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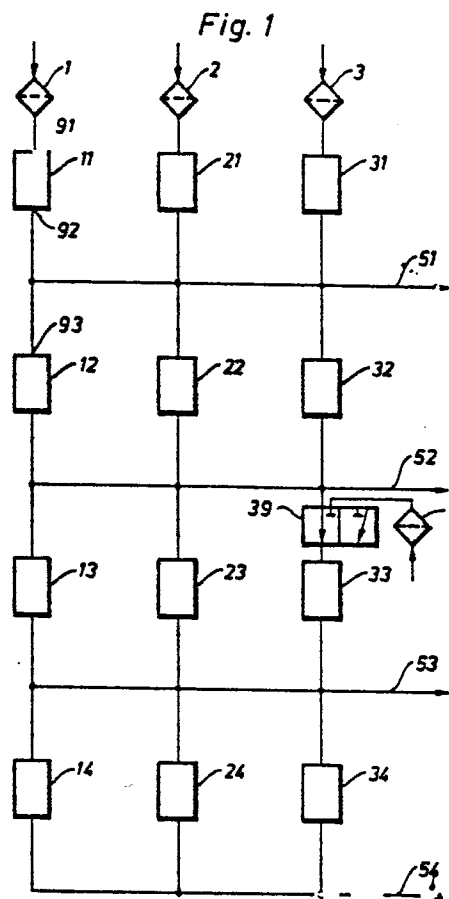
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54 A compressor plant.

57 A compressor plant comprising two or more compressor stages. Each stage (11) comprises a driving motor (19) having variable rotary speed. Pressure sensing means (82) is provided for each stage. The speed of the compressor stage is controlled so that the pressure at the outlet (92) is kept within desired limits. Pressure gas take-off means (51) of variable capacity is provided at the outlet of each compressor stage.



A compressor plant

The present invention relates to a compressor plant having two or more compressor stages where pressure gas can be taken off at variable capacity after each compressor stage so that pressure gas can be delivered at several pressure levels.

In prior art solutions where it has been desirable to deliver pressure gas at several pressure levels it has been common practice to compress all gas to the highest pressure level and then expand some of the gas to the desired lower levels. The reason for this is that the compressor stages of prior art compressor plants must operate in synchronism in order not to disturb one another. The compression to a high pressure and subsequent expansion to the desired pressure results in substantial losses.

The present invention, which is defined in the appended claim, aims at creating a compressor plant comprising two or more stages connected in series where pressure gas may be taken off at varying volume flow at the outlet of each compressor stage. This is made possible by using a separate driving motor for each compressor stage and additionally sensing the pressure at the outlet of the compressor stage and controlling the speed of each compressor stage such that that compressor stage delivers pressure gas at the desired pressure level.

One advantage with the invention is that it is easy to design a wide variety of compressor plant by using a small number of compressor stage sizes because the individual control of the stages makes it easy to use a number of compressor stages in parallel to obtain the desired capacity at any of the chosen pressure levels. When parallel stages are used it is also easy to get good control over the total running time for each stage. This is achieved by setting the desired pressure somewhat differently for the parallel stages. This means that the stages will become operative to deliver pressure gas in a predetermined order. The setting of these desired pressures is then changed at intervals so that the order in which the stages become operative changes. In this way it is easy to obtain the same running hours for each stage.

Another advantage with the present invention is that the pressures for the different stages can be set so that the pressure ratio built into each stage is used independent of the rotational speed of the stage. This makes it possible to use the optimum efficiency of the compressor stage.

An embodiment of the invention is described below with reference to the accompanying drawings in which fig 1 shows a compressor plant according to the invention. Fig. 2 shows an embodiment of each of the compressor stages of fig. 1.

The compressor plant shown in fig. 1 comprises a number of compressor stages connected as a network. Stages 11, 21 and 31 receive gas to be compressed through inlet filters 1,2 and 3 respectively. Each compressor stage has an inlet opening, shown by numeral 91 on stage 11. Each stage also has an outlet opening, shown by numeral 92 on stage 11. The outlets of stages 11,21 and 31 are interconnected by pressure gas take-off means 51 from which a variable flow of compressed gas can be taken off at a first pressure level. Further compressor stages 12,22,32 have their inlets, shown by numeral 93 on stage 12, connected to pressure gas take-off means 51. The outlets of stages 12, 22,32 deliver pressure gas to pressure gas take-off means 52 at a second pressure level. The inlets of compressor stages 13,23,33 are connected to pressure gas take off means 52 and their outlets to pressure gas take-off means 53 which can deliver a variable flow of compressed gas at a third pressure level. The last stage compressor stages 14,24,34 have their inlets connected to pressure gas take-off means 53 and their outlets to pressure gas take-off means 54 which delivers gas at a fourth or final pressure level. The pressure gas take-off means 51,52,53,54 shown in the drawing are conduits leading to different consumers. The example shown in the drawing has three compressor stages connected in parallel for each pressure level. However, any number of stages may be connected in parallel for any pressure level. In particular it is suitable to choose such a number of stages for the different pressure levels so that the same stage size can be used in all places. This means that the present invention makes it possible to increase the number of units of a particular stage size in series production. This can lead to quite substantial savings. As mentioned before the pressure of the gas delivered to the pressure gas take-off at any pressure level is set at somewhat different values for the compressor stages delivering gas at that pressure level.

The compressor plant shown in fig 1 also shows a possibility of changing the operating condition of the plant. This is shown by valve 39 by means of which the inlet of compressor stage 33 can take inlet gas through inlet filter 4 instead of from preceding compressor stages. Only one valve has been shown in the drawing. However, it is

possible to use such-valves at the inlet of any of the compressor stages. The possibility of changing the characteristics of the compressor plant in this way is a result of the way the operation of the different compressor stages is controlled. The individual control of the stages results in an automatic adaptation of the operation of each individual compressor stage to existing pressure conditions.

One example of what the individual compressor stages may look like is shown in fig. 2. The shown compressor stage 11 comprises a compressor 19 having an inlet opening 91 and an outlet passage 94 from where compressed gas is delivered via a check valve 61 and a cooler 63 to the outlet opening 92 of the compressor stage. The outlet opening 92 is via a conduit 59 connected to inlet opening 93 of compressor stage 12. Pressure gas take-off means 51 is also connected to outlet opening 92. Compressor 19 is driven by a three-phase brushless alternating current motor 81, e.g. an asynchronous motor. The motor is supplied with power from a converter 64 connected to a three-phase network. The converter comprises a three-phase rectifier, a direct current link, an inverter with six switching elements, e.g. transistors, and a controller 83. The controller is provided with an input 65 for a continuously variable speed controlling signal and an input 66 for a start/stop signal. The shown compressor plant comprises pressure sensing means 82 which delivers a voltage being proportional to the pressure at outlet opening 92. This voltage, which is negative, is applied via resistor 75 to one of the inputs of operational amplifier 73. A reference voltage corresponding to the desired maximum pressure at outlet 92 is set on potentiometer 71 and applied via resistor 72 to the input of amplifier 73. The closed loop amplification of amplifier 73 is set on the variable resistor 74 and corresponds to the desired difference between maximum pressure and minimum pressure at outlet 92. If the inverting input of amplifier 73 is used the voltage supplied to input 65 will change from zero volt, corresponding to minimum speed of motor 81, to a predetermined negative value, corresponding to maximum motor speed, when the pressure at outlet 92 changes from maximum pressure to minimum pressure. The output voltage of amplifier 73

is also applied to a means for sensing a preset maximum pressure in form of a comparator 67. If the pressure at outlet 92 exceeds the desired maximum pressure, the output voltage of amplifier 73 becomes positive so that the output voltage of comparator 67 changes from maximum positive voltage to maximum negative voltage or vice versa. This voltage is applied to input 66. Motor 81 is thus stopped. The motor is restarted when the output voltage of amplifier 73 becomes negative again. Controller 83 comprises a microprocessor and driving circuitry for the proper sequencing of the inverter switches. The controller also comprises memory necessary for the storing information about operating conditions which may be desirable to estimate service requirements for instance. In the drawing variable resistors have been shown for the setting of pressure levels. However, these pressure levels can equally well be stored in memory. The circuitry used for transforming the signal from pressure transducer 82 into signals to be applied to inputs 65,66 would then not be necessary. A suitable program for the microprocessor would be stored in memory instead.

Claims

A compressor plant comprising a first compressor stage (11) and a second compressor stage (12), each of said compressor stages being provided with an inlet opening (91) and an outlet opening (92), whereby the inlet opening (93) of the second compressor stage (12) is connected to the outlet opening (92) of the first compressor stage (11),

characterized in that each of said compressor stages is provided with a driving motor (81) the rotary speed of which is variable, that each of the compressor stages is provided with pressure sensing means (82) at the outlet, that each pressure sensing means is connected to a controller (83) for controlling the speed of the respective compressor stage (11) and that pressure gas take-off means - (51) of variable capacity is connected to the outlet - (92) of each compressor stage.

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Fig. 1

