A worm drive actuator for a spiral valve that opens and closes bypass ports on a rotary screw air compressor is provided.
SPIRAL VALVE ACTUATOR FOR AIR COMPRESSOR

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field
[0002] The present invention relates to an actuator for a spiral valve that controls the opening and closing of a bypass port on a twin screw air compressor.
[0003] 2. Background
[0004] Twin screw air compressors are known in the art. Examples of configurations for twin screw air compressors are shown in U.S. Pat. No. 7,285,882 and US Publication No. 2007/0241627. As depicted therein, inside a compressor housing, a motor (typically a permanent magnet rotor/stator motor) is used to drive one of the two compression screws, which in turn drives the other screw. Air is taken in through an inlet, compressed between the screws as they turn, and output through an outlet which is in the opposite side of the screws, in the axial direction, as the air inlet.

SUMMARY OF THE INVENTION

[0005] In one embodiment, an air compressor comprises: a compression chamber having an inlet and an outlet, the compression chamber defined by two radially intersecting axial bores, wherein each said bore contains an air compression screw; at least one bypass port in said compression chamber, wherein said at least one bypass port when open is in fluid communication with a spiral valve chamber that contains a spiral valve, wherein rotation of the spiral valve opens or closes the at least one bypass port; and a worm drive that actuates the spiral valve, the worm drive comprising: a worm gear coupled to the spiral valve, and a worm driven by an electric motor.

[0006] In another embodiment, the air compressor further comprises an effective compression volume of the compression chamber produced when at least one bypass port is open, which is smaller than a closed compression volume produced when at least one bypass port is closed. In still another embodiment, the at least one bypass port comprises multiple bypass ports, with a first port located closer to the compression chamber outlet than a second port.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which, like reference numerals identify like elements, and in which:

[0008] FIG. 1 is a cutaway, exploded perspective view of one end of the housing for the twin screws of the compressor showing a spiral valve that controls the opening and closing of a bypass port;
[0009] FIG. 2 is a side cross sectional view of one embodiment of a twin screw air compressor with spiral valve bypass;
[0010] FIG. 3 is a plan view of one embodiment of the inventive worm drive actuator for the spiral valve; and
[0011] FIG. 4 is a plan view of a prior art rack and pinion actuator for the spiral valve.

DETAILED DESCRIPTION

[0012] The present invention is an apparatus, method and system for controlling bypass airflow in a rotary screw air compressor, for example a twin screw air compressor. FIG. 1 shows a perspective cutaway, exploded view of a portion of a housing for a twin screw air compressor along with a spiral valve. The compressor housing 10 comprises two adjoining barrels 6 and 8, each of which houses one screw of the twin screw air compressor when the unit is assembled and functioning. The end of the housing shown in FIG. 1 is the inlet end, and the outlet end is cut off by the dashed line cutaway.

[0013] In the embodiment shown in FIG. 1, each barrel 6 and 8 comprises one or more bypass ports, represented, for example, by holes 12, 16 and 18. Each of the plurality of holes shown in FIG. 1 may be referred to as individual bypass ports, or the plurality of holes may be referred to collectively as a single bypass port. Each hole shown in FIG. 1 fluidly communicates with a chamber 22 that contains a spiral valve 20 along axis 24.

[0014] FIG. 2 is a side cross sectional view of one embodiment of an air compressor of the present invention. FIG. 2 more clearly shows how the spiral valve functions to regulate compression volume in the compressor. As depicted therein, the compressor housing has an air inlet 26 and an air outlet 28. As the screw 34 turns, air is compressed inside the compression chamber defined by radially intersecting barrels 6 and 8, which has a length that runs between a compression chamber inlet end 14 and a compression chamber outlet end 30. The compressed air is then output through the air outlet 28.

[0015] FIG. 2 also shows several bypass ports, examples of which are identified by reference numerals 12, 16 and 18. As depicted in FIG. 2, when the spiral valve 20 is turned to a point that allows one or more of the bypass ports to fluidly communicate with the spiral valve chamber 22, the effective compression volume of the chamber is reduced due to the smaller compression chamber length. With at least one bypass port open, the effective compression chamber length is defined by the distance between the open bypass port closest to compression chamber outlet end which (in FIG. 2 is represented by reference numeral 16) and the compression chamber outlet end itself 30. When the effective compression volume is reduced in this manner, cycle time and part-load is reduced, which saves power, increases efficiency, and extends the life of the components of the air compressor.

[0016] As shown in FIGS. 1 and 2, the spiral valve can be rotated (or actuated) along its axis 24 from a fully open position (where all of the bypass ports are open) to a fully closed position (where all of the bypass ports are closed), and all points in between. In FIG. 2, the spiral valve is rotated to a point that allows for a partial bypass of air from the compression chamber, represented by arrows 32. In prior art compressors, the spiral valve is rotated by a rack-and-pinion actuator assembly similar to the exemplary embodiment shown in FIG. 4.

[0017] In the actuator shown in FIG. 4, a housing 48 contains pinion 46, which is coupled to the spiral valve (not shown in FIG. 4). Therefore, when the pinion 46 turns, so does the spiral valve, and in the same direction. In this example, a linear rack gear 44 drives the pinion 46 through intermeshing teeth. From the perspective shown in FIG. 4, when the rack gear 44 is moved to the left, the pinion 46 turns counterclockwise, and when the rack gear 44 is moved to the right, the pinion 46 turns clockwise. The clockwise or counterclockwise motion of the pinion 46 in turn causes opening or closing of the spiral valve.

[0018] The linear rack gear 44 in known air compressors is driven by a pneumatic actuator (not shown) coupled to the
rack gear through passageway 42. This pneumatic actuator may be opened or closed by compressed air from the air compressor.

[0019] Inefficiencies associated with the rack-and-pinion actuator currently used in the industry can be overcome by the inventive air compressor described herein, which uses a worm drive to actuate the spiral valve. An example of a worm drive assembly used in accordance with one embodiment of the inventive air compressor described herein is shown in FIG. 3.

[0020] As shown in FIG. 3, the worm drive housing 58 contains a worm gear 56 driven by a worm 54. A worm 54 is a gear in the form of a rod with at least one helical ridge or groove wrapped around its circumference. When the worm is rotated about its cylindrical axis, the intermeshing of the worm and worm gear teeth causes the worm gear to turn, from the perspective shown in FIG. 3, in a clockwise or counterclockwise direction. This rotation, in turn, rotates the spiral valve between an open and closed position, because the worm gear is coupled to the spiral valve. The worm 54 is rotated by an electric motor (not shown) coupled to the worm's shaft through passageway 52. In one embodiment, the electric motor is a clear path integrated servo motor, but could be any other electric motor known in the art with enough power to drive the worm and actuate the spiral valve.

[0021] The ability of the worm drive unit to use an electric motor provides superior control over the position of the spiral valve. This more precise control allows a practitioner of the present invention to more accurately tune the capacity of the compressor to the demand on the system, resulting in power savings and increased efficiency. The electronic control over spiral valve position possible with the present invention is an improvement over the prior art rack-and-pinion actuator shown in FIG. 4, which had a position indicator coupled to the pinion on the exterior of the housing (the five-sided polygonal pointer shown in FIG. 4 in dashed lines). Testing of the inventive worm drive assembly versus the rack-and-pinion assembly has demonstrated between 3% and 5% efficiency savings in power use, which in an industrial setting can translate into significant cost savings over the life of the unit. Furthermore, the worm drive unit increases the amount of torque the motor can produce. This torque provides the holding power needed so the electric motor can hold the spiral valve in the correct position and provide the capacity demanded by the system.

[0022] While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed.

What is claimed is:

1. An air compressor comprising:
a compression chamber having an inlet and an outlet, the compression chamber defined by two radially intersecting axial bores, wherein each said bore contains an air compression screw;
at least one bypass port in said compression chamber, wherein said at least one bypass port when open is in fluid communication with a spiral valve chamber that contains a spiral valve, wherein rotation of the spiral valve opens or closes the at least one bypass port; and
a worm drive that actuates the spiral valve, the worm drive comprising:
a worm gear coupled to the spiral valve, and
a worm driven by an electric motor.

2. The air compressor of claim 1 comprising an effective compression volume of the compression chamber produced when at least one bypass port is open which is smaller than a closed compression volume produced when at least one bypass port is closed.

3. The air compressor of claim 1 wherein the at least one bypass port comprises multiple bypass ports, with a first port located closer to the compression chamber outlet than a second port.

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