



(11) **EP 1 844 236 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
06.04.2011 Bulletin 2011/14

(21) Application number: **06711366.2**

(22) Date of filing: **01.02.2006**

(51) Int Cl.:
F04C 18/16 ^(2006.01)

(86) International application number:
PCT/IN2006/000038

(87) International publication number:
WO 2006/095364 (14.09.2006 Gazette 2006/37)

(54) **A SYSTEM AND A METHOD FOR CAPACITY CONTROL IN A SCREW COMPRESSOR**

SYSTEM UND VERFAHREN ZUR STEUERUNG DER LEISTUNG EINES
SCHRAUBENVERDICHTERS

SYSTEME ET PROCEDE POUR LE CONTROLE DE LA CAPACITE DANS UN COMRESSEUR A VIS

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR**

(30) Priority: **02.02.2005 IN CH00852005**

(43) Date of publication of application:
17.10.2007 Bulletin 2007/42

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Description

[0001] The present invention relates to a rotary screw compressor and more particularly to a system and a method to control the discharge capacity of the screw compressor by using a combination bypassing the compressed medium and by varying the speed of the motor of the compressor.

Background and related art

[0002] Screw compressors are widely used for various industrial applications due its simplicity of operation, reliable & consistent performance over its life span. A screw compressor generally includes a male screw rotor and a female screw rotor in engagement with each other. These rotors are rotated by a prime mover like an electric motor, engine etc. to compress an intake air/gas to be supplied to an equipment, appliance or a process requiring compressed air or any other gas for its operation or functioning.

[0003] A screw compressor is normally designed for operating at a particular speed for optimum performance but most of the time it does not operate at the designed speed due to lack of demand of compressed air or any other gas from the dependent equipment or appliance or process, which requires supply of compressed air or any other gas for its operation or functioning. The part load operation of the screw compressor results into degradation of the performance and energy efficiency of the same. In ideal condition a compression system should operate in such a way that the compressor flow delivery is always in line with the demand without causing any additional energy & efficiency losses.

[0004] In order to ensure that the flow delivery of the compressed air/gas from a screw compressor is always in line of the demand several methods for capacity controls are in use and reported in various research literatures.

[0005] In a known way, capacity control in a screw compressor is performed by means of sliding valve mechanism, in which a sliding valve operated through suitable control mechanism is used to control the opening area of the bleeding port. This method offers unlimited capacity control over its capacity control range. But involvement of various sliding parts makes unsuitable due to problems related to maintenance.

[0006] In another known method, the capacity control operation is performed by a suction throttle, wherein controlling the valve at the compressor suction controls air mass entering into the compressor. The throttling of air through this valve causes pressure losses and corresponding increase in total pressure ratio and there by power input which offsets the gains of capacity control.

[0007] In yet another known method of capacity control by blow off by letting out of the pressurized air and also small quantity of oil mixed with pressurized air. This method doesn't offer any advantages on power consumption side and at the same time it can not be used for oil flooded compressors.

[0008] The capacity control of a rotary compressor motor is also performed by using multi-pole electric motor (Two Pole/Four Pole/Six Pole motors), which is not a dynamic type ,as disclosed in DE 4 221 494 A1, considered to represent the closest prior art document. In another known method, the capacity Control of Compressor is performed by varying the speed of the motor, by variable speed frequency drives. This method is efficient as it has a control over the capacity control process. The major drawbacks of this method are high cost and power reduction is not in proportional to capacity reduction with decrease in rotational speed of the equipment.

[0009] In the US patent application US 2003/0007879, a screw compressor for accommodating low compression ratio and pressure variation is described, which is intended to be achieved by varying the internal volume ratio by means of positioning of an internal volume ratio control valve at a pre-determined position. Further a bypass valve is arranged which operates between discharge and suction zones of the compressor.

[0010] As outlined above, many capacity control methods are available and are in use for dynamic capacity control of the screw compressors. The main drawback of these methods is that these systems operate most efficiently only for small capacity reduction ranges e.g. up to 20 to 30 % from 100 % capacity. These systems are also able to reduce the capacity further downwards but in such cases the reduction in screw compressor input power is same as that of reduction in capacity.

[0011] Due to problem of smaller range of capacity reduction ability of various dynamic capacity control methods, the market trend is shifting towards using the screw compression systems that are equipped with Variable Frequency Drives (VFD). These screw compressor systems equipped with VFD system offers a very fine control over the screw compressor capacity from 30 to 100 % range. While these systems with VFD matches well the delivery of the compressed air or any other gas to as required by the dependent equipment, appliance or process. The VFD as an additional component of a screw compressor system, itself generates energy losses in the form of heat generation during the process of supply frequency modulation. In addition to this energy loss it also creates distortions in the input supply grid & increase sound level. By modulating the supply frequency, the VFD runs the dependent screw compressor system at lower or higher revolutions. The dependent systems like screw compressors operates most efficiently at an optimum speed and running a screw compressor at lower speeds than the optimum or designed speed, degrades its performance due to various losses generated because of operating at lower speeds like reduced volumetric efficiency at lower speeds etc. So

apparently even if the system's supply and demand matches well, the energy efficiency of the complete system is very poor.

Objects of the present invention

[0012] The primary object of the present invention is to provide a system and a method for a screw compressor with in-built bypass flow arrangement and driven by a multi-speed or multi-capacity (speed and power) electric motor to generate, regulate the flow or delivery of the compressed air or gas.

[0013] An object of the present invention is to provide a system and method where no variable frequency drive (VFD) is used.

Summary of the invention

[0014] The present invention provides a system and a method for implementing capacity control in a screw compressor, said system comprising; a screw compressor, said compressor driven by a multi-capacity (speed and power) motor to compress air or gas medium, a bypass inlet member with a bypass valve, extending from the high pressure zone to the low pressure zone of the screw compressor to recirculate the gaseous medium, a bypass valve controller functionally connected to said bypass valve, a motor controller functionally connected to the motor to effect multi-capacity (speed and power) operations, a main processing control unit disposed to control the bypass valve and multi-capacity (speed and power) operations, measuring means disposed on the compressed medium passage for measuring the changes in the pressure and/or temperature changes in the form of signals, a signal converter functionally connected to the main processing unit and the measuring means to receive the signals, and said motor controller and bypass valve controller are functionally connected to the main processing unit to perform the capacity control of the screw compressor.

Brief description of the accompanied diagrams

[0015]

Fig 1 is a schematic expression of the system of the present invention.

Fig 2 is partial sectional view of the of the screw compressor of the present invention equipped with a bypass line connected to main controller.

Fig 3 is a side view of a motor drive depicting the functional connectivity of the drive elements with the main controller.

Fig 4 is a flow chart depicting the method of capacity control of the rotary screw compressor of the present invention.

Fig 5 is a graphical depiction of comparative account of the efficiency loss of the between the screw compressor of the present invention and a screw compressor driven by a variable frequency drive.

Fig 6 is a graphical representation of the sequence of operations/method of capacity control of the rotary screw compressor of the present invention for a 50Hz frequency power supply condition.

Detailed description of the invention

[0016] Accordingly, the present invention provides a rotary screw compressor system and a method to control the discharge capacity of the screw compressor by using a combination of bypassing the compressed air or gas and by varying the speed of the motor of the compressor. The constructional features of the system of the present invention are described by referring to **Fig 1-3**.

[0017] Initially, referring to **Fig 1**, which is a schematic diagram of the compression system of the present invention, wherein a rotary screw compressor **1** is driven by a multi-capacity (speed and power) motor **2** to compress a gas or air medium and to discharge the compressed medium.

[0018] The screw compressor **1** comprises rotor housing in which male rotor **11** and female rotor **12** rotates in continuous engagement. The gaseous medium air or gas enters into the rotor housing through the upstream pipe or intake pipe **13** and thereafter compressed to the desired pressure level during its transportation from suction end to discharge end of the rotor housing. This compressed air or gas is then transported to the end applications **6** through the network of various sub-components of a compression system hereinafter described.

Constructional features of the bypass arrangement of the present invention

[0019] A bypass line **14** extending from a bypass port **18** is provided with a bypass valve **10**, said bypass line **14** extending from the high-pressure zone to the low-pressure zone of the screw compressor to recirculate the gas or air medium. The bypass valve of the present invention either a vertically operated or a rotary valve, which is known in the

art to provide a controlled flow of the medium. A by pass valve controller 7, which is a device adapted to control the bypass valve 10. The valve controller 7 is a stepper motor or any suitable mechanical device that can drive or transmit the driving functions to the bypass valve 10. The bypass arrangement of the present can also be implemented by adapting a sliding valve mechanism.

Constructional features of the motor drive arrangement of the present invention

[0020] A multi-capacity (speed and power) electric motor 2 with a shaft used as a prime mover for the screw compressor 1 through suitable transmission assembly 19. The suitable power transmission mechanism 19 includes a direct coupling of the shaft of motor 2 with male rotor 11 or a gear drive or a belt pulley arrangement. The multi-capacity (speed and power) 2 is generally equipped with an in-built electrical winding network suitable to operate the multi-capacity (speed and power) motor 2 at different pole configurations e.g. 2-pole, 4-pole, 6-pole etc. Considering the working requirements of the compressor 1 the pole configuration of the motor 2 is configured to run at a particular speed by activation of the particular pole configuration.

[0021] A motor controller device 9 is connected the motor 2 to provide activation of the required winding configuration. The motor controller 9 is a stepper motor or any suitable mechanical device or electrical contactors that can drive or transmit the driving functions to the motor 2.

[0022] An oil separator tank 3 is disposed to collect the compressed discharge from the compressor 1 to filter the residual oil that is carried by the discharge gas or air during the compression operations. However, it is understood here that this requirement of having an oil separator tank may not be necessary if an oil-free screw compressor is used in place of oil-flooded screw compressors.

[0023] A storage container 5 is generally used as a temporary storage device, for storing the compressed gas or air and to further supply to end applications 6, wherever there is requirement of compressed air or gas supply

[0024] A non-return valve 4 is disposed between the oil separator tank 3 and the storage container 5, to facilitate unidirectional flow of the compressed air or gas.

[0025] A plurality of sensing means (not shown in figures), is disposed on the storage container 5. The sensing means can also be disposed on any location of the discharge passage between compressor outlet 13a and end applications 6. The sensing means are pressure transducers, the can sense a change in the pressure levels and transmit the same as analog signals 15. In the present invention, as an exemplary embodiment sensing is performed by using pressure transducers. However, alternatively either a temperature transducer or a combination of pressure and temperature transducers can also be used. It is also within purview of this invention to use a flow transducer to measure the flow rate of the discharged compressed gas or air to generate corresponding signals 15.

[0026] A signal converter interface unit 20 is disposed to convert the analog signals 15 generated from the sensing means to convert the same in to digital signals. The digital signals thus converted are further transmitted to main processing unit 8, which is hereinafter described.

Main processing control unit

[0027] Main processing control unit 8 of the present invention is a micro-controller based device having an instruction set to control the various connected devices including motor control unit 9, bypass control unit 7. The micro controller used in the present invention is a device, which is generally used to perform the control operations of this nature.

Integration of the main control-processing unit with bypass and motor controllers

[0028] Main processing control unit 8 is connected by means of an electrically conductive material to bypass controller 7 and motor controller 9.

Method of implementation of capacity control of the screw compressor by using the system of the present invention

[0029] The method of implementation of the capacity control of the screw compressor of the present invention is now described.

[0030] The process steps of the present invention is described by referring to various phases of operation that the compressor of the present invention undergoes to control the bypass flow of the compressed air or gas and the multi-capacity (speed and power) of the motor 2 to generate and regulate the flow or delivery of the compressed air or gas.

Initialisation process

[0031] A method to control the discharge capacity of the screw compressor 1 by using the system of the present

invention is now described. The screw compressor **1** along with the controlling elements and other devices as explained above is energized to carry out the process of compression of air or gas. At the outset, the main processing control unit **8**, which is a micro-controller based is loaded with an instruction set to control the operational aspects of the system.

[0032] In order to describe the working principle of the proposed step-less capacity control system, as an exemplary embodiment, a three-speed electric motor **2** with required number of poles and electrical windings/configurations for achieving these three speeds (**N1**, **N2** & **N3**) is used to perform the capacity control of the screw compressor **1** of the present invention.

Assignment of speed step values to the main processing control unit

[0033] After considering the speed configuration of the motor **2**, corresponding speed steps are allocated to each of the designated **N1**, **N2** & **N3** as **1500**, **1000** & **750** rpm respectively. It is also to be noted here that the value of **N1** is always maximum, which is generally the maximum value of the speed provided to the motor during fabrication. Once the maximum speed value **N1** of the motor **2** is established, a corresponding decreasing speed values are **N2** & **N3**. These values **N1**, **N2** & **N3** are used as input data for the main processing control unit **8** to enable the control unit **8** in regulating the desired rpm of the motor **2** at various stages of operation of the screw compressor **1**. It is to be understood here the values of **N** correspond to the motor speed configuration of any selected motor. Therefore **N** values can vary from **N1** to **Nn**.

Assignment of pressure values to the main processing control unit

[0034] In any given compressor-based system, the variation in the discharge pressure is a function of demand of the compressed air or gas of the dependant applications **6**. Therefore, it is necessary control the desired pressure at various stages of the working of the compressor. In the present invention, considering the speed values **N1**, **N2** & **N3**, corresponding pressure values are assigned in the form of **SP1**, **SP2** & **SP3** to the main processing control unit **8** as input data.

[0035] Since, the discharge pressure of the compressor of the present invention is constantly monitored during the operation, it is necessary to measure these values in order to provide a continuous input to the main control unit **8**. As described above, these values are measured by the sensing means. The value of discharge pressure at a given point of time is designated as **MP**.

[0036] After the screw compressor **1** starts functioning, the constantly monitored **MP** pressure value is compared with the pressure values **SP1**, **SP2** and **SP3** for finding the matching values. In the event of the matching of the value of **MP** with any one of the values of **SP1**, **SP2** or **SP3**, the motor control unit **9**, effect the change in the motor speed, by selecting the rpm from any one of the **N1**, **N2** or **N3** values, which correspond to **SP1** or **SP2** or **SP3**. Based on the above described initialization phase the working principle of the screw compressor **1** system of the present invention is now described. During operation the screw compressor system of the present invention is implemented in the following operational phases viz., Start-up phase, Working pressure built-up phase and Capacity control phase.

Start-up phase:

[0037] During start-up phase of the screw compressor **1**, active pole configuration of the motor **2** is suitable to run the motor **2** at a maximum speed available i.e. the motor **2** runs at speed value **N1**. At this stage, the bypass valve **10** is completely closed, since the normal pressure conditions are experienced in the initial stages of the operation.

Working pressure built-up phase:

[0038] It is understood that the pressure value **SP1** is designates as a normal working pressure of the screw compressor **1**. During working pressure built-up phase, the main processing control unit **8** will run the motor **2** at speed **N1** with bypass control valve **10** in completely closed condition until the continuously monitored discharge pressure value **MP** is equal to **SP1**.

Capacity Control phase:

[0039] The capacity control phase starts after completion of the working pressure built-up phase. The screw compressor **1** is required to be operated in capacity control phase whenever there is a reduction in the demand of the compressed air or gas from the end applications **6**. In the capacity control phase, the pressure sensing elements sense the pressure of the compressed air or gas and generates the signal **15**, in the form of an analog signal as an input to the analog-to-digital converter (ADC) **20** and thereafter supplied to the main processing control unit **8** for further processing.

[0040] Now by referring to the **Fig. 4**, the logical operations or instruction set of the main processing control unit **8** are

explained.

[0041] In the event where the continuously monitored pressure value **MP** is less than or equal to **SP1**, the main processing control unit **8** will not generate any signal for motor control unit **9** and for bypass control unit **7** so the motor keeps on running at **N1** with bypass valve **10** in completely closed state.

[0042] In the event where the continuously monitored pressure value **MP** is less than pressure value **SP2** and greater than the pressure value **SP1**, the main processing control unit **8** will generate signal **17** for the bypass control unit **7** and no signal will be generated for motor control unit **9** to enable the motor to run at the maximum speed **N1**. On receiving the signal **17**, the bypass control unit **7**, opens up the bypass valve **10** till the value of **MP** is equal to the value of **SP1**.

[0043] In the event where the continuously monitored pressure value of **MP** is equal to **SP2**, the main processing control unit **8** generates signals **16** and **17**. In response to the signal **17**, the bypass control unit **7**, closes the bypass valve **10** completely. After this closure of the valve **10** in response to signal **17**, the motor control unit **9** changes motor **2** speed value to **N2** i.e. motor **2** starts running at **N2**.

[0044] In the event where the continuously monitored pressure value **MP** is less than **SP3** and greater than **SP2**, the main processing control unit **8** does not generate the signal **16** and generates only the signal **17**. In response to signal **17**, the bypass control unit **7** opens-up the bypass valve **10** till the value of **MP** is equal to **SP1**.

[0045] In the event where the continuously monitored pressure value of **MP** is equal to **SP3**, the main processing control unit **8** generates the signals **16** and **17**. In response to signal **17** the bypass control unit **7**, closes the bypass valve **10** completely and there after in response to signal **17**, the motor control unit **9** changes the motor speed to speed value **N3** i.e. motor **2** starts running at **N3**.

[0046] In the event where the continuously monitored pressure value **MP** is greater than **SP3**, the main processing control unit **8** generates only the signal **17** and no signal **16** is generated. In response to signal **17**, the bypass control unit **7**, opens up the bypass valve **10** till the **MP** is equal to **SP1**. By executing the above set of operations, continuous capacity control of the screw compressor of the present invention is ensured.

[0047] It is to be noted here that the above set of operations are described considering 3-speed motor. It is appreciated by a person skilled in the art that the above operations are iterated 'n' number of times depending on the pressure and motor speed factors.

[0048] The system of the present invention can also be implemented by dispensing with the bypass inlet member, which is used to bypass the intermediately compressed air or gas. In such case, the multi-capacity (speed and power) of the motor is achieved by step-control arrangement. In such an arrangement the capacity control will be in stages.

[0049] The performance of the screw compressor of the present invention, where VFD is not used is described. The factors that contribute to the overall efficiency of the compressor system are compressor speed and motor efficiency. Accordingly, the system of the present invention is implemented to optimize these two factors resulting in the improved capacity control and efficiency of the compressor. In order to determine the enhanced efficiency of the compressor of the present invention, a comparative account with compressors run with VFD is made and results are tabulated in **Table 1**. However, it is to be noted here that the comparative values are indicative in nature, since these values are subject to change depending on the various capacities of the compressors.

TABLE 1

Compressor Capacity Range (%)	Screw compressor without bypass flow arrangement and driven a standard single speed motor with a VFD					Screw compressor with in-built bypass flow arrangement and driven by a multi-capacity (speed and power) motor			
	Efficiency Loss (%)					Efficiency Loss (%)			
	Speed (%)	VFD	Motor	Compressor	Total	Speed (%)	Motor	Compressor	Total
100	100	0	0	0	0	100	0	0	0
67	67	4	5	8	17	100	0	0	0
66.5	67	4	5	8	17	67	0	8	8
50.5	51	4	10	12	26	67	0	12	12
50	50	4	10	12	26	50	0	12	12
20	20	4	15	20	39	50	0	12	12

[0050] It can be seen from the above **Table 1** that the compressor of the present invention where VFD is not used is much more efficient than the compressors run with VFD. For instance if the capacity reduction required is 80 %, in case

of compressors with VFD, the same need to be run at 20 % of the desired speed. However, in the compressor of the present invention for the same capacity reduction of 80%, the compressor is run at the 50% of the designed speed.

[0051] The results of **Table 1** are plotted on **Fig 5**, by considering compressor capacity (%) and overall efficiency loss (%), which clearly shows the enhanced performance of the compressor of the present invention.

[0052] Now by referring to **Fig 6**, which is a graphical representation of the sequence of operations/method of capacity control of the rotary screw compressor of the present invention for a 50Hz frequency power supply condition. The same method can be made applicable for other frequency conditions such as 60Hz frequency condition. The sequence of operations or the method of capacity control is explained in **Fig.6**. The point "A" in this figure corresponds to the 100% capacity of the compressor. At this point, the multi-capacity motor 2 operates at its maximum design speed and the by pass valve 10 is fully closed. Between A-B, bypass valve gradually opens based on the capacity control requirement. The capacity at "B" with full opening of bypass valve 10 will be corresponding to the capacity of the compressor at next designed speed of motor at Point "C" with by-pass valve fully closed. Hence between B-C motor speed changes to next design speed of motor and at closes the bypass valve completely. The above sequence follows between C-D and D-E and so on.

Assumptions made for preparing performance comparison Table 1: -

[0053]

1. 100 % means the screw compressor 1 performance at optimum rotational speed for a given compressor.
2. The efficiency losses of the VFD have been taken as 4 % for any reduction in supply frequency.
3. Incase of a screw compressor 1 driven by a with multi-capacity (speed and power) motor 2, no motor efficiency losses have been considered as these motors are designed specially to operate at same efficiency for various active pole configurations or different speed steps.
4. Incase of a screw compressor 1 without bypass flow arrangement and driven by a standard single speed motor 1 equipped with a VFD, there will be marginal drop in motor 2 efficiency when it runs at lower speed as this motor 1 is standard one designed to operate most efficiently only for a particular active or designed pole configuration.
5. Screw Compressor 1 overall efficiency reduction has been assumed as 10 % for a reduction of 40 % in screw compressor 1 speed from its optimum or designed speed magnitude.
6. Various magnitudes given in performance comparison **Table 1** for a given range of 20 to 100 % have been calculated proportionately.

[0054] Various magnitudes given in performance comparison **Table 1** is only indicative nature and can defer from system to system.

[0055] Therefore, the present invention provides a system for implementing capacity control in a screw compressor, said system comprising; a screw compressor, said compressor driven by a multi-capacity (speed and power) motor to compress a medium, a bypass inlet member with a bypass valve, extending from the high pressure zone to the low pressure zone of the screw compressor to recirculate the gaseous medium, a bypass valve controller functionally connected to said bypass valve, a motor controller functionally connected to the motor to effect multi-capacity (speed and power) operations, a main processing control unit disposed to control the bypass valve and multi-capacity (speed and power) operations, measuring means disposed on the compressed medium passage for measuring the changes in the pressure and/or temperature changes in the form of signals, a signal converter functionally connected to the main processing unit and the measuring means to receive the signals, and said motor controller and bypass valve controller are functionally connected to the main processing unit to perform the capacity control of the screw compressor.

[0056] In an embodiment of the present invention, the system wherein the measuring means is pressure or temperature transducers.

[0057] In another embodiment of the present invention, the system wherein the bypass inlet member on the compressor where pressure of the air or gas moving through the screw compressor has a positive pressure.

[0058] The present invention also provides a method for method for capacity control in a screw compressor as claimed in claim 1, said method comprising the steps of; setting a plurality of pressure values along with corresponding motor capacity (speed and power) values for the compressor, measuring discharge pressure of the compressor, comparing the discharge pressure value with the pre-set pressure value, running initially the multi-capacity (speed and power) motor at a maximum speed with bypass valve closed, to deliver the compressed medium, when the discharge pressure value is equal to pre-set pressure value, and controlling the compressor capacity by relative regulation of the bypass valve and the speed of multi-capacity (speed and power) motor, through the main processing unit, to achieve the desired capacity of the compressor.

[0059] In another embodiment of the present invention, the method wherein the controlling of the compressor capacity is performed by; measuring the discharge pressure, comparing the discharged pressure with pre-set pressure value,

running the motor at the motor speed value corresponding to the pre-set pressure value, and controlling the bypass valve to achieve the desired capacity of the compressor.

[0060] In yet another embodiment of the present invention, the method wherein the initial motor speed value is varied to the corresponding pre-set pressure value whenever the discharge pressure value is equal to pre-set pressure value.

[0061] Further embodiment of the present invention, the method wherein the opening of the bypass valve is regulated when the discharge pressure value is not equal to pre-set pressure value.

Advantages of the present invention

[0062]

1. Less noise generation as compared to systems with VFD.
2. No distortion in the supply grid as there will not be any kind of grid frequency modulation as in case of VFD.
3. System costs are lower by about 25-30 % compared to costs of the system with VFD.
4. Very compact in size as all control systems can be mounted on the compressor & motor body itself.
5. Overall operating efficiency of the compression system is far better by about 30 to 40 % as compared to that with compression system with VFD.
6. Control systems for bleeding port flow area opening control & motor active pole control are simple and independent in operation.
7. Technology involved is not as complicated as VFD technology.

Claims

1. A system for implementing capacity control in a screw compressor, said system comprising:

- (a) a screw compressor driven by a multi-capacity motor with a constant power output corresponding to each selected speed, to compress a gaseous medium, said compressor having a compression zone between an intake pipe and a discharge passage,
- (b) a bypass zone disposed between the intake pipe and an area in the compression zone where the pressure is marginally higher than the pressure at the intake pipe,
- (c) a bypass line with a bypass valve, extending from the bypass zone to the intake pipe, to re-circulate the gaseous medium,
- (d) a main processing control unit,
- (e) measuring means disposed in a compressed medium passage of the compressor for measuring the changes in the pressure and/or temperature changes in the form of signals
- (f) a signal converter functionally connected to the main processing unit and the measuring means to receive the signals,
- (g) a bypass valve controller functionally connected to said bypass valve
- (h) a motor controller functionally connected to the motor to effect multi-capacity operations, said bypass valve controller and Motor controller functionally connected to the main processing unit,
- (i) the main processing control unit disposed to gradually open the bypass valve on receiving the signals to control the compressor capacity by means of said bypass valve controller, and
- (j) said main processing unit further disposed to shift the speed of the motor to next set speed by means of said motor controller on receiving the signals to control the compressor capacity by closing the bypass valve when the compressor capacity is equal to the capacity at the next set motor speed.

2. The system as claimed in claim 1, wherein the measuring means is pressure and temperature transducers.

3. A method for capacity control in a screw compressor as claimed in claim 1, said method comprising the steps of:

- (a) setting a plurality of pressure values along with corresponding motor speed values for the compressor,
- (b) measuring discharge pressure of the compressor,
- (c) comparing the discharge pressure value with the pre-set pressure value,
- (d) ruling initially the multi-capacity motor at a maximum speed with bypass valve, closed, to deliver the compressed medium, when the discharge pressure value is equal to pre-set pressure value, and
- (e) controlling the compressor capacity by relative regulation of the bypass valve and the speed of multi-speed motor, through the main processing cubit, to achieve the desired capacity of the compressor.

4. The method as claimed in claim 3, wherein the controlling of the compressor capacity is performed by,
 - (a) measuring the discharge pressure,
 - (b) comparing the discharged pressure with pre-set pressure value
 - (c) running the motor at the motor speed value corresponding to the pre-set pressure value, and
 - (d) controlling the bypass valve to achieve the desired capacity of the compressor.
5. The method as claimed in claim 4, wherein the initial motor speed value is varied to the corresponding pre-set pressure value whenever the discharge pressure value is equal to pre-set pressure value.
6. The method as claimed in claim 4, wherein the opening of the bypass valve is regulated when the discharge pressure value is not equal to pre-set pressure value.

Patentansprüche

1. Ein System zur Durchführung einer Leistungssteuerung in einem Schneckenverdichter mit:
 - (a) einem von einem Mehrfachleistungsmotor angetriebenen Schneckenverdichter mit einer gleich bleibenden Leistung entsprechend der jeweils gewählten Drehzahl, zum Verdichten eines gasförmigen Mediums, wobei der Verdichter eine Verdichtungszone zwischen einem Ansaugrohr und einem Auslasskanal aufweist,
 - (b) einer zwischen dem Ansaugrohr und einem Bereich in der Verdichtungszone angeordneten Bypass-Zone, in der ein etwas höherer Druck als am Ansaugrohr herrscht,
 - (c) einer Bypass-Leitung mit einem Bypass-Ventil, die zur Rückführung des gasförmigen Mediums von der Bypass-Zone zu dem Ansaugrohr verläuft,
 - (d) einer Hauptprozesssteuerungseinheit,
 - (e) einer in einem verdichteten Medium führenden Kanal des Verdichters angeordneten Messeinrichtung zum Messen der Druckänderungen und/oder Temperaturschwankungen in Form von Signalen,
 - (f) einem funktional mit der Hauptprocesseinheit und der Messeinrichtung verbundenen Signalumwandler zum Empfangen von Signalen,
 - (g) einem funktional mit dem Bypass-Ventil verbundenen Bypass-Ventilregler,
 - (h) einem funktional mit dem Motor verbundenen Motorregler zur Durchführung von Mehrfachleistungsvorgängen, wobei der Bypass-Ventilregler und der Motorregler funktional mit der Hauptprocesseinheit verbunden ist,
 - (i) der Hauptprozesssteuerungseinheit, die derart angeordnet ist, dass das Bypass-Ventil bei Empfang der Signale zur Steuerung der Verdichterleistung mittels des Bypass-Ventilreglers schrittweise geöffnet wird, sowie
 - (j) der Hauptprocesseinheit, die weiterhin derart angeordnet ist, dass die Motordrehzahl durch die Motorsteuerung bei Empfang der Signale zur Steuerung der Verdichterleistung auf die nächste eingestellte Drehzahl umgeschaltet wird, indem das Bypass-Ventil geschlossen wird, wenn die Verdichterleistung der Leistung in der nächsten eingestellten Motordrehzahl entspricht.
2. System gemäß Anspruch 1, wobei die Messeinrichtung aus Druck- und Temperaturwandlern besteht.
3. Verfahren zur Leistungssteuerung in einem Schneckenverdichter gemäß Anspruch 1, wobei das Verfahren folgende Schritte umfasst:
 - (a) Einstellen einer Vielzahl von Druckwerten zusammen mit entsprechenden Motordrehzahlwerten für den Verdichter,
 - (b) Messen des Förderdrucks des Verdichters,
 - (c) Vergleichen des Förderdruckwertes mit dem voreingestellten Druckwert,
 - (d) anfängliches Regeln des Mehrfachleistungsmotors bei maximaler Drehzahl mit dem Bypass-Ventil in geschlossenem Zustand, um das verdichtete Medium zuzuführen, wenn der Förderdruckwert dem voreingestellten Druckwert entspricht, und
 - (e) Steuern der Verdichterleistung durch relative Regulierung des Bypass-Ventils und der Drehzahl des Motors mit mehreren Geschwindigkeiten über die Hauptprocesseinheit, um die gewünschte Leistung des Verdichters zu erreichen.
4. Verfahren gemäß Anspruch 3, wobei die Steuerung der Verdichterleistung durchgeführt wird durch

- (a) Messen des Förderdrucks,
- (b) Vergleichen des Förderdrucks mit dem voreingestellten Druckwert,
- (c) Betreiben des Motors mit einem Motordrehzahlwert entsprechend dem voreingestellten Druckwert und
- (d) Steuern des Bypass-Ventils, um die gewünschte Leistung des Verdichters zu erreichen.

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5. Verfahren gemäß Anspruch 4, wobei der Ausgangswert der Motordrehzahl auf den entsprechenden voreingestellten Druckwert geändert wird, wenn der Förderdruckwert dem voreingestellten Druckwert entspricht.
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6. Verfahren gemäß Anspruch 4, wobei die Öffnung des Bypass-Ventils reguliert wird, wenn der Förderdruckwert nicht dem voreingestellten Druckwert entspricht.

Revendications

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1. Système pour mettre en oeuvre le contrôle de la capacité dans un compresseur à vis, ledit système comprenant :

- (a) un compresseur à vis entraîné par un moteur à capacité multiple avec une puissance de sortie constante correspondant à chaque vitesse sélectionnée, pour comprimer un milieu gazeux, ledit compresseur ayant une zone de compression entre un tube d'admission et un passage de refoulement,
- (b) une zone de dérivation disposée entre le tube d'admission et une zone dans la zone de compression où la pression est supérieure de manière insignifiante à la pression au niveau du tube d'admission,
- (c) une ligne de dérivation avec une vanne de dérivation, s'étendant de la zone de dérivation au tube d'admission, pour faire recirculer le milieu gazeux,
- (d) une unité de commande de traitement principale,
- (e) des moyens de mesure disposés dans un passage de milieu comprimé du compresseur pour mesurer les variations de la pression et/ou les variations de température sous la forme de signaux,
- (f) un convertisseur de signaux connecté fonctionnellement à l'unité de traitement principale et aux moyens de mesure pour recevoir les signaux,
- (g) un dispositif de commande de vanne de dérivation connecté fonctionnellement à ladite vanne de dérivation,
- (h) un dispositif de commande de moteur connecté fonctionnellement au moteur pour effectuer des fonctionnements à capacité multiple, ledit dispositif de commande de vanne de dérivation et ledit dispositif de commande de moteur étant connectés fonctionnellement à ladite unité de traitement principale,
- (i) l'unité de commande de traitement principale étant agencée pour ouvrir progressivement la vanne de dérivation à la réception des signaux pour contrôler la capacité du compresseur au moyen dudit dispositif de commande de vanne de dérivation, et
- (j) l'unité de commande de traitement principale étant agencée en outre pour changer la vitesse du moteur à la vitesse fixée suivante au moyen dudit dispositif de commande de moteur à la réception des signaux pour contrôler la capacité du compresseur en fermant la vanne de dérivation quand la capacité du compresseur est égale à la capacité au niveau de la vitesse fixée suivante.

2. Système selon la revendication 1, dans lequel les moyens de mesure sont des transducteurs de pression et de température.

3. Procédé pour le contrôle de la capacité dans un compresseur à vis selon la revendication 1, ledit procédé comprenant les étapes consistant à :

- (a) fixer une pluralité de valeurs de pression conjointement avec des valeurs de vitesse de moteur correspondantes pour le compresseur,
- (b) mesurer la pression de refoulement du compresseur,
- (c) comparer la pression de refoulement avec la valeur de pression prédéterminée,
- (d) faire fonctionner initialement le moteur à capacité multiple à une vitesse maximale avec une vanne de dérivation, fermée, pour délivrer le milieu comprimé, quand la valeur de pression de refoulement est égale à la valeur de pression prédéterminée, et
- (e) contrôler la capacité du compresseur par régulation relative de la vanne de dérivation et la vitesse du moteur à vitesse multiple, par le biais de l'unité de traitement principale, pour obtenir la capacité désirée du compresseur.

4. Procédé selon la revendication 3, dans lequel le contrôle de la capacité du compresseur est effectué en :

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- (a) mesurant la pression de refoulement,
- (b) comparant la pression de refoulement avec une valeur de pression prédéterminée,
- (c) faisant fonctionner le moteur à la vitesse de moteur correspondant à la valeur de pression prédéterminée, et
- (d) commandant la vanne de dérivation pour obtenir la capacité désirée du compresseur.

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5. Procédé selon la revendication 4, dans lequel la valeur de vitesse de moteur initiale est changée à la valeur de pression prédéterminée correspondante chaque fois que la valeur de pression de refoulement est égale à la valeur de pression prédéterminée.
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6. Procédé selon la revendication 4, dans lequel l'ouverture de la vanne de dérivation est ajustée quand la valeur de pression de refoulement n'est pas égale à la valeur de pression prédéterminée.

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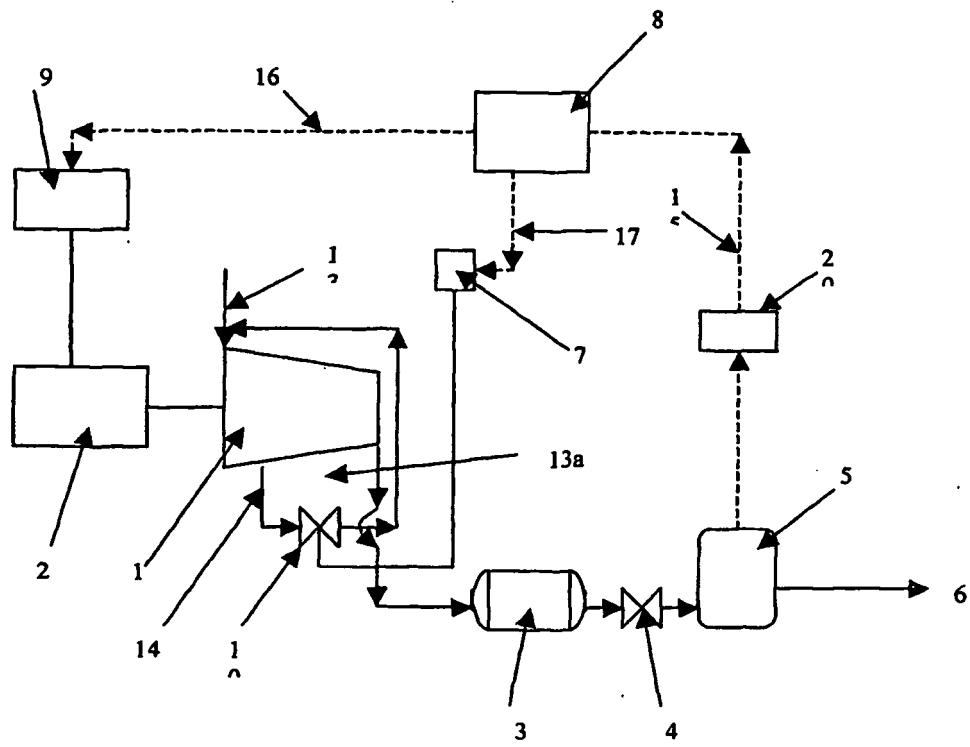


FIG 1

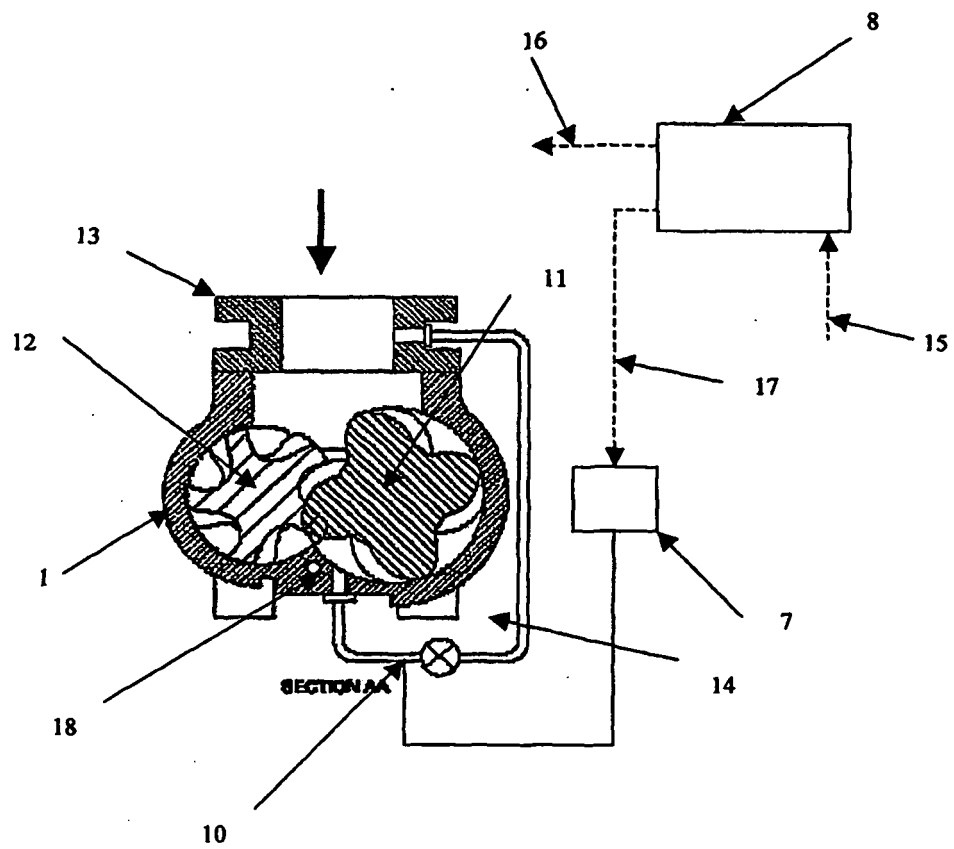


FIG 2

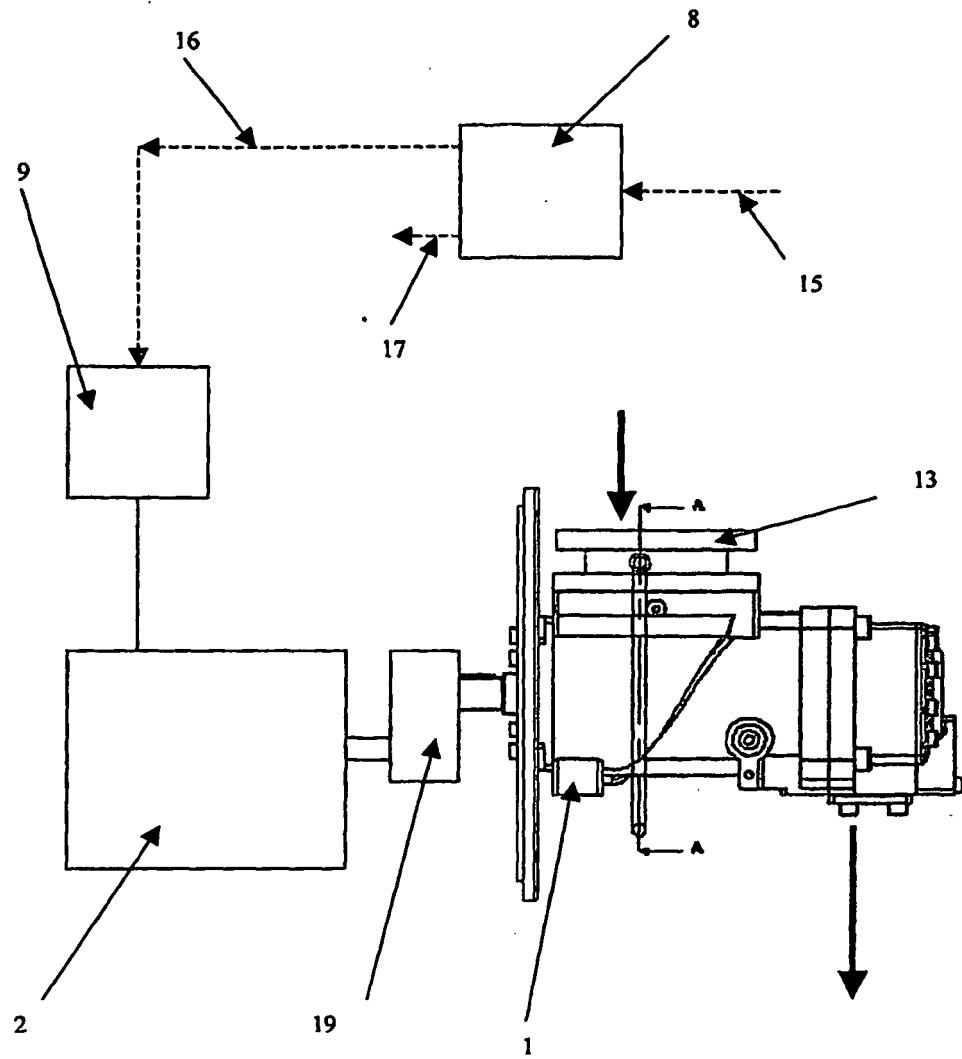
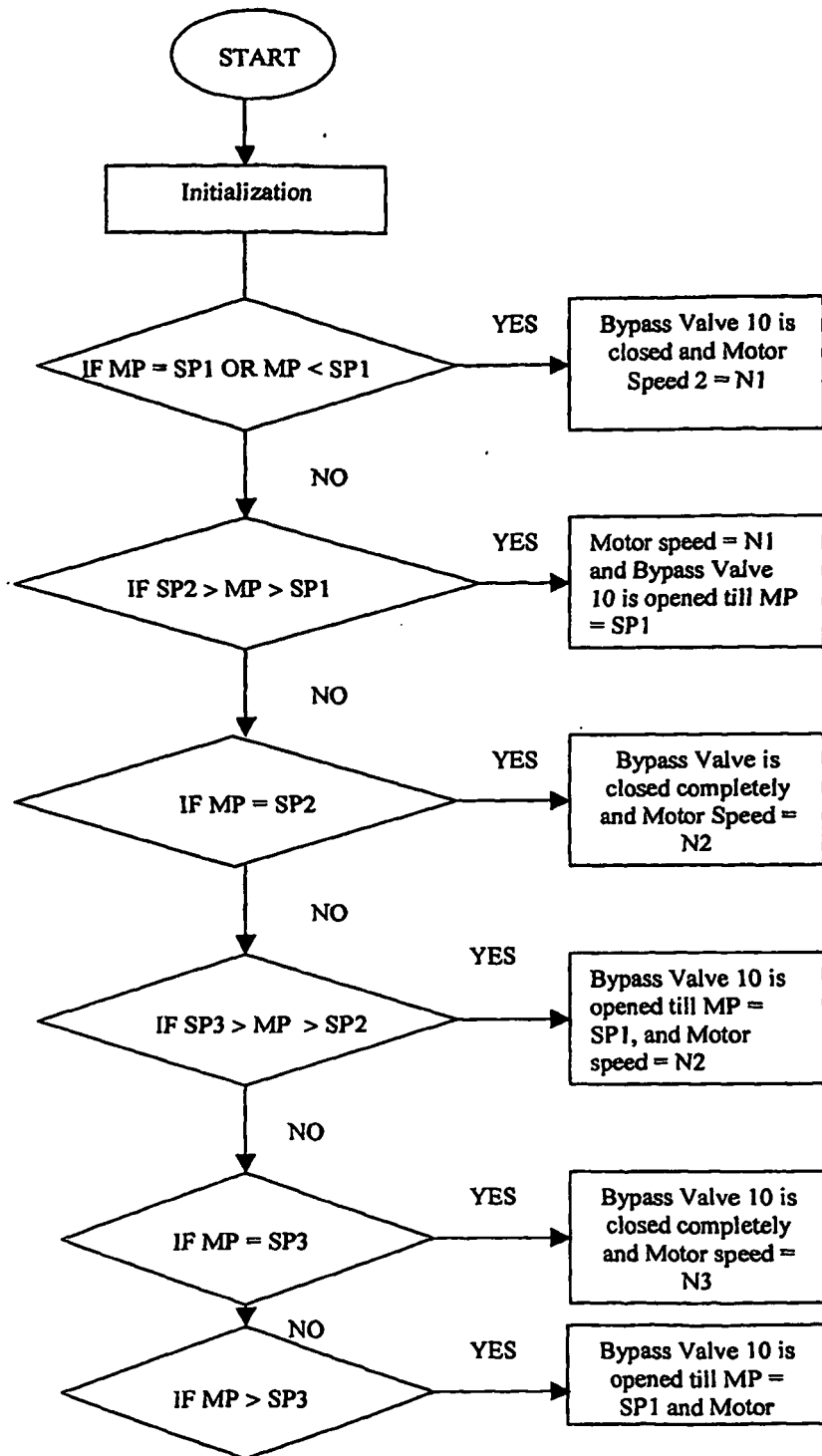


FIG 3



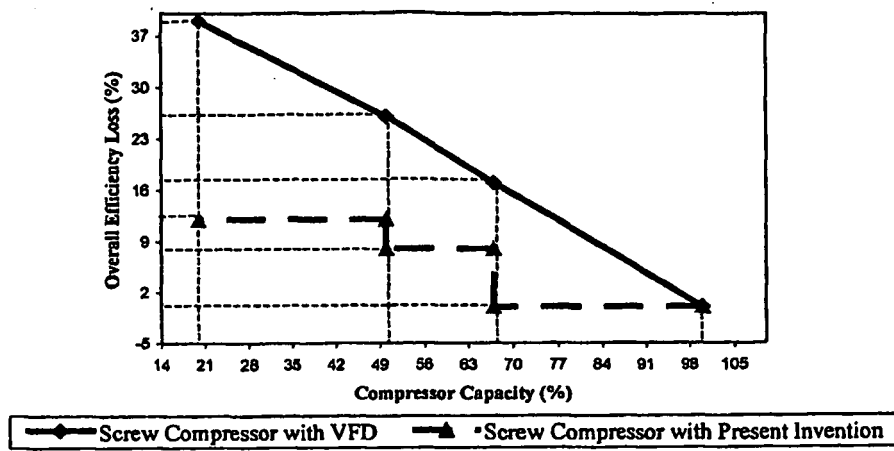


FIGURE 5

FIG 5

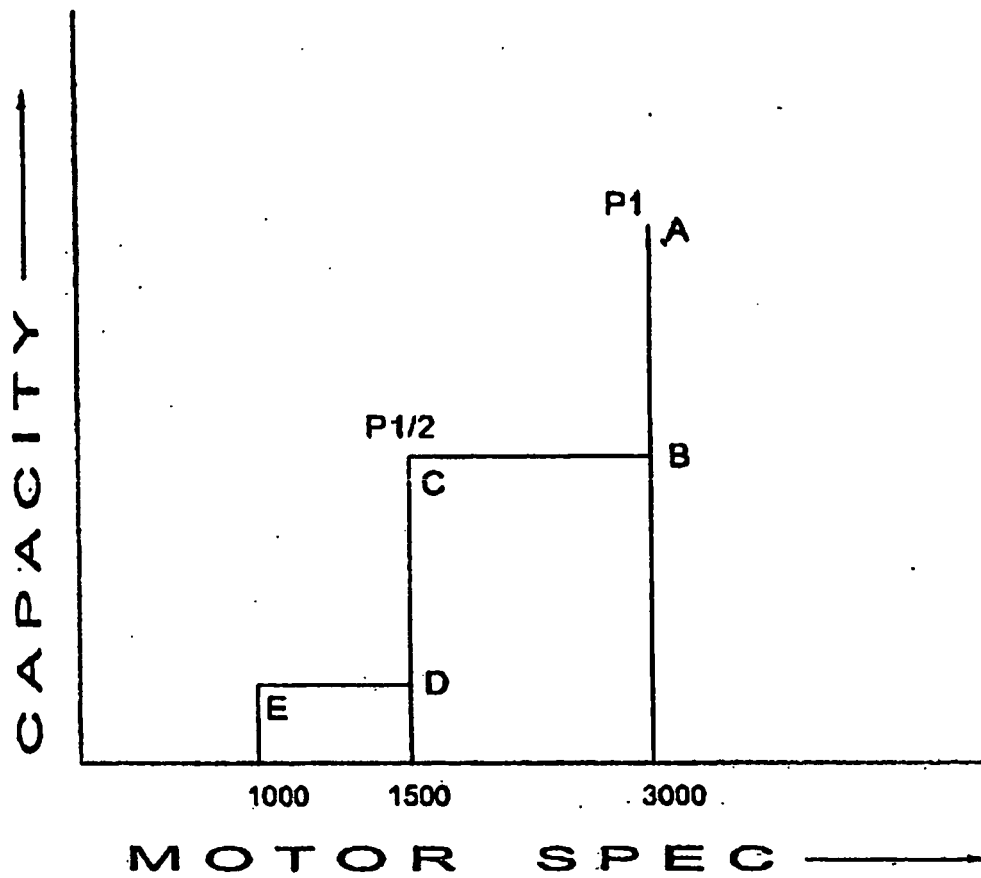


FIG 6

REFERENCES CITED IN THE DESCRIPTION

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