SYSTEM FOR MIXING GASES AND SPARGER VALVE FOR ACCOMPLISHING SAME


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ABSTRACT

In a vinyl acetate manufacture reactor feed line, oxygen is admixed with gaseous hydrocarbons in the process stream by discharging the oxygen through jets facing downstream within the hydrocarbon gas flow, with the oxygen jet velocity maintained substantially higher than the velocity of the hydrocarbon gas. Variations in oxygen mass flow are made by varying the area of the jet orifices while maintaining a predetermined pressure drop across the same. The pressure within the oxygen feed line is controlled to control the pressure drop across the orifices with the oxygen flow rate in turn varying with variations in the orifice size.

15 Claims, 4 Drawing Figures
SYSTEM FOR MIXING GASES AND SPARGER VALVE FOR ACCOMPLISHING SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a system for admixing a first gas stream within a second gas stream while preventing the maintenance of an inflammable mixture at the mixing area, and more particularly to the admixing of oxygen within vaporized acetate acid and ethylene in a vinyl acetate manufacture reactor feed line.

The present invention has particular use in processes where hydrocarbons or other flammable components are mixed with oxygen. Generally, the composition of such that it lies outside the region of oxygen/fuel ratios in which stable combustion, or flame, can occur; and, usually, this composition is on the fuel-rich side of the flammable range of oxygen/fuel ratios. However, in the portion of the apparatus where fuel and oxygen are mixed (hereinafter referred to as the "mixer") there are bound to be regions where the gas composition falls within the flammable range. Moreover, in parts of the apparatus where mixing is imperfect, it is possible to have diffusion-fed flame at the boundaries between oxygen-rich and fuel-rich regions. If the gas in such regions by chance becomes ignited, a more or less steady flame may result, and this can lead to fire or explosion or both. The mixer should therefore be designed in such a way that a steady flame cannot exist in the mixing region.

One method that has been used to prevent flames from forming in the mixing region provides a porous bed of metal, ceramic or stone packing in which the gas mixing occurs. The inert solid surfaces of the packing material draw heat from an incipient flame in the interstices, and thereby prevent the establishment of steady combustion. This type of mixer requires a relatively large volume, because flow rates in the mixer are relatively low, and a considerable portion of the space in the mixing region is taken up by the packing material. For this reason, porous bed mixers tend to be relatively expensive, adding substantially to the fixed equipment cost. Moreover, since the gas flow is impeded by the packing, the cost of power needed to maintain the flow of reactants through the equipment is increased. For some processes, it is difficult to find a type of packing material that will not corrode, or react chemically in the presence of the gas stream, also, a material must be provided that will not absorb excessive amounts of substances from the gas stream. For a variety of such reasons, the porous bed mixer is often an unsatisfactory solution to the mixer problem.

SUMMARY OF THE INVENTION

The method of the present invention prevents flame from forming in the mixer and depends on the injection of the oxygen component in a downstream direction through high-speed jets into the stream carrying the hydrocarbon component. The method further involves the complete elimination from the mixing region of solid obstacles, pipe turns, constriction or surface irregularities that tend to impede the flow and produce boundary regions in which flame could form. It is well known that in order for a flame to remain fixed in a region for an appreciable period of time, there must be some sort of anchor, a so-called "flameholder." Solid obstacles in a gas stream can act as flameholders, because the flow is arrested at the solid surface. The present invention therefore eliminates any solid obstacles or surface irregularities, or any other feature that would tend to disrupt the flow in the mixing region of the system. Since it is possible for the orifices through which the oxygen is injected to serve as flameholders for diffusion flames, the present invention involves injecting the oxygen at very high velocity, some hundreds of feet per second. Thus, this insures that the velocity gradients near the lip of the orifice are several times higher than the maximum value that would permit flame to lodge anywhere near the orifice. The extremely high turbulent intensities that are produced by the high-speed jets in the mixing region downstream not only provide for a very high rate of mixing, but they also produce shearing gradients in the gas flow that keep flame from existing, even momentarily in the mixing zone. The gas flow near the walls of the mixing zone, which is a straight section of smooth pipe, is parallel to the surface. In a flow configuration of this sort, there is virtually no tendency whatever for a flame to become attached to the surface. Moreover, the gas in the boundary layer immediately adjacent to the pipe wall tends to remain unmixed with oxygen up to a point near the end of the mixing region where the oxygen is very much diluted and the mixture composition is well outside the flammable range. Thus, both the flow conditions and the mixture composition are unfavorable for the occurrence of flame within the mixer chamber. The mixing concept of the present invention therefore provides for very rapid and efficient mixing under conditions that absolutely prevent combustion from occurring anywhere in the mixing apparatus.

Another important feature of our invention is the provision for varying the size of the jet orifices, so that mixing proportions can be adjusted through wide limits to suit process requirements at startup, shutdown and during periods of emergency without appreciably altering the oxygen supply pressure or the pressure drop across the orifices. Thus, the high velocity of the jets, which is responsible for the high mixing efficiency as well as for the positive prevention of flame, is maintained at all times, no matter what quantity of oxygen is being supplied. Moreover, the size of the orifices in this invention concept is kept under constant automatic control, and the change of orifice size takes place very rapidly without even momentarily interrupting the flow. The rapid and automatic adjustment of orifice size is of utmost importance, because it is just during periods of off-design operation, such as those at startup, at shutdown, or during emergency, that inflammation of the gases and subsequent fire or explosion is most likely to occur.

In the embodiment of the invention described herein, oxygen is injected through orifices on the downstream facing side of a 4-inch pipe intersects at a 10-inch pipe through which the hydrocarbons and other flammable components of the gas mixture are flowing. The orifices have the form of fixed slots in the 4-inch pipe. By using several narrow slots rather than a single large one, there is effected a reduction in the downstream length of 10-inch pipe needed to secure efficient mixing since, according to jet mixing principles, the length of the chamber required to obtain a given mixing efficiency is in direct proportion to the slot width.

The size of the jet orifices in this embodiment is adjusted through the rotary movement of a Teflon-faced liner tube within the 4-inch pipe, the liner having similarly shaped aperatures opposite each of the fixed slots. When the liner tube is rotated in a given direction, the liner and fixed slots are placed more and more in register which increases the size of the jet orifice. Movement of the liner is effected, and its position adjusted by the movement of an attached rod or shaft that connects to a pneumatic control motor. A biasing spring works against the pneumatic motion controller; and in the event of failure of the pneumatic pressure, the spring drives the liner to a position where it completely covers the jet orifices and cuts off entirely the flow of oxygen.

The mixer concept readily lends itself to automatic control. In the embodiment hereinafter described in more detail, the
The mass flow $G$ of oxygen in pound moles per hour is calculated by

$$G = 521 C_0 A_2 P_t \left( \frac{2k}{k-1} \right) \left( \frac{2}{M P_t} \right) \left[ \frac{P_t}{P_1} \right]^{k+1} \left( \frac{P_1}{P_t} \right)^{k-1} \left[ 1 - \left( \frac{P_t}{P_1} \right)^{2} \right] \left[ 1 - \left( \frac{P_t}{P_1} \right)^{k-1} \right]$$

where

- $C_0$ is the overall orifice discharge coefficient (for these calculations 0.6 is assumed);
- $A_2$ is the total available orifice (slot) area in in.$^2$;
- $k$ is the ratio of specific heats $(C_p/C_v) = 1.4$ for oxygen under these conditions;
- $P_t$ is the absolute pressure in in.$Hg$;
- $M$ is the mole weight;
- $T$ is the absolute temperature in $^oC$;
- Subscript 1 denotes the condition upstream of the orifice, subscript 2 denotes orifice throat conditions.

The oxygen mass flow in pounds per hour then becomes

$$G = 521 C_0 A_2 P_t(\rho) \left( \frac{2k}{k-1} \right) \left( \frac{2}{M P_t} \right) \left[ \frac{P_t}{P_1} \right]^{k+1} \left( \frac{P_1}{P_t} \right)^{k-1} \left[ 1 - (\frac{P_t}{P_1})^2 \right] \left[ 1 - (\frac{P_t}{P_1})^{k-1} \right]$$

The linear flow velocity of oxygen at the throat, $u$, in ft/sec, then becomes

$$u = 22C_0 (\rho) \sqrt{\frac{2k}{k-1} \left( \frac{T}{M} \right) \left[ 1 - (\frac{r_t}{r})^{k-1} \right]}$$

The above formulas (1) to (4) apply continuously as the pressure ratio $r$ decreases starting at a value of one and continuing until it reaches the value $r_c$, the critical pressure ratio. When $r = r_c$, the flow at the throat attains the local speed of sound. With further decrease of $r$ below $r_c$, there is no change in flow rate (given constant conditions of pressure and temperature at the inlet). The formula for $r_c$ is

$$r_c = \left( \frac{2}{k+1} \right)^{\frac{1}{k-1}} = 0.528 \text{ (the critical ratio for oxygen)}$$

The mass flow formulas (2) and (3) may be used to calculate the actual orifice size needed in the particular application. The calculation is based on the flow rates of reactants involved in the process and on the available oxygen supply pressure. For oxygen supply at about 70 psia, it was determined from formula (3) that an orifice area $(A_2)$ of 0.625 in.$^2$ would be needed to deliver a given concentration of oxygen in the hydrocarbon-oxygen mixture at a given process flow rate. Although any orifice configuration having this total area would deliver the required mass flow of oxygen, it is desirable to reduce the small dimension (width) of the orifice openings to a practical minimum, since the length of the downstream piping needed to achieve a given degree of mixing efficiency varies in direct proportion to the orifice width. Accordingly, the choice in the present application was to make five orifice slots, each 2 inches long and one-sixteenth in. wide. This
reduces the length of the effective mixing region by a factor of five as compared to a single orifice 5/16 in. x 2 in., for example, and thus permits a corresponding reduction in cost of this portion of the equipment. Referring to FIG. 2, the curves in this plot are based on formula 4 and (5) above. Formula (5) is more important because it specifies the critical pressure ratio n, which critical pressure ratio for oxygen is 0.528. The critical ratio, when used in formula (4), then gives the maximum velocity possible through the orifice. This maximum velocity, when combined with orifice area, gas density and overall orifice coefficient, provides the maximum flow value.

Preferably, the best mixing occurs between the oxygen and the hydrocarbon gas when the oxygen jet stream is no more than six times or less than 2.5 times the main hydrocarbon stream velocity. With the limits of five times and three times the main stream velocity of 100 ft/sec, which is appropriate for the vinyl acetate manufacturer reactor feed line application to which the present invention is particularly suited, the family of curves for pressure ratio range of 0.53 to 1.0 is illustrated in FIG. 2, covering probable overall orifice coefficients. Assuming the orifice coefficient is 0.6 and the reactor feedline pressure is in fact 45.0 psia, an internal pressure in the oxygen sparger of 68.7 psi (34.0 psig) will provide a velocity of 500 ft/sec through the orifice. The total flow, therefore, with the orifice in the full open position, will be 2,117 lbs/hr. Based on the assumption that the oxygen supply pressure within the 4 inch tube were to rise to 85 psi, flow would occur at only slightly greater than the above rate. Any higher pressure will have very small effect on flow because the maximum velocity has been reached at the critical pressure. Importantly, the adjustable orifice acts as a safety restriction against excess oxygen in that, regardless of increase in oxygen pressure above that creating flow at the preferred rate, the velocity of the oxygen exiting through the jet orifices will be limited to the value set by the critical pressure restriction.

Turning to FIG. 3, in the proposed system of the present invention, a relatively large diameter tube or stainless steel pipe 10 such as one 10 inches in diameter, comprises the pipe within which hydrocarbon gas, such as vaporized acetic acid and ethylene, flows in the direction of arrow 12. Pipe 10 constitutes a vinyl acetate manufacturer reactor feedline or one portion thereof. The oxygen supply line is comprised of a smaller diameter header or pipe 14 and carries a spring biased adjustable sleeve valve or sparger 16. Oxygen enters the end 18 of the oxygen supply pipe 14 from a source (not shown) as indicated by arrow 20, under pressure. The pressure of the oxygen supply within the sleeve valve is controlled principally by oxygen control valve 22, this valve being controlled by the pressure differential existing across the sparger orifices. In this respect, a gas pressure increases 26 reacts the equally coupled internally through casing means 24 to valve 22. Gas motor 26 is a conventional device for creating mechanical movement proportional to the pressure differential existing across the orifices of sparger 16.

A differential pressure controller 23 is coupled via tube 30 to oxygen supply pipe 14 upstream of sparger 16 while tube 28 opens up into main flow pipe 10 downstream of the sparger. A control signal passes from sensor 23 to air motor 26 through tube 25. An oxygen meter 29 of a conventional type is carried by oxygen supply pipe 14 upstream of oxygen control valve 22. In this respect, on each side of orifice 27 there is provided pressure sensing tubes 33 and 35 coupled to flow meter 29. Meter 29 comprises a Foxboro Taylor Instrument, commercially available Flow Controller, responsive to a pneumatic signal, e.g., 3-15 lbs to operate pneumatic motor 138.

Preferably, for safety purging, the system further includes a small diameter pipe 32 which opens into the oxygen supply pipe 14, downstream of oxygen control valve 22. In this case, the oxygen supply pipe is connected to a pressurized nitrogen gas supply (not shown) indicated by arrow 37. Pipe 32 carries a control valve 34, fluid coupled to a remote control means such as an emergency control signal control producer 36. Upon receiving an appropriate fluid pressure signal via tube 38, indicative of loss of hydrocarbon pressure for instance, which occurs when the main flow drops off, the valve 34 opens. This sweeps any residual oxygen out of the jet header. For instance, it takes about 1 minute to flush the sparger 16 and leave it in a safe shut down condition.

Turning to FIGS. 3 through 4, the sparger 16, constituting the most important component of the system of FIG. 1, includes a fixed outer sleeve 40 and a concentric, rotatable inner sleeve 42. The opposing surfaces of one or both sleeves may be coated with Teflon or the like as at 43 to reduce friction.

The sparger 16 is carried at the end of the small diameter oxygen feed pipe 14, the feed pipe or header 14 being flanged at 46 to sealably carry, at the end thereof, sparger 16. The concentric sleeves 40 and 42 extend through the center of the large diameter pipe 10 at right angles to the axis thereof. In this respect, the sparger body 47 is cylindrical in form, is formed of stainless steel or other suitable metal, and concentrically carries outer fixed sleeve 40 which extends through right hand opening 48 of the large diameter pipe 10 and is welded to the same at 50, about its outer periphery. The internal bore of the cylindrical sparger body 47 is recessed at 52 to receive one end of a flanged seal spacer 54, the spacer being fixedly coupled to the end face 56 of the sparger body 47 by a series of threaded screws 58. The inner end 60 of the seal spacer does not contact the end of recess 52, but presses against a Teflon O-ring 62 which in turn presses against the fixed sleeve 40 to effect a high pressure seal at this point. In turn, a series of circumferentially spaced threaded studs 64 extend through seal spacer 54 and are threadedly received by tapped and drilled holes 66, within the sparger body 47. The studs 64 carry threaded hex bolts 68 which press the flanged end 69 of the small diameter oxygen pipe 14 against the specially formed axial seal face 70 of seal spacer 54. The seal spacer 54 may also be formed of Teflon material, in similar fashion to linings of both the fixed sleeve 40 and the rotatable sleeve 42, forming the sparger valve members.

On the opposite side of the large diameter pipe from the oxygen inlet side to the sparger, the left hand opening 72 of the large diameter valve body 10 allows the fixed outer sleeve 40 to protrude slightly outwardly therefrom with the end 74 of the fixed sleeve being received within an annular recess 76 of a flanged metal stator 78. A complementary left hand sparger body 80, formed of stainless steel material, is welded at 82 about its outer peripheral contact edge to the outside of the large diameter pipe 10 with the bore of body 80 coincident with opening 72 within pipe 10. The annular sparger body 80 carries an internal peripheral recess 84 at the end remote from pipe 10, which receives an annular protrusion 86 of stator flange 78. Captured between protrusion 86 and shoulder 88 of the sparger body 80, is a Teflon O-ring 90 forming a seal between these mating parts within tapped and threaded holes 96 within the left hand sparger body 80. Stator flange 78 has its inner end face 98 abutting an annular thrust spacer 100, which in turn abuts end face 102 of the inner sleeve or rotor 42. The rotor 42 is cup-shaped in configuration and terminates with its lip 104 abutting a second annular thrust spacer 106 which in turn is held axially in position by a "waldes truarc" retaining ring 108. In this respect, the bore 110 of stator 40 carries an annular recess 112 which partially receives the ring, the ring expanding to lock itself in position and to maintain the thrust spacer in abutting contact with the lip 104 of the cup-shaped rotor 42. The sparger stator flange 78 carries an internal bore 114 through which projects the rotor shaft 116 which constitutes an integral extension of rotor 42. Stator flange 78 is further counterbored at 118 and 120 at its outer end to facilitate attachment of a shaft seal 122. In this regard, the rotor shaft is fixedly connected to a reduced diameter portion 124 which rotates in contact with the shaft seal 122, the shaft seal including a peripheral flange 126 through which passes a series of mounting screws 128 being received within tapped and threaded holes 130 carried by the stator flange 78. The cup-shaped shaft seal 122 is therefore received
within counterbore 118 with flange 126 occupying a portion of the second counterbore 120 and effecting, in conjunction with O-ring 90, a gas-tight seal for the left hand sparger body. A pair of mounting brackets 132 on each side of the left hand sparger body 80 are welded to the outer periphery of the large diameter pipe 10. These brackets 132 have coupled thereto secondary brackets 134 by bolt and nut connections 136, with the brackets 134 acting as extensions thereof. The brackets 132 and 134, in turn, support the rotary drive means constituting a pneumatic rotary motor, such as a Model 301-B Robotarm, manufactured by the Bettis Corporation, at 138, the pneumatic motor being mounted to respective brackets 134 by bolts 140. Air motor 138, which is conventional, is basically drive shaft 144 mechanically coupled to a small diameter shaft portion 142 of motor 42. The motor shaft 144 extends outwardly beyond the side of the motor casing which allows the motor 42 to be turned manually by a wrench or the like, if desired. Fluid connections are made to terminals 146 and 148, respectively, for instance, pressurized gas may be delivered to the motor 42 while connection 148 may be opened to the atmosphere. Means (not shown) within the air motor 138 biases motor 42 to the closed position in the absence of a fluid pressure signal being applied to terminal 146 of the same.

While both the rotor 42 and stator 40, or alternatively, slidable inner and outer sleeve members, are formed of AISI type 316L stainless steel 4 inch Sch. 80 pipe, the interfitting surfaces of the rotor may be coated with Teflon or other low friction material to facilitate relative rotation between the same to adjust the size of the individual orifices defined thereby. In this respect, it is noted (FIG. 4) that the rotor 42 carries five arcuate slots 150 which are rectangular in cross section while the stator 40 carries a similar number of arcuate slots 152. The width w of the arcuate slots in the illustrated embodiment is one-fourth inch, while the arcuate length is on the order of 2 inches. With respect to stator 40, the arcuate length is the same, that is, the arcuate length 1 is identical, that is 2 inches in length, but, the slots are rectangular in cross section for a short distance from the inner surface or bore 154 and being smaller in width w which, for the illustrated embodiment, is one-sixteenth inch for a height of one-eighth inch. The side wall 156 of the stator slots are divergent and define an angle α of 90° therebetween. The material forming the rotor is preferably stainless steel.

In operation, oxygen under pressure supplied to the inlet side 18 of the oxygen pipe 14 at a pressure approximating 55 psig. The flow of oxygen through the flow meter orifice 25 creates a signal at flow controller 29 which in turn is transmitted to air motor 138, causing rotation of sleeve valve rotor 42 against internal bias within the air motor to cause the sparger to open sufficiently to allow discharge of oxygen at jet velocity into the slower moving hydrocarbon flow within the large diameter pipe 10. The pressure drop across the orifices defined by stator and rotor slots 152 and 150, respectively, is set by the differential pressure controller 23 through lines 28 and 29 which transmit a pneumatic signal output to the pressure controller which is fed via line 25 to fluid motor 26 and to thus variably adjust the oxygen control valve 22. Thus, the pressure of the additive oxygen gas within pipe 14 is under control of valve 22 and the velocity of the jet stream entering the hydrocarbon gas is automatically maintained between a value less than six times that of the main gas stream velocity and in excess of a value 2.5 times the same. Increasing the size of the orifices results in, for the same pressure of oxygen within line 14, an increase in the mass flow of oxygen being jetted into the hydrocarbon flow line.

As mentioned previously, should the flow rate of hydrocarbons materially decrease within pipe 10, an emergency control signal, created at 36, shuts off the oxygen supply by means of a valve 37 upstream. No signal from means 36 is also transmitted as a pneumatic signal from tube 38 to fluid motor 34 controlling the valve in the nitrogen inlet pipe 32. Nitrogen under pressure enters the conduit 14 downstream of the oxygen control valve 22 flushing the sparger valve 16 in less than 1 minute. Thus, even under conditions in which reduction in hydrocarbon gas would, for the same mass flow of oxygen, create a possible flashback condition in the area of the mixer, a purge with nitrogen gas very quickly prevents the existence of such a condition or immediately eliminates the same. We claim:

1. A system for mixing oxygen forming a second gas stream within gaseous hydrocarbons passing through a vinyl acetate manufacture reactor feed line and forming a first gas stream, said system comprising:
   - a first pipe for confining the gaseous hydrocarbon flow as a relatively low velocity first stream,
   - a second pipe for supplying oxygen as said second gas stream to said first gas stream,
   - a sparger sleeve valve extending through said first pipe, fluid coupled to said second pipe and including a fixed outer sleeve,
   - a plurality of axially spaced, arcuate slots formed in said fixed outer sleeve on the downstream side of the gaseous hydrocarbon flow,
   - a rotatable inner sleeve including a like number of similarly spaced slots having a length on the order of the length of said arcuate slots of said outer fixed sleeve,
   - means biasing said sleeve valve towards closed position,
   - a flow meter within said oxygen line and means responsive to increased oxygen flow rate measured thereby for shifting said sleeve valve towards closed position,
   - a source of oxygen coupled to said second pipe,
   - an oxygen control valve within said second pipe upstream of said sparger sleeve valve, and
   - means for measuring the pressure drop across the orifices formed by said slots within both sleeves for controlling the pressure of oxygen flow to said sleeve valve where the oxygen jet stream exiting from said orifices is maintained at no less than 2.5 times the main hydrocarbon stream velocity, or more than six times thereof.

2. The system as claimed in claim 1, further comprising:
   - a conduit means fluid coupling a pressurized supply of nitrogen gas to said oxygen pipe intermediate of said oxygen control valve and said sparger sleeve valve, and
   - a nitrogen flow control valve for automatically releasing nitrogen gas under pressure to said sparger in response to reduction in gaseous hydrocarbon flow below a predetermined value to flush the same.

3. An oxygen sparger for discharging oxygen in jet form into a vinyl acetate manufacture reactor feed line carrying a gas stream of hydrocarbons comprising:
   - a large diameter pipe for confining the flow of gaseous hydrocarbons,
   - a small diameter pipe forming a fixed sleeve and bisecting said large diameter pipe at right angles to the direction of hydrocarbon gas flow, a plurality of axially spaced; arcuate slots carried by said small diameter pipe with said slots facing in the down stream direction, at least one movable sleeve carried within the outer fixed sleeve and defining with said fixed sleeve a sparger sleeve valve, a plurality of axially spaced slots carried by said movable sleeve and having a length on the order of the length of the arcuate slots of said fixed sleeve and movable into overlying position with respect thereto, spring biasing means for normally maintaining said sparger sleeve valve in closed position and means exterior of said sleeve valve for causing said inner sleeve to shift said outer sleeve and to open the valve by varying the size of the orifices created by the slots formed within respective sleeves.

4. The oxygen sparger as claimed in claim 3 further comprising:
   - means for mounting said inner sleeve within said outer sleeve for rotation about a common axis, and annular stop means fixed to the wall of said outer sleeve at respective ends of said inner sleeve for limiting axial movement of said rotatable inner sleeve.
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5. The oxygen sparger as claimed in claim 4 further comprising; fixed cylindrical sparger bodies welded to the outside of said large diameter pipe and extending in concentric contact with said outer fixed cylinder, said sparger body surrounding the inlet end of said fixed sleeve being provided with an internal, annular recess at its outer end, a flanged, annular seal spacer carried on the outer face of said inlet end sparger body, and having an axially projecting portion extending within said sparger body recess, an O-ring carried within said recess and in contact with said sparger body, said fixed outer sleeve and said seal spacer to prevent escape of oxygen to the atmosphere.

6. The oxygen sparger as claimed in claim 5 wherein; a second cylindrical sparger body concentrically overlies the other end of said fixed sleeve and is peripherally welded to said large diameter pipe, and said oxygen sparger further comprises; an O-ring, an internal, annular recess defined by a bore and counter bore within said sparger body, a flanged metal stator having an axial projection received by the bore of said second sparger body and an enlarged diameter portion received by said counter bore and defining therewith a shoulder for capturing said O-ring therebetween to effect a gas seal between said sleeve valve and said large diameter pipe and means for coupling said flanged stator to the outer end of said second sparger body and to thereby compress said O-ring within said annular recess to effectively prevent escape of oxygen gas from said sparger valve to the atmosphere.

7. The oxygen sparger as claimed in claim 6 wherein; said cylindrical inner sleeve is cup-shaped, and includes an integral end wall and an axially projecting drive shaft, said stator flange is bored to receive said shaft, and is doubly counterbored in a direction away from said sparger valve sleeve, and said oxygen sparger further includes: a flanged cup-shaped shaft seal including an outer annular portion in contact with said one counterbore, a radial flange portion carried by said other counterbore and a spaced, internal annular portion in sealing contact with said rotating shaft, and means for fixedly coupling said cup-shaped shaft seal to said stator flange.

8. The oxygen sparger as claimed in claim 7 wherein; said means for shifting said inner sleeve with respect to said outer sleeve comprises a rotary air motor including a drive shaft, and bracket means fixed to said large diameter pipe and removably coupled to said air motor for maintaining a drive coupling between said air motor drive shaft and said integral shaft of said cup-shaped rotor.

9. The oxygen sparger as claimed in claim 8 wherein; said internal(rotatable) sleeve carries a plurality of axially spaced arcuate slots of rectangular cross section having an arcuate length on the order of eight times the width of the same, and said outer fixed sleeve has a corresponding number of arcuate slots of the same arcuate length, said slots being rectangular in cross section for a portion of the slot depth closest to said inner sleeve, but having outwardly diverging sides defining a 90° diverging discharge path opening up onto the outer surface of the fixed outer sleeve.

10. The oxygen sparger as claimed in claim 9 wherein; the width of the slots on the fixed outer sleeve is on the order of one half the width of those carried by said movable sleeve.

11. The oxygen sparger as claimed in claim 3 wherein; the contact surface of at least one of said sleeves with the other carries a thin coating of lubricating material.

12. The oxygen sparger as claimed in claim 4 wherein; said coating comprises Teflon.

13. A system for mixing two gas streams to prevent the resulting gas mixture from supporting a flame comprising; first means causing a first gas stream to flow along a confined path at low velocity, and second means for causing a second gas stream to be discharged within said first gas stream in jet form at a velocity higher than that of the first gas stream, said second means comprising: a sparger sleeve valve including a stationary outer sleeve positioned across the path of said first gas stream, a plurality of spaced, narrow slots in said fixed stationary outer sleeve facing downstream, an inner movable sleeve receiving said second gas stream, a plurality of similarly spaced slots carried by said inner sleeve, means for moving said inner sleeve relative to said outer sleeve in response to a control signal to automatically vary the size of the orifices formed by said slotted sleeves to cause variation in the flow rate of said second gas stream through said sparger sleeve valve, and means for measuring the pressure drop of said second gas stream across said orifices for controlling the pressure of said second gas stream upstream of said orifices.

14. The system of claim 13 wherein said stationary outer sleeve extends substantially transversely across the path of said first gas stream.

15. The system of claim 13 wherein said second gas stream is discharged in jet form within said first gas stream at a velocity of more than two and less than six times that of the first gas stream.

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