FUEL FLOW RESTRICTOR FOR HIGH CAPACITY BURNERS

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ATTORNEYS
ABSTRACT OF THE DISCLOSURE

A fuel flow restrictor for high capacity burners in which there is provided oil restrictor tubes connected between inlet and outlet chambers and in which the inlet end of each tube is smoothly rounded for minimum flow disturbance and the length and diameter relation of the cylinder chosen to assure laminar flow and requisite pressure drop. The restrictors are connected in series with dual high capacity burners so that when the flow rate to one of the burners is changed, the pressure variation at the other burner is minimal.

This invention relates to a flow restrictor for placement in a pipe or line used to supply fuel oil to a burner and, more particularly, to such restrictor used with burners of high capacity and large turndown rates.

In many burner installations, for example burners used to fire marine boilers, it is desirable to provide for a large turndown rate, frequently twenty to one, or greater. In such installations it is expedient to supply oil to the burner through a restrictor or the like that effects a pressure drop in the fuel oil so that spurous and unwanted pressure variations upstream of the restrictor will have little or no effect at the burner. In order to accomplish controlled firing rates throughout the range of burner operation, it is desirable to construct the restrictor that oil flowing therethrough will experience laminar flow throughout the entire range of burner operation. It has been found that if the restrictor is designed to afford laminar flow at the maximum rate of burner operation, it will afford laminar flow at all lesser rates. Moreover, pressure at the outlet end of the restrictor, i.e., at the burner, can be smoothly and continuously varied (to vary the firing rate of the burner) if fuel is delivered thereto in a laminar flow condition throughout the entire operating range. Thus, it will be appreciated that a restrictor must afford both (a) a pressure drop thereacross and (b) laminar flow throughout the range of burner operation.

As higher capacity burners requiring greater rate of oil input come into use it has been typical in the prior art simply to enlarge previously existing single tube restrictors. Typically, the inner diameter of the tube is increased to assure adequate flow at high burner operating rates and such tube is necessarily lengthened to secure the requisite pressure drop in the restrictor. It has been found that the length of the restrictor tube does not increase linearly with the diameter but rather increases exponentially with the diameter. Moreover, as the diameter of the restrictor is increased, laminar flow can be maintained only by reduction of velocity of fuel flow, which reduction causes a corresponding decrease in rate of fuel discharge to the burner and a decrease in pressure drop thereacross. Because of such phenomena, single restrictor or burner systems for modern-day large burners are frequently fixed at five feet or more in length to provide the necessary flow and pressure-drop characteristics. In restricted burner room areas, particularly in marine installations, a restrictor of such size would be impracticable and unacceptable. Known prior art solutions to this problem have taken the form of eliminating the restrictor, a solution that necessitates additional control devices in the fuel supply system. Such additional control devices not only increase cost of the equipment, but are of marginal reliability and difficult of incorporation into automated burner systems.

Therefore, it is the object of the present invention to provide an oil flow restrictor for high capacity burners, which restrictor is of relatively small size and simple construction, which provides the necessary pressure drop thereacross, and which affords laminar flow throughout the entire operating range of the burner, or like fuel consuming appliance fed by the restrictor. This object is achieved by providing a restrictor having two or more parallel fuel passages through which the fuel oil is delivered from a high pressure source to the burner nozzle. Notwithstanding the non-linear relationship between the oil tube cross-sectional area and length, restrictors of reasonable length can be provided in even the highest capacity burners without sacrificing the desired laminar flow and fuel pressure drop characteristics.

In burners incorporated into systems that automatically control the firing rate over a large range it is convenient, and frequently mandatory, that the rate be controllable from 100% firing rate down to 5% or 10% firing rate in a smooth and continuous manner. Such smooth, continuous control is best accomplished by delivering the oil to the burner in a laminar flow condition throughout the entire operating range. Without a properly designed restrictor, it has been found that oil flow at high rates of burner operation will be turbulent and will change to laminar flow at some lower firing rate. The point or region of change from turbulent to laminar flow is unstable and occurs rather abruptly, thereby making difficult or impossible precise control of burner firing rate by control of fuel oil delivery rate. A restrictor affording laminar flow throughout the operating range of the burner avoids the above-mentioned instability and therefore expedites automatic control of firing rate.

To appreciate the desirability of providing a restrictor that imparts pressure drop to the fuel oil, it should be appreciated that most fuel oil pressure supply systems are subject to unwanted and unavoidable pressure variations. Such variations or surges are caused by erratic operation of oil pumps, by periodic actuation and de-actuation of other burners on the same fuel line, by change of variation of viscosity in the fuel oil, and by a myriad of other factors. To render the burner immune to these spurious fuel oil supply pressure variations, a flow restrictor is mounted adjacent the inlet side of the burner and is adapted to effect a pressure drop across the restrictor. Consequently, spurious variations or surges in fuel pressure upstream of the restrictor will be manifested only slightly or not at all at the downstream or burner side of the restrictor. Thus, the burner operating rate will be substantially independent of rapidly occurring variations or surges in fuel oil supply pressure by provision of a restrictor which affords a pressure drop thereacross.

The restrictor of the present invention affords both laminar flow throughout the entire operating range thereof and a pressure drop thereacross, thereby avoiding the problems to which allusion has been made hereinabove. Of equal importance, the restrictor is compact, thereby permitting its installation in restricted furnace room areas.

The foregoing as well as other objects and advantages of the invention will be apparent on referring to the following specification and accompanying drawings in which:

FIG. 1 is a side elevation view of a restrictor embodying the present invention, portions thereof being broken away to reveal certain internal details;

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1; and
FIG. 3 is a schematic diagram of a burner system employing restrictors of this invention.

Referring more particularly to the drawing, reference numeral 12 indicates an inlet fitting, reference numeral 14 indicates an outlet fitting, and reference numeral 16 indicates the active restrictor portion of the apparatus. Inlet fitting 12 is adapted for connection to a fuel pressure supply line by provision of an interiorly threaded opening 18, the rate of fuel supplied to the restrictor from the line being engaged in the threaded portion being controlled by conventional valving and metering apparatus, explained in more detail hereinbelow. Downstream of opening 18 inlet fitting 12 is formed with a diverging wall 20, which wall changes the fluid flow conduit from a circular cross-section at its inlet end 20a to a generally oval-shaped cross section at 20b. Disposed in the generally oval-shaped opening are a pair of substantially identical restrictor tubes 22, a rigid, oil-impervious joint being formed by a weld 24.

In the embodiment of the invention shown and described herein, outlet portion 20b of inlet fitting 12 is shown and described as defining a generally oval-shaped cross section because the device is shown by way of example, as including two oil restrictor tubes 22. Obviously the specific shape of outlet opening 20b will be different in devices embodying the invention and having more than two oil restrictor tubes incorporated therein. Irrespective of the number of tubes, it is preferred that outlet portion 20b is so formed that the restrictor tubes are disposed symmetrically about the central axis of opening 18.

Outlet fitting 14 includes a wall 26 having an inlet end 26a substantially congruent to opening 20b and into which opening restrictor tubes 22 are disposed. As in the case with inlet fitting 12, a rigid, oil-impervious joint is formed between outlet fitting 14 and the restrictor tubes by a weld, or the like. Wall 28, wall 26 converges into a portion of substantially circular cross section at 26b for joinder to an extensionally threaded nipple 29. The oil burner to which the restrictor of this invention is attached typically includes a threaded opening for receiving the threaded portion of nipple 28.

Since it is convenient to form oil restrictor tubes 22 in a substantially identical form only one of the tubes will be described in detail. The upstream end of the restrictor tube, that is, the end in communication with the oil chamber defined by wall portion 20b of outlet fitting 12, is formed with a cylindrical oil flow passage 30 that communicates with the chamber through a smoothly radiused portion 32. Radiused portion 32 at the upstream end thereof is tangent to a plane transverse of the longitudinal axis of the device and at its downstream end is tangent to the inner surface of cylindrical passage 30 to the end that fuel oil flowing thereinto into the cylindrical passage is subject to minimum flow disturbance. Consequently, the fuel oil traversing cylindrical passage 30 flows in a substantially laminar pattern. Cylindrical passage 30 has a length sufficient that oil flowing therethrough will be in the laminar region at the downstream end 30a of the passage and a diameter such that capillary action of the oil on the surface of the passage affords the requisite pressure drop.

Downstream of cylindrical passage 30 and coaxial therewith tube 22 is formed with an enlarged cylindrical bore 34 in which is disposed, for example by a force fit or press fit, a venturi 36. Venturi 36 includes a relatively short inlet cylindrical passage 38, of cross section area greater than that of cylindrical passage 30 and a relatively long diverging frusto-conical wall 40 to effect reduction of the velocity of oil flow therethrough. Placement of venturi 36 as described above materially contributes to the pressure drop afforded by the apparatus. The degree of divergence of venturi wall 40 is chosen in relation to the Reynolds number of the fuel oil to assure maintenance of laminar flow through the venturi and requisite pressure drop; calculation of the degree of divergence is well within the competence of a skilled artisan. Accordingly, fuel oil issuing from outlet or mouth 42 of the venturi experiences laminar flow and the fuel oil delivered to the burner will also experience laminar flow.

The diameter and degree of divergence of venturi 40 are established in accordance with well recognized criteria so that fuel flow through the restrictor will be laminar for all rates of fuel flow. The consequence of providing laminar flow throughout the entire operating range of the restrictor and therefore that the outlet end of the restrictor varies substantially linearly with the setting of a fuel oil control valve upstream of the restrictor. By avoidance of turbulent or transitional flow through the restrictor, the pressure of fuel oil supplied to the burner bears a substantially linear, and hence predictable and controllable, relationship to the setting of the fuel supply control valve. Such pressure is, however, substantially independent of abrupt or short duration surges upstream of the restrictor. Therefore, automatic control of fuel flow and of the boiler or the like which consumes the fuel can be accomplished with control systems of relatively uncomplicated construction.

FIG. 3 shows in schematic form a system employing the restrictor of the present invention. In such system a combustion chamber 50 of the type incorporated in, for example a steam boiler, is fired by dual burners 52 and 54. Fuel oil supplied to the burner through a restrictor 56 of the type explained hereinabove in connection with FIGS. 1 and 2, a shutoff valve 58 being disposed upstream of each of the restrictors. Fuel is supplied to the inlet side of each of the shutoff valves through branch lines from a main fuel control valve 60, the position of which is adjusted by signals from a conventional controller 62. Such systems, of course, include means for supplying combustion air at metered rates; air supply means, since it constitutes part of this invention, is not shown. In the burner system of FIG. 3, full or 100% firing rate is accomplished by opening both shutoff valves 58 and by opening control valve 60 fully. The firing rate is decreased by gradual and controlled closure of valve 60 in response to signals from controller 62. Because the cross-sectional area of the fuel lines is great, the velocity of fuel flow is small and laminar flow in the fuel lines is assured. The construction of restrictors 56 as described above assures laminar flow throughout as a consequence of which the pressure of fuel oil supplied to burners 52 and 54 varies substantially linearly with the position of valve 60.

Further reduction of firing rate in the system of FIG. 3 is accomplished by further closure of valve 60 until each burner 52 and 54 is firing at a rate of approximately 10%–20% of the respective burner's full operating rate. As is the practice in systems of this type, one of the burners, say burner 54, is then disabled by closure of shutoff valve 58 in series therewith to effect further reduction in firing rate. Such shutoff occurs rather abruptly in response to a signal from control system 62, which abrupt closure causes a momentary surge in the fuel supply line. In the absence of restrictor 56 in series with burner 52, such surge would be manifested in the combustion chamber by a momentary oversupply of fuel, which oversupply since it is not accompanied by additional combustion, would be wasteful of fuel and would produce excessive smoke. Because of the presence of the restrictor, such momentary oversupply of fuel to burner 52 is substantially obviated, and the firing of the combustion chamber from burner 52 continues in a constant fashion.

As the firing rate of the burners increases, the previously closed shutoff valve 58 will be opened abruptly and a similar surge in fuel supply pressure will occur. For the reasons given in the preceding paragraph such surge will have little or no effect on burner 52, and burner 54 will, in due course, be ignited.

Thus, it will be seen that the present invention provides a restrictor of relatively small size, which restrictor,
when placed in a fuel oil supply line, will isolate the burner fed by it from surges upstream of the restrictor and which restrictor will deliver fuel to the burner in continuous and smoothly controlled quantities throughout the operating range of the system. Such smooth and continuous control, which arises because laminar flow is assured throughout the entire operating range of the apparatus, permits employment of relatively uncomplex, reliable and inexpensive automatic control systems. The restrictor of this invention, because of its relatively small size, can be conveniently installed in existing systems with only a minimum amount of reconstruction.

Although one embodiment of this invention has been shown and described, it will be obvious that other adaptations and modifications can be made without departing from the true spirit and scope of the invention.

What is claimed is:

1. In combination with a combustion chamber having at least two oil burners in firing relation to the combustion chamber, apparatus for controllably supplying oil to said burners comprising an oil line for supplying fuel oil to the burners under pressure, a valve in said line for controlling the rate of oil flow therethrough, a plurality of branch oil lines downstream of said valve for distributing fuel oil to each of said burners, an oil flow restrictor associated with each said burner and disposed in series with the respective branch lines, each said restrictor having a plurality of parallelly extending cylindrical oil transporting passages therein, each said passage having a diameter and length sufficient to transport oil therethrough in laminar flow condition and to effect a pressure drop in the oil transported therethrough so that oil delivered to the associated burner can be continuously varied, and means for controlling the position of said valve in accordance with the heat energy demand of the combustion chamber.

2. Apparatus according to claim 1 including a shutoff valve in each branch line upstream of said restrictor and means for closing at least one said shutoff valve to reduce the rate of heat energy input to said combustion chamber.

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