

## FUEL CONDITIONING APPARATUS

### 5 Field of the Invention

The present invention relates to a fuel conditioning apparatus particularly, though not exclusively for an internal combustion engine.

10

### Background of the Invention

The present Inventor is the Inventor of a fuel supply system described in International Application No.

15 WO2003/056165. This system comprises a housing defining a chamber and provided with an inlet opening upstream of the chamber and an outlet opening downstream of the chamber. A fuel injector sprays a fuel mist into the chamber, and a heater heats air flowing into the chamber via the inlet to  
20 a temperature of between 110°C to 260°C. Pressure within the chamber is negative relative to ambient temperature. The fuel sprayed into the chamber by the fuel injector is thermally cracked so that a mixture of cracked fuel and heated air flows from the outlet to a combustion chamber  
25 in an associated internal combustion engine.

### Summary of the Invention

According to the present invention there is provided a  
30 fuel conditioning apparatus comprising:

a housing defining a chamber and provided with an inlet upstream of the chamber and an outlet downstream of the chamber;

35 a hemispherical seat with a first end in fluid communication with the inlet and a second end in fluid

- 2 -

communication with the chamber, the second end lying in a plane containing a diameter of the hemispherical seat;

5 a valve body comprising a curved surface and a planar surface extending across the curved surface, the valve body being movable between a closed position where the valve body seals the inlet, and an open position where the valve body is spaced from the inlet to produce a gap  
10 to flow through the first and second ends into the chamber; and,

a bias device that biases the valve body toward the closed position.

15 Preferably the curved surface is hemispherical in shape having a radius substantially the same as a radius of said seat, whereby when said valve body is in said closed position said planar surface lies in the plane containing  
20 the diameter of the seat.

Preferably the fuel conditioning apparatus further comprises a fuel delivery system that delivers fuel to the chamber.

25 Preferably the fuel delivery system sprays fuel into the chamber in a direction across the gap.

30 Preferably the fuel delivery system comprises one or more openings or jets that can open onto the internal surface near the second opening.

35 Preferably the chamber comprises an internal surface with a first portion that extends upward and outward from the second end toward the outlet.

- 3 -

Preferably the first portion of the internal surface is concavely curved when viewed in a direction from the outlet to the inlet.

5 Preferably the air is fresh air.

Preferably the apparatus further comprises a shaft associated with the valve body to guide the valve body when moving between the closed position and opened  
10 position.

Preferably the shaft extends through a passage formed in the valve body perpendicular to the planar surface and along a radius of the valve body.  
15

Preferably the bias device is mounted on the shaft.

Preferably the bias device applies a pressure in the order of one bar on the valve body.  
20

Preferably the apparatus further comprises a plate lying parallel to the planar surface and located centrally of a longitudinal axis of the chamber between the second end and the outlet, the plate dimensioned to provide an  
25 annular space between the plate and adjacent portion of the internal surface of the chamber.

Preferably the apparatus further comprises a first mesh screen extending across the chamber and located between  
30 the plate and the outlet.

Preferably the apparatus comprises a second mesh screen extending across the chamber and located between the first mesh and the outlet.  
35

Brief Description of the Drawings

An embodiment of the present invention will now be described only with reference to the accompanying drawings  
5 in which:

Figure 1 is a schematic representation of a first embodiment of a fuel conditioning apparatus in accordance with the present invention;  
10  
Figure 2 is a plan view of the fuel conditioning apparatus along line AA shown in Figure 1; and,  
Figure 3 is an enlarged partial view of the fuel  
15 conditioning apparatus.

Detailed Description of the Embodiment

Referring to Figure 1, a fuel conditioning system 10  
20 comprises a housing 12 defining a chamber 14 and provided with an inlet 16 upstream of the chamber 14 and an outlet 18 downstream of the chamber 14. A hemispherical seat 20 is formed in the housing 10 with a first end 22 in communication with the inlet 16, and a second end 24 in  
25 communication with the chamber 14. Second end 24 lies in plane containing a diameter of the seat 20. A valve body 26 is received within the seat 20 and comprises a curved surface 28 and a planar surface 30 which extends across the curved surface 28. The valve body 26 is movable  
30 between a closed position where the valve body 26 seals the inlet 16 (and the first end 22) and an open position where the valve body is spaced from the inlet 16 to allow air presented at the inlet 16 to flow through the first end 22 between the seat 20 and curved surface 28, and  
35 through a gap 38 between the second end 24 and an adjacent portion of the valve body 26 into the chamber 14. A bias device in the form of a spring 32 biases the valve body 26

- 5 -

toward the closed position. Fuel is injected into the chamber 14 by a fuel delivery system which in this embodiment comprises a fuel injector 34.

- 5 The fuel conditioner 10 is ideally suited for coupling to an internal combustion engine (not shown) via an intake manifold 36 connected to the outlet 18. Due to the coupling with intake manifold 36 of an internal combustion engine, a relative negative pressure is induced in the  
10 chamber 14. This pressure acts on a valve body 26 to lift it from the seat 20 against the bias of the spring 32.

Fresh air is delivered via a conduit 42 coupled to the inlet 16. The fresh air is drawn from over an exhaust  
15 manifold (not shown) associated with an engine to which the fuel conditioner 10 is attached. This heats the air to between about 30°C to 260°C after the engine has reached normal operating temperature.

- 20 Fuel injected into the chamber 14 is thermally cracked by collision with molecules of the heated air to form a thermally cracked fuel and heated air mixture.

Throughout this specification, the term "thermal cracking"  
25 in relation to fuel is used to mean vaporisation, volatilisation, or decomposition of high molecule weight hydrocarbons to lower weight molecule hydrocarbons, or any combination thereof.

- 30 The chamber 14 has an internal surface 46 a first portion 48 of which extends generally upward and outward from the second end 24 toward to the outlet 18. While the surface may be linearly inclined it is believed more preferable for the first portion 48 to be concavely curved when  
35 viewed in a direction from the outlet 18 to the inlet 16. More particularly, first portion 48 comprises a portion of a sphere intersected by two parallel planes, one of a

- 6 -

diameter greater than that of the hemispherical seat 20, and the other of a diameter identical to that of opening 24. Formed contiguously with the first portion 48 is a second portion 50 of the internal surface 46 which is of constant diameter. A third portion 52 of the internal surface 46 extends contiguously from the second portion 50 in a downstream direction toward the outlet 18 and has a progressively decreasing internal diameter. The third portion 52 in this embodiment is configured as a mirror image of the first portion 48. However in alternate embodiments, the third portion 52 may be formed as an extension of the second portion 50 having a constant inner diameter. In a further alternate embodiment, the third portion 52 can be formed with a lineally decreasing inner diameter in the downstream direction.

A shaft 54 is associated with the valve body 26 to guide the valve body 26 when moving between the closed position and the open position. Moreover, the shaft 54 extends into a passage 56 formed in the valve body 26 perpendicular to the planar surface 30 and along a radius of the valve body 26. Opposite ends of the shaft 54 are seated in the conduit 42 and intake manifold 36. The spring 32 is retained on the shaft 54 and acts between the planar surface 30 and a bush 58 held centrally within a plate 60 lying parallel to the planar surface 30.

Ideally the shaft 54 and spring 32 are made of stainless steel with the bush 58 being made of brass.

The plate 60 is spaced from the second opening 26 by, and supported on, a plurality of pins 62 that extend parallel to the shaft 54. The plate 60 is dimensioned to provide an annular space 64 between the plate 60 and an adjacent portion of the internal surface 46 of the chamber 14. The plate 60 is of the diameter ranging from about the diameter of the second opening 24 to approximately 85% of

- 7 -

the maximum internal diameter of the chamber 14. In this embodiment the plate 60 is at substantially the same level as the transition from surface portion 48 to surface portion 50.

5

A first mesh screen 66 extends across the chamber between the plate 60 and the outlet 18. The mesh 66 is parallel to the second opening 24 and may be made from stainless steel wire with the ratio of wire area to total screen area being from about 1:5 to 1:9 but preferably about 1:7.

10

A second mesh screen 68 of similar construction to, and parallel with, the first screen 66 extends across the chamber 14 between the first mesh screen 66 and the outlet 18.

15

The fuel injection system also comprises a fluid gallery 70 formed internally in the housing 12 which is in fluid communication with the fuel injector 34, and a plurality of openings or jets 72 (see Figure 2) that spray fuel laterally into the chamber 14. More particularly, the jets 72 spray the fuel across the gap 38 laterally onto the valve body 26 from a location adjacent the transition from the seat 20 to the first surface portion 48.

20

25

With reference to Figures 1 and 3, the valve body 26 is of hemispherical shape and of a complimentary configuration of the seat 20 so that the body 26 can be fully seated in the seat 20 with the surface 28 contacting the seat 20 and the planar surface 30 lying in a plane containing the opening 24.

30

When the valve body 26 is lifted from the seat 20 by application of vacuum in the chamber 14 a void 74 is formed between the surface 28 and the seat 20. The void 74 is in the shape of a three-dimensional curved shell having a crescent-shaped cross-section. This void leads

35

- 8 -

to the gap 38 created between the second opening 24 and an adjacent portion of the body 26. It should be appreciated that due to the complimentary hemispherical shapes of the seat 20 and the valve body 26, the gap 38 widens  
5 relatively slowly as the valve body 26 is lifted. Moreover, the size of the gap 38 increases at a slower rate than the distance between the body 26 and the seat 20 in the vicinity of the first end 22. When the engine to which the fuel conditioner 10 is coupled is at idle speed,  
10 the gap 38 may be in the order of 3mm to 7mm, the variation depending on the specific idle speed and engine size. At full throttle, the gap 38 is typically between 14mm to 18mm. Due to the shape of the valve body 26 and the seat 20 the gap 38 is in the shape of an annulus.

15 Air emanating from the annular gap 38 splays outwardly by approximately 15°. This is substantially commensurate with the inclination of the surface portion 48. This in turn minimises the likelihood of air, now carrying fuel  
20 vapour, bouncing or deflecting from the surface 48 toward a longitudinal axis of the chamber 14.

The spring 34 provides a pressure of approximately one bar (ie one atmosphere) on the valve body 26. Thus, there is  
25 a pressure drop of 1 atmosphere between the inlet 16 and outlet 18 when the valve body 26 is lifted from the valve seat 20 by action of vacuum applied by an engine to which the fuel conditioner 10 is coupled. This pressure reduction assists in vaporisation and thermal cracking of  
30 the fuel.

Fuel is injected into the chamber 14 via the injector 34 at a rate so as to produce a substantially stoichmetric fuel to air ratio at the outlet 18, namely fuel to air  
35 ratio of 14.78:1.

- 9 -

In one embodiment of the fuel conditioner 10, the inlet 16 and outlet 18 have an internal diameter of 52mm, the distance (diameter) across the end 24 is 100mm and the hemispherical surface portion 48 has a diameter of approximately 150mm. Distance d1 from the first end 22 to the second end 24 is about 43mm and the distance d2 between the second end 24 and the transition from surface 48 to surface 50 is in the order of 47mm. Total length of the housing 12 is in the order of 240mm, with an outside diameter in the order of 140mm. The valve body 26 is made of black nylon and has a weight of approximately 120g. However the above dimensions will vary for different sized (capacity) engines.

Typically, a throttle valve 76 is provided in the intake manifold 36 and can be actuated by a solenoid or other actuator in response to depression of an accelerator pedal and/or other control signals and inputs.

The operation of the fuel conditioner 10 will now be described.

Prior to starting of an engine to which the conditioner 10 is connected, the spring 32 biases the valve body 26 against the opening 16 thus sealing the inlet 14. Upon starting of the engine, a vacuum is created which is communicated through the intake manifold 36 to the chamber 14. The vacuum lifts the body 26 against the bias of the spring 32 allowing air to pass through the opening 16 and gap 38 into the chamber 14. Fuel is injected laterally into the chamber 14 against the valve body 26. The air passing through the gap 38 impacts with and carries the fuel in a downstream direction toward the outlet 18. After a short period of time, the temperature of the air flowing in through the gap 38 becomes heated between 30°C to 260°C. The impacting of the fuel molecules sprayed into the chamber 14 with the heated air causes thermal

- 10 -

cracking of the fuel. The thermal cracking is further enhanced by impacting of fuel drops and molecules against the plate 60, and meshes 66 and 68. The inclination and/or curvature of the surface 48 assists in minimising deflection of the air toward a central longitudinal axis of the chamber 14 which may otherwise cause accumulation of fuel within that region of the chamber 14.

Due to the relative configurations of the seat 20 and the valve body 26 variation in the gap size 38 occurs in a relatively controlled manner, as vacuum increases. This provides greater control over air speed and minimises "bounce" of the valve body 26.

The thermally cracked fuel passes through the inlet 18 into the inlet manifold 26 to the cylinders (not shown) of the internal combustion engine. The fuel, being thermally cracked and substantially in a stoichiometric ratio of 14.78:1 is conditioned for efficient burning in the engine.

A controller or engine management unit (not shown) controls the volume of fuel being sprayed in by the injector 34 commensurate with the throttle position 36 and engine vacuum.

All modifications and variations of the above described embodiment that would be obvious to a person of ordinary skill in the art are deemed to be within the scope of the present invention the nature of which is to be determined from the above description and the appended claims.

**CLAIMS:**

1. A fuel conditioning apparatus comprising:
  - 5 a housing defining a chamber and provided with an inlet upstream of the chamber and an outlet downstream of the chamber;  
a hemispherical seat with a first end in fluid communication with the inlet and a second end in fluid communication with the chamber, the second end lying in a plane containing a diameter of the hemispherical seat;
  - 10 a valve body comprising a curved surface and a planar surface extending across the curved surface, the valve body being movable between a closed position where the valve body seals the inlet, and an open position where the valve body is spaced from the inlet to produce a gap between the valve and the seat allowing air at the inlet to flow through the first and second ends into the chamber; and,
  - 20 a bias device that biases the valve body toward the closed position.
- 25 2. The fuel conditioning system according to claim 1 wherein the curved surface is hemispherical in shape having a radius substantially the same as a radius of said seat, whereby when said valve body is in said closed position said planar surface lies in the plane containing the diameter of the seat.
- 30 3. The fuel conditioning system according to claim 1 or 2 wherein the chamber comprises an internal surface with a first portion that extends upward and outward from the second end toward the outlet.
- 35

- 12 -

4. The fuel conditioning system according to claim 3 wherein the first portion of the internal surface is concavely curved when viewed in a direction from the outlet to the inlet.

5

5. The fuel conditioning system according to any one of claims 1-4 wherein the air is fresh air.

6. The fuel conditioning apparatus according to any one of claims 1-5 further comprising a shaft associated with the valve body to guide the valve body when moving between the closed position and opened position.

7. The fuel conditioning system according to claim 7 wherein the shaft extends through a passage formed in the valve body perpendicular to the planar surface and along a radius of the valve body.

8. The fuel conditioning system according to claim 7 wherein the bias device is mounted on the shaft.

9. The fuel conditioning system according to any one of claims 7 or 8 wherein the bias device applies a pressure in the order of one bar on the valve body.

25

10. The fuel conditioning system according to any one of claims 1-9 further comprising a plate lying parallel to the planar surface and located centrally of a longitudinal axis of the chamber between the second end and the outlet, the plate dimensioned to provide an annular space between the plate and adjacent portion of the internal surface of the chamber.

11. The fuel conditioning system according to claim 10 wherein a first mesh screen extends across the chamber and is located between the plate and the outlet.

- 13 -

12. The fuel conditioning system according to claim 11 wherein a second mesh screen extends across the chamber and is located between the first mesh and the outlet.
- 5 13. The fuel conditioning system according to any one of claims 1-12 further comprising a fuel delivery system that delivers fuel to the chamber.
- 10 14. The fuel conditioning system according to claim 13 wherein the fuel delivery system sprays fuel into the chamber in a direction across the gap.
- 15 15. The fuel conditioning system according to claim 14 wherein the fuel delivery system comprises one or more openings or jets that can open onto the internal surface near the second opening.