(51) International Patent Classification:
F02D 9/10 (2006.01)  F16K 1/22 (2006.01)

(21) International Application Number:
PCT/US20 10/03 1766

(22) International Filing Date:
20 April 2010 (20.04.2010)

(25) Filing Language:
English

(26) Publication Language:
English

(30) Priority Data:
61/170,942 20 April 2009 (20.04.2009) US
61/3 17,349 25 March 2010 (25.03.2010) US

(71) Applicant (for all designated States except US): INTER-
ATIONAL ENGINE INTELLECTUAL PROPERTY COMPANY, LLC [US/US]; 4201 Winfield Road, Warrenville, IL 60555 (US).

(72) Inventors; and

(54) Title: THROTTLE VALVE AND METHOD OF FABRICATION

(57) Abstract: A valve has a body having a fluid passageway and an opening; a shaft-plate assembly comprising a shaft and a plate coupled to the shaft; and a cover secured to the body and covering the opening. The cover has a shaft bore that receives the shaft of the shaft-plate assembly. The shaft-plate assembly is rotatable within the fluid passageway. A method of manufacture of a valve includes providing a body having a fluid passageway and an opening; providing a shaft-plate assembly comprising a shaft and a plate coupled to the shaft; providing a cover comprising a shaft bore. The method further includes inserting the shaft of the shaft-plate assembly into the shaft bore of the cover; positioning the plate of the shaft-plate assembly within the fluid passageway through the opening; and securing the cover to the body.
THROTTLE VALVE AND METHOD OF FABRICATION

BACKGROUND
[0001] In the truck industry, exhaust throttle valve designs are used to serve several different applications. For example, some are for engine brakes (increasing the exhaust backpressure to load down the engine for braking the vehicle), others are for exhaust diversion or engine exhaust bank balancing or turbo charger overpressure management, and yet others are for thermal management of exhaust gas emission mitigating devices. These throttle valves typically have a conventional throttle plate design, in which a shaft carrying the throttle plate serves as a flow modulator according to the shaft position inside the bore. In general all these valves are of single piece throttle body design with the plate being assembled to the shaft through the inlet or outlet port of the throttling device.

SUMMARY
[0002] A valve is described. In one embodiment, a valve has a body having a fluid passageway and an opening; a shaft-plate assembly comprising a shaft and a plate coupled to the shaft; and a cover secured to the body and covering the opening. The cover has a shaft bore that receives the shaft of the shaft-plate assembly. The shaft-plate assembly is rotatable within the fluid passageway.

[0003] In at least one embodiment, a method of manufacture of a valve is provided. The method includes providing a body having a fluid passageway and an opening; providing a shaft-plate assembly comprising a shaft and a plate coupled to the shaft; providing a cover comprising a shaft bore. The method further includes inserting the shaft of the shaft-plate assembly into the shaft bore of the cover; positioning the plate of the shaft-plate assembly within the fluid passageway through the opening; and securing the cover to the body.
BRIEF DESCRIPTION OF THE DRAWINGS

In order to facilitate a fuller understanding of the exemplary embodiments, reference is now made to the appended drawings. These drawings should not be construed as limiting but are intended to be exemplary only.

FIG. 1 is a perspective view of a throttle plate assembly in accordance with an exemplary embodiment.

FIG. 2 is a perspective view of a throttle valve, in accordance with an exemplary embodiment.

FIG. 3 is a perspective view of a throttle valve with the cover removed, in accordance with an exemplary embodiment.

FIG. 4 is a top view of a throttle valve with the cover removed, in accordance with an exemplary embodiment.

FIG. 5 is an exploded view of a cover and throttle plate assembly, in accordance with an exemplary embodiment.

FIG. 6 is a top view of a throttle valve with the cover removed, and the throttle plate assembly inserted, in accordance with an exemplary embodiment.

FIG. 7 is a sectional view of a throttle valve, taken along 7-7 of FIG. 6.

FIG. 8 is an illustration of a throttle valve in accordance with an exemplary embodiment.

FIG. 9 is an illustration of a throttle valve in accordance with an exemplary embodiment.

FIG. 10 is an illustration of a throttle valve in accordance with an exemplary embodiment.
FIGS. 11 a-d are illustrations of exemplary throttle bodies in accordance with the embodiments.

DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

The following description is intended to convey a thorough understanding of the embodiments by providing a number of specific embodiments and details involving a throttle valve. It is understood, however, that the invention is not limited to these specific embodiments and details, which are exemplary only. It is further understood that one possessing ordinary skill in the art, in light of known devices, systems, and methods, will appreciate the use of the invention for its intended purposes and benefits in any number of alternative embodiments.

Generally speaking, the throttle valve of the exemplary embodiments has a two piece throttle body design having a throttle body and a cover, and a unique single piece throttle shaft/plate. This type of two piece throttle body assembly may provide advantages over conventional valve assemblies, such as, for example, where the throttle plate is larger than the flow passages and the access is not in the line of sight through the inlet and outlet ports. The exemplary embodiments may provide additional advantages over conventional valve assemblies because the inlet and outlet bore geometry may be more independent of the actuator.

Referring to FIGS. 2 and 7, in exemplary embodiments, the throttle valve 100 has a throttle body/manifold 200 that has a passageway 220 providing at least one fluid inlet 222 and at least one fluid outlet 224. In exemplary embodiments, the throttle body/manifold 200 may have multiple passageways 200, providing multiple inlets 222 and outlets 224. The passageways 220 converge at hub 240, where a rotating throttle plate assembly 400 selectively controls the fluid flow between the passageways 220.
Referring to FIGS. 2-4, in an exemplary embodiment, at the hub 240, the throttle body/manifold 200 has an opening 210 and a cover 300 covering the opening. The opening 210 may have any suitable size and shape that is sufficient to enable the insertion of the throttle plate assembly 400 into the passageway 220. For example, referring to FIG. 6, opening may be a generally circular opening having a diameter greater than the width of throttle plate portion 410.

In exemplary embodiments, a cover 300 is provided to seal the opening 210. In exemplary embodiments, the cover 300 may be permanently or temporarily fastened to the throttle body/manifold 200. For example, referring to FIG. 2-4, cover 300 may have a fastening flange 310 that joins with a corresponding fastening flange 260 on the throttle body/manifold 200. One or more fasteners 340 may join the corresponding fastening flanges 310, 260. A seal 320 may optionally be provided between the cover 300 and the throttle body/manifold 200 to provide a sealed surface. Other suitable fastening means may be provided to join the cover 300 and the throttle body/manifold 200, such as, for example, welding, press fitting, engaging notch/groove assemblies, adhesive attachment, crimping, orbital forming, etc., including combinations of the foregoing.

In an exemplary embodiment, the cover 300 has an inner surface 302 that may form at least a part of one or more of the passages 220. For example, referring to FIG. 7, the inner surface 302 of cover 300 is curved, to form an upper portion of passageway 220. In one embodiment, the inner surface 302 of the throttle plate 410 may form a seal against at least part of the inner surface 302 of the cover 300.

In exemplary embodiments, cover 300 may have one or more features to align and/or retain the throttle plate assembly 400 within the valve 100. In various embodiments, the cover 300 forms part of the seating surface for the shaft 420 of the throttle plate assembly 400.
For example, referring again to FIG. 7, cover 300 has a shaft bore 330 that receives at least a portion of the shaft 420. In various embodiments, a bushing or bearing 332 may be disposed between the shaft bore 330 and the shaft 420.

[0023] Referring to FIG. 1, in various exemplary embodiments, the throttle plate assembly 400 has a shaft portion 420, and a plate portion 410. In an exemplary embodiment, throttle plate portion 410 and a throttle shaft portion 420 that are unitary with each other. In other embodiments, the throttle plate portion 410 and shaft portion 420 are separately formed, and otherwise joined together. The shaft portion 420 generally provides an axis of rotation for the throttle plate 410. In various embodiments, the shaft portion 420 may be disposed at about the centerline of the throttle plate 410. In other embodiments, the shaft 420 may be offset from the centerline of the throttle plate 410, providing an off-center axis of rotation. Where the axis of rotation is off-center to the throttle plate 410, unbalanced forces may be achieved, such as to bias the throttle plate 410 to an open or a closed position.

[0024] In exemplary embodiments, throttle plate 410 may have any suitable shape that enables it to rotate within the passageway 220, and provide a seal with portions of the passageway 220, as described herein. The throttle plate assembly 400, or any portion thereof, may be made of any suitable material, such as, for example, aluminum, cast iron, stainless steel, plastic, etc. The throttle plate 410 may have various other contours or devices, as necessary or desired, to provide necessary or desired structural or fluid flow characteristics. For example, the throttle plate 410 may have one or more aperture to provide a calibrated leak when the throttle plate 410 is in a closed position, or may have ribs toward the shaft portion to provide desired linear or nonlinear flow characteristics about the plate 410.
In various exemplary embodiments, the throttle plate assembly 400 is rotatably coupled with the throttle body 200. For example, the throttle plate 410 may be coupled with throttle body/manifold 200 so that it may rotate between an open position and a closed position in which the throttle plate 410 substantially blocks fluid flow, or between a first position and a second position. In a closed position, the throttle plate 410 may be configured to provide a seal against one or more surfaces of the throttle body passage 220, to prevent fluid flow between the throttle plate 410 and the passage 220. For example, the throttle plate 410 may be configured to provide a circumferential seal, an angular seal, a face seal, or the like, with the surface of the passage 220, including a combination of the foregoing seals.

Referring to FIG. 5, the throttle plate assembly 400 may couple with the throttle body/manifold 200 and/or cover 300 which retain the throttle plate assembly 400 in use. For example, shaft portion 420 may be received within shaft bore 330 of cover 300. A lower appendage 440 may be coupled with a lower bushing 450, which may be seated in a bore 250 in the throttle body/manifold 200 (seen in FIG. 4).

In various exemplary embodiments, the profile of the throttle plate 410 may have any suitable shape sufficient to enable it to rotate within the throttle body passage 220, and form a seal against one or more surfaces of the passage 220. Referring to FIG. 1, in an exemplary embodiment, the single piece throttle plate 410 may be a flat plate, having a first plate cheek 412, and a second plate cheek 414 that are generally co-planar about the shaft 420. Where the inner surface of the passageway 220 is asymmetrical or contoured, the throttle plate 410 may have a unique shape to follow the internal contours of the throttle body passageway 220 to reduce flow losses and turbulence. For example, the throttle plate 410 may have a symmetrical shape, or it may have an asymmetrical shape. In exemplary embodiments, the throttle plate 410 may have a
circular, oval, polygonal, heart, kidney, egg shape or any shape suitable for providing a seal with
the adjacent surfaces of the passageway 220.

[0028] Referring to FIG. 9, in various exemplary embodiments, the single piece throttle
plate 410 may be cast into an angled or angular shape, such as where a first plate cheek 412 and
second plate cheek 414 form an angle from about 90 degrees to about 180 degrees about the
shaft 420. In another exemplary embodiment, the throttle plate 410 may have a first plate cheek
412 that is parallel to, but offset from, second plate cheek 414. An angled or offset throttle plate
410 may provide a unique predetermined flow pattern within the valve 100. For example, the
angled configuration may be used in a uni-directional flow valve, such as to provide a constant
leak when the valve is in a closed position. Alternatively, as shown in FIG. 9, the angled or
offset throttle plate 410 may be used in a multiple-flow passage, such as to control flow between
multiple converging or diverging passageways.

[0029] In an exemplary embodiment, the throttle plate 410 may have a throttle plate 410
having variable thickness. For example, referring to FIG. 8, an exemplary throttle plate 410 may
have one or more cheeks that has a proximal thickness (adjacent to the shaft 420), and a distal
thickness (adjacent the edge) greater than the proximal thickness. Another exemplary throttle
plate 410 may have one or more cheeks that has proximal thickness that is greater than the distal
thickness. It will be appreciated that an exemplary throttle plate 410 may have any combination
thereof. As shown in FIG. 8, an exemplary V-shaped plate may have a first cheek 412 having a
proximal thickness that is greater than a distal thickness, and a second cheek 414 having a distal
thickness greater than a proximal thickness. Providing a V-shaped throttle plate 410 having a
variable thickness may help to better control the flow around the throttle plate 410 as the throttle
plate 410 initially rotates about the shaft 420.
In an exemplary embodiment, one or more of the throttle plate 410 and the passageway 220 may be configured to optimize the dynamic fluid flow through the valve 100 as the throttle plate 410 rotates. For example, referring to FIG. 10, in an exemplary embodiment, the passage 220 may have at least one contoured surface 230 adjacent the edge of the throttle plate 410. As the throttle plate 410 initially rotates from its closed position toward an open position, such as for about the initial 20 degrees of rotation, the gap between the edge of the throttle plate 410 and the contoured surface 230 may remain constant or change only slightly, providing a low change in pressure, and limiting the flow around the throttle plate 410. In an exemplary embodiment, the contour surface 230 may be configured to have a circular profile, in which the distance between the distal edge of the throttle plate 410 and the contoured surface 230 remains relatively constant, which may provide no flow or constant flow for a certain range of rotation of the throttle plate 410. In another exemplary embodiment, the contour surface 230 may be configured to have a parabolic profile, whereby the distance between the distal edge of the throttle plate 410 and the contoured surface 230 changes only slightly over a certain range of rotation of the throttle plate 410, such as to provide precise flow modulation. The contoured surface 230 may be provided adjacent one or both cheeks (412, 414) of the throttle plate 410.

In exemplary embodiments, the throttle plate assembly 400 may have certain features that restrict the throttle plate assembly 400 from moving axially inside the throttle body 200. For example, referring to FIGS. 1 and 7, the throttle plate assembly 400 may have a shoulder 430 that may cooperate with a corresponding structure on the throttle body 200 or cover 300, to prevent the throttle plate assembly 400 from moving axially inside the throttle body 200. Restricting the axial movement of the throttle plate assembly 400 may reduce friction between the throttle plate 410 and the passageway 220 in the valve 100. Conversely, enabling axial
movement of the throttle plate assembly 400 may help to avoid interference of thermally expanding parts. The axial movement of the throttle plate assembly 400 may be adjusted as necessary or desired to suit a particular throttle valve design.

[0032] In some embodiments, additional shaft sealing means may be used to further reduce the lateral leakage (i.e., leakage about the shaft 420). For example, labyrinth seals, spring energized axial seals, radial sealing rings (piston rings), etc. may be provided about the shaft portion 420, particularly in high temperature applications. In some embodiments, particularly for applications below 300°C, spring or elastomeric energized Teflon® based shaft seals can be used to reduce the lateral leakage by the shaft 420.

[0033] Referring to FIGS. 11a-I Id, in an exemplary embodiment, the throttle valve 100 may have multiple passageways 220 and/or throttle plate assemblies 400, in series and/or in parallel. For example, FIGS. 7b-d show exemplary throttle bodies 200 having two, three, and four passageways 220, respectively, in parallel. It will be understood that each of the multiple passageways 220 and/or throttle plate assemblies 400 may have similar features as those described above.

[0034] In exemplary embodiments, the valve 100 may be driven by any suitable actuator means. For example, the valve 100 may be driven by electric, hydraulic, or mechanical means. In exemplary embodiments, the valve 100 may be driven by an integrated actuator, or it may be driven by a remote actuator. Exemplary actuators are described in U.S. Pat. No. 7,591,245 and U.S. Pat. No. 7,658,177, the disclosures of which are incorporated herein by reference in their entirety. One having ordinary skill in the art would recognize the various actuating means that would be suitable for use in the embodiments described herein.
Referring to FIGS. 5 and 7, in various embodiments, the actuator is coupled to the throttle plate assembly 400 with actuator coupling linkage 350. Actuator coupling linkage may be any linkage device suitable for directly or indirectly coupling the actuator with the throttle plate assembly 400. For example, the actuator coupling linkage 350 may be an arm that is fastened to the shaft 410, such as with a screw fastener or the like.

In exemplary embodiments, a method of making a throttle valve 100 includes a step of providing a throttle body 200 having a passageway therethrough. A throttle body 200 may be made by any suitable method for forming a throttle body 200. An exemplary method includes the step of providing an opening 210 in the throttle body 200. The opening has a predetermined size, shape, and configuration so that a throttle plate assembly 400, and/or throttle plate 410 may be inserted through the opening into the passageway 220 of the throttle body. In exemplary embodiments, the method includes inserting a throttle plate 410 through the opening into the passage of the throttle body. A cover 300 may be attached to the throttle body 200, to seal the opening 210, and prevent axial movement of the throttle plate assembly 410.

In exemplary embodiments, the single piece throttle plate assembly 400 may be manufactured using any suitable manufacturing process. For example, the throttle plate assembly 400 may be manufactured using a forging, sand casting, investment casting or billet machining process. In an exemplary method of manufacture, a rough one-piece workpiece may be cast. The cast throttle shaft/plate may then be machined to shape certain features such as journals and axial end-stops that assure centering of the throttle plate assembly 400 within the two piece throttle body 200. For example, the rough cast part may be machined using a form grinding, centerless grinding, on center grinding, hard machining, wire Electrical Discharge Machining (EDM), or plunge EDMing process. One having ordinary skill in the art would
understand the various methods that could be used to provide a throttle plate assembly 400 having the features described herein.

[0038] In an exemplary embodiment, assembling the throttle valve 100 may be simplified when compared to the assembly of conventional air valves. For example, most conventional valves are assembled by inserting a shaft through a shaft bore, inserting a throttle plate through one of the passageways, and assembling the shaft and the throttle plate within the passageway. In the exemplary embodiments, the throttle plate assembly 400 may simply be inserted through the opening 210 in the throttle body/manifold 200, and seated in a bore 250 in the throttle body/manifold 200. Cover 300 may then be joined with the throttle body/manifold 200, such as by joining mating fastening flanges 340, 260. This simplified method of assembly also provides more flexibility in the throttle plate 410 and passageway 220 design. For example, the size of the throttle plate 420 is not necessarily bound by the size of the passageway 220 upstream or downstream of the hub 240. The throttle plate 420 and passageway 220 may have any suitable size and shape so long as the opening 210 and the portion of the passageway 220 adjacent to the throttle plate 420 are configured to enable the throttle plate 420 to be inserted and rotated within the passageway 220.

[0039] In the preceding specification, various embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments implemented, without departing from the broader scope of the exemplary embodiments as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.
What is claimed is:

1. A valve comprising:
   a body having a fluid passageway and an opening;
   a shaft-plate assembly comprising:
      a shaft; and
      a plate coupled to the shaft.
   a cover secured to the body and covering the opening, the cover comprising a shaft bore
   that receives the shaft of the shaft-plate assembly;
   wherein the shaft-plate assembly is rotatable within the fluid passageway.

2. The valve of claim 1, wherein the shaft-plate assembly is of a unitary construction.

3. The valve of claim 1, wherein the plate is flat.

4. The valve of claim 1, wherein the plate is V-shaped.

5. The valve of claim 1, wherein the plate comprises at least one contour on a circumference
   of the plate.

6. The valve of claim 1, wherein the plate comprises at least one opening.

7. The valve of claim 1, wherein the plate is textured.

8. The valve of claim 1, wherein the plate comprises a seal on a circumference of the plate.

9. The valve of claim 1, further comprising an actuator for rotating the shaft-plate assembly.

10. The valve of claim 1, wherein the shaft is offset from a centerline of the plate.

11. The valve of claim 1, wherein the shaft is centered on a centerline of the plate.
12. The valve of claim 1, wherein the cover comprises an inner surface that is part of the fluid passageway.

13. The valve of claim 1, wherein the valve is a throttle valve.

14. A method of manufacture of a valve comprising:
   providing a body having a fluid passageway and an opening;
   providing a shaft-plate assembly, the shaft assembly comprising a shaft; and a plate coupled to the shaft;
   providing a cover comprising a shaft bore;
   inserting the shaft of the shaft-plate into the shaft bore;
   positioning the plate of the shaft-plate within the fluid passageway through the opening;
   and
   securing the cover to the body.

15. The method of manufacture of claim 14, wherein the shaft-plate assembly is of a unitary construction.

16. The method of manufacture of claim 14, wherein the plate is flat.

17. The method of manufacture of claim 14, wherein the plate is V-shaped.

18. The method of manufacture of claim 14, wherein the plate comprises at least one contour on a circumference of the plate.

19. The method of manufacture of claim 14, wherein the plate comprises at least one opening.

20. The method of manufacture of claim 14, wherein the plate is textured.
21. The method of manufacture of claim 14, wherein the plate comprises a seal on a circumference of the plate.

22. The method of manufacture of claim 14, further comprising providing an actuator for rotating the shaft-plate assembly.

23. The method of manufacture of claim 14, wherein the shaft is offset from a centerline of the plate.

24. The method of manufacture of claim 14, wherein the shaft is centered on a centerline of the plate.

25. The method of manufacture of claim 14, wherein the cover comprises an inner surface that is part of the fluid passageway.

26. The method of manufacture of claim 14, wherein the shaft plate is positioned within the fluid passageway through the opening before the shaft is inserted into the shaft bore.
INTERNATIONAL SEARCH REPORT

A CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F02D 9/10, F16K 1/22 (2010 01)
USPC - 188/273, 251/305
According to International Patent Classification (IPC) or to both national classification and IPC

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - F02D 9/00, 9/04, 9/06, 9/08, 9/10, F16K 1/22 (2010 01)
USPC - 60/524, 602, 123/323, 188/273, 251/305

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents

C DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where applicable, of the relevant passages</th>
<th>Relevant to claim No</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5,503,367 A (THOMPSON et al) 02 April 1996 (02 04 1996) entire document</td>
<td>1-3, 5, 7, 9, 11, 13-16, 18, 20, 22, 24, 26</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,174,547 A (VUILLEMOZ) 29 December 1992 (29 12 1992) entire document</td>
<td>4, 6, 8, 10, 12, 17, 19, 21, 23, 25</td>
</tr>
<tr>
<td>Y</td>
<td>US 4,083,529 A (SANTY et al) 11 April 1978 (11 04 1978) entire document</td>
<td>8, 21</td>
</tr>
<tr>
<td>Y</td>
<td>US 4,347,068 A (COOPER) 31 August 1982 (31 08 1982) entire document</td>
<td>12, 25</td>
</tr>
</tbody>
</table>

D Further documents are listed in the continuation of Box C

Date of the actual completion of the international search
01 June 2010

Date of mailing of the international search report
18 JUN 2010

Name and mailing address of the ISA/US
Mail Stop PCT, Attn ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No 571-273-3201

Authorized officer
Blaine R. Copenhagen
PCT Helpdesk 571-272-4300
PCT OSP 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)