HYDROCARBON INJECTOR FOR BLAST-FURNACES

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It is known that techniques of injection of hydrocarbons in blast-furnaces have been studied, and are now applied commercially. It is also known that in order to carry out such injections, it is preferable to atomize liquid fuels by means of a compressed gas which is hydrocarbon or not and with which the liquid has been mixed, by expansion of the mixture through an orifice in which the flow takes place at sonic speed.

There do exist a few known types of injectors which inject liquid or gaseous hydrocarbons into blast-furnaces and which make use of this principle. To a varying extent, they all have the disadvantage of becoming obstructed after a certain time of operation by the carbonized deposits derived from a decomposition of hydrocarbons which is usually referred-to as "cracking" or "coking."

This decomposition of hydrocarbons which is productive of carbon-charged deposits is assisted by the heating of the nose of the injector, and by any geometric factor which is conducive to the formation of hydrocarbon droplets which either settle on or run on the nose of the injector. This phenomenon, which is already highly troublesome if only one kind of hydrocarbon which is either liquid or gaseous is injected, is accordingly even further accentuated if a liquid hydrocarbon and a gaseous hydrocarbon are injected simultaneously, above all if one of these latter contains in suspension pulverized coal.

Furthermore, the complete injector unit which is usually composed of a number of concentric tubes often has a considerable length. Since the different tubes are subjected to temperatures which can be variable and which are subject to differences between each other which are both substantial and variable, the expansions can result in prohibitive relative displacements of the different tubes, thereby producing irregular atomization which assists the formation of carbon-charged drops and deposits.

The object of the present invention is to overcome these drawbacks and to produce an injector which makes it possible to employ simultaneously a liquid hydrocarbon fuel and an atomizing gas, hydrocarbon or not, while one of the two or both can hold in suspension pulverized coal, without any troublesome deposit of a product which is charged with carbon and which is derived from the decomposition of fuel being liable to take place at the nose of the injector.

With this object in view the hydrocarbon injector for blast-furnaces of the present invention comprises an outer heat resisting tube, an intermediate tube co-axial therewith for the supply of atomizing gas, a heat resisting cylindro-conical head terminating said intermediate tube and having an outlet orifice the length thereof being substantially equal to its diameter, a central coaxial tube for the supply of at least a liquid hydrocarbon fuel, a cylindro-conical head terminating said central tube and having a central passage for the flow of fuel adapted to slide freely into the cylindro-conical head, the outlet extremity of the cylindro-conical head being at a distance from said outlet orifice of the cylindro-conical head comprised between twice and eight times the diameter of said outlet orifice, said cylindro-conical head being provided with peripheral passages for the flow of the atomizing gas having a total section such that the velocity of said gas is comprised between 50 and 150 metres per second, bearing means between said cylindro-conical head and said cylindrical head, and a spring to apply said cylindrical head against said cylindro-conical head.

The bearing means between the cylindro-conical head and the cylindrical head are preferably constituted by a conical bearing surface formed inside the cylindro-conical head and fins fixed to the cylindrical head and adapted to bear against the conical bearing surface. The peripheral passages provided in the said cylindrical head which terminates the central tube may be constituted by helical grooves which impart a vertical movement to the atomizing gas so as to pull away any drops of liquid which can possibly be formed.

As will be understood, the present invention provides a more reliable method of maintaining the good geometry of the injector, which governs the perfect atomization of the fuel. A strictly accurate centering of the inner tube through which the liquid hydrocarbon fuel is supplied and with respect to the nose of the injector proper is thus maintained in spite of variations of temperature and of pressure to which the device is subjected in the course of its operation. Since it is cooled by the circulation of the liquid fuel, the inner tube is thus always at a lower temperature than that of the intermediate tube through which the atomizing gas is supplied at a relatively low rate of flow.

Since the injector unit as a whole is frequently greater in length than two metres, the expansions could result in substantial relative displacements of the extremity of the inner tube with respect to the nose of the injector, which would seriously disturb the atomizing process. This drawback is completely eliminated if the heads which form the ends of the two inner tubes are so arranged as to bear against each other, and if they are held in contact in their most effective relative position by means of a spring which absorbs all differences of expansion between the tubes.

The elements of this combination thus work together so as to prevent the formation of any carbon-charged deposit by virtue of a practically complete entrainment of the drops which are liable to form at the nose of the central tube of the injector, and by virtue of the maintenance of a relatively low temperature in the region in which the atomization takes place.

Other objects and advantages of the invention will be apparent during the course of the following description, reference being made to the accompanying drawing, wherein:

FIG 1 is an axial cross section of the fluid supply portion B of the injector of the present invention; and
FIG. 2 is an axial cross section of the injection portion A of the injector of the present invention.

In these figures, there have been drawn to the same
scale the two extremities of the injector which have been disposed one above the other on account of the dimensional requirements of the drawing, but it is quite clear that these two portions are each in the line of extension of the other. The portion A is the injection extremity which finds access into the tuyere of the blast-furnace, whilst portion B is the rear portion through which the supply of fluids is effected. The total length of an injector can reach two to three metres according to the dimensions of the blast-furnace considered, and the central portion thereof which is composed only of concentric tubes and orifices is omitted from the drawings.

The injector first comprises an intermediate tube 1 of heat-resisting steel terminating in a frusto-conical head 2 also of heat-resisting steel and forming an angle of 30° with the axis of the tube 1, any angle smaller than 35° being particularly conducive to the reflection of the radiations produced by the blast-furnace into which the injector is introduced, and consequently conducive to heat insulation. In this example, the head 2 is made of solid heat-resisting steel, the insulating qualities of which are less favorable than those offered by an insulating refractory material, but which has better behavior in service. The tube 1 comprises an axial orifice 3, the length of which is approximately equal to the diameter thereof and which is slightly flared at the outlet end so as to facilitate the divergence of the jet of fuel, as will be stated below.

The injector also comprises a central tube 4 which serves for the supply of liquid fuel and which terminates in a head 5 fitted with a terminal passage 6 which is coupled to the tube 4 through the intermediary of a convergent nozzle 7.

An outer tube 12 of heat-resisting steel protects the whole injector unit against heating by radiation and by convection. A circulation of cooling air can additionally be provided between the tubes 1 and 12. The air then passes out through the holes 13.

The strictly accurate centering of the tube 4 and of the orifice 6 with respect to the tube 1 and the head 5 is ensured by means of helicoidal grooves 14 machined in the head 5 and which play the part of spacing elements by sliding with moderate play inside a bore 15 of the head 2. The said helicoidal grooves 14 permit the flow of atomization air which arrives through the space between the tubes 1 and 4 and impart to the said flow of air a very rapid movement of rotation which is maintained within the mixing chamber and in the orifice 3. Moreover, a substantial expansion of the atomizing gas takes place inside the said helicoidal grooves and this expansion, in conjunction with the gyrovatory movement imparted to the gas, produces an excellent atomization of the liquid which passes out of the passage 6. The cone frustum 16 which terminates the head 5 plays the part of a "drop-remover." If a drop tends to form at this point, it is immediately dispersed by the vertical current which encloses the jet of liquid, and can neither settle on the walls nor form a carbon deposit. The vortical current and the flared and rounded shape of the orifice 3 produce a substantial divergence of the atomized jet of fuel, thereby resulting in rapid mixing with the blast of the furnace and in a rapid and complete combustion.

It is, without immaterial, with the spirit of the present invention, whether the helical grooves 14 are formed on the head 5 or on the head 2. In the present example, they are formed on the outer surface of the head 5, but they could be formed on the inner surface of the head 2, these two solutions being equivalent. In the second case, the outer surface of the head 5 would be smooth. The important feature is that the two heads are capable of sliding freely one inside the other, and that passages for the flow of the atomizing gas having a suitable section are disposed between the said two heads. This feature must be taken into consideration for the interpretation of the claims which appear at the end of the present application.

In normal service, the inner tube 4 is powerfully cooled by the circulation of a liquid fuel whilst the tube 1 is cooled to a considerably lesser extent by the low-velocity circulation of the atomization air. It follows as a result that substantial and variable differences of temperature between these two tubes can arise. In order to prevent the expansions from producing a relative displacement of the heads 2 and 5, which would result in faulty atomization in certain positions, the tubes 1 and 4 can be adapted to slide freely one with respect to the other, and the heads 2 and 5 are maintained in contact by means of a powerful spring 17. To this end, the head 2 is provided with a conical bearing surface 18, and the head 5 is provided with fins 19 which are brought to bear against the said bearing surface 18 while nevertheless permitting the atomization air to circulate between the said fins. The spring 17 is applied on the one hand against a shoul-dered portion 20 which forms one piece with the inner tube 4 and on the other hand against a threaded cup 21 which is rigidly fixed to the tube 1.

The supply of fuel is carried out by means of a tube 22, the atomization air is introduced through a junction 23, while the additional cooling air can be introduced through a tube 24 and through a junction 24. Fluid-tightness between the two sliding tubes 1 and 4 is ensured by means of conventional toric sealing-rings 25a, 25b.

The tube 12 need not necessarily be of heat-resisting steel over its full length. The said tube is extended in that portion thereof which is not exposed to the radiation of the blast-furnace charge by a tube 12a of ordinary steel.

The said injector can operate, for example, under the following conditions. The central tube 4 which terminates in a passage 6 having a diameter of 1.7 mm. is supplied with fuel oil at a pressure of 7 kilograms per square centimetre with an hourly rate of flow of 100 kilograms per hour. The orifice 6 is placed at a distance of 12 mm. from the outlet section of the orifice 3, the minimum diameter of the said orifice being equal to 4 mm. The gas blown round the central tube is air, at a pressure of 4 kilograms per square centimetre with an hourly rate of flow of 18.5 kilograms per hour, namely approximately 14.3 Nm³ per hour.

The injector is fixed to the blast-furnace by means of any desired system of fastening constituted for example by a tube 26 inside which slides the tube 12a, the injector being held in position by means of a threaded cap 27 which makes it possible for the injector to be easily dismantled.

It is obvious that variations and modifications may be resorted to by those skilled in the art without departing from the scope of the invention as disclosed in the present specification and defined by the appended claims.

What is claimed is new and desired to be secured by Letters Patent is:

1. A hydrocarbon injector for blast furnaces, which comprises an outer heat resisting tube, an intermediate tube co-axial therewith for the supply of atomizing gas, a heat resisting cylindrical head terminating said intermediate tube and having an outlet orifice the length thereof being substantially equal to its diameter, a central coaxial tube for the supply of at least a liquid hydrocarbon fuel, a cylindrical head terminating said central tube and having a central passage for the flow of fuel adapted to slide freely into the cylindrical-conical head, the outlet extremity of the cylindrical-conical head being at a distance from said outlet orifice of the cylindrical-conical head comprised between twice and eight times the diameter of said outlet orifice, said cylindrical head being provided with peripheral passages for the flow of the atomizing gas having a total section such that the velocity of said gas is comprised between 50 and 500 meters per second, bearing means between said cylindrical-conical head and said cylindrical head, and a spring to apply said cylindrical head against said cylindrical-conical head.
2. The combination of claim 1 wherein said bearing means are constituted by a conical bearing surface formed inside the cylindro-conical head and fins fixed to the cylindrical head and adapted to bear against the conical bearing surface.

3. The combination of claim 1 wherein said peripheral passages of the cylindrical head are constituted by helical grooves.

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