FUEL DENSITY COMPENSATOR REGULATOR
Filed Nov. 18, 1963, Ser. No. 324,476
14 Claims. (Cl. 158—36)

The present invention relates to multifuel engines and more particularly to an improved control means for automatically varying the quantity of fuel for such an engine to maintain a maximum power output for any fuel being used.

The different fuels which may be utilized in multifuel engines have a wide variation in heating value per gallon. Thus when such engines are equipped with conventional type fuel systems and a given constant quantity of fuel is delivered to the engine for the power desired regardless of the type of fuel being used, the engine will produce a variation in maximum power directly proportional to the equivalent heating value of the volume of fuel injected into the engine.

Our copending patent applications Serial No. 189,379, filed April 23, 1962, now Patent No. 3,170,503, issued February 23, 1965, and Serial No. 281,715, filed May 20, 1963, now Patent No. 3,204,623, issued September 7, 1965 disclose and claim control means for use in multifuel engines and which are automatically operable to vary the quantity of the fuel being used in accordance with its heating value per gallon so that the maximum power output of the engine will remain substantially constant regardless of the type of fuel being used.

As disclosed in our aforementioned patent applications, there is almost a direct relationship between the density or viscosity of the different hydrocarbon fuels commonly used and the heating value per gallon of those fuels. This discovery led to the devices disclosed in our aforementioned applications.

Each of the devices hereinafter disclosed comprise essentially a means of passing a portion of the fuel in series through two orifices. The fuel is delivered to the first orifice at a constant pressure and because the orifices are formed to have widely different flow characteristics a pressure drop is produced intermediate the orifices which depends upon the density or viscosity of the fuel being used. It is this pressure drop change which is used to actuate means for varying the full load stop on the injection pump so that a greater or lesser quantity of fuel can be delivered to the engine to produce a substantially constant maximum power output.

The present invention operates in accordance with the principles disclosed in our aforementioned co-pending applications, but provides a construction which offers considerable improvement over the heretofore disclosed devices. First, the number of elements comprising the device and thus the cost of manufacturing has been reduced to a minimum. Secondly, the device of the present invention provides an improved sealing means which substantially reduces friction and thus produces a device in which the changes in pressure drop caused by the changes in the viscosity of the fuel are more accurately transmitted to the means varying the full load stop of the injection pump.

To provide a viscosity responsive control means having these advantages and improvements over our heretofore disclosed devices then is the principal object of the present invention. Other objects and advantages of the present invention will readily occur to one skilled in the art to which the invention pertains upon reference to the following drawings in which like reference characters refer to like parts throughout the several views and in which

FIG. 1 is a chart illustrating the relationship between viscosity and heating value for several types of fuels and at various temperatures.

FIG. 2 is a diagrammatic view illustrating the relation of a preferred control to a multifuel engine.

FIG. 3 is a cross sectional view of a preferred embodiment of the present invention as seen substantially from line 3—3 of Fig. 4.

FIG. 4 is a cross sectional view as seen substantially from line 4—4 of Fig. 3.

FIG. 5 is a fragmentary cross sectional view as seen from line 5—5 of Fig. 4, and

FIG. 6 is a fragmentary cross sectional view as seen substantially from line 6—6 of Fig. 4, and with portions removed for purposes of clarity.

Description

FIG. 1 illustrates the relationship between the viscosity and heating value of various fuels which is made use of in the present invention. As can be seen on this chart, the relationship is almost a straight line for the various hydrocarbon fuels that are shown. These fuels are the types commonly used in multifuel engines and by sensing changes in viscosity in effect it is possible to also sense changes in the heating value per gallon of the fuel being used.

FIG. 2 illustrates diagrammatically a multifuel engine A having a fuel injection pump B preferably drivingly connected thereto and operable to deliver fuel to the engine A from a fuel tank C. An oil pump D is also preferably drivingly connected to the engine A to deliver engine oil under pressure thereto to provide lubrication for the engine A. A fuel compensator device 10 is provided with a fuel inlet port 12 connected to the discharge side of the pump B by a suitable conduit member 14. The compensator device 10 is also preferably provided with an outlet port 16 connected to the fuel tank C by conduit 18. Linkage 20 operably connects the compensator device 10 and the fuel pump B as will be described in greater detail below. The compensator device 10 is also preferably provided with an oil inlet 22 connected to the oil pump D by conduit 24.

As can best be seen in Figs. 3, 4, 5 and 6, the compensator device 10 of the present invention preferably comprises a housing structure 26. The housing structure 26 is provided with a central axially extending cavity 28 defined by a substantially annular wall portion 30 of the housing structure 26 and a boss portion 32 extending axially inwardly from the lower portion of the housing structure 26. The cavity 28 is closed by an end cap 34 secured to the housing structure 26 by bolts 36.

A piston 38 is axially slidably carried in the cavity 28. The piston 38 is substantially cup shaped as shown and is provided with a skirt portion 40 substantially concentric to and encompassing the boss portion 32. The skirt portion 40 is provided with an annular surface 42 which as can best be seen in Figs. 5, 6 and 7 is slightly radially inwardly spaced from the wall portion 30 to form an annular and longitudinally extending orifice 44. The skirt portion 40 of the piston 38 defines a pressure chamber 46 upstream of the orifice 44.

The piston 38 is secured to a rod 48 which is axially slidably carried in a bore portion 50 provided in the boss portion 32. The rod 48 extends into an eccentrically positioned boss portion 52 provided on the upper portion of the piston 38. The boss portion 52 provides a seat for a spring 54 biasing the piston 38 away from the end cap 34.

As can best be seen in Fig. 3 a vertically extending
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A passage 56 is provided in the housing structure 26. A passage 58 provides communication between the passage 56 and the pressure chamber 46. As can be best seen in FIGS. 3–4, the inlet port 12 is provided in the end cap member 34. The inlet port 12 intercepts a transverse passage 60. An angularly extending passage 62 provides communication between the transverse passage 60 and the passage 56. The transverse passage 60 is closed at each end by suitable fittings 64 and 66 threaded into the cap member 34. A spool valve 68 is axially slidable carried in the transverse passage 60 and the fitting 64 is formed to provide a seat for a spring 70 which urges the valve 68 toward the fitting 66. The outlet port 16 is also provided in the cap member 34 and communicates with a passage 72. The passage 72 extends across the cap member 34 as can be best seen in FIG. 4 to intercept an annular recess 74 provided in the transverse passage 60 adjacent the fitting 64. In this way, one side of the valve 68 is subjected to substantially atmospheric pressure existing in the fuel drain system plus the force produced by the spring 70. The valve 68 is provided with a medial reduced portion to provide an annular recess 76 normally communicating with the passage 62. The valve 68 is also provided with a central passage 78 extending axially from the end of the valve 68 adjacent the fitting 66 to a point coinciding with the axial position of the recess 76. Radially extending passages 80 provide communication between the central passage 78 and the recess 76. In this way, it is clear that the pressure of the fuel entering inlet port 12 is normally transmitted through the recess 76 and the passages 78 and 80 to the end of the valve 68 adjacent the fitting 66 to oppose the force produced by the spring 70 and the fuel drain pressure transmitted by the passage 72. The fitting 66 is provided with a port 92 which may be either plugged or connected to a suitable pressure gauge.

As can be best seen in FIG. 5 a vertical passage 84 is provided in the end cap 34. The passage 84 is open to the cavity 28 downstream of the orifice 44 and intercepts the passage 72. An adjustable needle valve 96 is disposed in the passage 84 to adjustably vary the restrict fuel flow therefrom and to provide an adjustable orifice 88 downstream of the orifice 44.

As can be best seen in FIG. 3, a lever arm 98 is pivotally connected as at 92 to a fork member 94. The forked member 94 is in turn pivotally connected to a rod 48 as at 96. A wedge block 98 is secured to a pin member 100 which is in turn axially adjustably carried in an extension of the housing structure 26 by nuts 102 and a spring 104. A guide surface 106 is provided on the housing structure 26 and an extension 108 of the wedge block 98 is provided with a surface complementary to and slidingly engaging the guide surface 106. It is apparent that tightening the nuts 102 will move the pin member 100 axially to the left as seen in FIG. 3 so that the wedge block 98 may be adjusted to the right or left as desired. The lever arm 90 is provided with a grooved inclined face portion 109 which is complementary to and slidably engages an inclined face 110 of the wedge block 98. An opposite edge 112 of the lever arm engages the linkage 20 so that as the rod 48 is moved axially a corresponding horizontal movement is produced in the first link member 114 of the linkage 20. The linkage 20 is operably connected to the fuel pump B to vary the full load stop (not shown) thereof.

The sealing means provided in the compensator of the present invention preferably comprises a pair of axially spaced annular recesses 116 and 118 provided in the bore portion 50 as can best be seen in FIGS. 3, 5, and 6. The recess 116 is connected to the engine 12 and the recess 118 is connected to the lubricating oil pump D by the conduit 24. The recess 118 is connected to the fuel outlet 16 by passage 122 as shown in FIG. 5.

In operation fuel is delivered by the fuel pump B to the engine A and to the fuel inlet 12 of the compensator device 10. The valve 68 acts to reduce the pressure of the fuel passing to the passage 62 to some constant value by balancing the pressure of the entering fuel against fuel drainage system pressure (substantially atmospheric) and the force of the spring 70. When the inlet 12 of the recess 76 is greater than that desired, the excess pressure acts through the passages 78 and 80 to move the valve 68 toward a position variably closing communication between the inlet port 12 and the passage 56. In this way the pressure of the fuel entering the pressure chamber 46 is maintained at some predetermined constant value so that only changes in pressure produced by other variables.

The downward axial movement of the piston 38 then is opposes by the substantially constant pressure in the chamber 46. The fuel passes from the chamber 46 through the first orifice 44 and then through the second orifice 88 formed by the needle valve 86 and from there out the outlet port 16 to be returned to the fuel tank C. The orifice 44 is the oil fuel passageway which is widely different flow characteristics and therefore have flow coefficients which change with changes in the viscosity of the fuel so that pressure in the cavity 28 above the piston 38 will vary with changes in the viscosity of the fuel. The axial position of the piston is thereby varied in accordance with this pressure change due to the viscous character of the fuel.

The oil pump D is provided with a series of orifices 90 and 92 communicating with the upper portion of the cavity 28 may be provided if desired so that upon connection of the port 124 with a suitable gage viscosity changes of the fuel can be indicated. The changes in axial position of the piston 38 are transmitted through the lever arm 94, the rod 48, the link 100 and the pin member 100. The full load stop in the injection pump B and thus to vary the quantity of fuel delivered by the injection pump B to the engine A. The amount of compensation required to maintain a constant maximum power output for a wide range of fuels can be easily obtained by a proper selection of the wedge angle formed on face portions 109 and 110 of the lever arm 90 and wedge block 98, respectively.

As has been disclosed in our aforementioned copending applications, and as is apparent from FIG. 1 herein, fuel temperature affects the viscosity of the fuel and thus it is desirable to include some compensating means to offset the tendency of the device to permit an excessive quantity of fuel to be injected at higher than normal ambient temperatures and to prevent an amount of fuel to be injected which would produce maximum power when the fuel is at lower than normal ambient temperatures. To avoid this result, as heretofore disclosed, a combination of materials for the housing 26 and the piston 38 may be selected which will produce a variance in the orifice 44 in response to changes in temperature in proportions commensurate with the attendant fuel quantity demands. For instance, the combination of a relatively high expansion material for the piston 38 and a relatively low expansion material for the housing 26 would reduce the orifice 44 with increased temperature and enlarge it at lower temperatures. A reduction in the size of the orifice 44 would reduce the pressure acting on the upper portion of the piston 38 and thus maximum fuel flow to the engine would be reduced.

The advantages produced by the reduction in parts of the present invention over the devices disclosed in our copending applications are readily apparent. In addition, by providing the offcenter spring construction and the fluid sealing means in the device of the present invention, the result has been an extremely accurate compensator device not possible with the constructions heretofore disclosed. When a piston and a rod are used to actuate the control mechanism as disclosed in our copending application Ser. No. 281,715, a serious sealing prob-
lem between the rod and the housing is produced. If escape of the fuel is to be prevented, the seals must be so tight as to increase the friction to a point where accuracy of the device is substantially diminished. In addition to insure free movement between the rod and the housing, there must be a slight clearance between these members. This produces a tendency in the piston and rod to wobble in all directions as it moves axially and this again upsets the accuracy of the device. The offcenter spring member 54 of the present device prevents the piston 38 from wobbling and thus provides a more accurate device. The sealing means of the present invention provided by the fluid seals comprising the lower recess 116 connected to the engine lubricating oil pumping means D and the upper recess 118 connected to the fuel outlet 16, reduces friction to a minimum and yet provides sufficient sealing to prevent fuel from escaping along the rod. Any fuel which escapes from the pressure chamber 46 will be collected by the recess 118 and directed by the passage 122 to the fuel outlet 16. The fuel will be prevented from moving farther axially along the rod 48 by the engine lubricating oil being delivered to the recess 116 at a pressure higher than that of the fuel. The high viscosity of the engine lubricating oil will prevent all but insignificant amounts of the oil from escaping along the rod 48.

Although we have described but a single embodiment of the present invention, it will be readily apparent that many changes and modifications can be made without departing from the spirit of the invention as expressed by the appended claims.

We claim:
1. In a multifuel engine having a fuel supply means, a fuel control system for regulating the volume of fuel to the engine in response to changes in the viscosity of the fuel, said system comprising
   (a) means adapted for connection to said fuel supply means and operable to regulate the fuel to a predetermined constant pressure, and
   (b) a viscosity responsive control device communicat- ing with said pressure regulating means and oper- ably connected with said fuel supply means to vary the fuel delivered to the engine by said supply means, said device comprising
   a housing having a first orifice and a second orifice connected in series and having different flow characteristics, said first orifice communicating with said pressure regulating means,
   said housing being further provided with a cavity intermediate said first and second orifices,
   a piston carried in said cavity and being operable to move in response to changes in the viscosity of said fuel,
   a rod axially slidably carried in said housing and operably connecting said piston to said fuel supply means, and
   a fluid sealing means intermediate said housing and said rod comprising an annular recess provided in said housing and said rod and means adapted for connecting said recess with a source of fluid pressure greater than the constant pressure of the fluid delivered to said first orifice.
2. The system as defined in claim 1 and in which the wall defining said cavity and the outer peripheral surface of said piston form said first orifice.
3. The system as defined in claim 1 and including temperature responsive means being provided in said housing and operable to vary the size of at least one of said orifices in response to temperature variations in the fuel being delivered to the engine to vary the size of said fuel delivery in response to changes in the temperature of the fuel being delivered.
4. The fuel control system as defined in claim 1 and including means for manually adjusting the size of at least one of said orifices.

5. The fuel control system as defined in claim 1 and in which
   (a) one side of said piston is exposed to said constant pressure produced by said regulating means and the other side of said piston is exposed to the pressure of said cavity,
   (b) a spring member urging said piston to move axially against said constant pressure,
   (c) said spring member being positioned off center with respect to the axial movement of said piston.
6. The fuel control system as defined in claim 5 and in which the wall defining said cavity and the outer peripheral surface of said piston are spaced to form said first orifice.
7. The control system as defined in claim 1 and in which said fluid seal means further comprises
   (a) a second annular recess provided in said housing and encompassing said rod intermediate said first mentioned recess and said cavity,
   (b) said second recess being adapted for connection downstream of said second orifice.
8. A viscosity sensing device comprising
   (a) a housing having a first orifice and a second orifice connected in series and having different flow characteristics,
   (b) said first orifice being adapted for communication with a source of fluid of a predetermined constant pressure,
   (c) said housing being further provided with a cavity intermediate said first and second orifices,
   (d) a rod axially slidably carried in said housing and carrying a piston disposed in said cavity and being operable to move in response to changes in the pressure in said cavity whereby said rod moves in response to changes in the viscosity of said fluid,
   (e) a fluid sealing means intermediate said housing and said rod comprising an annular recess provided in said housing and said rod and means adapted for connecting said recess with a source of fluid pressure greater than the constant pressure of the fluid delivered to said first orifice.
9. The device as defined in claim 8 and in which the wall of said housing defining said cavity and the outer peripheral surface of said piston form said first orifice.
10. The device as defined in claim 8 and including temperature responsive means being provided in said housing and operable to vary the size of at least one of said orifices in response to temperature variation in the fluid being delivered to said first orifice.
11. The device as defined in claim 8 and including means for manually adjusting the size of at least one of said orifices.
12. The device as defined in claim 8 and in which
   (a) one side of said piston is exposed to said constant pressure delivered from said fluid source and the other side of said piston is exposed to the pressure of said cavity,
   (b) a spring member urging said piston to move axially against said constant pressure, and
   (c) said spring member being positioned off center with respect to the axial movement of said piston.
13. The device as defined in claim 12 and in which the wall defining said cavity and the outer peripheral surface of said piston are spaced to form said first orifice.
14. The device as defined in claim 8 and in which said fluid sealing means further comprises
   (a) a second annular recess provided in said housing and encompassing said rod intermediate said first mentioned recess and said cavity,
   (b) said second recess being adapted for connection downstream of said second orifice.

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