INJECTION LANCE WITH A NOZZLE ADAPTED FOR ABOVE THE BATH OPERATION

William W. Berry, Pittsburgh, Pa., assignor to Berry Metal Company, Harmony, Pa., a corporation of Nevada

Filed Apr. 7, 1967, Ser. No. 629,186

Int. Cl. C21c 7/04

U.S. Cl. 266—34

3,525,509

10 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to fluid injection apparatus, and more particularly, pertains first, to an improved injection lance for blowing oxygen down on the surface of a bath of molten material in a high temperature furnace, and secondly, to an improved method of utilization that is generally applicable to the type of oxygen or other fluid injection lance having a nozzle tip for use above the bath.

The nozzle tip has a generally cylindrically-shaped outer side wall provided thereon with a plurality of oxygen outlet ports that are regularly positioned on the nose of the nozzle tip circumferentially about the axis of the nozzle tip, each of which oxygen outlet port of the nozzle tip is slot-shaped, with long dimensions thereof extending generally in a direction normal to the lance axis. An improved method of cooling is employed wherein the coolant is accelerated.

BACKGROUND OF THE INVENTION

Field of invention

The nozzle tip of an oxygen injection lance is typically subjected, during its operation to a number of different deterioration producing factors inherent to its operational environment. Such factors effect an early deterioration of the nozzle tip and thus severely limit its usable life. One major detrimental factor that is encountered in the use of a nozzle tip above the surface of the liquid steel is in the constant splashing action of the extremely turbulent motion of liquid steel, oxides and gases under and around the nozzle tip, which turbulence causes the gradual eroding away of the nozzle tip.

Therefore, it has been an objective of this invention to devise a new construction for an oxygen lance, with such construction including improved gas and liquid flow systems inherently capable of reducing the effect of the aforementioned deterioration factors and providing a new construction which will create a more efficient operation.

Description of prior art

Injection lances for use in steelmaking furnaces have generally comprised a cylindrical tube with water cooling and gas passageways. These have been refined to improve lance life by several configurations such as that shown in Jilek et al. Pat. No. 3,241,825 for use with admixtures, Berry Pat. No. 3,201,104, Elbit Pat. No. 3,216,714, and Hinds Pat. No. 3,020,035. These have employed circular outlet ports directed downward generally parallel to the axis of the lance, and arranged around the bottom or face of the nozzle tip. My copending application Ser. No. 624,287, filed on Mar. 20, 1967 jointly with Louis M. Herff, having common assignee, teaches an improved lance for subsurface use employing outlet ports in the form of slots on the sides of the nozzle tip.

SUMMARY OF THE INVENTION

This invention comprises an improved lance for use above the bath for blowing oxygen or other fluid into the melted material in a high temperature furnace through a nozzle tip comprising a plurality of oxygen outlet ports channels on the face of the nozzle tip and having a slot-like configuration defined as follows:

(a) Depth being the distance generally parallel to the lance axis.
(b) Width being the distance along the circumference in a plane perpendicular to the lance axis.
(c) Length generally being the radial distance measured on the radius of the lance.

The ratio of length to width shall be equal or larger than 3 to 1, and the ratio of depth to width shall be equal to or larger than 5 to 1; these slots may be a plurality of different lengths or of equal length.

Internally the water fluid conduit is arranged to have a restricted portion in the cold water channel near the face of the nozzle tip, so as to accelerate the water and increase the Reynolds number. In addition vanes are provided inside the outer shell of the nozzle tip for support and for causing the return flow of water to spiral upward.

These and other features will better be understood by the more detailed explanation below.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a lance nozzle tip in accordance with this invention taken along the line 1—1 of FIG. 2.

FIG. 2 is an end view of the nozzle tip of the lance taken from beyond the face of the nozzle tip along line 2—2 of FIG. 1.

FIG. 3 is a cross-sectional view of part of the lance nozzle tip taken on line 3—3 of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

In the figures it will be seen that the nozzle tip in accordance with my invention is a rigid body formed from a metallic composition such as copper. The nozzle tip body broadly comprises an outer cylindrical pipe or wall 8, an intermediate wall or pipe portion 6 and an inner wall or pipe portion 4.

Wherever in this description the term "oxygen" is used, it is understood that it is applicable to oxygen or other fluid.

With specific reference to FIG. 1, it will be noted that the annular oxygen inlet passage 12 widens inwardly at its lower end to form an oxygen settling chamber. From the oxygen settling chamber of the oxygen passage 12, a plurality of downwardly directed port wall portions 16 lead outwardly to respective oxygen outlet ports 18.

The oxygen ports 18 at the termination of the oxygen outlet channels 16 are located on the face of the lance nozzle tip near the outer edge of the face of the nozzle tip and generally at a right angle to the axis of the nozzle tip or, described differently, they are located so as to commence substantially at the beginning of the curved or tapered portion of the nozzle tip face or bottom.

In accordance with a preferred embodiment of my invention, I provide a central conduit 10 for water which is tapered inward distant from the face of the nozzle tip. This taper produces a restriction in the main water channel 10 to approximately one-half the cross-sectional area of the main water channel and the restricted area continues for a distance whereby its length to diameter is in a ratio of at least 2 to 1. It will be noted that the restriction in the water channel near the nozzle tip of the lance also produces an enlargement of the oxygen channel 12 and creates an oxygen settling chamber.

Inside of the nozzle tip I provide oxygen conduits, leading to the exit ports 18 which are of slot-like internal cross-sectional configuration the same as the exit or outlet ports 18. Further in accordance with a preferred embodiment of my invention as shown in FIG. 1, I provide
that the oxygen outlet channels 16 near the outlet ports 18 have a direction generally downward toward the face of the nozzle tip and outward at approximately 30° from the axis of the lance. The oxygen flow into channels 16 is shaped with an outside configuration cross-sectionally substantially in an oval shape but varied slightly so as to produce streamlined surfaces to the flow of water as shown in FIG. 3. Outside of the oxygen outlet channels I provide vanes 20 which extend up along the water exit conduit 12 so as to give a generally spiraling configuration with an increasing slope from the vertical and with an average slope such that they would spiral completely around the lance in a distance up the lance equal to approximately two and one-half times the diameter of the lance. These vanes extend between the outside wall or pipe 8 of the nozzle tip and the adjacent intermediate wall or pipe 6 so as to produce a spiraling wall between the outside wall or pipe 8 of the lance and the adjacent wall or pipe 6.

In accordance with a preferred embodiment of my invention as shown in FIG. 3, the oxygen outlet conduits and the water deflecting vanes are joined together so as to form hollow streamlined curved vanes wherein the hollow portions of the vanes constitute the oxygen outlet channels.

An enlarged area is provided near the face of the tip of the lance which acts as a settling chamber to smooth out the flow of oxygen. It will be noted that proper oxygen expansion in the nozzle requires a ratio of depth of the oxygen output channel to width of the channel which is at least 5 to 1. The characteristic dimension of a slot is its width or smaller cross sectional dimension. Thus the depth of the oxygen output channel from the interior of the tip to the outer surface of the tip for the oxygen is easily maintained at its desired relationship, i.e., where the width of the slot is ½ of the depth of the slot.

In the operation of apparatus in accordance with my invention, water flows down through the central tube 10 to the face of the nozzle tip at which point the water contacts a substantially conical projection 24 in the center of the interior of the face tending to cause the water to flow radially outward toward the outside areas of the nozzle tip in a manner that is turbulent but which has a relative absence of dead water zones. The water flows thus across the face of the nozzle tip past the streamlined outer wall of the oxygen outlet port in a relatively unimpeded manner so that substantially the entire face of the nozzle tip has a rapid water flow across it so as to produce a maximum cooling at the face. The usual practice of the prior art provide cylindrical oxygen outlet channels in the bottom face of the nozzle tip which both obstruct the flow of water across the face, and create dead water zones which interfere with the cooling of the face. In the present nozzle tip, water is relatively unimpeded because the oxygen outlet channels through the bottom face of the nozzle tip are of streamlined configuration and water flows outward in a manner relatively free of dead zones to the outside cylindrical walls of the nozzle tip where the water turns and moves upward around the radial reinforcing pieces between the outer wall or pipe 8 and the intermediate wall or pipe 6. In accordance with the preferred embodiment of my invention, the reinforcing pieces are the vanes 20 which extend between the outside wall or pipe of the nozzle tip and the intermediate wall or pipe within the nozzle tip. The oxygen flow flows down the shank of the lance through the intermediate channel 12 into the settling chamber and through the connecting nozzles or outlet channels 16 in the hollow of the vanes into the liquid metal being processed. The oxygen flow outward through the face of the nozzle tip is through a plurality of small slots so that the oxygen stream is broken up into large, the number of small streams placed all around the face of the lance. Depth of penetration therefore is controlled by the distance of the nozzle tip from the bath and velocity of the fluid being injected.

The use of the slots as described herein having preferably a length to width ratio of at least 3 to 1, produces a number of distinct advantages. The use of the slot configuration produces much shorter supersonic core than is possible with a round hole of the same area while injecting the same amount of oxygen per unit time into the bath (flow rate). A shorter supersonic core results in less impact pressure on the bath. Reduced impact results in less penetration, agitation and splashing in the bath My invention, for the same flow rate, produces less agitation and penetration than prior lances.

For the same impact pressure I can use higher flow rates than can lances of the prior art.

In the lances of the prior art with round oxygen channels in the coolant stream there are dead water zones which are highly undesirable. Prior art reduces these dead water zones by reducing the water velocity which also reduces cooling. I have therefore provided a long thin oxygen channel which is so profiled as to be streamlined and to produce substantially no dead water at high velocity in the coolant channel.

I have concluded that it is desirable to increase the Reynolds number for the coolant flow to an amount larger than 100,000 prior to reaching the tip of the flow so as to obtain turbulent flow and to maintain that turbulent flow throughout and substantially beyond the entire nozzle tip of the lance. I have therefore built a lance which produces a high velocity turbulent flow and which encourages the flow to remain continuously turbulent throughout and beyond the tip of the lance by continuous reduction of area and acceleration of flow.

In addition, in the cooling mechanism, I am of the opinion that a maximum cooling can be accomplished at those points where a centrifugal force may be maintained at a maximum. Thus the water is caused to move downward along the longitudinal length of the lance until it reaches the tip at which point a high centrifugal acceleration is applied to the water by the natural change in direction at the face of the nozzle tip. This causes the steam bubbles collected on the wall of the lance to move from the outside regions toward the interior of the lance under the pressure gradient force due to the centrifugal force, somewhat in the manner in which water boiling causes bubbles to move from the bottom of the vessel to the surface by the force of gravity. In the nozzle tip I am able to obtain the desired centrifugal force merely by the simple requirement that the water must change direction by moving downward, due to the centrifugal force. As the water moves back up along the side walls of the nozzle tip, there is no natural centrifugal force. I have, therefore, provided a plurality of vanes for causing the water to move rotatably about the major axis of the lance so as to produce a centrifugal force. The combination of centrifugaally created pressure gradient and high turbulence preserves nucleate boiling on the hot wall and a detrimental film boiling mechanism could not develop.

In lances of prior art, the interior pipes were free standing supported by the nozzle tip which was supported by the outside pipe, which, in turn, was solidly secured at the other end of the lance. The plurality of vanes also serve to transfer directly the weight of the intermediate pipe to the outer pipe and thereby reduce the stresses presented by the otherwise free standing intermediate pipe in the nozzle tip.

What I claim is:

1. A fluid injection lance having a substantially elongated shank and a nozzle tip for use above the melted material in a high temperature furnace wherein said shank comprises three substantially concentric pipes in spaced relation to each other, the inner pipe defining a water supply conduit, the outer pipe defining a shell, and the intermediate pipe defining with the inner pipe a fluid passageway and defining with the outer pipe a water
return passageway, and said nozzle tip comprises a face end, an open end for connection to said shank, an outer side wall of generally cylindrical shape between said open end and said face end, a plurality of fluid outlet ports opening from the face of said tip, said fluid outlet ports being of slot-like configuration, and a plurality of fluid outlet channels extending from said intermediate pipe at the nozzle tip of said shank to said plurality of fluid outlet ports, said channels having an inner cross-section of slot-like configuration corresponding to said fluid outlet ports and having an outer cross-sectional configuration which is streamlined for flow of coolant thereby.

2. Apparatus as defined in claim 1, wherein coolant deflectors are provided which extend upward in a spiraling manner toward the shank of said lance in said water return passageway and extending radially between said intermediate pipe and said outer pipe, thereby adding support of the intermediate pipe by the outer pipe.

3. A lance as described in claim 2 wherein said coolant deflectors and said fluid outlet channels are connected so as to form a streamlined unit in the water channel.

4. A lance as defined in claim 1 wherein an inner coolant supply channel has a restricted cross-section near the face of said lance.

5. A lance as described in claim 4, wherein said inner pipe is restricted in diameter near the face of said lance to form a cross-sectional area approximately one-half the cross-sectional area of the main body of said inner pipe.

6. A lance as described in claim 5 wherein fluid outlet channels extend through said outer coolant channel and have a streamlined outer wall.

7. A lance as described in claim 1 wherein the fluid outlet ports issue from fluid outlet channels wherein the depth to width ratio is at least five to one.

8. A lance as described in claim 1 wherein the oxygen channel is expanded near the face of the nozzle to form an oxygen settling chamber.

9. A lance as described in claim 1 wherein said fluid channels extend at an angle between 30° and 45° to the axis of the lance.

10. Apparatus as described in claim 1 wherein the apertures of said fluid outlet ports have a ratio of length to width of at least three to one.

References Cited

UNITED STATES PATENTS

3,043,577 7/1962 Berry ............... 239—132.3
3,385,586 5/1968 Kemmetmueller .......... 266—34

FOREIGN PATENTS

6508187 7/1965 Netherlands.

J. SPENCER OVERHOLSER, Primary Examiner

U.S. Cl. X.R.

239—132.3
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION


Inventor(s) William W. Berry

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 6, the word "Nevada" should read ---Delaware---.

SIGNED AND SEALED

OCT 27 1970

(SEAL)
Attest:
Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents