COMPRESSOR UNLOADING CONTROL

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ABSTRACT

An unloading control arrangement for a liquid injected air compressor of the type which includes a pneumatically operated inlet throttling valve, a liquid separator-reservoir tank, and compressed air storage means. A pressure responsive switch connected to the compressed air storage means is operative, at a predetermined pressure condition, to actuate a single power operated valve which vents the separator-reservoir tank and causes the inlet throttling valve to reduce inlet air flow to the compressor. A vent line connected to the power operated valve includes a flow restrictor of suitable size to provide for a low residual pressure in the reservoir tank to insure adequate liquid circulation during compressor unloaded operation.

7 Claims, 2 Drawing Figures
COMPRESSOR UNLOADING CONTROL

BACKGROUND OF THE INVENTION

In the art of controls for gas compressors it is usually desirable to unload or idle the compressor while running by throttling the compressor inlet air flow and reducing the gas pressure downstream of the compressor to reduce power demand. It is also usually necessary in most liquid injected gas compressor systems to provide a flow of liquid through the compressor during unloaded operation to lubricate and cool the compressor. Moreover, certain liquid injected compressors such as rotary helical screw and sliding vane types require the circulation of small quantities of inlet gas through the compressor during unloaded operation to promote quiet operation and to scavenge the liquid injected into the compressor.

Various arrangements of compressor controls are known in the prior art for providing the above mentioned type of unloaded or idling operation of gas compressor units including liquid injected compressors. U.S. Pats. Nos. 2,997,227 to G.E. Ternent; 3,542,497 to H. Chapuis; and 3,582,233 to C. Bloom disclose compressor unloading systems wherein the air pressure downstream of the compressor is relieved in various ways while substantial throttling of the compressor inlet is used to reduce compressor throughput. For the most part prior art compressor unloading controls for providing the herein discussed mode of operation tend to be somewhat complex wherein a plurality of separate valve devices and numerous conduits are required to make up the control system. The complexity of the control system, of course, increases the cost and reduces the inherent reliability of the compressor unit.

SUMMARY OF THE INVENTION

The present invention provides an unloader control system for a liquid injected compressor which substantially throttles inlet gas flow and relieves the gas pressure in the discharge system downstream of the compressor while providing a suitable reduced compressor throughput and pressure in the liquid reservoir to provide adequate liquid circulation and quiet vibration free operation.

The compressor unloader control system of the present invention includes a single powered control valve operable at a predetermined pressure in a compressed gas storage means to relieve the gas pressure in a separator-reservoir tank downstream of the compressor and provide pressure gas to at least partially close a pressure fluid actuated inlet throttling valve.

With the compressor unloader control of the present invention a steady state running condition of reduced compressor gas throughput together with sufficient liquid circulation to insure adequate lubrication is realized with a structurally uncomplicated and reliable arrangement requiring a minimum number of component devices. Accordingly, the compressor unloader control system of the present invention provides a reliable and economical arrangement which functions to control compressor operation in a way similar to more complex control systems.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates schematically a liquid injected compressor including the unloader control system of the present invention.

FIG. 2 is a detail section view of the inlet throttling valve of the control system shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 of the drawing, a liquid injected air compressor unit is shown schematically and generally designated by the numeral 10. The compressor unit 10 includes a positive displacement rotary compressor 12 which may be of the helical screw or sliding vane type, both well known. The compressor 12 is suited for the direct injection of a liquid into the compressor working chamber for mixing with the air being compressed. The liquid used is usually a suitable oil and serves as a lubricant for the compressor bearings and other parts subject to wear as well as a coolant for absorbing the heat of compression and a sealant for reducing the rotor clearances in the working chamber. The compressor 12 is connected to an electric motor 14, although other types of prime movers may be used.

The compressor unit 10 is also characterized by discharge means including an air-oil separator and reservoir tank 16 and a discharge line 18 which is connected to the compressor 12 for conducting to the tank 16 the oil-air mixture discharged from the compressor. The tank 16 includes suitable means, not shown, for separating oil from the oil-air mixture whereby substantially oil free air may be conducted through a conduit 20 to a compressed air storage means 22. A check valve 24, interposed in the conduit 20, is operable to prevent the backflow of pressure air from the storage means 22 to the oil reservoir tank 16. The compressed air storage means 22 includes an outlet conduit 26 for work purposes of the compressed air stored therein. An oil return conduit 28 is connected to the tank 16 for conducting oil through a filter 30 and a heat exchanger 32 and finally to the compressor 12 for continuous re-injection.

Referring to FIGS. 1 and 2, the compressor unit 10 is further characterized by an inlet throttling valve generally designated by numeral 34. The inlet throttling valve 34 includes a housing 36 having an opening 38 into an interior 40 which is in communication with the compressor inlet means 41 opening into a working chamber 43. A suitable air filter-silencer 42 is fitted in the opening 38. The housing 36 also includes a portion forming a valve seat 44 which may be engaged by a valve closure member 46 to close off the compressor inlet. The closure member 46 includes a stem 48 which is supported in a housing portion 50. The housing portion 50 includes a chamber 52 in which is disposed actuating means comprising a piston 54 engageable with the stem 48 for moving the closure member 46 toward the seat 44 to throttle the flow of inlet air into the compressor 12. The valve 34 also includes a coil spring 56 in the housing portion 50 for biasing the piston toward a cover member 58. A coil spring 60 is disposed between the stem 48 and piston 54 for biasing the closure member 46 against the seat 44 with light force to prevent the backflow of oil out of the compressor 12 under certain conditions on shutdown.

The inlet throttling valve 34 comprises part of an unloader control system for the compressor unit 10 which also includes a conduit 62 leading from the tank 16 to a power operated valve 64. The valve 64 is represented schematically in the drawing as a two-position normally
open valve having a solenoid actuator 66; that is the valve is open to permit the relief of pressure in the tank 16 when not energized and is closed when energized. The valve 64 is commercially available in a number of conduit sizes. The valve 64 is also connected to the chamber 52 by a conduit 68 and to the inlet opening 38 by a conduit 70. The conduit 70 opens into the inlet opening 38 through restricted passage means 72 formed in the valve housing 36.

The unloader control system for the compressor unit 10 also includes a pressure responsive electric switch 74 in communication with the air storage means 22 by way of a conduit 76. The switch 74 may be of a well known type which is adjustable to open a set of circuit contacts on increasing pressure at a first predetermined pressure and close said contacts to complete an electrical circuit at a second predetermined pressure less than the first pressure. The switch 74 is suitably connected to the solenoid valve 64 and to a source of electric energy, not shown, to energize the valve to be in the closed position when the air pressure in the storage means 22 decreases to a value below the second predetermined pressure and to remain closed until the air pressure increases to the first predetermined pressure.

The unloader control system herein described operates to control the compressed air output of the compressor 12 and to reduce the compressor power demand during periods of nonuse of compressed air from the storage means 22. Assuming that the compressor unit 10 is running and the pressure in air storage means 22 is less than the pressure required to open the switch 74, the valve 64 will be in the closed position and the inlet throttling valve piston 54 will be biased toward the cover member 58 permitting the closure member 46 to be open to allow air to enter the compressor inlet. Normal use of the compressor unit 10 will result in a sufficient pressure in the tank 16 to force the oil separated therein to continuously recirculate through filter 30 and heat exchanger 32 and back to the compressor 12. A reduction or cessation of use of compressed air for work purposes will cause a pressure increase in storage means 22. When the pressure increases to the first predetermined pressure the switch 74 will be actuated to open the circuit to valve 64 to deenergize the solenoid 66 causing the valve to open. The opening of valve 64 will substantially vent pressure air in the tank 16 through conduit 70 into the inlet opening 38. The check valve 24 will prevent back flow of compressed air from storage means 22 to the tank 16. Venting the tank 16 into the inlet opening 38 will not create objectionable noise due to the noise muffling ability of the air inlet filter-silencer 42. The restricted passage 72 will limit the rate of bleeddown or venting of the tank 16 and, accordingly, pressure air in the conduit 68 will be conducted to the chamber 52 to cause the piston 54 to move the closure member 46 toward the seat 44 to throttle the flow of inlet air to the compressor.

The closure member 46 will move to throttle inlet air to the compressor 12 until a balanced or steady state condition of reduced compressor air throughput is reached. This balanced operating condition is desirably one wherein the pressure in the tank 16 is on the order of 5-16 percent of the normal working pressure of the compressor unit. Under this operating condition a sufficient pressure differential will exist between the tank 16 and the compressor working chamber to assure adequate oil flow to the compressor. The back pressure which the compressor must work against together with the reduced compressor inlet flow will result in suitably low power consumption while the compressor is unloaded and the small amount of air admitted to the compressor will provide quiet operation and scavenging of the oil being injected for lubrication and cooling purposes. When the pressure in storage means 22 drops to the second predetermined pressure the switch 74 will close to energize the solenoid 66 closing the valve 64. Pressure air in the chamber 52 will be vented to the inlet opening 38 and the valve closure member 46 will open in response to the vacuum developed in the inlet of the compressor 12 to admit full inlet air flow to the compressor to restore normal loaded operation.

The reduced pressure and flow conditions at which the compressor unit operates while unloaded may be controlled by selection of the size of the restricted passage means 72 as well as by determining the area of the piston pressure surface 55 and the force-deflection characteristic of the spring 56. The restricted passage means 72 may be formed as an orifice at any location in the conduit 70 downstream of the junction with conduit 68, and the restriction to flow may be provided by proper selection of the internal diameter and length of the conduit 70 itself rather than the orifice formed by the passage means 72.

As may be appreciated from the foregoing disclosure a structurally simple and reliable unloader control system is provided by the present invention which is capable of providing for reduced unloaded power consumption of a liquid injected gas compressor while maintaining suitable liquid circulation and quiet running of the compressor. Although the control system of the present invention is disclosed in detail in combination with a liquid injected gas compressor unit it is contemplated that certain so-called dry type compressor units may also use the disclosed arrangement. Moreover, the unloader control system of the present invention provides for the same functions as certain prior art control systems but with a minimum of attendant devices. The electric pressure switch 74 and solenoid operated valve 64 may be replaced by equivalent fluid operated devices such as a pilot pressure valve responsive to pressure in the storage means and connected to a two-position pilot pressure fluid actuated valve.

What is claimed is:
1. In combination:
a gas compressor including gas inlet and discharge means;
gas storage means connected to said discharge means for receiving and storing compressed gas;
a check valve between said discharge means and said storage means for substantially preventing backflow of gas from said storage means to said discharge means;
a compressor inlet throttling valve connected to said inlet means and including a closure member and pressure fluid actuating means for moving said closure member to throttle inlet gas flow to said compressor; and an unloader control system characterized by:
a conduit interconnecting said discharge means and said actuating means;
power operated valve means interposed in said conduit between said discharge means and said actuating means;
3,788,776

5 pressure responsive means in communication with said storage means for operating said valve means to open in response to a predetermined pressure in said storage means; and, vent means connected to said conduit between said valve means and said actuating means for controlled venting of said discharge means to a gas pressure in said discharge means which is less than the gas pressure in said storage means in response to opening of said valve means.

2. The invention set forth in claim 1 wherein:
   said vent means includes conduit means connected to said conduit between said valve means and said actuating means and including means for controlling the venting of said discharge means in response to the opening of said valve means.

3. The invention set forth in claim 2 wherein:
   said inlet throttling valve includes a housing including an inlet opening, a chamber, and piston means disposed in said chamber and movable in response to the admission of pressure fluid to said chamber to move said closure member to throttle inlet gas flow to said compressor, and said conduit opens into said chamber for admitting gas from said discharge means to exert a pressure force on said piston means.

4. The invention set forth in claim 3 together with:
   biasing means for biasing said piston means to move against the pressure force exerted on said piston means by said gas in said chamber.

5. The invention set forth in claim 3 wherein:
   said means for controlling the venting of said discharge means comprises restricted passage means of a predetermined size which will control the venting of said discharge means to provide a reduced pressure in said conduit and said chamber for moving said closure member to a position which will provide for a reduced inlet gas flow to said compressor.

6. The invention set forth in claim 5 wherein:
   said restricted passage means opens into said inlet opening in said housing.

7. The invention set forth in claim 1 wherein:
   said compressor is liquid injected, said discharge means includes a gas-liquid separator tank and said vent means is operable to vent said tank to a reduced pressure less than said predetermined pressure in response to the opening of said valve means.