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(54) SPRAYING APPARATUS

(71) We, CENTRE DE RECHERCHES METALLURGIQUES / CENTRUM VOOR RESEARCH IN DE METALLURGIE, of 47 Rue Montoyer, Brussels, Belgium, a Belgian Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to spraying apparatus making it possible to impart high momentum to a composite fluid in the form of a mist (a liquid suspended in a gas), for example for ejecting the fluid onto a given surface for cooling purposes. The invention also relates to the use of such apparatus.

In the above-mentioned field, a large number of types of sprayer exist which are adapted to a more or less satisfactory extent to specific uses. Among types of sprayer one should mention that comprising a central convergent-divergent duct of Laval nozzle type. A plurality of lateral conduits inclined with respect to the longitudinal axis of the nozzle open into the diverbent part of the central conduit. Such a sprayer makes it possible to effect considerable cooling on a liquid surface at high temperature, such as molten slag, which can thus be granulated in a satisfactory manner.

The invention also relates to spraying apparatus designed to cool a surface at high temperature, but under completely different conditions from an operating viewpoint and insofar as the nature of the object onto which the cooling fluid is ejected is concerned. Such an object can be a roller of a rolling mill whose temperature must be uniformly and adjustably controlled to ensure a long life for the roller without the risk of cracking or modifying its tempered state. The object could also be a rolled product emerging at high temperature from the rolling mill. Cooling of such a product must also be well controlled as far as its intensity and uniformity are concerned in order to give it a well defined and uniform structure. The object could also be a continuously cast strand whose energetic cooling makes it possible to considerably increase its extraction speed without risk of rupturing its wall.

On the other hand, it is well known that a surface at high temperature in contact with an oxidizing agent (e.g. air) rapidly covers itself with an oxide layer (scale) which is generally detrimental for subsequent operations. Spraying of a cooling jet onto this surface by means of a suitable sprayer causes heat shock which results in the oxide layer being ruptured or broken up, and thus it is easier to eliminate it. This utilization is also one of the fields of application of the invention.

Such spraying apparatus makes it possible to produce a mist including for example fine water droplets suspended in air, this mist being ejected at high speed against the surface of the object to be cooled.

Spraying apparatus according to the present invention has the advantage of being able to achieve a particularly large cooling capacity with respect to its small dimensions (its largest dimension being generally smaller than 20 mm). On the other hand, the apparatus makes it possible to vary within a surprisingly wide range its cooling possibilities, while ensuring excellent uniformity.

Compared with the cooling capacity of sprayers which have been used up to now for the same cooling operations of products whose cooled surface is at a temperature of 1000 to 1500°C, the cooling capacity of spraying apparatus according to the invention can be at least double that of the conventional sprayers, while providing particularly uniform cooling.

The present invention provides a spraying apparatus for ejecting a mist at high speed, comprising a central duct along which a gas is to be supplied, the longitudinal configuration of the central duct being that of a Laval

nozzle having, in the direction of gas flow, a neck with a diameter of 0.5 to 2 mm followed by a divergent part, and at least one lateral duct along which a liquid is to be supplied, the or each lateral duct opening towards the longitudinal axis of the central duct adjacent the outlet end of its divergent part, the or each lateral duct having a liquid flow axis which at the outlet of the duct is inclined more than 30° (preferably substantially 45°) with respect to the longitudinal axis of the central duct in the direction of gas flow.

In one embodiment of the invention, the or each lateral duct is substantially straight and there are preferably no more than four lateral ducts.

In another embodiment of the invention, there is at least one lateral duct whose liquid flow axis is helicoidal and defines a frustoconical surface coaxial with and surrounding the Laval nozzle and converging towards the outlet of the nozzle, the helicoidal duct opening into the outlet of the said nozzle, for example downstream of outlets of substantially straight ducts (if any), or to the outside in the immediate proximity of the nozzle outlet.

Preferably, the lateral ducts are circular in cross-section and their diameter does not exceed 4 mm.

In another embodiment of the invention, the lateral duct is substantially annular and surrounds the outlet of the central duct.

Moreover, according to the invention, the apparatus may advantageously comprise at least two parts.

The diameter of the neck of the Laval nozzle, according to the invention, is preferably 0.5 to 1 mm. Constructively, the Laval nozzle preferably has a small divergence, i.e. 8 to 12°, more preferably substantially 10°.

In another embodiment of the invention, the nozzle is coaxially prolonged by a member which is arranged at its outlet and has an inner frustoconical bore having a conicity greater than that of the nozzle, the smaller end of the bore being spaced by a small distance from the outlet end of the nozzle and having a diameter substantially equal to that of the outlet end of the nozzle but sufficinetly small that the outlet(s) of the lateral duct(s) is (are) not axially visible.

The spraying apparatus may be used by supplying it with, for example, compressed air at the inlet of the nozzle and with, for example, water at the lateral ducts. It has been found that in thse conditions and under suitable pressure, a very uniform mist comes out from the nozzle and is distributed throughout the opening of the divergent cone adjacent to the Laval nozzle.

In the case in which the lateral ducts have at their outer surface a frustoconical convergent surface enveloping them, this surface is advantageously delimited by a circular sleeve the inner face of which has two frustoconical surfaces forming a convergent-divergent path and adjoining at their small base which has the same diameter as that of the outlet of the nozzle, at least about 1 mm, the divergent surface delimiting the above-mentioned member.

The applicants have found that the sound from such apparatus, in use, has a high level for a relatively narrow frequent band. Consequently, the spraying apparatus advantageously has at its outlet a resonator (Helmholz type) designed to resonate within the band of sound generated by the apparatus, which makes it possible to considerably reduce the intensity of the sound emitted.

According to an advantageous variant of the invention, the resonator may have a substantially toroidal configuration with an inner radial circular slit opening towards the outlet of the apparatus. In the case in which one resonator is used for a number of spraying apparatuses, the resonant cavity surrounds and opens into the assembly of outlets of the apparatuses in question.

The present invention also provides a method of using the above-described apparatus, in which a liquid is supplied to the lateral duct or ducts under a pressure which can reach 6 kg/cm^2, a gas being supplied at a pressure which preferably exceeds by 0.5 kg/cm^2 the liquid supply pressure, however with a minimum of 3 kg/cm^2, this gas supply taking place along the central duct.

By way of example, a spraying apparatus with a diameter of 1 mm at the neck of the nozzle and having four inclined ports having a diameter of 3 mm and opening into the divergent path of the Laval nozzle, is supplied with water under pressure of 3 kg/cm^2 and with air under a pressure of 3.5 kg/cm^2, the respective flow rates being 7 l/min of water and 2 Nm^3/hour of air. Under these pressures, the cooling capacity of the spraying apparatus is, in the case of products whose cooled surface is at a temperature of 1000 to 1500°C, higher than 2 MW/m^2, with a particularly notably cooling uniformity.

An unexpected advantage of the spraying apparatus is the fact that such uniformity is maintained over a large range of variation of the water supply pressure. It has been found that, if the water pressure is low, the mist obtained consisting of well dispersed water droplets with a very small diameter, uniformly filling the entire injection cone. On the other hand, if the value of the supplied water pressure increases, the water droplets become larger and are displaced at a higher speed while being well dispersed in the atomization air, which is also uniformly distributed throughout the injection cone. The practical result is that the apparatus ensures uniform

cooling within a wide range of variations in the intensity of its cooling capacity (of the order of 1 to 10).

Preferably one sprays amounts of water and air such that the water-to-air ratio by weight ranges from 20:1 to 200:1.

As already mentioned above, the spraying apparatus has a particularly high cooling capacity when atomization of water by air leads to the formation of a mist. Obviously it is possible to modify the pressures at which the apparatus is fed with air and/or gas in order to modify the composition and the structure of the above-mentioned mist. These variations correspond to a variation in the cooling capacity, but it has been unexpectedly found that the most interesting values of the cooling capacity are obtained when the level of the sound from the apparatus, in use, ranges from 80 to 120 dB. Consequently, it is advantageous, to adjust the pressure at which the apparatus is supplied with air and water so that the level of sound is in the range of 80 to 120 dB.

The invention will be described further, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows an axial cross-section of a sprayer whose central duct is convergent-divergent duct in the form of a Laval nozzle whose neck has a diameter of 0.5 to 1 mm, a plurality of lateral ducts inclined with respect to the longitudinal axis of the central duct in the direction of the flow of the fluids opening towards the divergent end of the central duct; and

Figure 2 shows a side view of a sprayer similar to that of Figure 1 and further comprising helicoidal lateral ducts, as well as a cross-sectional view of a sleeve arranged in front of the sprayer.

Figure 1 shows an inlet air nozzle 1, inlet water duct 2 (diameter up to 4 mm), and an outlet nozzle 3 for an air-water mist. The sprayer has two coaxial cylindrical shoulders 4 and 6; the first shoulder 4 is formed with a groove 5 designed to locate a seal, the second shoulder 6 being provided with a screw-threaded portion 7.

It is appropriate to mention here a very satisfactory feeding system which supplies water and air to the sprayer by means of two headers one inside the other. The outer header is designed to supply water and is in the form of a U fixed by a welded plate. This plate is formed with a number of screw-threaded holes having the same pitch as the threaded portion 7 of the sprayer. The inner header designed to supply air is also in the shape of a U closed by a welded plate having the same number of holes as that of the plate of the outer header. The holes in the plate of the inner header are coaxial with the holes in the plate of the outer header and their diameter is such as to make it possible to easily but sealingly introduce the shoulder 4 of the sprayer. The two headers are locally fixed to one another by means of welded spacers ribs. These two headers are supplied with air and water by means of suitable pipes fixed to the back of the headers. The sprayers are thus directly supplied with air from the inner header and with water from the spaces delimited between the inner and outer headers. The inlet water ducts 2 of the sprayers open into the free space between the welded plates when the sprayers are screwed into these headers.

In Figure 2, the sprayer 8 proper has a substantially cylindrical configuration, an axis 9 and an axial conduit 10 in the form of a Laval nozzle with a small divergence (8 to 12°). The divergent part of this nozzle terminates at the face 11. The groups of lateral ducts are oriented towards the outlet of the nozzle. The first group comprises four straight ducts 12 opening into the nozzle at the end of its divergent portion, at 13, and regularly distributed around the nozzle. The second group comprises four helicoidal conically convergent ducts 14 opening at 15 into the outer face of the nozzle around its outlet. The outer face of these ducts 14 is formed by a circular sleeve 16 the inner surface of which is delimited by two frustoconical surfaces 17 and 18 arranged opposite to each other, the convergent surface 17 forming and delimiting the outer face of the ducts 14, whereas the surface 18 is divergent. The diameter of the neck 19 is slightly greater than that of the outlet of the nozzle and slightly smaller than the minimum diameter corresponding to the outlets of the ducts 14 at the face 15.

The field of application of the spraying apparatus according to the invention is very wide and comprises particularly, as already mentioned above, cooling off: a liquid surface at high temperature, such as molten slag, for example for its granulation; the surface of a roller of a rolling mill in use, in order to ensure long service life of the roller; a hot-rolled product, for giving it a well-defined and uniform structure; a continuously cast strand, with a view to increasing its extraction rate; or an oxidized surface, in order to facilitate descaling.

WHAT WE CLAIM IS:—

1. A spraying apparatus for ejecting a mist at high speed, comprising a central duct along which a gas is to be supplied, the longitudinal configuration of the central duct being that of a Laval nozzle having, in the direction of gas flow, a neck with a diameter of 0.5 to 2 mm followed by a divergent part, and at least one lateral duct along which a liquid is to be supplied, the or each lateral duct opening towards the longitudinal axis of the

central duct adjacent the outlet end of its divergent part, the or each lateral duct having a liquid flow axis which at the outlet of the duct is inclined more than 30° with respect to the longitudinal axis of the central duct in the direction of the gas flow.

2. Apparatus as claimed in claim 1, in which the inclination of the liquid flow axis of the or each lateral duct, at the outlet of the duct, with respect to the longitudinal axis of the central duct is substantially 45°.

3. Apparatus as claimed in claim 1 or 2, in which at least one lateral duct is substantially straight.

4. Apparatus as claimed in claim 3, in which there are up to 4 straight lateral ducts.

5. Apparatus as claimed in any of claims 1 to 4, in which the or each lateral duct has a circular cross section with a diameter of up to 4 mm.

6. Apparatus as claimed in any of claims 1 to 5 in which there is at least one lateral duct whose liquid flow axis is helicoidal and defines a frustoconcal surface coaxial with the Laval nozzle and surrounding it and converging towards the outlet of the nozzle.

7. Apparatus as clamed in claim 1 or 2, in which the lateral duct is annular.

8. Apparatus as claimed in any of claims 1 to 7, consisting of at least two parts.

9. Apparatus as claimed in any of claims 1 to 8, in which the diameter of the neck of the Laval nozzle is 0.5 to 1 mm.

10. Apparatus as claimed in any of claims 1 to 9, in which the divergent of the divergent part of the Laval nozzle is 8 to 21°.

11. Apparatus as claimed in any of claims 1 to 10, in which the nozzle is coaxially prolonged by a member arranged at its outlet and having a frustoconical bore diverging in the same direction as the divergent part of the Laval nozzle and having greater conicity, the smaller end of the bore being spaced from the outlet end of the Laval nozzle and having a diameter which is substantially equal to that of the outlet end of the nozzle but which is sufficiently small that the outlet of the or each lateral duct is not axially visible.

12. Apparatus as claimed in any of claims 1 to 11, including at its outlet a Helmholtz resonator designed to resonate within the band of sound emitted by it.

13. A method of spraying a mist using a spraying apparatus as claimed in any of claims 1 to 12, comprising supplying the lateral duct or ducts with a liquid under a pressure of up to 6 kg/cm^2, and supplying the central duct with a gas under pressure of at least 3 kg/cm^2.

14. A method as claimed in claim 13, in which the gas pressure exceeds the liquid pressure by 0.5 kg/cm^2.

15. A method as claimed in claim 13 or 14, in which the liquid-to-gas ratio by weight is 20:1 to 200:1.

16. A method as claimed in any of claims 13 to 15, in which the pressures at which gas and liquid are supplied to the apparatus are such that the intensity of the sound from the apparatus is 80 to 120 dB.

17. A method as claimed in any of claims 13 to 16, in which the gas and liquid are air and water.

18. Spraying apparatus substantially as described herein with reference to, and as shown in, Figure 1 or Figure 2 of the accompanying drawings.

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Fig.1.

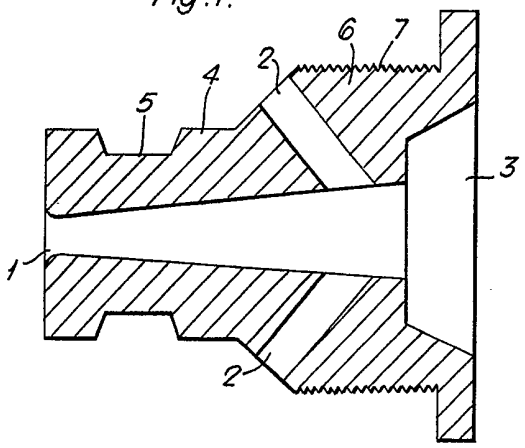

Fig.2.