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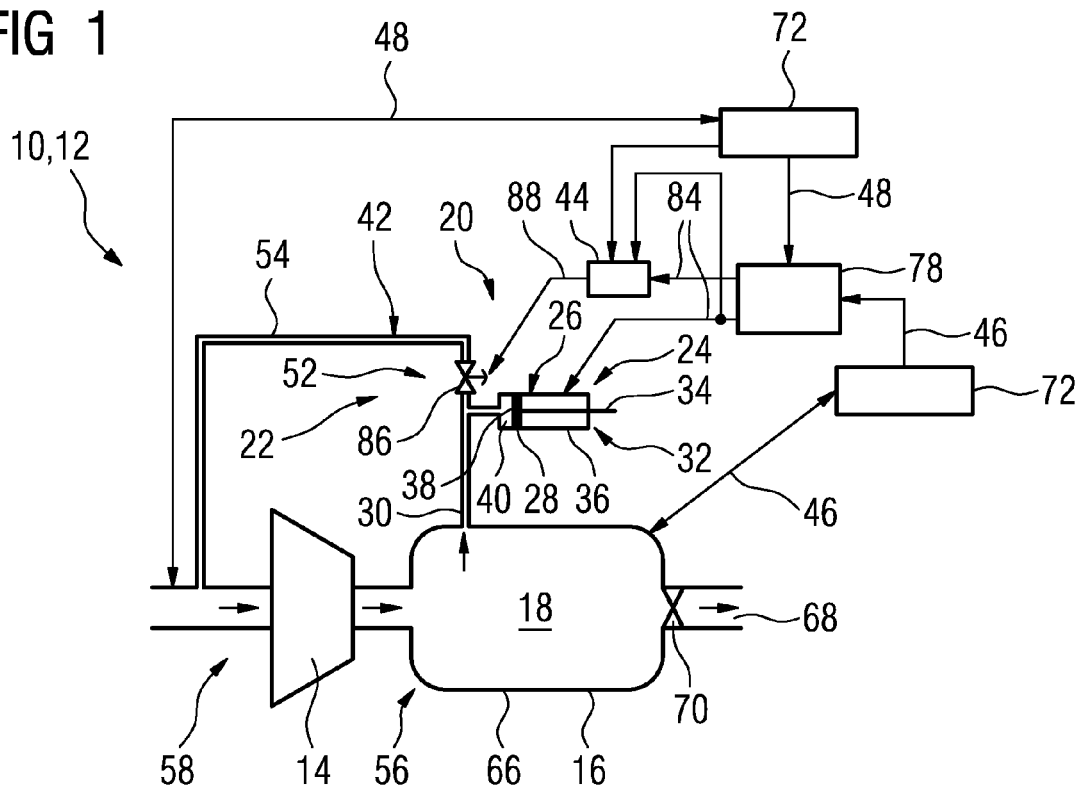
(54) **Industrial compressor system**

(57) The invention relates to an industrial compressor system (10), especially industrial turbo compressor system (12), with at least one compressor (14) comprising a pressure section (16) encasing a pressure volume (18) and an anti surge device (20) having a first anti surge

means (22) for counteracting a surge condition of the compressor (14) by means of a passive mechanism.

It is provided that the anti surge device (20) comprises at least a second anti surge means (24) comprising an active anti surge mechanism.

FIG 1



Description

[0001] The invention relates to an industrial compressor system, especially an industrial turbo compressor system, according to the preamble of claim 1 and to a method for operating such an industrial compressor system according to the preamble of claim 12.

[0002] A compressor is used in many applications to increase the fluid pressure which passes through the compressor. A compressor flow rate is limited by surge and stone wall phenomena at low and high mass flow, respectively. A compressor operating area is bounded by surge line and stone wall in the left and right sides of a compressor map, respectively. Surge line represents the operating points where surge is occurring. It becomes the limit of stability of compressor operation at low mass flow. Crossing the surge line causes the compressor to enter surge and the turbo compressor becomes unstable. The surge line is the limit of minimum mass flow in operating the compressor. Stone wall is the limit of maximum mass flow in operating the compressor. The compressor is only allowed to operate in between the surge line and stone wall and therefore in the compressor operating area. However, the high efficiency operating point of the compressor is laid close to the surge line. Operating at that point may endanger the compressor crossing the surge line due to any disturbance. To avoid that the compressor undergoes surge, it is usual practice in the field of industrial compressors to use an anti surge system to keep the compressor in the stable area when the compressor is operated near the surge line. This system operates for example with a control line that is defined on the right side of the surge line with certain margin. The control line becomes the minimum mass flow in operating the compressor. The anti surge system is working when the operating point cross the control line. It works by operating a recycle device to reduce the pressure in a pressure section of the compressor and thus increase the flow through the compressor. This will bring an operating point back to the right side of the control line.

[0003] The problem addressed by the invention is that an industrial compressor with an anti surge device should be provided which could be operated more efficiently and safe near a surge line, and even cross the surge line.

[0004] The problem addressed by the invention is that invention by the features of claim 1. Favourable embodiments and advantages of the invention result from the further claims, the drawing, and the description.

[0005] The invention is directed to an industrial compressor system, especially an industrial turbo compressor system, with at least one compressor comprising a pressure section encasing a pressure volume and an anti surge device having a first anti surge means for counteracting a surge condition of the compressor by means of a passive mechanism.

[0006] It is provided that the anti surge device comprises at least a second anti surge means comprising an active anti surge mechanism. "Provided" is intended to

mean specially equipped and/or designed. It is therefore advantageously possible to provide an industrial compressor with an anti surge system which is able to allow working near or on a surge line of the compressor and even to obtain a new surge line which allows working in a more or high efficient range with a high pressure and an advantageously low mass flow. Thus, a compressor operating area can be advantageously enlarged. Therefore, costs for operating the compressor can be reduced.

[0007] An "industrial compressor" is intended to mean, in particular, a compressor, which is used in industrial plants, like an oil refinery, natural gas production and distribution. Moreover, a "turbo compressor" is intended to mean, in particular, a rotational machine. A "pressure section" particularly defines a pipeline system which is arranged opponent from a suction section located upstream of the compressor and/or has a higher pressure as a pressure of the suction section and/or is located downstream of the compressor and/or in, in particular, embodied as a plenum of the compressor. An "anti surge device" particularly depicts a device by means of which a surge condition of the compressor can be avoided and/or which stabilizes a operating point of the compressor in a compressor operating area located between a surge line and a stone wall of the compressor and/or stabilizes the operating point on a right hand side of the surge line. Surge is a phenomenon resulting from the inability of a compressor impeller to produce the amount of required energy that the process system requires. The energy is produced by the action of the vanes and flow between blade and vanes. The inability brings the compressor operation to unstable condition. It can be a result of flow separation, caused by low gas velocity, anywhere in a compressor stage (inlet guide vane, impeller suction, impeller mid section, impeller discharge or diffuser). Some facts concerning surge are that it is a high speed phenomena, flow reversal can occur in less than 150 milliseconds, pressure rapidly fluctuates, noise is generated, temperature increase can be very rapid and mechanical damage can occur.

[0008] Moreover, the term "counteract" is intended to mean, in particular, minimize and/or preferably suppress. The phrase "by means of a passive mechanism" is intended to mean, in particular, that a surge line and/or a course of the surge line, respectively, of the compressor is unaffected by the action of the first anti surge means. Thus the first anti surge means is a passive anti surge means. Furthermore, an "active mechanism" displays a mechanism where the compressor operating area is enlarged and/or a course of the surge line is shifted, in particular to a lower mass flow and/or in a compressor map more to the left. Thus, an active feedback to stabilize a compression system by modifying its dynamics is utilized. Due to the second/active anti surge means the area on the left side of the surge line in the compressor map can be stabilized in a certain range to provide a new surge line. A new surge phenomenon will occur in the lower mass flow than the original surge. Hence, the sec-

ond anti surge means is an active anti surge means. The active mechanism can work by controlling of the pressure of the pressure section by actuating an exit throttle of the pressure section and/or by controlling a couple valve located close to an outlet of the compressor. Alternatively, the active mechanism can be intended to control the mass flow of the compressor by injecting small volumes of extra fluid into the compressor or an impeller, respectively, and/or the mechanism can influence surge by controlling the torque of the electrical motor driving the compressor. Moreover, it is possible to control a volume of the compressor or the volume of the pressure section or the plenum, respectively, by means of a movable plenum wall. Generally every other mechanism that is feasible to a person skilled in the art could be intended.

[0009] The second anti surge means or the active anti surge means, respectively, preferably comprises at least one sensor, which detects a condition and/or at least a controller, which evaluates the condition and/or at least an actuator, which adapts the condition according to a signal generated dependent to the evaluated condition. The sensor detects advantageously a compressor duct mass flow, a compressor face total mass flow, a compressor face static pressure, a pressure in the pressure section (plenum), a suction temperature, a recooling temperature and/or another parameter that is suitable to a person skilled in the art. Furthermore, an "actuator" in this context is intended to mean, in particular, a valve, a throttle, an injected gas flow, a wall, a temperature controller and/or another device that is practical for a persons skilled in the art. Preferably, the passive and the active anti surge means provide a control system for the industrial compressor.

[0010] It is a further object of the present invention to provide that the second anti surge means has at least one volume activator. A "volume activator" is intended to mean, in particular, a device which is an actuator and/or which changes through its own action the volume of the pressure section or the plenum, respectively. It is favoured that the volume of the pressure section is increased by the volume activator, which results advantageously in a reduction of the pressure of the pressure section or the plenum and thus will take the compressor back to a stable operating condition. Additionally an enlargement of the compressor operating area is achieved. However, this enlargement is depended e.g. of a volume capacity of the volume activator.

[0011] Advantageously, the volume activator has at least a moveable means for varying the pressure volume of the pressure section. The moveable means in preferably embodied as a moveable wall. Due to the moveable means it is constructively easy to adjust a volume of the pressure section.

[0012] Moreover, it is provided that the volume activator is arranged outside of the pressure section at a duct of the pressure section. The phrase "outside of the pressure section" is intended to mean, in particular, that it is not located in the volume of the pressure section and/or

is not a structure or not a part of a structure, like a wall of the pressure section/the plenum, of the pressure section. By means of this arrangement the volume activator can be easily connected with the pressure section and/or an action of the volume activator can easily influence or adjust the volume of the pressure section. Advantageously, the volume activator forms the dead end of the duct of the pressure section, wherein the volume activator terminates advantageously the duct of the pressure section.

[0013] Furthermore, it is advantageous when the volume activator possesses a piston as the moveable means. Thus, the moveable means can be manufactured with minimum costs and weight.

[0014] Moreover, it could be designed robustly and reliable. Favourably, the movable means possesses a surface facing the duct of the pressure section, whereby a good and efficient working surface could be provided.

[0015] In a further embodiment of the invention, the volume activator possesses a barrel, by which the piston can be guided effortlessly. Advantageously, the movable means is arranged inside a barrel of the volume activator, whereby the moveable means or the piston, respectively, can be arranged and operated loss-proof.

[0016] Additionally, it is a further object of the present invention that a volume, which is encased by the surface of the moveable means and a barrel of the volume activator, is at least 10 % of the pressure volume of the pressure section. In other words, it is intended that the volume activator could enlarge a volume of the pressure section at least up to 10 % and/or that the volume activator has a storage capacity of a volume which is at least about 10 % of the volume of the pressure section. It is generally possible, that the volume, which is encased by the surface of the moveable means and a barrel of the volume activator, has a different percentage of the pressure volume of the pressure section than 10 %. A person skilled in the art would select a suitable value in accordance to the properties and dimension of the used compressor. This results in the enlargement of the pressure volume at least up to 10 % and therefore in an advantageous enlargement of the compressor operating area.

[0017] Safe performance of the active anti surge means or reliable avoidance of surge by using the piston is limited by the storage capacity or the volume, respectively, of the volume activator. Thus it is furthermore provided that the first anti surge means is embodied as a security means to ensure a safe operation of the compressor in case of failure of the second anti surge means. The term "failure" is intended to mean particularly, a situation in which the active anti surge means is destroyed and/or is defect and/or in which the capacity of the volume activator is insufficient. With the usage of the first anti surge means as security feature an already existing structure could easily accomplish a second function, wherein manufacturing costs and components can be reduced. Moreover, the security means could be realized in a space saving manner.

[0018] In addition, it is advantageous when the security means has a switch. In this case a "switch" defines a means which is intended to change a mode of the compressor e.g. a mode operating solely with the active anti surge means to a mode operating with both anti surge means and/or to change an arrangement of parts of the security means relative to one another. By means of the switch the performance of the security means could be effortlessly activated.

[0019] Preferably the switch is activated when at least one detected parameter exceeds a predetermined value and the moveable means is at rest. In case of surge, the volume activator is activated and increases due to its movement the pressure volume of the pressure section. The activation is triggered by a signal from the controller, wherein the controller had evaluated a sensor detected parameter or parameters referring to the current work point or work condition, respectively, of the compressor. The controller compares the detected parameter value (s) with a threshold or with a predetermined value representing a dangerous condition of the compressor. The predetermined value could e.g. be represented by parameter pairs belonging to the surge line in dependence of the pressure and the mass flow and/or by any other condition or parameter which is feasible to a person skilled in the art. When the controller detects, that at least one detected parameter exceeds the predetermined value and therefore that the working condition of the compressor is at risk to go into surge and/or that the operating point is near or on or even left of the surge line, it triggers the volume activator. Thus, also a command signal for the volume activator exceeds a predetermined value, namely 0. When the compressor is working in the mode with solely the active anti surge means, as described above, this has the first priority to suppress the surge phenomenon. However, if the piston is at its maximum stroke and/or is unmoving or at rest and therefore the volume activator is out of its work area and the detected parameter still exceeds the predetermined value, the security means takes effect. By means of the inventive embodiment a precise adjustment could be archived and it is ensured that the compressor works at all times both safely and highly efficient.

[0020] Alternatively, the security means could be embodied as a second active anti surge means, which is intended to function in parallel to the first active anti surge means. This second active anti surge means could be designed after any active mechanism, which is feasible to a person skilled in the art.

[0021] Advantageously, the first anti surge means is embodied as a recycle valve configuration, wherein the security means or the first anti surge means, respectively, could be constructed constructively easy after an already used and well-proved idea. A valve of the recycle valve configuration is preferably controlled by the switch of the security means. Therefore, an activation of the security means is performed easily and trouble-free.

[0022] An effective and easily constructed surge de-

vice can be achieved when the first anti surge means possesses a recycle line. A "recycle line" is intended to mean, in particular, a passage which connects at least two areas which have at least one concordant parameter, such as the same pressure, the same volume, a same temperature and/or preferably the same composition of a fluid or a gas, respectively. Preferably, the recycle line connects at least two volumes, which have the same composition of a fluid or a gas. Moreover, it is preferable when the recycle line connects a region located downstream of the compressor with a region located upstream of the compressor. Thus, a surplus fluid/gas volume accumulated downstream of the compressor could be used an additional time. Furthermore the recycle line may be connected to the valve.

[0023] Particularly advantageously, the first and/or the second anti surge means are controlled by means of a control law, by which the turbo compressor could be controlled easily and reliably. A person skilled in the art will chose the type of control law single handed according to the properties of the used compressor and its components.

[0024] The invention is directed to a method for operating a compressor system, especially a turbo compressor system, with a compressor comprising a pressure section encasing a pressure volume and an anti surge device having a first anti surge means for counteract a surge condition of the compressor by means of a passive mechanism.

[0025] It is provided that the anti surge device comprises at least a second anti surge means working with an active anti surge mechanism and wherein the second anti surge means has at least one volume activator with a moveable means that varies the pressure volume of the pressure section. Thus, with this method an industrial compressor or a turbo compressor, respectively, could be operated with an anti surge device which allows a working condition of the compressor near or on a surge line of the latter and even to obtain a new surge line which allows working in a more or high efficient range with a high pressure and an advantageously low mass flow. Therefore, a compressor operating area can be advantageously enlarged, which additionally results in a reduction of costs for operating the compressor. Moreover, due to the increase of the volume of the pressure section by the volume activator, the pressure of the pressure section or the plenum could be advantageously decreased and hence will stabilize compressor.

[0026] The invention is explained in the following in greater detail, as an example, with reference to an embodiment depicted in drawings.

[0027] They show:

FIG 1 a section of an industrial compressor system according to the invention,

FIG 2 a compressor map of the system from figure 1, and

FIG 3 a setup with the system of figure 1 and a control unit.

[0028] Elements that are functionally identical or similar-acting are labelled using the same reference numerals in the figures. The figures are schematic depictions of the invention. They do not depict specific parameters of the invention. Furthermore, the figures merely show a typical embodiment of the invention and should not limit the invention to the embodiment shown.

[0029] Regarding elements in a figure that are not described further, reference is made to the respective description of the elements in preceding figures to avoid unnecessary repetition.

[0030] Fig. 1 shows a section of an industrial compressor system 10 or an industrial turbo compressor system 12, with a compressor 14, in the form of a turbo compressor, comprising a pressure section 16 embodied as plenum 66 encasing a pressure volume 18. The pressure section 16 is located in a region 56 which is located downstream of the compressor 14 and has at an outlet 68 a throttle 70 to adjust an operating point 80 of the compressor 14. In addition, the industrial compressor system 10 comprises an anti surge device 20 having a first anti surge means 22 for counteracting a surge condition of the compressor 14 by means of a passive mechanism and a second anti surge means 24 comprising an active anti surge mechanism.

[0031] The second anti surge means 24 has a volume activator 26, which is arranged outside of the pressure section 16 or the plenum 66, respectively, at a duct 30 of the pressure section 16 and forms the dead end 32 of the duct 30. Moreover, the volume activator 26 possesses a barrel 36 and a moveable means 28 for varying the pressure volume 18 of the pressure section 16. The moveable means 28 is embodied as a piston 34 and is arranged inside the barrel 36 and possesses a surface 38, which faces the duct 30 of the pressure section 16. The volume activator 26 is enabled to absorb a volume 40, which is encased by the surface 38 of the moveable means 28 and the barrel 36. Thus, the volume activator 28 can enlarge the pressure volume 18 of the pressure section 16. A capacity or an uptake capacity of the volume activator or the volume 40, respectively, is approximately 10 % of the pressure volume 18 of the pressure section 16.

[0032] The second anti surge means 24 further comprises sensors 72, which detect a condition or a feedback signal or parameters 46, 48 referring to the current operating point 80 or work condition, respectively, of the compressor 14, like the pressure 74 in the pressure section 16 or a mass flow 76 in a region 58 located upstream of the compressor 14. The sensors 72 feed the detected information to a controller 78, which evaluates the detected condition by using a control law. The controller 78 compares the detected parameters 46, 48 with a predetermined value 50 representing a dangerous condition of the compressor 14. The predetermined value 50 represents a parameter pair of pressure 74 and mass flow

76 belonging to an operating point 80 of a surge line 82 (see Fig. 2). When the controller 78 detects, that the detected parameters 46, 48 exceeds the predetermined value 50 and therefore that the operating point 80 is on the surge line 82 and that the working condition of the compressor 14 is at risk to go into surge, it triggers the volume activator 26 with a command signal 84 that is # 0.

[0033] In case of an activation of the volume activator 26 it increases due to the movement of the moveable means 28 or the piston 34, respectively, the pressure volume 18 of the pressure section 16. Thus, the pressure 74 in the pressure section 16 is decreased and the mass flow 76 of the initial surge point is reduced. As a result the compressor 14 is back in a stable working condition. When the compressor 14 is working in the mode with solemnly the active anti surge means 24, as described above, this has the first priority to suppress the surge phenomenon.

[0034] However, if the piston 34 is at its maximum stroke or at rest the volume activator 26 is out of its work area and if the detected parameters 46, 48 are still exceeding the predetermined value 50, a security means 42 takes effect. Hence, the first anti surge means 22 is embodied as the security means 42 to ensure a safe operation of the compressor 14 in case of failure of the second anti surge means 24. Moreover, the security means 42 has a switch 44, which is activated when the detected parameters 46, 48 exceed the predetermined value 50 and the moveable means 28 is at rest. The switch 44 controls a valve 86 of the first anti surge means 22 which is embodied as a recycle valve configuration 52. Since the first anti surge means 22 possesses a recycle line 54, which connects the region 56 located downstream of the compressor 14 with a region 58 located upstream of the compressor 14, and the valve 86 opens and closes the recycle line 54 in dependence of a signal 88 from the switch 44 the pressure 74 in the pressure section 16 could be reduced by an efflux of fluid out of the pressure section 16.

[0035] In fig. 2 a compressor map 90 of the industrial compressor system 10 is shown. Due to the operation of the compressor system 10 and the anti surge device 20 with the passive and active anti surge means 22, 24 and thus the variation or the increase of the pressure volume 18 of the pressure section 16 by the volume activator 26 with its moveable means 28 the surge line 82 can be shifted more to the left to gain a new surge line 92. Therefore, a compressor operating area 94, which is limited on the left side at a low mass flow 76 by the surge line 82 or the new surge line 92, respectively, and on the right side at a high mass flow 76 by means of a stone wall 96, can be enlarged.

[0036] Fig. 3 shows a setup with an industrial compressor system 10 with the compressor 14 and a control unit 98. The first and second or the passive and active, respectively, anti surge means 22, 24 are controlled by means of a control law 60. Various parameters 46, 48 are detected at different points of the compressor 14 for

example by sensors 72 detecting a compressor inlet pressure and temperature, a discharge pressure and temperature, a compressor mass flow rate or a plenum pressure and temperature and are feed to the controller 78 which belongs to the control unit 98. The control unit 98 can be every unit a person skilled in the art thinks is feasible.

Claims

1. Industrial compressor system (10), especially industrial turbo compressor system (12), with at least one compressor (14) comprising a pressure section (16) encasing a pressure volume (18) and an anti surge device (20) having a first anti surge means (22) for counteracting a surge condition of the compressor (14) by means of a passive mechanism, wherein the anti surge device (20) comprises at least a second anti surge means (24) comprising an active anti surge mechanism.
2. Industrial compressor system according to claim 1, wherein the second anti surge means (24) has at least one volume activator (26) with a moveable means (28) for varying the pressure volume (18) of the pressure section (16).
3. Industrial compressor system according to claim 2, wherein the volume activator (26) is arranged outside of the pressure section (16) at a duct (30) of the pressure section (16).
4. Industrial compressor system according to claim 3, wherein the volume activator (26) forms the dead end (32) of the duct (30) of the pressure section (16).
5. Industrial compressor system according to claims 2 to 4, wherein the volume activator (26) possesses a piston (34) as the moveable means (28).
6. Industrial compressor system according to claims 3 to 5, wherein the volume activator (26) possesses a barrel (36) and the movable means (28) is arranged inside the barrel (36) and possesses a surface (38) facing the duct (30) of the pressure section (16) and a volume (40), which is encased by the surface (38) of the moveable means (28) and the barrel (36), is at least 10 % of the pressure volume (18) of the pressure section (16).
7. Industrial compressor system according to one of the proceeding claims, wherein the first anti surge means (22) is embodied as a security means (42) to ensure a safe operation of the compressor (14) in case of failure of the second anti surge means (24).
8. Industrial compressor system according to claims 2

and 7, wherein the security means (42) has a switch (44), which is activated when at least one detected parameter (46, 48) exceeds a predetermined value (50) and the moveable means (28) is at rest.

9. Industrial compressor system according to one of the proceeding claims, wherein the first anti surge means (22) is embodied as a recycle valve configuration (52).
10. Industrial compressor system according to one of the proceeding claims, wherein the first anti surge means (22) possesses a recycle line (54), which connects a region (56) located downstream of the compressor (14) with a region (58) located upstream of the compressor (14).
11. Industrial compressor system according to one of the preceding claims, wherein the first and/or the second anti surge means (22, 24) are controlled by means of a control law (60).
12. Method for operating a turbo compressor system (10), especially an industrial turbo compressor system (12), with a compressor (14) comprising a pressure section (16) encasing a pressure volume (18) and an anti surge device (20) having a first anti surge means (22) for counteracting a surge condition of the compressor (14) by means of a passive mechanism, wherein the anti surge device (20) comprises at least a second anti surge means (24) working with an active anti surge mechanism and wherein the second anti surge (24) means has at least one volume activator (26) with a moveable means (28) that varies the pressure volume (18) of the pressure section (16).

Amended claims in accordance with Rule 137(2) EPC.

1. Industrial compressor system (10), especially industrial turbo compressor system (12), with at least one compressor (14) comprising a pressure section (16) encasing a pressure volume (18) and an anti surge device (20) having a first anti surge means (22) for counteracting a surge condition of the compressor (14) by means of a passive mechanism, wherein the anti surge device (20) comprises at least a second anti surge means (24) comprising an active anti surge mechanism, **characterized in that** the second anti surge means (24) has at least one signal triggered volume activator (26) with a moveable means (28) for varying the pressure volume (18) of the pressure section (16).
2. Industrial compressor system according to claim 1, wherein the volume activator (26) is arranged out-

side of the pressure section (16) at a duct (30) of the pressure section (16).

3. Industrial compressor system according to claim 2, wherein the volume activator (26) forms the dead end (32) of the duct (30) of the pressure section (16). 5

4. Industrial compressor system according to claims 1 to 43, wherein the volume activator (26) possesses a piston (34) as the moveable means (28). 10

5. Industrial compressor system according to claims 2 to 4, wherein the volume activator (26) possesses a barrel (36) and the movable means (28) is arranged inside the barrel (36) and possesses a surface (38) facing the duct (30) of the pressure section (16) and a volume (40), which is encased by the surface (38) of the moveable means (28) and the barrel (36), is at least 10 % of the pressure volume (18) of the pressure section (16). 15 20

6. Industrial compressor system according to one of the proceeding claims, wherein the first anti surge means (22) is embodied as a security means (42) to ensure a safe operation of the compressor (14) in case of failure of the second anti surge means (24). 25

7. Industrial compressor system according to claims 1 and 6, wherein the security means (42) has a switch (44), which is activated when at least one detected parameter (46, 48) exceeds a predetermined value (50) and the moveable means (28) is at rest. 30

8. Industrial compressor system according to one of the proceeding claims, wherein the first anti surge means (22) is embodied as a recycle valve configuration (52). 35

9. Industrial compressor system according to one of the proceeding claims, wherein the first anti surge means (22) possesses a recycle line (54), which connects a region (56) located downstream of the compressor (14) with a region (58) located upstream of the compressor (14). 40 45

10. Industrial compressor system according to one of the preceding claims, wherein the first and/or the second anti surge means (22, 24) are controlled by means of a control law (60). 50

11. Method for operating a turbo compressor system (10), especially an industrial turbo compressor system (12), with a compressor (14) comprising a pressure section (16) encasing a pressure volume (18) and an anti surge device (20) having a first anti surge means (22) for counteracting a surge condition of the compressor (14) by means of a passive mechanism, wherein the anti surge device (20) comprises 55

at least a second anti surge means (24) working with an active anti surge mechanism and wherein the second anti surge (24) means has at least one signal triggered volume activator (26) with a moveable means (28) that varies the pressure volume (18) of the pressure section (16).

FIG 1

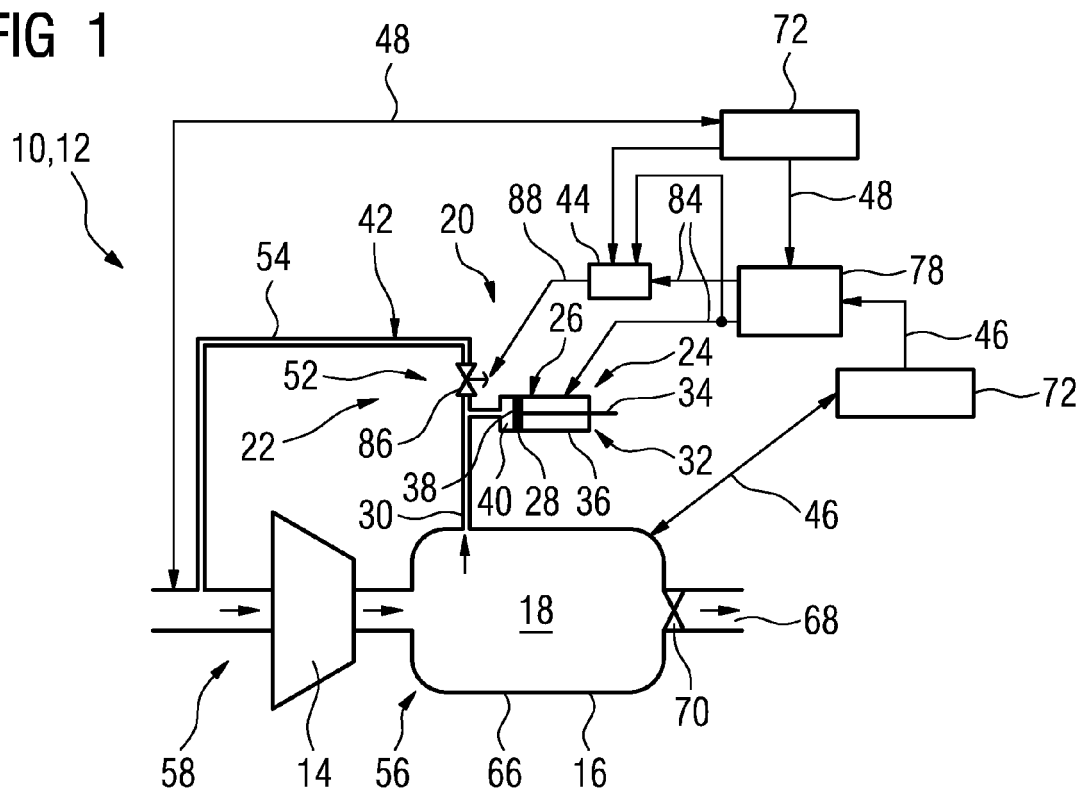


FIG 2

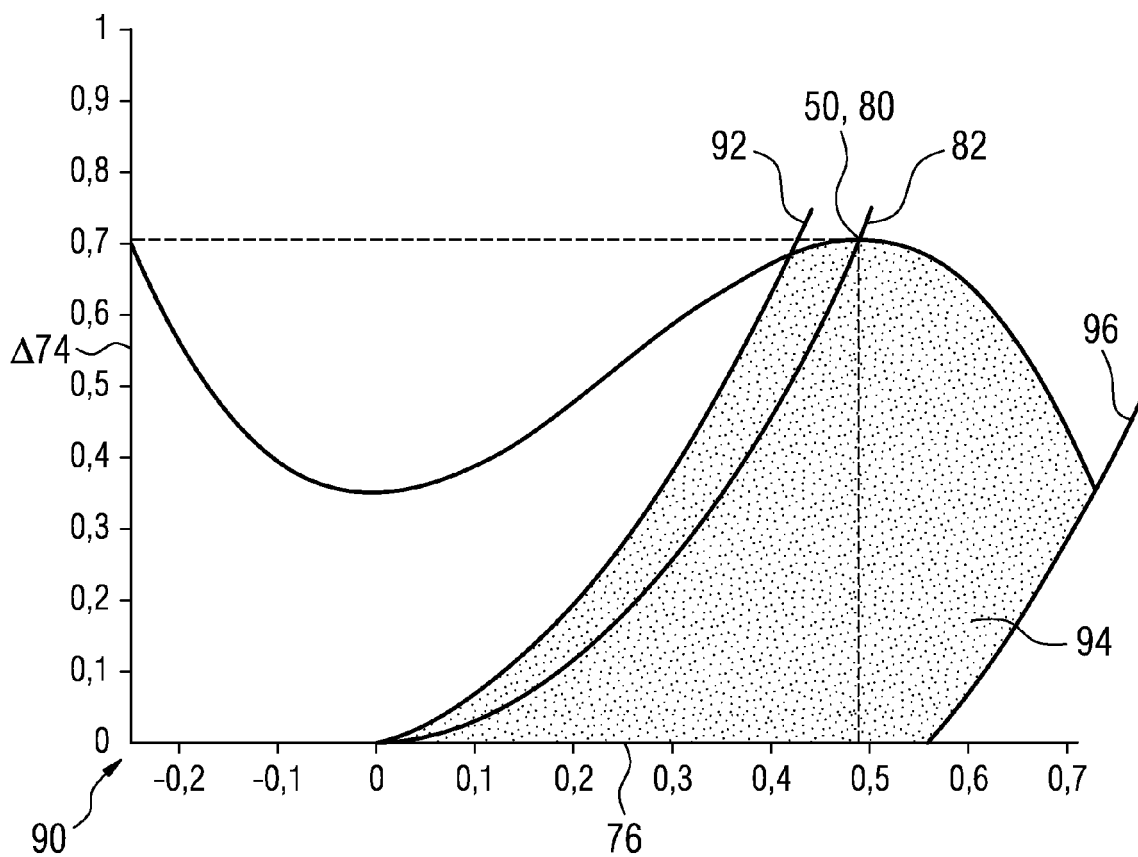
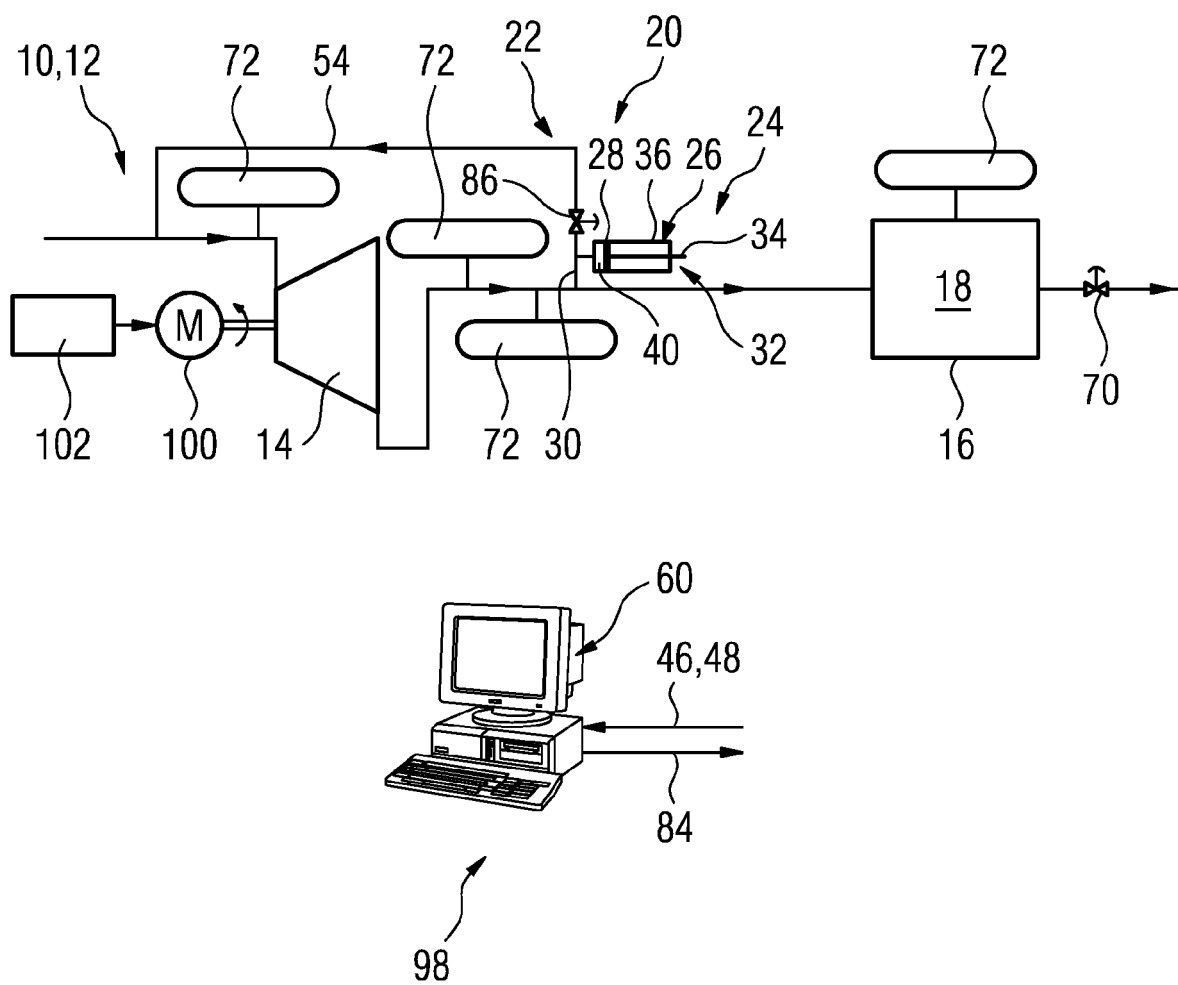


FIG 3





EUROPEAN SEARCH REPORT

Application Number
EP 10 17 3999

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	DE 43 16 202 A1 (ATLAS COPCO ENERGAS [DE]) 17 November 1994 (1994-11-17)	1	INV. F04D27/02
Y	* the whole document * * claims 1,4 *	2-12	
Y	----- US 5 199 856 A (EPSTEIN ALAN H [US] ET AL) 6 April 1993 (1993-04-06) * the whole document * * claim 1 *	2-12	
X	----- EP 0 500 196 A2 (COMPRESSOR CONTROLS CORP [US]) 26 August 1992 (1992-08-26) * the whole document * * page 5, lines 1-9 * * claims 1,2 *	1	
A	----- EP 1 091 129 A1 (UNIV DEGLI STUDI UDINE [IT]) 11 April 2001 (2001-04-11) * the whole document * * claim 1 *	1-12	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F04D
Place of search		Date of completion of the search	Examiner
The Hague		1 February 2011	Ingelbrecht, Peter
CATEGORY OF CITED DOCUMENTS			
<p>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</p> <p>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</p>			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 10 17 3999

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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