(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 039 983 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
10.08.2022 Bulletin 2022/32

(21) Application number: **21155928.1**

(22) Date of filing: **09.02.2021**

(51) International Patent Classification (IPC):
F04D 27/02 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F04D 29/5826; F04D 17/12; F04D 27/0207; F04D 27/0269; F05D 2230/72

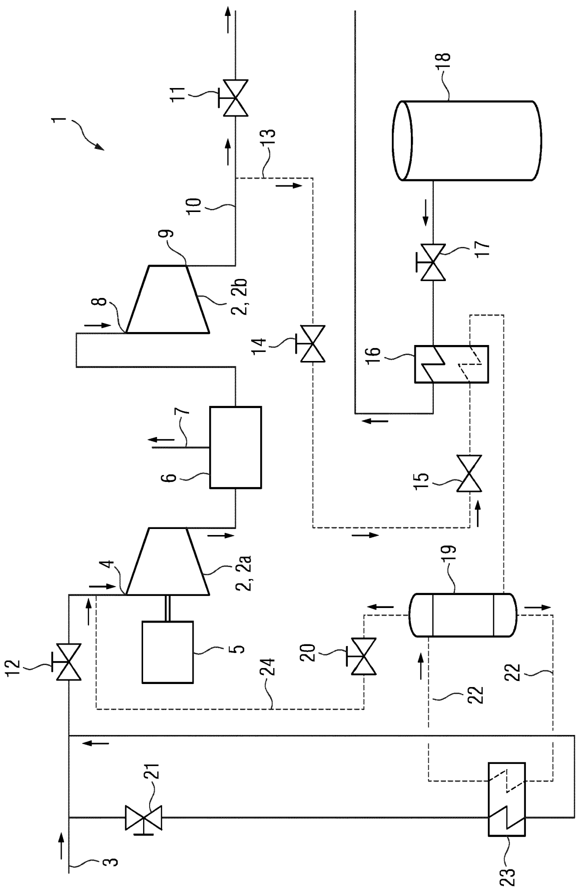
(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Siemens Energy Global GmbH & Co. KG**
81739 München (DE)

(72) Inventors:
- **Ahmad, Suhel**
  47198 Duisburg (DE)
- **Mönk, Thomas**
  45964 Gladbeck (DE)

(54) **COMPRESSOR WITH LOCAL RECIRCULATION OF PROCESS GAS IN CASE THE COMPRESSOR IS FLUIDICALLY ISOLATED FROM UPSTREAM AND DOWNSTREAM FACILITY PIPINGS**

(57) The invention relates to a method for the intermediate storage of a process gas in an installation (1), wherein the process gas is compressed in an installation (1) comprising a compressor (2, 2a, 2b), which is designed for compressing the process gas, and, in response to an event, the process gas flowing out of the compressor (2, 2a, 2b) is cooled in a cooling unit (16), and is stored thereafter in a storage unit (19) .



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Description

[0001] The invention relates to an installation for compressing a process gas, wherein the installation comprises: a compressor for compressing a process gas, wherein the compressor has a stator and a rotor, a drive, which is connected to the rotor in a torque-transmitting manner, an infeed line, which is fluidically connected to the input of the compressor, and a discharge line, which is fluidically connected to the output of the compressor.

[0002] The invention further relates to a method for the intermediate storage of a process gas in an installation, wherein the process gas is compressed in an installation which comprises a compressor, which is designed for the compression of the process gas.

[0003] In installations for compressing a process gas, the components and lines are essentially designed and manufactured for continuous duty. A key function of installations of this type is the compression of a process gas by means of a compressor. The gas thus compressed is required thereafter in a downstream process.

[0004] The compressors are essentially comprised of a rotatably-mounted rotor and a stator which is arranged about the rotor. The rotor is connected in a torque-transmitting manner via a drive. The drive can be an electrically-powered motor, a gas turbine or a steam turbine. Other torque-transmitting drives can also be employed.

[0005] The energy of the drive is converted into rotational energy of the compressor rotor, wherein this rotational energy is ultimately converted into compression energy of the process gas, in a compression process which is executed in the compressor. In general, the pressure and temperature of the process gas are thus significantly increased.

[0006] However, it can occur that, in response to an event, e.g. a malfunction, it is necessary for the infeed of compressed process gas to be suspended. In general, in a case of this type, a valve on the output of the compressor is closed, such that the process gas remains in the installation. In such a case, the drive of the compressor can be switched off.

[0007] If a compressor is in service and is suddenly shut down, for whatever reason, the pressure in the interior of the compressor remains high, and rises over time in response to the prevailing ambient temperature and volatile components which circulate in a closed system, as an outlet valve remains closed.

[0008] After a certain time, a pressure equilibrium is established within the compressor or in the downstream pipe system, which can result in a problem upon the restarting of the compressor. In order to start up the compressor under these conditions, a higher starting torque and run-up torque, and thus a higher capacity and more expensive drive are required than will suffice as a drive in normal duty.

[0009] The restoration of an installation of this type to speed, or the restarting of the drive of the compressor rotor, thus constitutes a technical challenge, as the process gas which is present in the installation, and is under pressure, can result in an increased torque demand.

[0010] This problem is counteracted, either by reducing the pressure in the installation, which can be achieved by the tap-off and torching of a proportion of the process gas via a line to the atmosphere, or alternatively, this problem can be counteracted by the design and employment of the drive with a correspondingly higher capacity rating.

[0011] The pressure which is constituted at the outlet of the compressor in such a case is described as the setting pressure. Accordingly, the above-mentioned problem can also be described as a setting pressure problem.

[0012] The invention is employed in this context.

[0013] The object of the invention is the disclosure of an installation and a method which are cost-effective, even in the event of a high setting pressure.

[0014] This object is fulfilled by an installation for compressing a process gas, wherein the installation comprises: a compressor for compressing a process gas, wherein the compressor has a stator and a rotor, a drive, which is connected to the rotor in a torque-transmitting manner, an infeed line, which is fluidically connected to the input of the compressor, and a discharge line, which is fluidically connected to the output of the compressor, having a storage line, which is fluidically connected to the discharge line, and wherein the storage line is fluidically connected to the input of a cooling unit, wherein the installation further comprises a storage unit for storing the process gas, wherein an input of the storage unit is fluidically connected to an output of the cooling unit, and wherein an output of the storage unit is fluidically connected to the input of the compressor via a storage output line.

[0015] This object is further fulfilled by a method for the intermediate storage of a process gas in an installation, wherein the process gas is compressed in an installation comprising a compressor, which is designed for compressing the process gas, and, in response to an event, the process gas flowing out of the compressor is cooled in a cooling unit, and is stored thereafter in a storage unit.

[0016] Accordingly, by means of the solution proposed herein, a novel concept for the solution of the setting pressure problem in compressor-driven installations is proposed. The proposed solution can effectively contribute to the reduction of investment costs for the drive, and simultaneously provides a solution for the setting pressure problem, in consideration of the employment of the conventional drive for normal duty.

[0017] There is consequently no necessity, either for the cost-intensive partial torching of the process gas, or for a higher capacity drive.

[0018] The drive can be rated for normal duty, with no requirement for additional torque associated with the approach to a state of pressure equilibrium. This has a substantial influence upon the investment costs for the drive.

[0019] As a result of the new concept, it is no longer necessary for the process gas, in the event of decaying pressure ratios or in the event of restarting, to be firstly torched, and for the same process gas to be replenished thereafter. The continuous procurement and delivery of a gas composition, particularly to remote areas, is a consistent logistical issue. Thus, according to the invention, the operating costs are reduced and the availability of an installation of this type is increased.

[0020] If the process gas is a coolant mixture, and the conditions in the event of a malfunction are such that the coolant is released from the closed system by venting/torching, it is extremely difficult to restore the original composition of the coolant in order to operate the installation. The concept proposed herein eliminates this problem, as coolant is no longer released from the closed system into the atmosphere. In turn, this results in a reduction of operating and servicing costs.

[0021] Advantageous further developments are disclosed in the subclaims.

[0022] Thus, in a first advantageous further development, a JT valve for cooling the process gas is arranged upstream of the cooling unit.

[0023] A JT valve is also known as a Joule-Thomson valve, wherein the Joule-Thomson effect is exploited in the JT valve, as a result of which the process gas is further cooled.

[0024] In a further advantageous further development, cooling in the cooling unit is executed by means of an energy exchange, using liquid nitrogen. Liquid nitrogen has a temperature of 77°K (-192°C), and is employed according to the invention for cooling by means of a heat exchanger.

[0025] In a further advantageous further development, the compressor comprises a first compressor and a second compressor, wherein the output of the first compressor is fluidically connected to the input of the second compressor by means of a connecting line, wherein an intercooler is arranged in the connecting line for cooling the compressed process gas originating from the first compressor.

[0026] In a further advantageous further development, the overall efficiency of the installation can be increased, wherein the installation the storage unit comprises a first preheating line, and wherein the process gas which is stored in the storage unit flows through this preheating line, wherein the preheating line is fed through a heat exchanger, which is designed to transfer heat from the process gas in the infeed line to the process gas in the preheating line, wherein the process gas, downstream of the heat exchanger, flows via a valve to the compressor.

[0027] The invention is described in greater detail hereinafter with respect to specific exemplary embodiments, with reference to the drawings.

[0028] The abovementioned properties, features and advantages of the present invention, and the manner in which these are achieved, are clarified and elucidated in conjunction with the following description of exemplary embodiments, which are described in greater detail with reference to the drawings.

[0029] Identical components, or components having an identical function, are identified by the same reference numbers.

[0030] Exemplary embodiments of the invention are described hereinafter with reference to the drawings. It is not intended for the exemplary embodiments to be represented in a true-to-scale fashion, but rather that the drawing, in the interests of clarity, is executed in a thematically-defined and/or slightly distorted form. With respect to any extensions of the instruction which is directly perceptible from the drawing, reference should be made to the relevant prior art.

[0031] In the drawing:

The figure: shows a schematic representation of the installation according to the invention.

[0032] The figure shows a schematic representation of the installation 1. The installation 1 is designed for compressing a process gas, and comprises a compressor 2 for compressing the process gas. The compressor 2 is constituted of a first compressor 2a and a second compressor 2b.

[0033] A process gas flows via an infeed line 3 to an input 4 of the first compressor 2a. A valve 12 is arranged in the infeed line 3. The compressors 2, 2a, 2b respectively comprise a rotor and a stator (not represented). The rotor is rotatably mounted about an axis of rotation, wherein the stator is arranged about the rotor. In operation, the process fluid flows between the stator and the rotor, wherein a mechanical rotational energy of the rotor is converted into pressure energy of the process gas.

[0034] The rotor is coupled in a torque-transmitting manner by means of a drive 5, which is not represented in greater detail. The drive 5 can be an electrically-powered motor, a gas turbine, a steam turbine or similar.

[0035] In the first compressor 2a, the pressure and temperature of the process fluid are raised. After flowing through the first compressor 2a, the process fluid flows through an intercooler 6. The intercooler 6 is designed to cool the process gas originating from the first compressor 2a. In the intercooler 6, heat 7 is evacuated from the process gas.

[0036] Downstream of the intercooler 6, the process gas flows into a second input 8 of the second compressor 2b. Here again, mechanical rotational energy is converted into pressure energy of the process fluid, wherein the temperature and pressure are raised. The process gas is thus compressed in two stages. The process fluid thus heated and pressurized exits the second compressor 2b via an output 9 and flows via a discharge line 10 to a process installation, which is not represented in greater detail, in which the compressed process gas undergoes further processing. A valve 11 is arranged in the discharge line 10. By means of the valve 11, the flow of the process gas in the process installation can be interrupted.

[0037] In normal duty, the valves 11 and 12 are open.

[0038] However, as soon as it is necessary to execute a sudden shutdown of the compressor 2, 2a, 2b, on whatever grounds (for example, in the event of a malfunction), limiting conditions will occur in service. In this situation, the valve 12 at the intake of the first stage and the valve 11 downstream of the second stage are closed.

[0039] In this situation, a fixed quantity of process gas is present in the compressor 2, 2a, 2b and in the lines. After a certain time, the pressure of the process gas begins to rise on the grounds that, after a certain time, the rise in the ambient temperature and the volatile nature of the components present in the process gas initiates an increase in the pressure of the process gas.

[0040] By way of a remedy, a storage line 13 is fluidically connected to the discharge line 10. A valve 14 is arranged in this storage line 13, which is open.

[0041] The process gas then flows to a JT valve 15, which is also described as a Joule-Thomson valve. In the JT valve 15, the process gas is expanded in the evaporator to a pressure slightly in excess of atmospheric pressure.

[0042] The installation 1 further comprises a cooling unit 16, which is fluidically connected to the storage line 13. The cooling unit 16 is a heat exchanger, which is fluidically connected via a valve 17 to a container 18 in which liquid nitrogen is stored.

[0043] The process gas thus cooled is further cooled, wherein the liquid nitrogen (which is present at a temperature of -192°C) further cools the process gas by the opening of the valve 17. The liquid nitrogen further cools the process gas, which is converted into two phases at a lower temperature and a lower pressure, and is stored in a storage unit 19.

[0044] The storage unit 19 comprises a first preheating line 22, wherein the process gas which is stored in the storage unit 19 flows through this preheating line 22, wherein the preheating line 22 is fed through a heat exchanger 23, which is designed to transfer heat from the process gas in the infeed line 3 to the process gas in the preheating line 22, wherein the process gas, downstream of the heat exchanger 23, can flow via the valve 20 to the compressor 2, 2a, 2b.

[0045] An output of the storage unit 19 is fluidically connected by means of a storage output line 24 to the input 4 of the compressor 2, 2a, 2b.

[0046] A proportion of the process gas is routed directly by the opening of the valve 20 to the input of the compressor 2, 2a, 2b, and the liquid phase is vaporized in the heat exchanger 22 by fresh process gas, by the opening of the valve 21.

[0047] In this situation, the drive 5 requires no surplus torque for the operation of the installation 1.

[0048] Although the invention has been illustrated and described in greater detail with reference to the preferred exemplary embodiment, the invention is not limited by the examples disclosed, and further variations can be inferred herefrom by a person skilled in the art, without departing from the protective scope of the invention.

Claims

1. An installation (1) for compressing a process gas, wherein the installation (1) comprises:

    a compressor (2, 2a, 2b) for compressing a process gas,
    wherein the compressor (2, 2a, 2b) has a stator and a rotor, a drive (5), which is connected to the rotor in a torque-transmitting manner,
    an infeed line (3), which is fluidically connected to the input (4) of the compressor (2, 2a, 2b),
    and a discharge line (10), which is fluidically connected to the output (9) of the compressor (2, 2a, 2b), having a storage line (13) which is fluidically connected to the discharge line (10), and
    wherein the storage line (13) is fluidically connected to the input of a cooling unit (16),
    wherein the installation (1) further comprises a storage unit (19) for storing the process gas,
    wherein an input of the storage unit (19) is fluidically connected to an output of the cooling unit (16),
    and wherein an output of the storage unit (19) is fluidically connected to the input (4) of the compressor (2, 2a, 2b) via a storage output line (24).

2. The installation (1) as claimed in claim 1,
wherein a JT valve (15) for cooling the process gas is arranged upstream of the cooling unit (16).

3. The installation (1) as claimed in claim 1 or 2,
wherein cooling in the cooling unit (16) is executed by means of an energy exchange, using liquid nitrogen.

4. The installation (1) as claimed in one of the preceding claims,
wherein the compressor (2) comprises a first compressor (2a) and a second compressor (2b),
wherein the output of the first compressor (2a) is fluidically connected to the input (8) of the second compressor (2b) by means of a connecting line,
wherein an intercooler (6) is arranged in the connecting line for cooling the compressed process gas originating from the first compressor (2a).

5. The installation (1) as claimed in one of the preceding claims, wherein the storage unit (19) comprises a first preheating line (22),
wherein the process gas which is stored in the storage unit (19) flows through this preheating line (22),
wherein the preheating line (22) is fed through a heat

exchanger (23), which is designed to transfer heat from the process gas in the infeed line (3) to the process gas in the preheating line (22), wherein the process gas, downstream of the heat exchanger (23), flows via a valve (20) to the compressor (2, 2a, 2b).

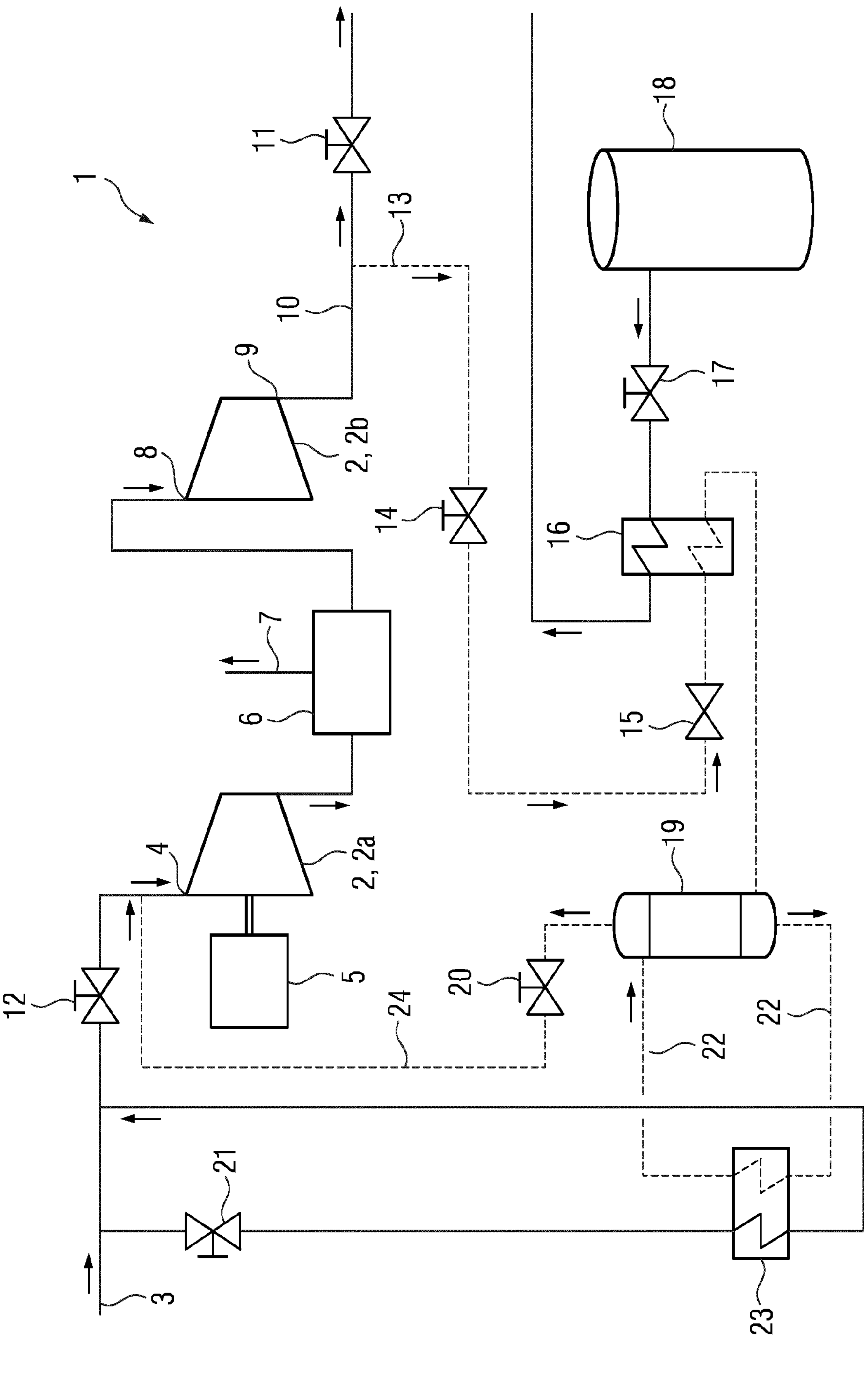
6. A method for the intermediate storage of a process gas in an installation (1),
wherein the process gas is compressed in an installation (1) comprising a compressor (2, 2a, 2b), which is designed for compressing the process gas, and, in response to an event, the process gas flowing out of the compressor (2, 2a, 2b) is cooled in a cooling unit (16), and is stored thereafter in a storage unit (19).

7. The method as claimed in claim 6,
wherein the process gas is cooled in a JT valve (15), upstream of the input to the cooling unit (16).

8. The method as claimed in one of claims 6 or 7,
wherein cooling of the process gas in the cooling unit (16) is executed by means of an energy exchange, using liquid nitrogen.

9. The method as claimed in one of the preceding claims,
wherein the compressor (2, 2a, 2b) comprises a first compressor (2a) and a second compressor (2b), and the gas flowing from the first compressor (2a) to the second compressor (2b) is cooled in an intercooler (6).

10. The method as claimed in one of the preceding claims,
wherein a proportion of the process gas from the storage unit (19) is preheated by means of an energy exchange with the process gas from the infeed line (3).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EUROPEAN SEARCH REPORT

Application Number
EP 21 15 5928

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2017/254338 A1 (LEE JOA HYOUNG [KR]) 7 September 2017 (2017-09-07) * abstract; figures 7-10 * * paragraphs [0043] - [0050] * -----	1-4,6-9 5,10	INV. F04D27/02
A	DE 31 14 522 A1 (SULZER AG [CH]) 18 November 1982 (1982-11-18) * claim 1; figures 1-3 * * page 7, line 12 - page 9, line 14 * -----	1,6	
A	WO 2014/118087 A1 (SIEMENS AG [DE]) 7 August 2014 (2014-08-07) * page 7, lines 10-11 * -----	2,7	

TECHNICAL FIELDS SEARCHED (IPC)

F04D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 June 2021	Brouillet, Bernard

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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

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17-06-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017254338 A1	07-09-2017	KR 20170102736 A	12-09-2017
		US 2017254338 A1	07-09-2017
DE 3114522 A1	18-11-1982	DE 3114522 A1	18-11-1982
		FR 2503279 A1	08-10-1982
		IT 1151364 B	17-12-1986
		JP S57179399 A	04-11-1982
WO 2014118087 A1	07-08-2014	DE 102013201482 B3	10-10-2013
		WO 2014118087 A1	07-08-2014

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