

Description

AIR PRE-CLEANER SPIN TUBE

Technical Field

The present disclosure relates to air pre-cleaner air tube used in
5 engines or the like to move debris, dust, particles, etc. before a pleated filter.
Specifically, the present disclosure relates to such air pre-cleaners that remove a
higher percentage of particulate than previously known.

Background

In order to for an engine to convert chemical energy stored in fuel
10 into mechanical work, the engine utilizes air from the surrounding environment
to cause the fuel to combust. However, because the air in the surrounding
environment is often laden with debris particles (e.g., dust, sand, or other
contaminants, more generally referred to as particulate), which may damage
components of the engine and/or cause inefficient combustion, etc., air filter
15 assemblies are employed to clean the incoming air.

While pre-cleaner tubes and pleated filters (including those that
employ cellulose and the like) are known in the industry. For example, U.S. Pat.
No. 4,008,059 discloses a miniature centrifugal separator for use in a n engine air
cleaner (e.g., before a fabric or cellulose filter is employed). Two clean air take-
20 off tubes may be provided that are coaxially aligned in the main flow tube for
successively removing selected fractions of the outer annular portion of the
swirling gas stream. The clean air tube may be spaced pre-selected distances
downstream from the swirl means such that entrained dust particles are enabled
to complete approximately one swirl revolution prior to encountering each tack-
25 off tube. This patent seeks to accomplish a relatively high collection efficiency
with a relatively short flow tube.

However, improved collection efficiency is still desirable over
pre-cleaner tubes that are already known in the art.

Summary

An air pre-cleaner spin tube according to an embodiment of the present disclosure may comprise a vaned inlet section including an inlet flange, and an outer tube inlet portion including an outer wall forming a nozzle that
5 defines a radial direction, and a longitudinal axis. Also, a central stem may be disposed in the nozzle, and a plurality of vanes may extend from the central stem to the outer wall.

An air pre-cleaner spin tube according to another embodiment of the present disclosure may comprise a midsection including an outer wall
10 including a first diffuser section defining a first flare angle, and a second diffuser section extending from the first diffuser section defining a second flare angle that is greater than the first flare angle. The outer wall may define a longitudinal axis, a radial direction, and a circumferential direction.

An air pre-cleaner spin tube according to yet another embodiment
15 may comprise an outlet section including an inner tubular base defining a central axis, a radial direction, and having an outlet flange including an outer face. Also, a tapered diffuser section may extend axially from the outlet flange, while a taperless outlet aperture may extend through the outlet flange, defining an outlet aperture diameter and an outlet aperture height measured from the outer face of
20 the outlet flange to the tapered diffuser section. A ratio of the outlet aperture diameter to the outlet aperture height may range from 11.6 to 17.4.

An air pre-cleaner spin tube according to an embodiment of the present disclosure may comprise a vaned inlet section including an inlet flange defining an inlet outer face, an outer tube inlet portion including an outer wall
25 forming a nozzle defining a radial direction and a longitudinal axis, a central stem, as well as a plurality of vanes extending from the central stem to the outer wall. The tube may further comprise a diffuser midsection including at least a first diffuser portion, and an outlet section including an inner tubular base defining a central axis, and a radial direction, and having an outlet flange
30 including an outlet outer face.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the disclosure and together with the description, serve to explain the principles of the disclosure. In the drawings:

FIG. 1 is a perspective view of an air pre-cleaner spin tube configured according to an embodiment of the present disclosure.

FIG. 2 is an alternate perspective view of the pre-cleaner spin tube of FIG. 1 with hidden features shown in hidden lines.

FIG. 3 is a side sectional view of the air pre-cleaner spin tube of FIG. 1 taken along lines 3-3 thereof.

FIG. 4 is a top view of the air pre-cleaner spin tube of FIG. 1.

FIG. 5 is a bottom view of the air pre-cleaner spin tube of FIG. 1.

FIG. 6 is another side sectional view of FIG. 3 (see lines 6-6 in FIG. 1).

FIG. 7 is a sectional view taken along lines 7-7 of FIG. 1 (angled about 45 degrees to lines 6-6).

FIG. 8 is a sectional view taken along lines 8-8 of FIG. 1 (angled about 45 degrees orthogonal to lines 7-7).

FIG. 9 is a sectional view taken along lines 9-9 of FIG. 1 (angled about 45 degrees orthogonal to lines 8-8).

FIG. 10 contains a table correlating features of the air pre-cleaner spin tube of FIG. 1 with their dimensions.

FIG. 11 contains another table showing improvement over a baseline design of an air pre-cleaner spin tube.

Detailed Description

Reference will now be made in detail to embodiments of the disclosure, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts. In some cases, a reference number

will be indicated in this specification and the drawings will show the reference number followed by a letter for example, 100a, 100b etc. It is to be understood that the use of letters immediately after a reference number indicates that these features are similarly shaped and have similar function as is often the case when geometry is mirrored about a plane of symmetry. For ease of explanation in this specification, letters will often not be included herein but may be shown in the drawings to indicate duplications of features discussed within this written specification.

Various embodiments of the present disclosure include an air cleaner spin tube described that may achieve an increase in separation efficiency that results in a doubling of select air cleaner group service intervals over a common industry leader in spin tube technology.

Starting with FIGS. 1 thru 3, an air pre-cleaner spin tube 100 in totality according to an embodiment of the present disclosure may comprise a vaned inlet section 200 including an inlet flange 202 defining an inlet outer face 204, an outer tube inlet portion 206 including an outer wall 208 (see FIG. 3) forming a nozzle 210 defining a radial direction 212, and a longitudinal axis 214.

As best seen in FIG. 3, a central stem 216 may be disposed in the nozzle 210, and a plurality of vanes 218 may extend from the central stem 216 to the outer wall 208. Also, a diffuser midsection 300 may be provided that include at least a first diffuser portion 302, and an outlet section 400 including an inner tubular base 402 that may define a central axis 403 (may be collinear with longitudinal axis 214), and a radial direction 404 (may be parallel with radial direction 212). In addition, the outlet section 400 may further comprise an outlet flange 406 including an outlet outer face 408. Other configurations for these various features may be provided in other embodiments of the present disclosure.

In FIG. 3, the vaned inlet section 200 may further comprise an inlet sleeve 220 (may also be referred to as a lip) extending axially from the inlet outer face 204 away from the outer tube inlet portion 206. In such a case, the inlet sleeve may define an inlet sleeve axial height 234 that ranges from 1.0 mm to 3.0 mm (e.g., the amount the inlet sleeve protrudes axially away from the inlet

outer face 204). In some embodiments, this protrusion or lip may be omitted. Also, the inlet sleeve 220 may define an aperture (e.g. inlet aperture 222) that is at least partially formed by a inlet sleeve radius 223 (see also FIG. 7) that may range from 0.9 mm to 1.1 mm in some embodiments of the present disclosure. In
5 some embodiments, the inlet sleeve may not protrude from the inlet flange 202. In such a case, a sleeve radius may or may not be provided.

Furthermore, and the outlet section 400 may include an inner tubular base 402 that has a base exit radius 414 (see also FIG. 7) at its free end that ranges from 0.15 mm to 0.35 mm in some embodiments of the present
10 disclosure. The base exit radius may be omitted in other embodiments of the present disclosure.

Moreover, a face to face axial height 102 may be provided that is measured from the inlet outer face 204 to the outlet outer face 408 that ranges from 87.5 mm to 93.5 mm in some embodiments of the present disclosure. This
15 may not be the case in other embodiments of the present disclosure.

As best seen in FIG. 6, the diffuser midsection 300 may include a second diffuser portion 304 that flares radially away from the first diffuser portion 302 at point 306 (or plane that is perpendicular to the axes 214, 403 described herein). This point 306 may be disposed a predetermined axial
20 distance 308 from the outlet outer face 408 that ranges 27.0 mm to 31.0 mm in some embodiments of the present disclosure. This may not be the case in other embodiments of the present disclosure.

As air with particulates, dust, debris, etc. enter the tube, the vanes and nozzle may create enough velocity and centrifugal force to force the
25 particulates, etc. to radial outer portions of the tube. When these particulates reach the diffuser midsection, they may slow down so that turbulence does not force them back to the center of the tube. Also, the pressure drop may be decreased by the diffuser midsection. As a result, these particulates may reach the vent and stay radially outside of the radially inner tubular base, enhancing the
30 percentage of debris that is removed without exceeding a desirable amount of pressure drop from the inlet to the outlet of the spin tube.

As shown in FIGS. 1 thru 3, etc. the tube 100 may be formed as unitary body. However, to facilitate manufacturability and serviceability, the tube 100 may be divided into different sections that are nested, attached, etc. to each other. For example, U.S. Pat. No. 4,008,059 (see FIG. 1) illustrates that at least the inlet section and the outlet section may be nested together, being formed of different components.

More specifically, one or more components or portions of the tube 100 may be manufactured using injection molding from a thermoplastic material (e.g., nylon 6/6, etc.). The nominal wall thickness of the tube may range from about 1.5 mm to 2.5 mm (e.g., 2.0 mm) in some embodiments of the present disclosure.

For example, an air pre-cleaner spin tube 100 may comprise a vaned inlet section 200 that is provided as a separate component to aid in manufacturing including an inlet flange 202, an outer tube inlet portion 206 including an outer wall 208 forming a nozzle 210, defining a radial direction 212, and a longitudinal axis 214. A central stem may 216 be disposed in the nozzle 210, and a plurality of vanes 218 may extend or connect the central stem 216 to the outer wall 208 (e.g., the outer radial wall). At least 2 vanes but not more than 4 vanes may be provided in some embodiments of the present disclosure (e.g., 3 vanes may be employed).

Focusing on FIG. 6, the inlet sleeve portion (e.g., see 220) may extend from the inlet flange 202, and may define an inlet inner diameter D220 that may range from 29.0 mm to 33.0 mm in some embodiments of the present disclosure.

In addition, the central stem 216 may extend a stem axial distance 224 (may also be referred to as the vaned tube axial distance) from an outer face 204 of the inlet flange 202, terminating at a free end 226. The stem axial distance 224 may be measured from the outer face 204 of the inlet flange 202 to the free end 226 that ranges from 30.0 mm to 34.0 mm in some embodiments of the present disclosure.

Moreover, the vaned inlet section may define a minimum outer tube inner diameter D206 that ranges from 28.0 mm to 32.0 mm in some embodiments of the present disclosure.

With continued reference to FIG. 6, the plurality of vanes 218 may
5 define a vane pitch 232 that ranges from 50.5 mm to 60.5 mm in some
embodiments of the present disclosure. It should be noted that this vane pitch
may be theoretical as the actual vanes may not extend a full vane pitch. Also, the
central stem 216 may define a stem inlet outer diameter 228 that ranges from 12.5
mm to 16.5.0 mm, as well as a stem outlet outer diameter 230 that ranges from
10 11.5 mm to 15.5 mm in some embodiments of the present disclosure. In some
embodiments, the nozzle 210 is internally defined by the central stem 216.

For example, the draft of the outside of the central stem may
match the draft of the inside of the outer wall of outer tube inlet portion. This
may not be the case for other embodiments of the present disclosure.

15 Still referring to FIG. 6, a midsection 300 may be provided that
includes an outer wall 208 including a first diffuser section (e.g., see 302)
defining a first flare angle 310, and a second diffuser section (e.g., see 304)
extending from the first diffuser section (e.g., axially) defining a second flare
angle 312 that is greater than the first flare angle 310. The outer wall may also
20 define a circumferential direction 314 (see FIGS. 3 and 4).

Focusing on FIG. 6, the outer wall in the first diffuser section may
define a minimum inner diameter 316 that ranges from 28.0 mm to 32.0 mm, and
a maximum inner diameter 318 that ranges from 30.0 mm to 34.0 mm in some
embodiments of the present disclosure. This may not be the case for other
25 embodiments.

With continued reference to FIG. 6, a portion 320 of the outer wall
extends axially downwardly from the second diffuser section (e.g., see 304),
forming a vent 322 with a vent axial height 324 that ranges from 20.5 mm to 24.5
mm in some embodiments of the present disclosure. As best seen in FIG. 2, the
30 portion 320 of the outer wall forming the vent 322 may extend circumferentially
about the longitudinal axis an angle 326 that may range 70.0 degrees to 110.0

degrees. Put another way, the vent may extend a vent angle 327 ranging from 250.0 degrees to 290.0 degrees (e.g., 270.0 degrees) in some embodiments of the present disclosure.

In FIG. 7, the outer wall in the second diffuser section defines an outlet inner diameter 328 at its end that ranges from 32.0 mm to 36.0 mm in some embodiments of the present disclosure. Other values are possible in other embodiments.

Likewise, an outlet section 400 or component may be provided that includes in inner tubular base 402 defining a central axis 403 (may be collinear with the longitudinal axis 214 previously described herein), a radial direction 404 (may be parallel to the radial direction 212 previously described herein), and an outlet flange 406 including an outer face (e.g., see 408 that faces axially outwardly). In general terms, all three sections 200, 300, and 400 are concentric with each other, but not necessarily so. Also, the outlet section 400 may have a tapered diffuser section 416 extending axially from the outlet flange 406 toward the middle of the tube 100.

In addition, a taperless outlet aperture 412 (i.e., there is less draft than the flare angles) may extend through the outlet flange 406, defining an outlet aperture diameter D412, and an outlet aperture height H412 measured from the outer face 408 of the outlet flange 406 to the tapered diffuser section 416. In some embodiments, a ratio of the outlet aperture diameter D412 to the outlet aperture height H412 ranges from 11.6 to 17.4. In some embodiments, this may not be the case.

Similarly, the tapered diffuser section extends axially to a cylindrical annular portion 420 (e.g., there is less draft than the flare angles), defining a taper axial height H416 measured from the outlet flange 406 to the cylindrical annular portion 420. A ratio of the outlet aperture diameter D412 to the taper axial height H416 may range from 3.31 to 4.97 in some embodiments of the present disclosure.

In such a case, the outlet aperture diameter D412 may range from 27.0 mm to 31.0 mm, and the outlet aperture height may range from 1.5 mm to

2.5 mm. Also, the taper axial height H416 may range from 5.0 mm to 9.0 mm in some embodiments of the present disclosure..

Still referring to FIG. 7, the inner (e.g., radially inner) tubular base 402 may define a base axial height 418 measured from the outer face (e.g., see 408) of the outlet flange 406 to a free end 422 of the cylindrical annular portion 420. Also, the cylindrical annular portion 420 may define a cylindrical annular outer diameter 424. The base axial height 418 may range from 23.0 mm to 27.0 mm, and the cylindrical annular outer diameter 424 may ranging from 22.0 mm to 26.0 mm in some embodiments of the present disclosure.

Also, the outlet section 400 may further comprise an outer annular portion (e.g., see 320) that at least partially radially surrounds the inner tubular base 402, and the outer annular portion defines an outlet inner diameter 328 that ranges from 32.0 mm to 36.0 mm in some embodiments of the present disclosure.

Again, for any of the embodiments discussed herein, the materials, and features may be modified in configuration, material, or omitted in various embodiments of the present disclosure, etc. For example, the spin tube or its components may be made from sheet metal, or molded from a plastic, etc.

Industrial Applicability

In practice, a spin tube, an inlet section of the spin tube, a midsection of the spin tube, or the outlet section of the spin tube, and/or any component or assembly/combination of these components may be sold, manufactured, bought etc. and in the aftermarket or original equipment manufacturer (OEM) scenarios according to any of the embodiments discussed herein. That is to say, the components, subassembly, and/or assembly may be sold with an engine or a machine using an engine in the OEM (original equipment manufacturer) or aftermarket contexts.

In use, a technician may service or replace the spin tube as a whole or as separate components as alluded to earlier herein.

The inventors of the present disclosure have performed a CFD analysis (computational fluid dynamics) on the spin tube using various boundary conditions and design constraints.

For example, a pressure boundary of 1 atm was set at the inlet of the spin tube, an assumption of symmetry was employed in the model, and an
5 volumetric air flow of 0.648 m^3 was set at the outlet of tube. The particles were seeded at the pressure boundary, and the particle velocity was assumed to be the same as the local fluid velocity. Particles were grouped according to a particle size distribution table. The mass flow of each size of the particle was calculated
10 using the particle volume fraction distribution in the table. Also, one way coupling for LPT (Lagrangian particle tracking assuming small particle mass fraction) was also modeled. Gravitational effects were neglected.

CFD calculations for 500 scenarios were then evaluated, then the “New” design was chosen as meeting the desired performance criteria.
15 Specifically as shown by the table of FIG. 11, the desired maximum pressure drop of 1312 Pa was not exceeded, and the particle removal efficiency was increased by 5.0% or more as compared to the baseline spin tube design.

Surprisingly, the inventors found that the nozzle in conjunction with the stationary vanes caused the incoming air (see arrows 500 in FIGS. 2 and
20 7) to spin more rapidly, leading to a larger centrifugal force that spun out dust and dirt toward the outer wall(s) (see arrows 502 in FIGS. 2 and 8). The diffuser midsection unexpectedly slowed down the air, reducing pressure drop and allowing the dust and dirt to still be removed with scavenged air flow out the vent. This win-win scenario (design tradeoff was broken) may be attributed to
25 the decrease in air flow turbulence near the outer wall as scavenging takes place. Clear air (see arrows 504 in FIGS. 2 and 7) was free to continue on through the spin tube to the primary air cleaner (e.g. such as a filter with pleated filter media or the like), or to the engine, or other apparatus as desired.

As used herein, the articles “a” and “an” are intended to include
30 one or more items, and may be used interchangeably with “one or more.” Where only one item is intended, the term “one” or similar language is used. Also, as

used herein, the terms “has”, “have”, “having”, “with” or the like are intended to be open-ended terms. Further, the phrase “based on” is intended to mean “based, at least in part, on” unless explicitly stated otherwise.

It will be apparent to those skilled in the art that various
5 modifications and variations can be made to the embodiments of the apparatus
and methods of assembly as discussed herein without departing from the scope or
spirit of the invention(s). Other embodiments of this disclosure will be apparent
to those skilled in the art from consideration of the specification and practice of
the various embodiments disclosed herein. For example, some of the equipment
10 may be constructed and function differently than what has been described herein
and certain steps of any method may be omitted, performed in an order that is
different than what has been specifically mentioned or in some cases performed
simultaneously or in sub-steps. Furthermore, variations or modifications to
certain aspects or features of various embodiments may be made to create further
15 embodiments and features and aspects of various embodiments may be added to
or substituted for other features or aspects of other embodiments in order to
provide still further embodiments.

Accordingly, it is intended that the specification and examples be
considered as exemplary only, with a true scope and spirit of the invention(s)
20 being indicated by the following claims and their equivalents.

Claims

1. An air pre-cleaner spin tube (100) comprising:
a vaned inlet section (200) including
an inlet flange (202);
5 an outer tube inlet portion (206) including an outer wall (208)
forming a nozzle (210) defining a radial direction (212) and a longitudinal axis
(214);
a central stem (216) disposed in the nozzle (210); and
a plurality of vanes (218) extending from the central stem (216) to
10 the outer wall (208).
2. The air pre-cleaner spin tube (100) of claim 1, wherein the
plurality of vanes (218) includes at least 2 vanes (218) but not more than 4 vanes
(218).
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3. The air pre-cleaner spin tube (100) of claim 2, wherein the
plurality of vanes (218) includes 3 vanes (218).
4. The air pre-cleaner spin tube (100) of claim 3, further
20 comprising an inlet sleeve portion (220) that extends from the inlet flange (202)
and defines an inlet inner diameter (D220) that ranges from 29.0 mm to 33.0 mm.
5. The air pre-cleaner spin tube (100) of claim 4, wherein the
central stem (216) extends from an outer face (204) of the inlet flange (202),
25 terminating at a free end (226), and defining a stem axial distance (224) measured
from the outer face (204) of the inlet flange (202) to the free end (226) that ranges
from 30.0 mm to 34.0 mm.

6. The air pre-cleaner spin tube (100) of claim 5, wherein the vaned inlet section (200) defines a minimum outer tube inner diameter (D206) that ranges from 28.0 mm to 32.0 mm.

5 7. The air pre-cleaner tube of claim 2, wherein the plurality of vanes (218) define a vane pitch (232) that ranges from 50.5 mm to 60.5 mm, the central stem (216) defines a stem inlet outer diameter (228) that ranges from 12.5 mm to 16.5.0 mm, and a stem outlet outer diameter (230) that ranges from 11.5 mm to 15.5 mm such that the nozzle (210) is internally defined by the central
10 stem (216).

8. An air pre-cleaner spin tube (100) comprising:
a midsection (300) including
an outer wall (208) including a first diffuser section (302) defining
15 a first flare angle (310), and a second diffuser section (304) extending from the first diffuser section (302) defining a second flare angle (312) that is greater than the first flare angle (310);

wherein the outer wall (208) defines a longitudinal axis (214), a radial direction (212), and a circumferential direction (314).
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9. The air pre-cleaner spin tube (100) of claim 8, wherein the outer wall (208) in the first diffuser section (302) defines a minimum inner diameter (316) that ranges from 28.0 mm to 32.0 mm, and a maximum inner diameter (318) that ranges from 30.0 mm to 34.0 mm.

25 10. The air pre-cleaner spin tube (100) of claim 8, wherein a portion (320) of the outer wall (208) extends axially downwardly from the second diffuser section (304), forming a vent (322) with a vent axial height (324) that ranges from 20.5 mm to 24.5 mm, the portion (320) of the outer wall (208)
30 forming the vent (322) extends circumferentially about the longitudinal axis (214) an angle (326) that ranges from 70.0 degrees to 110.0 degrees, and the

outer wall (208) in the second diffuser section (304) defines an outlet inner diameter (328) that ranges from 32.0 mm to 36.0 mm.