METAL MAKING LANCE TIP ASSEMBLY

Inventors: Nicholas M. Rymarchyk, Cranberry Township, PA (US); George Cingle, Gibsonia, PA (US); Todd G. Smith, Grove City, PA (US)

Assignee: Berry Metal Company, Harmony, PA (US)

Correspondence Address:
JOHN F. LETCHFORD
ARCHER & GREINER, P.C., ONE CENENNIAL SQUARE
HADDONFIELD, NJ 08033

Abstract

A metal making lance tip assembly including a tip face member having a plurality of outlets, a plurality of nozzles corresponding in number and in communication with the tip face member outlets, and a coolant flow baffle member for directing coolant flow around the nozzles. The lance tip assembly further includes both a generally centrally disposed coolant fluid diverting protrusion and a plurality of radial vanes at the inner surface of the lance tip face member, which vanes preferably extend essentially the entire axial distance between the inner surface of the lance tip face member and a lower surface of the coolant flow baffle member and essentially the entire radial distance from the central protrusion to an annular coolant fluid return passageway.
COOLING REINFORCEMENT RATIO (CRR)
\[ CRR = \frac{T}{H} \approx 0.3 \]

**FIG. 6**

DIMPLE PROFILE RATIO (DPR)
\[ DPR = \frac{D}{H} \approx 2.7 \]

**FIG. 7**
METAL MAKING LANCE TIP ASSEMBLY
CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of U.S. Provisional Patent Application No. 60/794,258, filed Apr. 21, 2006, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates in general to metal making equipment and in particular to metal making lances.

BACKGROUND OF THE INVENTION

[0003] In many metal making processes, water-cooled lances are inserted into a furnace vessel to perform desired metal processing functions. For instance, in steelmaking processes a water-cooled lance is inserted into a steelmaking vessel (e.g., a basic oxygen furnace (BOF), electric arc furnace (EAF), etc.), to promote melting, decarburization, refining and other processes useful in converting iron-containing scrap material within the vessel into steel. A typical lance may inject gaseous materials such as oxygen, hydrocarbon gas and/or inert gas at high velocity at various times to achieve desired treatment of the charged material (scrap and hot metal) and/or maintenance of the interior of the vessel. Some lances may also inject particulate carbon and/or lime (or other substances) to achieve desired properties in the steel ultimately produced.

[0004] Water-cooled lances generally comprise an adapter portion, an elongated barrel portion connected at a first end thereof to the adapter portion and a lance tip portion connected to a second end of the barrel portion.

[0005] The adapter portion comprises at least one inlet for receiving the gaseous and/or particulate matter to be injected into the furnace vessel, which matter will hereinafter be generally referred to as “active material.” The adapter portion also includes a water inlet and a water outlet for circulating pressurized cooling water throughout the lance.

[0006] The barrel portion comprises at least three substantially concentrically arranged metal, typically steel, pipes for communicating the cooling water and/or active material(s) between the adapter portion and the lance tip portion. The outermost and first innermost pipes normally define an annular water return passageway for conveying coolant water from the lance tip portion to the adapter portion. The first and second innermost pipes normally define an annular water delivery passageway for conveying coolant water to the lance tip portion from the adapter portion. And, the interior of the second innermost pipe (and any additional pipes arranged interiorly thereof) defines at least one passageway for conveying active material from the adapter portion to the lance tip for injection into the furnace vessel.

[0007] The lance tip portion usually comprises an assembly having one or more parts which may be secured by welding, soldering or the like to the concentric pipes of the barrel portion. The lance tip assembly comprises at least one nozzle in communication with the at least one active material passageway of the barrel portion for injecting or discharging the active material into the furnace vessel. The tip assembly further comprises passage means for connecting the water delivery and return passageways of the barrel portion to one another. So constructed, water or other coolant fluid may be continuously circulated through the lance to cool the lance, especially the lance tip assembly which is exposed to the greatest temperatures during lance operation. Indeed, if coolant water is not effectively conveyed through the lance tip portion then the assembly may become non-uniformly heated. This, in turn, may lead to so-called “hot-spots” or “burn-through” sites which often result in premature failure of the lance tip.

[0008] A common practice by which the steelmaking lance manufacturing industry has sought to impart cooling to the lance tip assembly is to provide a generally centrally disposed protrusion or dimple at the inner surface of the tip face member of the tip assembly. The object of such protrusion is to direct coolant water radially outwardly through the interior space of the lance tip to cool all areas of the outer working surface face of the lance tip. The water-diverting protrusions have assumed an assortment of sizes and shapes and have met with varying degrees of success for their intended purposes. Examples of such protrusions may be found in U.S. Pat. Nos. 3,224,749; 3,525,508; 3,525,509; 3,823,929; 3,827,632; 4,083,539; 4,083,541; 4,083,542; 4,083,543; 4,083,544; 4,106,756; 4,322,033; 4,432,534; 4,702,462; 4,951,928; 6,234,406 and U.S. Reissue Pat. No. 28,769; as well as United Kingdom Pat. Nos. 1,190,137 and 1,255,082.

[0009] U.S. Pat. No. 4,417,721 proposes an alternative means for improving coolant water flow across the inner surface of a lance tip. In particular, a plurality of intricately configured radial water flow passages are provided between a lower surface of a coolant water baffle member and the inner surface of the lance tip face member. The radial flow passages are defined by and located between flow vanes of uniform thickness.

[0010] U.S. Pat. Nos. 3,222,419 and 3,337,203 and United Kingdom Pat. No. 1,255,082 combine a centrally disposed protrusion and a plurality of radially arranged coolant flow vanes at the inner surface of the lance tip face member. However, in each of these designs the vanes do not extend either (1) essentially the entire axial distance or height between the inner surface of the lance tip face member and the lower surface of a coolant flow baffle member or (2) essentially the entire radial distance from the central protrusion to the annular coolant fluid return passageway. The considerable radial or axial coolant flow gaps in these designs permit cross flow between adjacent coolant flow passages at the inner surface of the lance tip face member. It is believed that such cross flow produces eddy currents and dead spaces in coolant water flow which could result in the formation of hot spots at the outer working surface of the lance tip face member.

[0011] An advantage exists, therefore, for a metal making lance tip assembly which is comparatively easy to assemble and durable in operation and which provides substantially uniform cooling of the working face of the lance tip via structural features that promote high coolant water flow and velocity throughout the tip.

[0012] A further advantage exists for a metal making lance tip assembly having a structurally reinforced face for improved operating performance and service life.

SUMMARY OF THE INVENTION

[0013] The present invention provides a lance tip assembly for a water-cooled lance. In general, the assembly includes a tip face member having a plurality of outlets, a
plurality of nozzles corresponding in number and in communication with the tip face member outlets and with a corresponding number of inlets provided in an active material well member, a coolant baffle member for directing coolant flow around the nozzles, and a tip face member support post connecting the tip face member and the active material well member for providing structural support to the tip face member during lance operation.  

Unlike other lance tip assemblies, the lance tip assembly of the present invention further includes both a generally centrally disposed coolant fluid diverting protrusion and a plurality of radial vanes at the inner surface of the tip face member, which vanes extend essentially the entire axial distance between the inner surface of the lance tip face member and the lower surface of the coolant fluid flow baffle member and essentially the entire radial distance from the central protrusion to the annular coolant fluid return passageway. The resultant construction provides high velocity and essentially eddy and void free coolant fluid flow across the inner surface of the lance tip face member which, in turn, uniformly cools the lance tip face member and greatly enhances the service life of the lance tip assembly.  

Other details, objects and advantages of the present invention will become apparent as the following description of the presently preferred embodiments and presently preferred methods of practicing the invention proceeds.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will become more readily apparent from the following description of preferred embodiments thereof shown, by way of example only, in the accompanying drawings wherein:

FIG. 1 is an elevational cross-section view of a lance tip assembly according to the present invention taken along line I-I of FIG. 2;  
FIG. 2 is a view the working face of the lance tip assembly of FIG. 1;  
FIG. 3 is a plan view of the inner surface of the tip face member of the lance tip assembly;  
FIG. 4 is an elevational cross-section view of the tip face member taken along line V-V of FIG. 4;  
FIG. 5 is an elevational cross-section view of the tip face member taken along line VI-VI of FIG. 5 and illustrating a preferred cooling reinforcement ratio for coolant vanes constructed according to the present invention; and  
FIG. 7 is an elevational cross-section view of a central portion of the tip face member according to the present invention illustrating a preferred dimple profile ratio for a central recess provided therein.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings wherein like or similar references indicate like or similar elements throughout the several views, there is shown FIGS. 1-3, collectively, a metal making lance assembly according to the present invention which is identified generally by reference numeral 10. Assembly 10 preferably comprises: a tip face member 12 having a plurality of outlets 14, a plurality of outwardly divergent nozzles 16 corresponding in number and in communication with the tip face member outlets 14 and with a corresponding number of inlets 18 provided in an active material well member 20, a coolant baffle member 22 for directing coolant flow around the nozzles 16, and a tip face member support post 24 connecting the tip face member 12 and the active material well member 20 for providing structural support to the tip face member during lance operation. The illustrated example in FIG. 2 depicts four nozzles equiangularly disposed about the central longitudinal axis 26 of assembly 10. However, any desired number of nozzles in any desired orientation may be provided in the assembly. As is known, nozzles 16 permit gaseous and/or particulate active material to pass from an active material flow space, described below, through corresponding outlets 14 and into a unillustrated furnace vessel such as, for example, a steelmaking vessel.

An exemplary, although not limitative, procedure for assembling lance tip assembly 10 is as follows. The various components of assembly 10 may be formed of metal or metal alloys including, without limitation, copper, brass, steel, stainless steel and the like, as may be appropriate for the intended function(s) or desired characteristic(s) of the components (e.g., structural strength, thermal conductivity, etc.). One end of support post 24 is welded to the uppermost portion of a centrally located protrusion 28 provided on inner surface 30 of tip face member 12. Protrusion 28 is described in detail in connection with the discussion of FIG. 5. Tip face member is desirably made of highly thermally conductive metal such as, for example, solid cast or forged copper or brass. Thereafter, the tip face member 12 and nozzles 16 are cleaned and prepared for brazing, including cutting and inserting unillustrated brazing rings into the lower ends of the nozzles. The coolant fluid baffle member 22 is then placed into mating recesses, described hereinafter, provided on radially extending coolant flow directing vanes 32 that extend upwardly from the inner surface 30 of tip face member 12. Nozzles 16 are then inserted into corresponding openings in coolant baffle member 22 in alignment with tip face member outlets 14. Lastly, the active material well member 20 is placed atop the upper ends of nozzles such that its inlets 18 are in alignment with the upper ends of nozzles 16. The assembly is then clamped together and the lower ends of the nozzles are brazed to upper ends of the outlets of the tip face member, the coolant fluid baffle member is welded to the nozzles, the upper ends of the nozzles are welded to the inlets of the active material well member, and the upper end of the support post is welded to the active material well member.

Although shown and described as separate components assembled into a collective whole, it is also contemplated that nozzles 16, active material well member 20 and baffle member 22 may be a single component. For example, they may be formed as a unitary casting of copper or brass in a manner similar to that described in U.S. Pat. No. 6,217,824, the disclosure of which is incorporated herein by reference thereto. It will be appreciated that by forming nozzles 16, active material well member 20 and baffle member 22 as a single component, several of the above-described assembly steps may be eliminated.

FIG. 3 illustrates how tip assembly 10 is secured to a the lower end of the barrel portion of a water cooled metal making lance. Typically, a water cooled metal making lance includes a plurality of concentrically arranged metal, e.g.,
steel, pipes. As shown in FIG. 3, the lance barrel has a central pipe 34 welded or otherwise suitably affixed to the active material well member 20. Central pipe 34 defines a central passageway 36 for delivering pressurized active material to nozzles 16. An annular space formed between pipe 34 and a second pipe 37 defines a coolant fluid inlet passageway 38 which is connected to an unillustrated supply of cooling water and delivers water to the lance tip assembly. Preferably, although not necessarily, coolant fluid baffle member 22 includes at least one internally formed bypass passageway 40 desirably corresponding in number and disposition to nozzles 16 to enable cooling of the radially outermost areas thereof. During lance operation, coolant water continuously flows through coolant fluid delivery passageway 38 into passage means defined by lower surface of the active material well member 20, the coolant fluid baffle member 22 and the inner surface 30 of the tip face member 12 and then into a coolant fluid return passageway 42. More particularly, coolant water flows downwardly through passageway 38 into a first coolant fluid flow space defined by lower surface of the active material well member 20 and the coolant fluid baffle member 22 and bypass passageway(s) 40 (if present), around the exterior surfaces of nozzles 16, and through a central opening 44 in coolant fluid baffle member 22. As coolant water passes through central opening 44, its direction of travel is changed. Specifically, the generally conical profile of protrusion 28 redirects the coolant water flow from substantially parallel to substantially perpendicular to the longitudinal axis 26 of the lance as it flows through a second coolant fluid flow space defined by the coolant fluid baffle member 22 and the inner surface 30 of the tip face member 12. While in the second coolant fluid flow space, the coolant water flows radially outwardly and around the exterior surfaces of the tip face member outlets 14 and between a plurality of radially arranged vane(s) 32, described below. Upon exiting the second coolant fluid flow space, the coolant water combines with the coolant water exiting bypass passageway(s) 40, if present, and enters a coolant fluid return passageway 42 formed between second pipe 37 and third, and outermost pipe 46 whereupon the water is returned from the lance tip to the coolant water supply and is again recirculated through the lance. Coolant water flow volumes may be expected to range from about 100 to about 2000 gallons per minute (gpm) through a typical water cooled lance, although greater and lesser flows may be accommodated by the present invention as may be desired or necessary.

As seen in several of the figures, protrusion 28 is preferably located coaxially with the central longitudinal axis 26 of the lance tip assembly. The contour of the protrusion 28 is preferably substantially conical, although it may have a somewhat convex or concave profile in relation to the central longitudinal axis 26. According to a presently preferred embodiment, the profile of protrusion 28 is substantially conical whereby the circumferential wall of the protrusion diverges from the central longitudinal axis 26 at an angle α (FIG. 5) of between about 20°-50°, more preferably about 35°.

Additionally, the outside or working face of the tip face member 12 is preferably formed, either during or after manufacture, with a recess 48 (FIGS. 1, 2, 4, and 5) generally corresponding in shape to protrusion 28. Recess 48 is desirable in that it substantially equalizes the working face thickness of the tip face member 12 in the region of protrusion 28 which promotes substantially uniform thermal characteristics therefrom. Moreover, as discussed below in connection with FIG. 7, the contour of recess 48 may be optimized to achieve a preferred “dimple profile ratio.”

FIGS. 4 and 5 reveal a presently preferred configuration of coolant flow directing vanes 32. Unlike those disclosed in U.S. Pat. Nos. 3,522,419 and 3,377,203 and United Kingdom Pat. No. 1,255,082, vanes 32 extend essentially the entire axial distance or height between the inner surface 30 of the lance tip face member 12 and the lower surface of the coolant flow baffle member 22, and essentially the entire radial distance from the central protrusion 28 to the annular coolant fluid return passageway 42. A first set of vanes, identified by reference numeral 32a, intersect and are in contact with outlets 14 and nozzles 16, whereby vanes 32a provide structural support to the outlets and nozzles which serves to minimize distortion of the tip face member 12 during lance operation. In unreinforced lance tip assemblies the working face distorts under normal operating conditions. This typically results in internal nozzle distortion approximately two inches from the nozzle exit. This nozzle distortion causes the oxygen jet to act non-symmetrically which, in turn, reduces jet efficiency, increases slag FeO and reduces metallic yield. By making them an integral part of the nozzles 16, vanes 32a function as reinforcing ribs to minimize nozzle distortion.

A second set of vanes, identified by reference numeral 32b, are preferably circumferentially spaced midway between adjacent vanes 32a. As best seen in FIG. 5, each of vanes 32b are preferably formed, such as by machining, or the like, with a depression 50 having a contour which is adapted receive the lower surface of the coolant flow baffle member 22. A preferred, although non-limitative, shape of depression is a generally lobe-shaped concavity. It is preferred that the lower surface of the coolant flow baffle member also be formed or machined to produce a shape that essentially mates with depression 50. In this way, coolant cross-flow between vanes is effectively prevented whereby coolant flow control is optimized during lance operation.

The provision of vanes 32a and 32b radiating from protrusion 28 establishes highly controlled coolant water flow paths that enhance the ability of the lance tip assembly to convey water at high velocity and more uniformly cool the lance tip. Additionally, the vanes provide structural reinforcement for the lance tip face and nozzles, thereby resulting in enhanced lance tip performance and service life.

FIG. 6 shows a presently preferred elevational cross-section configuration of vanes 32. According to the present invention, each vane has a height “H” and an average thickness “t” (measured at approximately 1/2) at any point along the radial extent of the vane. H is the axial distance between the inner surface 30 of the lance tip face member 12 and the lower surface of the coolant flow baffle member 22. As seen in FIG. 5, since the inner surface 30 the tip face member 12 is preferably defined by a convex, preferably frustum-conical shape, the height “H” of the vanes varies from protrusion 28 throughout the radial extent of the vanes. It is likewise preferable that the working face have a shape corresponding to that of inner face 30 so as to present a tip of substantially uniform thickness at its distal end, thereby minimizing the potential for “hot spots” and uneven cooling of the working face. That is, according to the present invention, vanes 32 have thicknesses which vary as a function of radial distance from protrusion 28 to the perim-
eter of the lance tip face member. This thickness is represented by the variable “T” in FIG. 6 and can be observed most clearly in FIG. 4. It will be understood, however, that the working face of the lance tip face member may be essentially flat, in which case the height “H” and thickness “T” of vanes would be essentially constant throughout the radial extent of the vanes beyond central protrusion. As part of the present invention, a “coolant reinforcement ratio” or “CRR” with respect to the vanes is defined as T/H. Without intending to be bound by theory, it is believed that a CRR of approximately 0.3 contributes to the superior cooling characteristics of the lance tip assembly according to the present invention versus conventional lance tip assemblies known in the art.

Turning to FIG. 7, there is shown a limited cross-section of the central region of lance tip face member. That figure illustrates the flow path of coolant water as it passes through coolant flow baffle member and becomes radially outwardly deflected by internal protrusion. Also shown in FIG. 7 are certain dimensional variables defining the general size and shape of recess formed at the working face of the tip. As depicted in FIG. 7, dimension “D” is the diameter of a circle defined by the foremost projection of the working face of the lance tip circumcising recess. As also depicted in that figure, “d” is the depth of recess from the foremost projection of the outer surface or working face of the lance tip to the deepest point of the recess as measured along the central longitudinal axis of assembly. The aforementioned “dimple profile ratio” or “DPR” is defined as D/d and a beneficial DPR has been observed to be approximately equal to 2.7.

A known failure mechanism in a typical BOF lance tip is center face wear caused by slag and/or metal entrained in the furnace gasses. In the present invention, a recess of appropriate depth “d” in relation to dimension “D” may substantially reduce the exposed area of the tip working face which reduces face wear. In contrast, a relatively flat tip face would have a high DPR ratio. In any design, however, the final recess profile is dependent on a compromise between the requirements of the internal water distribution profile, nozzle leg spacing and face thickness.

Similar to a beneficial CRR (and, again, without intending to be bound by theory) it is believed that a beneficial DPR contributes to the superior cooling characteristics of the lance tip assembly according to the present invention versus conventionally constructed lance tip assemblies known in the prior art (as observed by the inventors through empirical comparative experimentation).

The following are among the many advantages of a lance tip assembly constructed according to the present invention:

1. higher momentum oxygen jets resulting in increased height or distance of the lance from the metal bath (which, in turn, translates to reduced potential for damage to the lance during operation);
2. reduced nozzle exit erosion;
3. less decay of the oxygen jets resulting in improved bath mixing and lower slag FeO;
4. less decay of the oxygen jets resulting in lower oxygen consumption per ton of steel produced;
5. extended lance service life without increasing slag FeO;
6. increased cooling water flow (by reducing eddy currents and other flow disturbances);
7. lower temperature differentials in the lance tip;
8. improved cooling water efficiency (through convection) by virtue of the radial vanes;
9. improved cooling water distribution and velocity by virtue of the flow-directing central protrusion;
10. increased cooling water volume via a less restrictive design that results in lower friction (more specifically, a metal making mill water cooling system is rated at a given output for a given pressure drop across the lance (a/k/a “pump curve”); by reducing the tip pressure drop, pump output increases without any additional energy requirements;
11. reinforced tip face by virtue of the radial vanes and the support post, thereby resulting in reduced tip face distortion;
12. reinforced nozzles by virtue of the radial vanes, thereby resulting in reduced tip distortion;
13. reduced exposed area at the center of the tip face by virtue of the central recess generally corresponding in shape to the central protrusion; and
14. reduced exposed area for steel/slag adherence to the center of the tip face (which may result in localized burning) by virtue of the central recess generally corresponding in shape to the central protrusion.

Although the invention has been described in detail for the purpose of illustration, it is to be understood that such detail is solely for that purpose and that variations can be made therein by those skilled in the art without departing from the spirit and scope of the invention as claimed herein. For example, although the illustrated lance assembly is constructed with a single centrally located active material delivery conduit, it is possible that the lance may contain more than one such passageway for delivering similar or dissimilar active materials. Likewise, it is also possible that the coolant water inlet passageway may disposed interiorly rather than exteriorly of one or more of the active material passageway(s).

What is claimed is:

1. A metal making lance tip assembly comprising:
   a tip face member having an inner surface, an outer surface and at least one active material discharge outlet;
   at least one nozzle for delivering active material to a furnace vessel through said at least one active material discharge outlet;
   a coolant fluid baffle member for directing coolant flow around said at least one nozzle;
   a coolant fluid diverting protrusion provided on said inner surface of said tip face member; and
   a plurality of vanes provided on said inner surface of said tip face member, said vanes extending essentially the entire axial distance between said inner surface of said lance tip face member and a lower surface of said coolant fluid flow baffle member and essentially the entire radial distance from said protrusion to a coolant fluid return passageway.

2. The assembly of claim 1 further comprising an active material well having at least one active material receiving inlet in communication with said at least one nozzle.

3. The assembly of claim 2 further comprising a post having an upper end connected to said active material well and a lower end connected to said coolant fluid diverting protrusion for providing structural support to said tip face member during operation of said assembly.
4. The assembly of claim 1 wherein said vanes have a height “H” and an average thickness “T” and wherein a beneficial cooling reinforcement ratio is attained when T/H is approximately 0.5 at any point along the radial extent of said vanes.

5. The assembly of claim 1 further comprising a recess formed in said outer surface of said lance tip face member in general alignment with said protrusion, wherein “D” is the diameter of a circle defined by the foremost projection of said outer surface circumscribing said recess, wherein “d” is the depth of said recess from the foremost projection of said outer surface to the deepest point of said recess, and wherein a beneficial dimple profile ratio is attained when D/d is approximately equal to 2.7.

6. The assembly of claim 1 wherein said vanes have a height “H” and a thickness “T”, wherein a beneficial cooling reinforcement ratio is attained when T/H is approximately 0.3 at any point along the radial extent of said vanes; said assembly further comprising a recess formed in said outer surface of said lance tip face member in general alignment with said protrusion, wherein “D” is the diameter of a circle defined by the foremost projection of said outer surface circumscribing said recess, wherein “d” is the depth of said recess from the foremost projection of said outer surface to the deepest point of said recess, and wherein a beneficial dimple profile ratio is attained when D/d is approximately equal to 2.7.

7. The assembly claim 1 wherein said protrusion is substantially conical and wherein a circumferential wall of said protrusion diverges from a central longitudinal axis of the assembly at an angle of between about 20°-50°.

8. A metal making lance tip assembly comprising: a tip face member having an inner surface, an outer surface and at least one active material discharge outlet; at least one nozzle for delivering active material to a furnace vessel through said at least one active material discharge outlet; a coolant fluid baffle member for directing coolant flow around said at least one nozzle; and a plurality of vanes provided on said inner surface of said tip face member, wherein said vanes have a height “H” and an average thickness “T” and wherein a beneficial cooling reinforcement ratio is attained when T/H is approximately 0.3 at any point along the radial extent of said vanes.

9. A metal making lance tip assembly comprising: a tip face member having an inner surface, an outer surface and at least one active material discharge outlet; at least one nozzle for delivering active material to a furnace vessel through said at least one active material discharge outlet; a coolant fluid baffle member for directing coolant flow around said at least one nozzle; and a coolant fluid baffle member for directing coolant flow around said at least one nozzle; and

10. A metal making lance tip assembly comprising: a tip face member having an inner surface, an outer surface and at least one active material discharge outlet; at least one nozzle for delivering active material to a furnace vessel through said at least one active material discharge outlet; a coolant fluid baffle member for directing coolant flow around said at least one nozzle; a plurality of vanes provided on said inner surface of said tip face member, wherein said vanes have a height “H” and an average thickness “T” and wherein a beneficial cooling reinforcement ratio is attained when T/H is approximately 0.3 at any point along the radial extent of said vanes; and a recess formed in said outer surface of said lance tip face member, wherein “D” is the diameter of a circle defined by the foremost projection of said outer surface circumscribing said recess, wherein “d” is the depth of said recess from the foremost projection of said outer surface to the deepest point of said recess, and wherein a beneficial dimple profile ratio is attained when D/d is approximately equal to 2.7.

11. A metal making lance tip assembly comprising: a tip face member having an inner surface, an outer surface and at least one active material discharge outlet; at least one nozzle for delivering active material to a furnace vessel through said at least one active material discharge outlet; a coolant fluid baffle member for directing coolant flow around said at least one nozzle; and a coolant fluid diverting protrusion provided on said inner surface of said tip face member, wherein said protrusion is substantially conical and wherein a circumferential wall of said protrusion diverges from a central longitudinal axis of the assembly at an angle of between about 20°-50°.

* * * * *