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(54) **METHOD FOR OPERATING A HOT ISOSTATIC PRESSING PLANT AND HOT ISOSTATIC PRESSURE PLANT**

(57) The invention relates to a method for operating a hot isostatic pressing plant (100), wherein a high pressure vessel (150) is filled with gas (a), such as argon or nitrogen, and wherein the gas (a), after being filled into the high pressure vessel (150), is heated in order to generate high pressure acting onto an object (160) placed in the high pressure vessel (150), wherein the gas (a) is

filled into the high pressure vessel (150) by means of a constant pressure accumulator (140). The invention also relates to a hot isostatic pressing plant (100) comprising a constant pressure accumulator (140) and to the accumulator (140) itself, which is preferably a hydraulically operated piston accumulator.

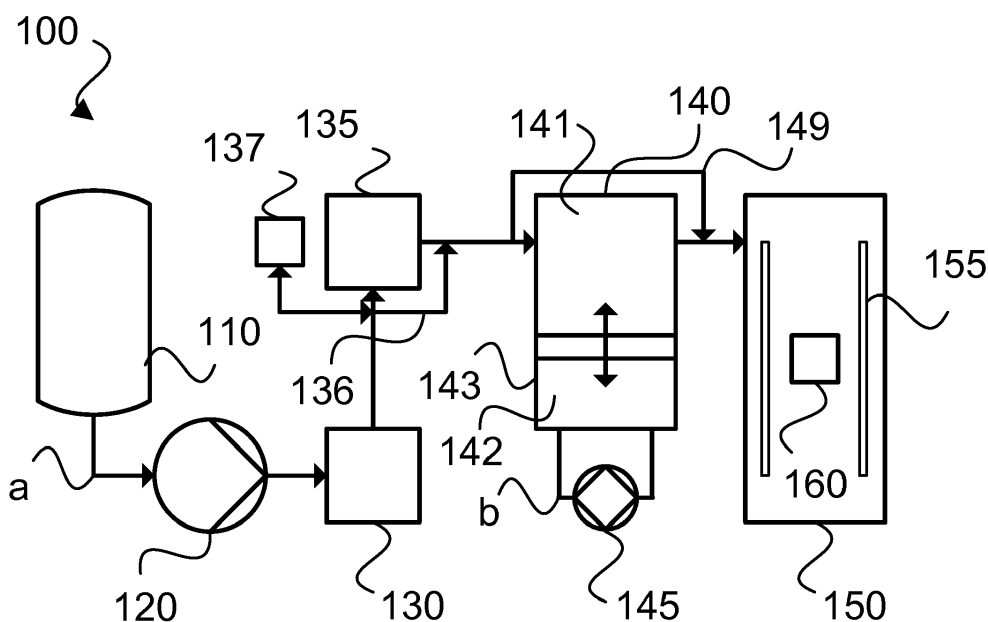


Fig. 1

Description

Technical Field

[0001] The invention relates to a method for operating a hot isostatic pressing plant, a hot isostatic pressing plant and a constant pressure accumulator arranged for providing gas to a high pressure vessel of a hot isostatic pressing plant.

Prior Art

[0002] Hot isostatic pressing is a forming and densification process using heated gas, most commonly argon or nitrogen, under very high pressure. Unlike mechanical force which compresses a workpiece from one or two sides, isostatic pressure is applied uniformly on all sides of an object eliminating internal porosity.

[0003] The process can be used to treat preformed metal, ceramic or composite parts, and for compaction of containerized powder shapes. Operating pressures are typically specified from 200 to 2000 bar or more. Temperatures can range up to 2000°C. Higher pressures and temperatures might be provided for special applications.

[0004] A high pressure vessel is filled with the gas, and the gas, after being filled into the high pressure vessel, is heated in order to generate high pressure acting onto an object placed in the high pressure vessel. By heating, the pressure of the gas is increased since its volume will not change. Typically, the gas is filled into the high pressure vessel with a pressure of about 200 to 400 bar, afterwards - or already during filling - the pressure is increased by heating.

[0005] In order to fill the gas into the high pressure vessel, pumps and/or compressors can be used. For large hot isostatic pressing plants, i.e., for large high pressure vessels of high volume of, e.g., up to 8 m³, large (fresh) gas buffers can be used, which can be filled by means of cryogenic pumps or compressors (after using a vaporizer) in advance. Such large gas buffers are, however, very expensive and need large storing capacities.

[0006] In view of this background, the object of the present invention is to improve the operation of a hot isostatic pressing plant.

Disclosure of the Invention

[0007] This object is achieved by providing a method of operating a hot isostatic pressing plant, a hot isostatic pressing plant and a constant pressure accumulator according to the independent claims.

[0008] A method according to the invention serves for operating a hot isostatic pressing plant, wherein a high pressure vessel is filled with gas, preferably argon or nitrogen, and wherein the gas, after being filled into the high pressure vessel, is heated in order to generate high pressure acting onto an object placed in the high pressure vessel. Further, the gas is filled into the high pressure

vessel by means of a constant pressure accumulator.

[0009] A constant pressure accumulator is a gas storage that can provide the gas at a constant pressure, while for usual gas storages like gas buffers the pressure of the gas to be provided decreases with gas being taken from the gas storage. While usual gas storages have a constant volume for storing the gas, the constant pressure accumulator has a storage volume for gas that can be changed in its volume. When filling gas into the storage volume of the constant pressure accumulator, the volume of the storage volume is increased, and when taking gas out of the storage volume of the constant pressure accumulator, the volume of the storage volume is decreased. This is achieved by using a further volume, an operating volume, which is changed vice versa.

[0010] A preferred kind of a constant pressure accumulator is a so-called hydraulically operated constant pressure accumulator. Such hydraulically operated constant pressure accumulator is arranged such that a hydraulic fluid can be provided to the operating volume in order to decrease the storage volume (by increasing the operating volume) while maintaining constant pressure in the storage volume for the gas being provided by the constant pressure accumulator.

[0011] It is to be noted that also two or more of those constant pressure accumulators can be used in parallel to provide gas to a high pressure vessel. By that, the constant pressure accumulators can be made smaller and/or the high pressure vessel can be made larger.

[0012] A major advantage of such constant pressure accumulator over a (fresh) gas buffer is that there is (much) less pressure equalization between the constant pressure accumulator and the high pressure volume than between the gas buffer and the high pressure volume since the (storage) volume of the constant pressure accumulator is decreased. Thus, even if a constant pressure accumulator and a gas buffer can (initially) provide gas at the same pressure, the final pressure to be achieved in the high pressure vessel is higher for the constant pressure accumulator. However, the constant pressure accumulator is preferably operated at a pressure of at least 100 bar, more preferably of at least 300 bar, and even more preferably of at least 500 bar, which can even increase gas provision efficiency.

[0013] This allows the overall process of establishing a desired high pressure of, e.g., 2000 bar in the high pressure vessel, to be expedited. Taking into account refilling of the constant pressure accumulator, the availability of such hot isostatic pressing plant can be increased by more than 10% (in terms of time). In addition, (cryogenic) pumps and/or compressors, preferably used for providing gas to (or filling) the constant pressure accumulator can be smaller or of less power compared to those used for filling (fresh) gas buffers.

[0014] The invention also refers to a hot isostatic pressing plant comprising a high pressure vessel, the vessel being arranged to be filled with gas like argon, and being adapted such that the gas, after being filled into the high

pressure vessel, can be heated in order to generate high pressure acting onto an object placed in the high pressure vessel. The hot isostatic pressing plant further comprises a constant pressure accumulator, preferably a hydraulically operated constant pressure accumulator, arranged to fill the gas into the high pressure vessel. In particular, the constant pressure accumulator is arranged to be operated at a pressure of at least 100 bar, preferably of at least 300 bar, more preferably of at least 500 bar.

[0015] Further, the hot isostatic pressing plant can include a pump and/or a compressor arranged to provide the gas to the constant pressure accumulator, for example, for initial filling and/or re-filling of the constant pressure accumulator.

[0016] The invention also refers to a constant pressure accumulator arranged for providing gas, preferably argon, to a high pressure vessel of a hot isostatic pressing plant, at a pressure of at least 100 bar, preferably of at least 300 bar, more preferably of at least 500 bar. In particular, the constant pressure accumulator is formed as hydraulically operated constant pressure accumulator.

[0017] With respect to the advantages and further preferred embodiments of the hot isostatic pressing plant and of the constant pressure accumulator, it is referred to the above remarks to the method in order to avoid repetition.

[0018] The invention will now be further described with reference to the accompanying drawings, which show a preferred embodiment.

Brief description of the drawings

[0019]

Fig. 1 schematically shows a hot isostatic pressing plant according to the invention in a preferred embodiment.

Detailed description of the drawings

[0020] In Fig. 1, a hot isostatic pressing plant 100 according to the invention in a preferred embodiment is schematically shown. Such plant can be used and be adapted for carrying out a method for operating a hot isostatic pressing plant according to the present invention.

[0021] In a (liquefied) gas storage 110 gas, preferably argon (or nitrogen), can be stored. The (liquefied) gas, denoted by reference numeral a, can be pumped by means of a (cryogenic) pump 120 to a vaporizer 130 (which also can be used as a buffer storage) in order to gasify the (liquefied) gas. Further, the gas is proceeded to a constant pressure accumulator 140 via bypass line 136 bypassing a compressor 135.

[0022] If needed, e.g., if additional pressure has to be applied in order to compensate losses, compressor 135 can be used. Also, a compressor feed buffer 137 can be used between the vaporizer 130 and the compressor

135, if required.

[0023] The constant pressure accumulator 140 is formed as a hydraulically operated constant pressure accumulator in the form of a piston accumulator. The constant pressure accumulator 140 comprises a storage volume 141 into which the gas provided by the compressor 135 is fed.

[0024] Further, the constant pressure accumulator 140 comprises an operating volume 142 which is coupled to a hydraulic circuit including a hydraulic pump 145 such that hydraulic fluid, denoted by reference numeral b, can be pumped into and taken from the operating volume 142.

[0025] The constant pressure accumulator 140 further comprises a movable (indicated by a double arrow) piston 143 dividing the storage volume 141 from the operating volume 142. Increasing the operating volume by means of pumping hydraulic fluid into it decreases the storage volume 141.

[0026] By that, the pressure of gas stored in the storage volume 141 can be maintained constant when gas is taken out from the storage volume 141. In the storage volume 141 of the constant pressure accumulator 140 a pressure of the gas of up to 600 bar and more can be provided.

[0027] It is to be noted that the constant pressure accumulator 140 is shown and described only schematically. Typically, different kind of inlets, outlets and valves and the like are provided and used for ordinary operation. Further, from the constant pressure accumulator 140, in particular from the storage volume 141, the gas is provided to a high pressure vessel 150.

[0028] In the high pressure vessel 150 an object 160 is provided that is to be compacted or densified by means of hot isostatic pressing. Such object 160 is only shown exemplarily and can comprise, e.g., preformed metal, ceramic or composite parts, or (metal) powder, e.g., provided in a container.

[0029] After being filled into the high pressure vessel 150 with a certain pressure of, e.g., 600 bar, the gas in the high pressure vessel is heated, e.g., by means of a heating apparatus 155, in order to generate high pressure of, e.g., up to 2000 bar, acting onto the object 160. By that, the object 160 is compacted and/or densified.

[0030] It is to be noted that the high pressure vessel 150 and the heating apparatus 155 are shown and described only schematically since the specific details and operations are not particular relevant for the present invention.

[0031] In particular due to the constant and relatively high pressure provided by the constant pressure accumulator 140, a high availability of the hot isostatic pressing plant 100 can be achieved, in particular, compared to usual (fresh) gas buffers used instead of the constant pressure accumulator 140.

[0032] Further, a bypass line 149 can be used to feed gas from the vaporizer 130 and/or the compressor 135 to the high pressure vessel 150, bypassing the constant pressure accumulator 140, if required, e.g., in the case

of a failure.

Claims

1. Method for operating a hot isostatic pressing plant (100), wherein a high pressure vessel (150) is filled with gas (a), and wherein the gas (a), after being filled into the high pressure vessel (150), is heated in order to generate high pressure acting onto an object (160) placed in the high pressure vessel (150), **characterized in that** the gas (a) is filled into the high pressure vessel (150) by means of a constant pressure accumulator (140). 5
2. Method according to claim 1, wherein the constant pressure accumulator (140) is operated at a pressure of at least 100 bar, preferably of at least 300 bar, more preferably of at least 500 bar. 10
3. Method according to claim 1 or 2, wherein the gas (a) is provided to the constant pressure accumulator (140) by means of a pump (120) and/or compressor (135). 15
4. Method according to any of the preceding claims, wherein a hydraulically operated constant pressure accumulator is used as the constant pressure accumulator (140). 20
5. Method according to any of the preceding claims, wherein argon or nitrogen is used as the gas (a) to be filled into the high pressure vessel (150). 25
6. Hot isostatic pressing plant (100) comprising a high pressure vessel (150), being arranged to be filled with gas (a), and being adapted such that the gas (a), after being filled into the high pressure vessel (150), can be heated in order to generate high pressure acting onto an object (160) placed in the high pressure vessel (150), and a constant pressure accumulator (140) arranged to fill the gas (a) into the high pressure vessel (150). 30
7. Hot isostatic pressing plant (100) according to claim 6, wherein the constant pressure (140) accumulator is arranged to be operated at a pressure of at least 100 bar, preferably of at least 300 bar, more preferably of at least 500 bar. 35
8. Hot isostatic pressing plant (100) according to claim 6 or 7, further including a pump (120) and/or a compressor (135) arranged to provide the gas (a) to the constant pressure accumulator (140). 40
9. Hot isostatic pressing plant (100) according to any of claims 6 to 8, wherein the constant pressure accumulator (140) is formed as a hydraulically operat- 45

ed constant pressure accumulator.

10. Hot isostatic pressing plant (100) according to any of claims 6 to 9, arranged to be used with argon or nitrogen as the gas (a). 5
11. Constant pressure accumulator (140) arranged for providing gas (a), preferably argon, to a high pressure vessel (150) of a hot isostatic pressing plant (100), at a pressure of at least 100 bar, preferably of at least 300 bar, more preferably of at least 500 bar. 10
12. Constant pressure accumulator (140) according to claim 11, formed as hydraulically operated constant pressure accumulator. 15

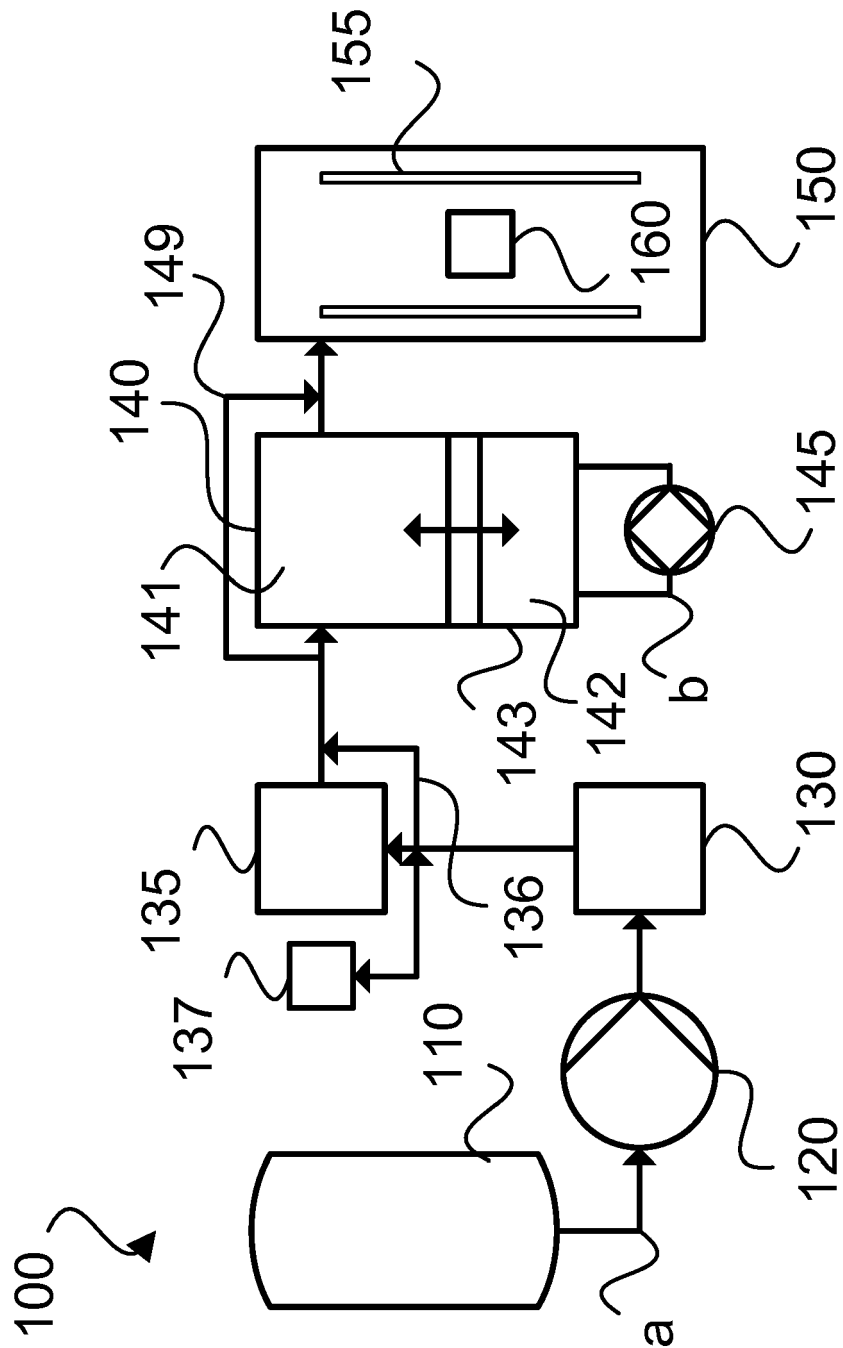


Fig. 1



EUROPEAN SEARCH REPORT

 Application Number
 EP 19 02 0432

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Place of search		Date of completion of the search	Examiner
The Hague		4 November 2019	Papakostas, Ioannis
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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