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I-20122 Milan(IT)**(54) **Device for atomizing liquid metals for powder production.**

(57) Device (1) for atomizing liquid metals complete with a hollow element (3), having a longitudinal symmetry axis, in which liquid metal flows towards an outlet section, and with a symmetrical cylindrical chamber (5,7) enclosing said hollow element (3) and having the same longitudinal symmetry axis, in which the outlet section of the metal of the hollow element (3) is set below outlet sections from the gas atomization chamber (5,7) from which, in turn, the gas flows concentrically in annular conduits (8,10) of the chamber (5,7) thus providing both an energetic breaking action, intersecting the fluid stream in hollow cone form with the vertex of said axis of symmetry pointed towards the outside, and also an effective containing action, being projected parallel to the whole periphery of the fluid stream.

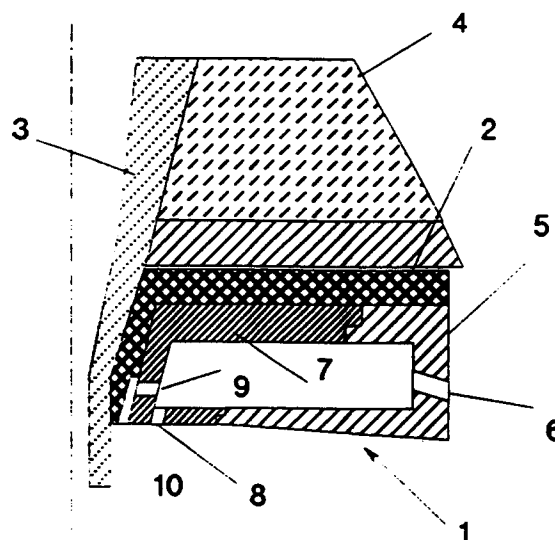


fig. 1

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The present invention concerns a device for atomizing liquid metals for the production of powders. More precisely it concerns a device which avoids harmful splash-backs, while at the same time ensuring the production of particles with a particle-size distribution and shape particularly suitable for use also in plasma-coating processes.

The production of powders by atomizing liquid metals has come to be of increasing importance because of the performance and cost advantages it offers, compared with other technologies.

Different uses call for powders with different characteristics.

Thus, for instance, powders with good morphological characteristics can be utilized in the hot isostatic pressing (HIP) process to produce elements having complicated shapes such as metal rings or gear wheels or anyway items calling for precise machining allowances.

The importance of obtaining powders with particular morphologies required for the technology to be utilized emerges clearly in the case of such increasingly important innovatory processes as plasma arc transfer, which is utilized, for instance for cobalt and/or nickel based coatings. Flowability, the relative absence of satellites and roundness are all factors bound up with the morphology of the powders and, moreover, they clearly have repercussions on the properties of a coating and on the continuity and regularity of the process needed to attain this.

The properties of powder obtained via a gas-atomization process depend on a large number of parameters including the chemical and physical properties of the liquid metal and the characteristics of the gas utilized.

Of particular importance in this regard is the geometry of the atomizing-gas nozzles, together with the fluid dynamics aspects which are bound up with system geometry.

Hence, in order to optimize powder characteristics. e.g. particle-size distribution or mean dimensions, attention must be paid to the study of special designs and geometrical solutions for the atomizers.

Much has been written on this matter, including a book entitled "The Production of Metal Powders by Atomization" (Heydan & Son Ltd. 1978) which, inter alia, provides descriptions of various examples of annular atomizers for the production of metal powders.

Among the problems encountered, according to the author, is the gas swirling which causes back-splashing of the liquid metal that solidifies and cloges the gas-outlet holes, thus rapidly rendering the entire apparatus unserviceable.

Reference may also be made, for example, to US Patent No. 2,997,245 concerning a method

which employs an acoustic-fluid dynamics synergism for atomizing liquid metals.

Yet another US Patent No. 3,988,084 describes a device where a thin stream of metal is intercepted inside the atomization chamber, by gas jets directed on the metal in the form of an inverted hollow cone.

Then, too, devices are known (US Patent No. 4,416,600) which utilize atomization chambers in the form of spiral-shaped canals transversed by the atomizing gases which are thus projected tangentially on the liquid metal.

Finally, there are devices (US Patents 1,856,679, 3,501,802 and 2,440,531) whose objective is to try to control particle size and gas flow.

However, existing devices all suffer from numerous, marked limitations such as undesirable turbulence affecting fluid stream control, leading to the clogging of the gas nozzles owing to splash-backs and hence to anomalous operation of the equipment.

Furthermore, problems concerning particle size, distribution and morphology still have to be resolved.

There is also a pressing need to optimize fluid dynamics conditions in the atomization zone in order to obtain particles that are as round as possible, with very few satellites and good flowability, since these are particularly suitable for very important coating processes, such as PTA, which call for an absolutely constant powder feed in order to guarantee reliability and performance.

The object of the present invention is to produce powders with a high percentage of spherical particles, few satellites and hence good flowability, which are therefore suitable also for plasma coating processes.

A further object of the invention is to furnish a device that can guarantee gas-dynamics conditions in the atomization zone that do not result in splash-backs, thus ensuring continuity of operation.

According to this invention, a device is proposed for atomizing liquid metals to form powders. Said device comprises:

- a hollow central element
- a chamber enclosing said hollow element
- annular conduits contained in the chamber

in which in said hollow element, with longitudinal symmetry axis, liquid metal flows towards an outlet section, and said chamber has a longitudinal symmetry axis coincident with that of said hollow element and at least one face directed downwards, while said conduits are such as to permit the ingress and projection of atomizing gas onto the liquid metal, characterized by the fact that said chamber has on said face:

- one set of holes each having its axis of symmetry essentially parallel to the axis of

symmetry of the hollow element, said holes being located on a concentric circle that is external to said hollow element;

- another set of holes each having its axis incident to the axis of symmetry of the hollow element so as to form with it an angle of between 2 and 4 degrees, the axis of said holes being at a distance of between 2 and 6 centimetres from the axis of symmetry of said hollow element, said holes also being positioned on a concentric circle external to said first set of holes, and also by the fact that in said hollow element said liquid-metal outlet section is located below said face of the chamber at a distance of 8 to 12 millimetres therefrom.

The present invention will now be described in greater detail by reference to the accompanying sketch which illustrates the device purely by way of example, without in any way limiting the objects and breath of the invention itself, and in which:

- Fig. 1 represents a schematic longitudinal section of the invention.

With reference to fig. 1, the atomization apparatus 1 is solidly connected via flange 2 to nozzle 3 which, in its turn, is solidly connected to and fed by a source of liquid metal (tundish) 4.

The body of the atomizer which is cylindrical in shape with a longitudinal symmetry axis with that of the stream of liquid metal, is constructed by the assembly of an element 5 that has ingress holes 6 for the atomizing gas, with an element 7 that has outlet holes for the gas 8,9.

When in operation the liquid metal which comes from the tundish 4 and flows through nozzle 3 is struck by jets of gas, such as nitrogen or argon for example, that enter the body of the atomizer via holes 6 at a pressure of between 4 and 16 bar.

One portion of the gas jets leaves by a set of holes 8 arranged concentrically about nozzle 3.

These jets issue forth in the form of a hollow cone tapering towards the outside, having an average angle of aperture between 2 and 4 degrees, axis of symmetry coincident with the axis of metal outflow, and strike the liquid stream after having travelled a distance of between 70 and 80 centimetres. The impact of these gas jets on the stream of fluid metal results in the maximum breaking action thanks to the shortness of the distance between stream and jets and hence the minimum loss of kinetic energy.

Another portion of the gas passes through holes 9 and leaves via holes 10 providing effective fluid-dynamic control of the process.

These jets of gas, arranged concentrically around the nozzle, impinge on the external walls thereof and leave the atomizer parallel to the stream of metal, enveloping the whole of its periph-

ery.

The effect of these latter jets, combined with the fact that the liquid-metal outlet section of the nozzle is at a distance of between 8 and 12 mm from the gas outlet sections, is to eliminate dangerous instability which can be caused by back-splashes of the liquid metal towards the atomizer owing to local turbulence.

Claims

1. Device (1) for atomizing liquid metals into powders, comprising:

- a hollow central element (3)
- a chamber (5,7) enclosing said hollow element
- annular conduits (6,8-10) contained in the chamber

in which in said hollow element (3), with longitudinal symmetry axis, liquid metal flows towards an outlet section, and said chamber (5,7) has a longitudinal symmetry axis coincident with that of said hollow element (3) and at least one face directed downwards, while said conduits (6,8-10) are such as to permit the ingress and projection of atomizing gas onto the liquid metal, characterized by the fact that said chamber (5,7) has on said face:

- a set of holes (10) each having its own symmetry axis essentially parallel to the symmetry axis of the hollow element, said holes (10) also being positioned on a concentric circle external to said hollow element (3);
- another set of holes (8) each having its own axis incident to the axis of symmetry of the hollow element (3) so as to form with it an angle of between 2 and 4 degrees, the axis of said holes (8) being at a distance of between 2 and 6 centimetres from the axis of symmetry of said hollow element (3), said holes also being positioned on a concentric circle external to the said first set of holes (10), and also by the fact that in said hollow element (3) said liquid-metal outlet section is located below said face of the chamber at a distance of 8 to 12 millimetres therefrom.

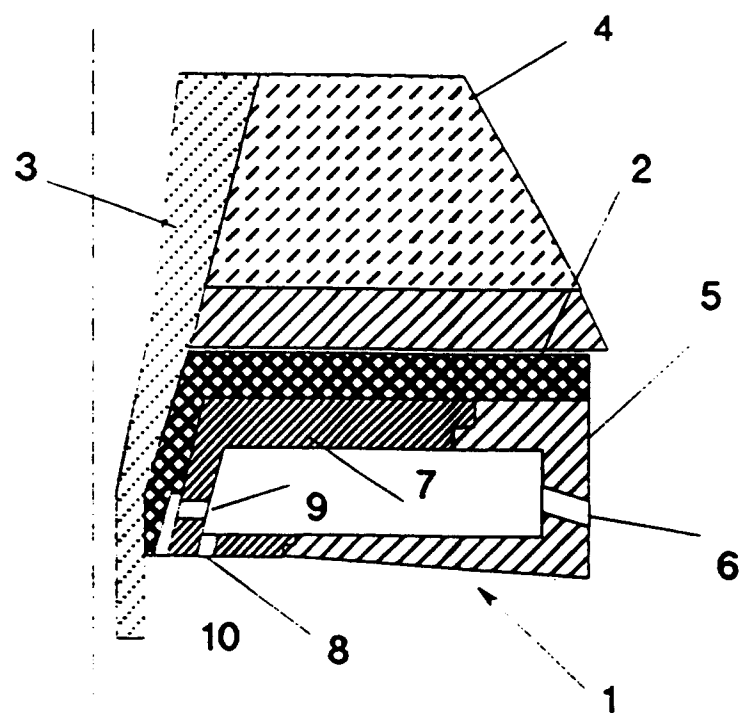


fig. 1