination or permutation of those elements shown or described (or one or more aspects thereof), either with respect to a particular example (or one or more aspects thereof), or with respect to other examples (or one or more aspects thereof) shown or described herein.

[0040] In this document, the terms “a” or “an” are used, as is common in patent documents, to include one or more than one, independent of any other instances or usages of “at least one” or “one or more.” In this document, the term “or” is used to refer to a nonexclusive or, such that “A or B” includes “A but not B,” “B but not A,” and “A and B,” unless otherwise indicated. In this document, the terms “including” and “in which” are used as the plain-English equivalents of the respective terms “comprising” and “wherein.” Also, in the following claims, the terms “including” and “comprising” are open-ended, that is, a system, device, article, composition, formulation, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms “first,” “second,” and “third,” etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

[0041] The above description is intended to be illustrative, and not restrictive. For example, the above-described examples (or one or more aspects thereof) may be used in combination with each other. Other embodiments can be used, such as by one of ordinary skill in the art upon reviewing the above description. The Abstract is provided to comply with 37 C.F.R. §1.72(b), to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. Also, in the above Detailed Description, various features may be grouped together to streamline the disclosure. This should not be interpreted as intending that an unclaimed disclosed feature is essential to any claim. Rather, inventive subject matter may lie in less than all features of a particular disclosed embodiment. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment, and it is contemplated that such embodiments can be combined with each other in various

combinations or permutations. The scope of the invention should be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.

Claims

1. A fan assembly, comprising:
 - a first fan;
 - a second fan;
 - a common nozzle coupled to an outlet of both the first fan and the second fan;
 - a damper configured to close off either the first fan or the second fan in the event of failure of either the first fan or the second fan;

wherein both the first fan and the second fan run during normal operation and an RPM of a remaining good fan is increased in the event of failure of either the first fan or the second fan to compensate for the failed fan; and

further including a first motor coupled to the first fan by a drive belt, and a second motor coupled to the second fan by a drive belt, wherein the first motor is coupled to an assembly housing by a first hinge, and wherein the second motor is coupled to the assembly housing by a second hinge.
2. The fan assembly of claim 1, wherein the damper is passive, and is configured to be open to both the first fan and the second fan while both the first fan and the second fan are in operation.
3. A fan assembly, comprising:
 - a first fan;
 - a second fan;
 - an integrated common nozzle coupled between the first fan and the second fan, and a windband;
 - a damper configured to close off either the first fan or the second fan in the event of failure of either the first fan or the second fan;

wherein both the first fan and the second fan run during normal operation and further an RPM of a remaining good fan is increased in the event of failure of either the first fan or the second fan to compensate for the failed fan; and

further including a first motor coupled to the first fan by a drive belt, and a second motor coupled to the second fan by a drive belt, wherein the first motor is coupled to an assembly housing

by a first hinge, and wherein the second motor is coupled to the assembly housing by a second hinge.

4. The fan assembly of claim 3, wherein the damper configured to be actively actuated within a range of motion.

5. The fan assembly of claim 3, further including an access cover over a belt drive motor.