HOT-GAS PISTON ENGINE

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4 Claims

ABSTRACT OF THE DISCLOSURE

A hot-gas engine with a duct system and a single valve means for controlling the flow of fluid medium into and out of a plurality of working spaces to regulate the average pressure therein, and the corresponding power output.

The invention relates to a hot-gas piston engine comprising one or more working spaces, each space having connected to it, (a) a first duct with a nonreturn valve opening towards the working space, and (b) a second duct with a nonreturn valve inhibiting a flow of medium towards the working space. The sides of the first ducts remote from the associated working spaces are all connected to a first common duct, and the sides of the second ducts remote from the associated working spaces are all connected to a second common duct. In known hot-gas piston engines the first ducts and the first common duct serve to supply the working medium to the relevant working spaces, whereas the second ducts and the second common duct serve to remove the medium from these working spaces. The power of the hot-gas engine can be controlled by regulating the supply and removal of medium, with the medium generally removed with the aid of a compressor. Since the dimensions of this compressor must not be unduly large, the removal of medium and hence reduction of the power supplied can only proceed comparatively slowly. However, under certain circumstances, it is necessary to instantaneously reduce the power of the hot-gas piston engine from a certain high value to a certain low value.

In addition to the above-mentioned control, by means of supply and removal of the medium to and from the working spaces, it is known to use to this end the so-called bypass control so that the power decreases very rapidly. Here the working space is connected to a space of substantially the same average pressure. A stream of gas passing back and forth then occurs in the connection, with the result that the pressure volume diagram undergoes a phase shift and the torque becomes smaller. In a multi-cylinder engine the working space may be connected to the bypass space. In a multi-cylinder engine having an even number of cylinders it will be possible to connect together two cylinders situated side by side so that an engine having 2n cylinders includes n connection cocks.

An engine having an odd number of cylinders each cylinder will have to be provided with a cock capable of connecting the relevant working spaces to the bypass spaces.

A drawback of this control in multi-cylinder engines is the large number of bypass cocks required, especially in engines having an odd number of cylinders. Furthermore, the possibility of placing the relevant bypass cocks is rather limited for the purpose of limiting the additional useless space in the connection ducts. A further difficulty is the very accurate adjustment of the open position of the connection cocks in such manner that all cocks open simultaneously.

Opening not simultaneously results in an irregular running of the engine.

An object of the invention is to provide a hot-gas piston engine in which all above-mentioned drawbacks are avoided. To this end the hot-gas piston engine according to the invention is characterized in that the first and second common ducts are connected together by a connection duct including a shutter which is continuously adjustable between its closed position and its entirely open position.

The engine according to the invention thus includes only one adjustable shutter by means of which the power can be controlled centrally. When this shutter is opened a unidirectional gas stream arises; from the working space into the second common duct through the shutter to the first common duct and thence through the nonreturn valve back into the cylinder. As a result a distortion of the pressure volume diagram occurs resulting in a reduction of output. In this manner, when the shutter is partially opened, the problem of the additional useless space does not substantially arise, while all working spaces are simultaneously controlled since only one cock is present and an irregular running of the engine cannot occur. In addition the shutter can be placed in arbitrary positions which considerably simplifies the constructions. An advantageous side effect is that the first and second common ducts may be used simultaneously for the supply and removal of working medium to and from the engine.

An advantageous embodiment of the hot-gas piston engine according to the invention has each working space bounded by a piston adapted to reciprocate in the cylinder, a buffer space present on the side of the piston remote from the working space, and all buffer spaces communicating with one another. The second duct of each working space is formed by the gap between piston and cylinder wall, the relevant nonreturn valve being formed by one or more piston rings which rings or the wall of the groove cooperating therewith are so constructed that their sides facing the buffer space cannot engage in a sealing manner the wall of the groove cooperating with this side and accommodating this ring; and the second common duct is formed by the buffer space.

In order that the invention may be readily carried into effect, it will now be described in detail by way of example, with reference to the accompanying diagrammatic drawings, which show two embodiments of hot-gas piston engines constructed as hot-gas motors.

The reference numerals 1, 2, 3 and 4 in FIG. 1 indicate working spaces of hot-gas engines. Each working space is connected to a first duct 5, 6, 7 and 8. Non-return valves 9, 10, 11 and 12 opening towards the working space are provided in these first ducts. Furthermore, second ducts 13, 14, 15 and 16 are connected to the working spaces which ducts include non-return valves 17, 18, 19 and 20 which inhibit flow of medium towards the relevant working spaces. The sides of the first ducts 5, 6, 7 and 8 remote from the relevant working spaces are connected to a first common duct 21, while the sides of the second ducts 13, 14, 15 and 16 remote from the relevant working spaces are connected to a second common duct 22. The first and second common ducts are connected together by means of a connection duct 23 including an adjustable shutter 24. If a certain average pressure prevails in the working spaces 1, 2, 3 and 4 the hot-gas motor will provide a certain output. On closed position of the adjustable shutter 24, the minimum pressure which occurs in the working spaces 1, 2, 3 and 4 will prevail in the common duct 23, while the maximum pressure which occurs in the working space will prevail in the second common duct 22. If the output of the motor must become smaller this can be achieved by opening the adjustable shutter.
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3

nt 24 to a greater or smaller extent. As a result a flow of medium will occur from the working spaces 1, 2, 3, and 4, through the non-return valves 17, 18, 19, and 20 to the second common duct 23 and then through the adjustable shutter 24 to the common duct 21 and then through the nonreturn valves 9, 10, 11, and 12 again to the working spaces 1, 2, 3, and 4. Due to this circulation of the medium the pressure volume diagram which occurs in the working spaces 1, 2, 3, and 4 will be distorted in such manner that the output of the hot-gas motor increases. This decrease of output is thus obtained by operating only one shutter 24 so that all working spaces are controlled simultaneously to the same extent. If the motor further comprises a device for supplying and removing medium to and from the motor, the first and second common ducts 21 and 22 may also serve as supply and drain ducts.

FIG. 2 shows not to scale a hot-gas motor which comprises four units A, B, C, and D, in which a hot-gas engine cycle is accomplished. Each unit includes a cylinder 31 in which a piston 32 and a displace 33 can reciprocate. The piston 32 and the displacer 33 are connected by means of a piston rod 34 and a displacer rod 35 to a driving mechanism not shown which can move this piston and displacer with phase shift. A compression space 36 is located between the piston 32 and the displacer 33 where compression space is connected through a cooler 37, a regenerator 38 and a heater 39 to an expansion space 40 above the displacer 33. The heater 39 is constructed of a number of pipes 41 which are connected to the regenerator 38 at one end and to a ring duct 42 at the other end, and a number of pipes which are connected to the duct 42 at one end and to the expansion space 40 at the other end. Heat is supplied to this heater with the aid of a burner 44. A buffer space 45 is located below the piston 32, the buffer spaces of all units A, B, C, and D communicating freely with one another. The seal between the piston 32 and the cylinder 31 is formed by a piston ring 46 which is provided with grooves 47 at its side facing the buffer space 45. These grooves prevent the piston ring 46 from engaging in a sealing manner the wall of the groove facing said side and accommodating the piston ring 46. This means that the piston ring passes medium towards the buffer space. The piston ring 46 thus operates as a non-return valve which imposes flow of medium towards the units A, B, C, and D while the medium from the units is supplied to the compression space 36. The piston rings 46 are thus compatible with the non-return valves 17, 18, 19, and 20 of the hot-gas motor of FIG. 1, in which the buffer space 45 is now comparable with the second common duct 22. Furthermore, the first ducts 5, 6, 7, 8, and 9 non-return valves 9, 10, 11, and 12 incorporated therein are connected to the compression space 36 of the different units. The sides of these first ducts remote from the working spaces are again connected to the common duct 21. The buffer space 45 and the first common duct 21 are connected together by means of a connection duct 23 including a shutter 24. The first common duct 21 is connected through an adjustable shutter 50 to a supply vessel 51 which contains working medium under pressure. The buffer space 45 is furthermore connected through an adjustable shutter 52 to the suction side 53 of a compressor 54. The exhaust 55 of the compressor is connected to the supply vessel 51. When the adjustable shutters 50 and 52 and the shutters 24 are closed, a certain average pressure will prevail in the working spaces of the units A, B, C, and D the motor supplying a certain power. Furthermore the maximum pressure which occurs in the working space will prevail in the buffer space 45 because the piston ring 46 passes medium towards said space, while the minimum pressure which occurs in this working space will prevail in the common duct 21. If the power must rapidly be adjusted to a lower value, this can be effected by opening the adjustable shutter 52 and the shutter 24 simultaneously. By opening the adjustable shutter 24, medium will again be circulated from the working spaces of the units A, B, C, and D through the common duct 23 to the common duct 21 and then back into the working spaces again.

As a result the power supplied decreases. The compressor 54 pumps medium towards the supply vessel 51 through the adjustable shutter 52. As a result the average pressure in the working spaces of the units A, B, C, and D will decrease so that a reduction of power occurs. The shutter 24 is brought to its closed position simultaneously with the reduction of the average pressure. A situation is then eventually reached at which the average pressure in the working space again corresponds to the power desired. At that moment the shutter 24 and the shutter 52 are closed again. If on the other hand it is desired to obtain an increase in power supplied, shutter 50 must be opened, so that high-pressure medium can flow from the supply vessel 51 through the common duct 21 and the non-return valves 9, 10, 11, and 12 into the relevant working spaces. As a result, an increase of the average pressure is obtained and hence an increase of the power supplied by the motor.

What is claimed is:

1. In a hot-gas engine operable with a source of pressurized fluid, the engine having a piston reciprocally movable within a cylinder, the piston's ends bounded by a working space and a buffer space respectively, a first one-way valve permitting flow from the source only into working space and a second one-way valve permitting flow only out of the working space into the buffer space, the piston having an annular groove and a piston ring therein which cooperate with the adjacent cylinder wall forming said second valve, duct means interconnecting the source with the first and second valves, and third continuously adjustable valve means in said duct means intermediate said source and first and second valves, whereby the average pressure of the fluid in the working space is regulated.

2. Apparatus according to claim 1 comprising a plurality of said piston and cylinder combinations including first and second valves in each, said duct means comprising a first common duct interconnecting said first valves and a second common duct interconnecting said second valves, and a third common duct interconnecting said first and second common ducts.

3. Apparatus according to claim 2 wherein said third valve means comprises an adjustable valve in said third common duct.

4. Apparatus according to claim 2 wherein said source comprises a fluid storage chamber and a compressor discharging into the chamber, the compressor inlet and chamber outlet communicating respectively with said second and first common ducts, the adjustable valve means comprising a third valve in the third common duct, and fourth and fifth valves immediately adjacent the compressor inlet and chamber outlet respectively.

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62--6