

Description

Method and apparatus for producing a powder aerosol, and their use

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The invention relates to a method for producing a powder aerosol, and to its use. In addition, the invention also relates to an associated apparatus having a vessel which is connected via an ultrasound
10 horn to an ultrasound transmitter and which has a feed tube and an outlet tube.

A high-power plasma burner, with radio-frequency excitation, can be used to completely vaporize substances which are in the form of powder in
15 a short time, and then to deposit, from the vapor phase, a coating with a predetermined composition onto a substrate, with a high growth rate. A first application for this method, which is known as plasma flash evaporation, is the evaporation of fine-grained
20 powder composed of yttrium-barium-copper oxide, with subsequent deposition of a high-temperature superconductor layer (HTSL). Another major application is the coating of components, for example the application of a protective coating to a turbine blade.

25 In order to propel the powder into the plasma, it is introduced into a propellant gas, so that an aerosol is produced which can be passed into the plasma burner. The aerosol must be free of accumulations of powder particles which cannot be vaporized, that is to
30 say accumulations formed from individual particles, and the feed process is intended to be reproducible and uniform, that is to say free of fluctuations with time.

Various methods, which originate from the general plasma spraying technique, are known for
35 producing the aerosol required for plasma flash evaporation. For example, a disk feed device operates in such a way that

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an amount of powder which is defined by the dimensions of the groove is deposited continuously, by means of a metering groove, on a slowly rotating disk. The powder, which revolves with the disk, is moved by a
5 wiping apparatus to the edge of the disk where it falls into a retaining apparatus, where it is held by a gas flow. In the case of powders whose grain size is very fine, for example in the region equal to or less than 20 μm , the sprinkling capability is highly restricted
10 by the forces which act between the particles. This leads to accumulations with dimensions in the millimeter range entering the gas flow at certain time intervals rather than continuously individual powder grains, which are separated from one another, as
15 required. Even if the accumulations are broken down, in ideal cases, during transportation to the plasma burner, the lumpy structure of the introduced powder results in fluctuations with time which are no longer tolerable, that is to say a pulsation of the amount of
20 powder introduced into the plasma. Screw-type or worm-type feed devices, which are likewise known from the prior art, and in which the powder is fed by a worm to a mixing area where it enters the propellant gas flow, have the same disadvantage.

25 In the case of a brush metering device, the powder which is formed into a plug in the form of a cylindrical body is pushed forward through a tube to a rotating metal brush which removes from the plug body an amount of powder proportional to the feed rate. A
30 gas flow passing through the brush area picks up the powder and transports it to the point at which it is required. Experience has shown that the process of rubbing the powder off the plug body results in accumulations which cannot be vaporized.

35 WO 96/03216 A1 discloses a powder feed device which operates on the ultrasound principle. In this

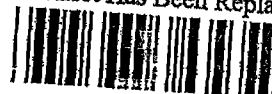


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case, the powder to be fed has ultrasound applied to it in a vessel in which it is also stored, is swirled, its accumulations are broken down, and it is picked up by a gas flow passing through the vessel.

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Experiments have shown that the feed process is reproducible and is free of fluctuations. This method is limited by the fact that only a limited amount of powder can be stored and fed. In particular, the feed
5 rate, that is to say the mass fed per unit time, can in this case not be adjusted independently of the gas flow rate, since the gas flow also contributes to the swirling of the powder, in addition to the effect of the ultrasound.

10 Against this background, the object of the invention is to improve the preparation of the aerosol and to specify a suitable application and an associated apparatus.

 In the case of a method of the type mentioned
15 initially, the object is achieved according to the invention by the following method steps:

- powder is drawn from a reservoir area and converted into a powder aerosol,
- the powder aerosol is introduced into a container
20 to which ultrasound is applied, with powder lumps and accumulation being broken down by the ultrasound effect so that a finer powder aerosol is produced.

 The invention results in the finer powder
25 aerosol being present with a uniform particle distribution in the propellant gas. At the same time, the powder aerosol which has been treated in this way has its accumulations broken down, and the initially fluctuating mass flow is stabilized in this way.

30 Mechanical means are preferably used to convert the powder to an aerosol in the invention. For the purposes of the invention, the gas flow is fed with the powder aerosol to a plasma burner. In this case, the volume to which ultrasound can be applied is
35 advantageously used as a storage and/or buffer means for the powder aerosol.

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In the case of the associated apparatus of the type mentioned initially according to the invention, the feed tube is connected to a mechanical

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powder feed device. In consequence, a powder aerosol enters the volume formed by the ultrasound vessel, is made more uniform by the effect of the ultrasound, and leaves the ultrasound vessel as a more uniform and continuous aerosol flow. In this case, the vessel is preferably closed at the top by a cover. In particular, the vessel may at the same time contain the ultrasound horn.

The invention thus makes it possible for a very fine powder to be introduced into a plasma in any desired amount continuously, without accumulations, reproducibly and without any fluctuations with time. This is achieved by the combination of a disk, worm or brush feed device using the ultrasound principle on which WO 96/03216 A1 is based.

The invention is used for the coating of components and is particularly suitable for applying a protective coating to turbine blades. In this case, it is particularly advantageous that suitable coating thicknesses can be deposited in reasonable times due to the slight relative movement which is possible between the apparatus according to the invention and the turbine blades.

Further refinements and advantages of the invention result from the following description of a figure of an exemplary embodiment, based on the single figure in the drawing, in conjunction with the patent claims.

The figure shows an exemplary embodiment of a powder feed system according to the invention, which is intended for operation of a plasma burner. The plasma burner is an induction plasma generator 11 which is excited at radio frequency and forms an inductively coupled plasma, with a directed plasma flame 12, from a fuel gas. An aerosol which is completely vaporized owing to the high plasma temperatures is introduced into the plasma flame 12. This makes it possible



to deposit materials from the vapor phase onto component surfaces, with a high growth rate.

The latter is intended to be used to apply protective coatings to turbine blades. A portion of a
5 curved turbine blade 13 is indicated in the figure, including the coating 14. Such turbine blades are subject to severe stresses in conjunction with alternating temperatures during operation, for which reason the blades, which are made from special alloys,
10 are coated. By way of example, coatings composed of ceramic, in particular zirconium oxide (ZrO_2), or else other oxidic or nitridic materials, may be used. The coating materials may also be interchanged in induction plasma burners without any major effort, so that
15 multicoating systems can easily be produced.

An ultrasound horn 2, which is connected to an ultrasound generator 1 in order to generate ultrasound at a predetermined frequency, is designed partially in the form of a hollow body in order to transmit the
20 ultrasound at a suitable wavelength, and forms a container to which ultrasound can be applied. A "cup-type ultrasound horn" is thus defined as the ultrasound vessel 10, and can be closed by a cover 3. The cover 3 has a feed tube 4 and an outlet tube 5 passing through
25 it, with the feed tube 4 and the outlet tube 5 being arranged symmetrically with respect to one another.

In an alternative embodiment, a separate ultrasound horn 2 can be connected, for ultrasound purposes, to a separate vessel.

30 A powder feed device 6, which may be a mechanical disk, worm, brush or other feed device which is suitable for the metering of very fine powders and which is only indicated in the figure, is used to introduce a powder P, which is stored in a container 7,
35 into a gas flow of a propellant gas T, thus producing a powder aerosol A.

The powder feed device 6 is connected to the cup-type ultrasound horn 2 in such a way that the powder aerosol A produced by it is passed through the feed tube 4 into the interior of the cup-type
5 ultrasound horn 2, where it floats in the gas flow. If ultrasound were not applied, relatively heavy particles, such as powder lumps and accumulations, would in this case be deposited on the bottom of the vessel 10.

10 The effect of the ultrasound leads to powder lumps and accumulations being broken down, and this has led to problems in the past. Now, a powder aerosol A', which is processed with a desired, uniform, fine particle distribution, leaves the cup-type ultrasound
15 horn 2 through the outlet tube 5, and can be fed in the gas flow to the plasma burner 11.

The specific combination of the powder feed device 6 and the ultrasound device which has been described in detail advantageously results in the
20 unexpected effect of the powder flow being made uniform. The process of making the powder flow uniform can be explained by the storage and/or buffer effect of the volume, to which the ultrasound is applied, with the powder aerosol A. This results in a particularly
25 high quality coating 14 being produced by the plasma burner 11 on a substrate, in particular on a turbine blade 13.



Patent claims

1. A method for producing a powder aerosol (A), comprising the following method steps:
 - 5 - powder (P) is drawn from a reservoir area (7) and it is converted by a gas flow (T) into a powder aerosol (A),
 - the powder aerosol (A) is introduced into a container (10) to which ultrasound is applied,
10 with powder lumps and accumulation being broken down by the ultrasound effect so that a finer powder aerosol (A') is produced.
2. The method as claimed in claim 1, characterized in that the powder (P) is introduced into the
15 propellant gas (T) by mechanical means (69).
3. The method as claimed in claim 1 or claim 2, characterized in that the finer powder aerosol (A') is fed to a plasma burner (11).
4. The method as claimed in claim 3, characterized
20 in that an induction plasma generator (11) is used as the plasma burner.
5. The method as claimed in one of claims 1, 2 or 3, characterized in that the volume to which ultrasound is applied is used as a storage and/or buffer means for
25 the powder aerosol (A').
6. An apparatus for producing a powder aerosol (A), having a container (10) which is connected to an ultrasound transmitter (1) via an ultrasound horn (2) and which has a feed tube (4) and an outlet tube (5),
30 in which case the feed tube (4) is connected to a powder feed device (6) which

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contains connections for a reservoir container (7) for a powder (P) and for a propellant gas (T).

7. The apparatus as claimed in claim 6, characterized in that the ultrasound horn (2) is in the
5 form a cup.

8. The apparatus as claimed in claim 7, characterized in that the ultrasound horn (2), which is in the form of a cup, forms the container (10).

9. The apparatus as claimed in one of claims 6, 7
10 or 8, characterized in that the container (10) is closed at the top by a cover (3).

10. The apparatus as claimed in one of claims 6 to 9, characterized in that the feed tube (4) and the outlet tube (5) are arranged symmetrically with respect
15 to the ultrasound horn (2) or the container (10) to which ultrasound is applied.

11. Use of the method as claimed in one of claims 1 to 5, and/or of the apparatus as claimed in one of claims 6 to 10, for applying a protective coating (14)
20 to a turbine blade (13).

12. Use as claimed in claim 11, characterized in that the protective coating (14) is a ceramic coating (14).

13. Use as claimed in claim 11 or claim 12,
25 characterized in that the coating (14) is composed of zirconium oxide (ZrO_2).

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