

FOUR ROTOR INTERNAL COMBUSTION ENGINE

PART 1: PATENT DESCRIPTION

Field of the Invention

This invention relates to positive displacement internal combustion engines.

Background of the Invention

The modern positive displacement internal combustion engine is usually the reciprocating piston type or the Wankel trochoid rotor type. These two types of designs have the following disadvantages:

1. The compression ratio is the same as the expansion ratio, with the result that the combustion gasses enclosed by the working volume is not allowed to expand fully to ambient pressure before it is expelled from the working volume. This results in loss of potentially useful work and hence the thermal efficiency of the engines is limited.

2. There is no means of providing separate cooling tailored for the compression stroke alone, the provision of which would otherwise result in near-isothermal compression, thus reducing the negative work of the working cycle and hence improving the thermal efficiency. A further limitation, applicable to petrol powered engines, is that the heat produced during compression may cause the fuel-air mixture in the working volume to pre-ignite or detonate, thus producing knocking.

3. The moving parts do not have a pure rotary motion, with the result that the engines vibrate during operation, thus requiring multiple cylinders or rotors and balancing components as well as complex and relatively costly mountings and other structural parts.

4. The reciprocating or elliptical motion of the moving parts restricts the maximum operating speed of the engine, limited by piston or rotor acceleration limits. This restriction on maximum operating speed further results in the engines having a large size per unit power output.

5. The four-stroke version of reciprocating engines requires valves thus adding to the cost, weight and complexity of the engine.

6. While the two-stroke version does not need valves or has only simple valves, the efficiency and emissions performance is quite poor due to poor charging and scavenging of the working volume.

7. The four-stroke version produces only one power stroke every two revolutions of the output shaft and the two-stroke version, every revolution. Thus to produce a smooth torque output, multiple cylinders have to be used, again adding to the cost and complexity of the engine.

8. The Wankel type engine produces one power stroke every one-third of a revolution, which, while much better than the piston engines, is still far from the ideal of constant torque output.

9. The torque output, being not constant, is negative during certain portions of the working cycle. Thus the engines require a heavy flywheel together with a relatively high idling speed to prevent stalling during idling. The heavy flywheel results in poor engine acceleration while the high idling speed leads to poor fuel economy in stop-go applications (such as automobiles).

10. The fluctuating torque output results in the need to give a greater margin of oversize to the transmission and other such components of the engines, thus increasing the overall weight and cost of the complete powerplant.

11. The minimum working volume condition (the top dead centre) is instantaneous and not of a finite duration, thus the ignition of fuel air mixture has to be advanced at higher engine speeds. This results in reduced thermal efficiency because of increased negative work. It also results in poor emissions performance due to inadequate time for the combustion to carry out to completion.

12. The compression and expansion processes take place in the same chamber with the result that implementation of catalytic ignition methods, which requires the segregation of fuel-air mixture until just prior to the top dead centre condition, may be complex as it then requires a separate working volume for segregating the mixture.

13. The compression and expansion processes take place in the same chamber with the result that suitable catalysts may not be coated on the interior surfaces of the expansion chamber alone, the presence of which would ensure more complete combustion and hence reduce the level of pollutants, especially carbon monoxide and unburned hydrocarbons, in the exhaust.

The prior art in overcoming some of these disadvantages is shown in US patent specification number 5192199 (PCT/SE89/00505). However, this machine is unable to overcome disadvantages 1, 2, 6, 11, 12 and 13 listed above. A reference on catalytic combustion may be found in Newton, K., Steeds, W. and Garret, T. K., 1989, The Motor Vehicle, 11th ed., Butterworths, UK.

Object of the Invention

The object of the invention is to provide a positive displacement internal combustion engine to overcome the disadvantages inherent in current reciprocating piston and trochoid rotor engines, in particular, these engines' (i) inability to provide an compression ratio larger than the compression ratio, (ii) reciprocating or elliptical output, (iii) need for addition complexity if catalytic ignition is required, and (iv) inability to possess a catalyst coated expansion chamber which may reduce the level of pollutants in the exhaust.

Summary of the Invention

The invention comprises two units of gear-type, positive displacement machines. These machines are found in such applications such as gear pumps and Roots turbochargers which should be familiar to those in the automotive field.

On the first unit of machine, the intake port leading to the suction side of the machine are exposed to an appropriate gaseous working fluid. As the rotors rotate, the increasing volumes of the suction chambers draw the working fluid into the said chambers. This operation is the intake operation.

After completion of the intake operation, further rotation of the rotors brings the chambers to the other side of the machine where the rotors continually come into mesh. The volume of the chambers decrease continually with rotation, thus compressing the working fluid. This operation is the compression operation.

After completion of the compression operation, the compressed working fluid is transferred via an exit port on the first machine, through an entry passage into a combustion chamber. At an appropriate time during the passage through the combustion chamber, the working fluid is heated, by the ignition and subsequent combustion of fuel contained in it or otherwise, raising its pressure and temperature. The heated working fluid then transferred via the combustion chamber exit passage, through an entry port on a second gear-type machine, into the chambers in the said second machine. This operation is the combustion operation.

The heated working fluid enclosed by the second machine expands and increases the volumes of its chambers, thus forcing the rotors of the second machine to rotate. This operation is the power operation. The forced rotation can be harnessed via one or more shafts attached to the rotors of the second machine to perform useful work, including the rotation of the rotors of the first machine.

After completion of the power operation, further rotation of the rotors of the second machine brings the chambers to the expulsion side where the rotors continually come into mesh.

The volume of the chambers decrease continually with rotation, thus expelling the expanded working fluid through the exhaust port. This operation is the exhaust operation.

Description of the Drawings

The accompanying drawings which are incorporated into and constitute a part of the description of the invention, illustrate embodiments of the invention and serve to explain the principles of the invention. It is to be understood, however, that the drawings are designed for the purposes of illustration only, and not as a definition of the limits of the invention for which reference should be made to the claims at the end of the description.

Figure 1 is an exploded assembly drawing of one unit of gear-type machine.

Figure 2 is a drawing of the end view of the rotors and casing of the gear-type machine with one of the rotors appropriately sectioned for clarity.

Figure 3 is a drawing of a pair of rotors rotor made to rotate in mesh via gears.

Figure 4 is an exploded assembly drawing of one embodiment of an engine constructed according to the present invention.

Figure 5 is a detailed cross-sectional drawing of the combustion chamber region.

Figure 6 is a detailed cross-sectional drawing of the multiple combustion chambers of another embodiment of an engine constructed according to the present invention.

Description of the Embodiments of the Invention

The engine comprises two gear-type machines. Figure 1 shows one such machine, indicated generally by reference numeral 10. It comprises a pair of intermeshing rotors 11. The rotors have shafts 12, 13, 14 and 15 which support the rotors and/or transmit rotary motion to and from the rotors. One of the rotors, rotor 16, has lobes 17. The other rotor, rotor 18, has recesses 19 that meshes with the lobes 17. This pair of intermeshed rotors are enclosed by a casing 20. The internal cross-sectional shape of the casing is formed by two intersecting cylindrical spaces 21 and 22. The diameter of cylindrical space 21 is equal to that of the rotor with lobes, rotor 16. The diameter of cylindrical space 22 is equal to that of the rotor with recesses, rotor 18. The axes of the two intersecting cylindrical spaces are coincident with axes of the intermeshed rotor pair. The length of the casing is equal to the length of the rotors. The parallel faces of the casing is covered by endplates 23 and 24 which has holes 25, 26, 27 and 28 concentric with the shafts of the rotors and provision for mounting one or more rotor bearings.

With reference to figure 2, entrapped spaces are thus formed by the lobes, meshing recesses, endplates and the casing. Each machine has two sides. On one side, side 29, the rotors continually come out of mesh as they rotate. The volumes of the entrapped spaces on this side

are continually increasing. On the other side, side 30, the rotors continually come into mesh as they rotate. On this other side, the volumes of the entrapped spaces are continually decreasing. Port 31 positioned on the casing together with communicating troughs 32 (figure 1) on the inner faces of the endplates and ports 33 on the recesses allow the entry and exit of fluid into the two types of entrapped spaces independently.

A variation to the gear-type machine is shown in figure 3. In this machine, indicated generally by the reference numeral 40, the rotors are made to rotate in mesh via a pair of external meshed gears 41 and 42.

Figure 4 shows an embodiment of an engine constructed according to the present invention, indicated generally by the numeral 50. It comprises two units of gear-type machine. On the first unit of machine, the compression machine, indicated generally by the numeral 51, the intake port 53 leading to the entrapped spaces whose volumes are continually increasing are exposed to an appropriate gaseous working fluid source, for example, a conventional carburetor. As the rotors rotate, the increasing volumes of the entrapped spaces draw the working fluid into the said spaces. This operation is the intake operation.

After completion of the compression operation, further rotation of the rotors brings the entrapped spaces to the other side of the casing where the rotors continually come into mesh. The volume of the entrapped spaces decreases continually with rotation, thus compressing the working mixture. This operation is the compression operation.

Figure 5 shows a detailed cross-sectional drawing of the region between the two units of gear-type machines. After completion of the intake operation, the compressed working fluid is transferred via exit port 54 on the compression machine, through the combustion chamber entry passage 55 into the combustion chamber 56. At an appropriate time during the passage through the chamber, the working fluid is ignited by spark plug 59 and burned, raising its pressure and temperature. The heated working fluid is then transferred via the combustion chamber exit passage 57, through entry port 58 on a second gear-type machine, the expansion machine, indicated generally by the numeral 52 (figure 4), into the entrapped spaces in the said expansion machine. This operation is the combustion operation.

The heated working fluid enclosed by the expansion machine 52 expand and increase the volumes of the entrapped spaces of the expansion machine, thus forcing its rotors to rotate. This operation is the power operation. The forced rotation is transmitted to the rotors of the compression machine via square key 60 to perform the compression, and transmitted out of the engine via shaft 61 to perform useful work.

After completion of the power operation, further rotation of the rotors of the expansion machine brings the entrapped spaces to the other side of the casing where the rotors continually

come into mesh. The volume of the entrapped spaces decreases continually with rotation, thus expelling the expanded working fluid through the exhaust port 62. This operation is the exhaust operation.

While the abovementioned embodiment of the engine relies on a spark plug as the means of ignition, it is to be understood that other means of ignition are to be included in the scope of the invention. Another possible method of ignition is by catalytic means. In this embodiment, the interior surfaces of the entrapped spaces of the expansion machine 52 are plated or otherwise coated with a suitable catalyst such as, but not limited to, platinum. During the passage of the working fluid from the combustion chamber 56 to the expansion machine 52, the working fluid ignites catalytically when it comes into contact with the coated interior surfaces of the expansion machine.

Yet another possible method of ignition is by the heat of compression as in conventional diesel engines. In such an embodiment, the working fluid initially inducted by the compression machine 51 is a gaseous oxidiser such as, but not limited to, air. During the compression operation, the temperature of the air rises to such a value that it is able to ignite a suitable fuel such as, but not limited to, diesel oil injected into the air at an appropriate time during the passage of the air in the combustion chamber 56.

Figure 6 shows the detail cross-sectional drawing of the combustion chambers of another embodiment of an engine constructed according to the present invention. There are two combustion chambers 56A and 56B generally parallel to each other. The exit ports 54 on adjacent recesses on the rotor are axially staggered. The combustion chamber entry passages 55A and 55B are similarly staggered. A similar arrangement is made for the expansion machine. The combustion chamber exit passages 57A and 57B and the entry ports 58 are similarly staggered. This arrangement allows more time for the transfer of working fluid.

Regardless of the details of the method of ignition and the construction, it is possible to plate or otherwise coat the interior surfaces of the entrapped spaces of the expansion machine with a suitable catalyst such as, but not limited to, platinum so that during the expansion process, any pollutants formed by incomplete combustion during the combustion operation may be converted to less polluting substances.

While only a few embodiments of the present invention have been described in the foregoing paragraphs, it is to be understood that many changes, modifications and variations could be made to the engine of the present invention without departing from the scope or spirit of the invention.



PART 2: CLAIMS

1. A positive displacement internal combustion engine comprising two units of gear-type positive displacement machines ("the Machine"),

with each of the Machine comprising

(i) a pair of intermeshing rotors of equal length having shafts attached at one or both ends which are used to support the rotors via rotor bearings and to transmit rotational motion to and from the rotors, one of (the rotors) which having lobes while the other having recesses that meshes, with or without additional assistance, with the said lobes;

(ii) a casing enclosing the pair of intermeshed rotors the internal cross-sectional shape of which is formed by two intersecting cylindrical spaces, with the diameter of one of the cylindrical spaces being equal to that of the rotor with lobes while the diameter of the other cylindrical space being equal to that of the rotor with recesses and the axes of the two intersecting cylindrical spaces being coincident with axes of the intermeshed rotor pair and the length of the casing being equal to the length of the rotors;

and, (iii) an endplate, which has provision for mounting one or more rotor bearings or supports concentric with the axis of rotation of the rotors, covering each of the parallel faces of the casing;

thus forming entrapped spaces enclosed by the lobes, meshing recesses, casing and the endplates;

and having two sides, one side of which the rotors continually come out of mesh as they rotate, thus continually increasing the volumes of the entrapped spaces on this same side, and the other side of which the rotors continually come into mesh as they rotate thus continually decreasing the volumes of the entrapped spaces on this other side;

with ports on the casing together with communicating troughs on the inner faces of the endplates and ports on the rotor recesses allowing the entry and exit of fluid into the two types of entrapped spaces independently;

where in the first unit of the Machine,

the intake port leading to the entrapped spaces whose volumes are continually increasing with rotation is exposed to an appropriate gaseous working fluid source, including, but not limited to, a fuel-oxidiser mixture, so that as the rotors rotate, the



increasing volumes of the entrapped spaces draw the working fluid into the said spaces; (this operation being the intake operation)

after which, further rotation of the rotors bring the entrapped spaces to the other side of the Machine where the rotors continually come into mesh so that the volume of the entrapped spaces are decreasing continually with rotation, and thus compressing the working fluid; (this operation being the compression operation)

and where in a region adjoining both units of the Machine, after the completion of the compression operation,

the compressed working fluid is transferred via an exit port on the first unit of the Machine, through an entry passage into a combustion chamber, within which the working fluid is heated, at an appropriate time, by the ignition and subsequent combustion of fuel contained in it or otherwise, raising its pressure and temperature, after which the heated working fluid is transferred through an exit passage from the combustion chamber via an entry port on the second unit of the Machine, into the entrapped spaces in the second unit of the Machine; (this operation being the combustion operation)

and where in the second unit of the Machine, after the completion of the combustion operation,

the heated working fluid enclosed by the second unit of the Machine expand and increase the volumes of the entrapped spaces of the second unit of the Machine, thus forcing the rotors of the second unit of the Machine to rotate; (this operation being the power operation)

and finally which further rotation of the rotors bring the entrapped spaces to the side of the second unit of the Machine where the rotors continually come into mesh so that the volume of the entrapped spaces are decreasing continually with rotation, and thus expelling the expanded working fluid through the exhaust port. (this operation being the exhaust operation)

2. The engine of claim 1, wherein the swept volume of the first unit of the Machine is not equal to the swept volume of the second unit of the Machine.
3. The engine of claim 1 or 2, wherein the rotor pair of one or both units of the Machine are made to rotate in mesh partly or completely via a pair of additional meshed gears or other motion transmission devices or couplings attached to their shafts.
4. The engine of claim 1, 2 or 3, wherein one or both rotors of the first unit of the Machine is coaxial and axially adjacent with, and coupled, directly or otherwise, to the corresponding rotor or rotors, as the case may be, of the second unit of the Machine.



5. The engine of claim 4, wherein the fluid drawn into the first unit of the Machine during the intake operation is a fuel-oxidiser mixture, including, but not limited to, a petrol-air mixture, and heat addition to the working fluid is by the ignition by a spark plug protruding into the combustion chamber, and subsequent combustion of the said mixture.
6. The engine of claim 4, wherein the fluid drawn into the first unit of the Machine during the intake operation is a fuel-oxidiser mixture, including, but not limited to, petrol-air mixture, and heat addition to the working fluid is by the ignition, by exposure to a suitable catalyst such as, but not limited to, platinum, plated or otherwise deposited on the interior surfaces of the entrapped spaces of the second unit of the Machine, and subsequent combustion of the said mixture.
7. The engine of claim 4, wherein the fluid drawn into the first unit of the Machine during the intake operation is a gaseous oxidiser, including, but not limited to, air, and heat addition to the working fluid is by the ignition, by the heat generated within the gaseous oxidiser during the compression operation, and subsequent combustion of fuel injected into the gaseous oxidiser.
8. The engine of claim 5, 6, or 7, wherein there is more than one combustion chamber and the exit ports of the first unit of the Machine and entry passages of the combustion chambers are arranged in such a relative position that the combustion chambers are alternately (for the case of two such chambers) or cyclically (for the case of more than two chambers) communicating with consecutive entrapped spaces in the Machine, the duration of communication of which may overlap, and wherein the exit passages of the combustion chambers and the entry ports of the second unit of Machine are similarly positioned.
9. The engine of claim 5, 6, 7 or 8, wherein the interior surfaces of the entrapped spaces of the second unit of the Machine is plated or otherwise deposited with a suitable catalyst such as, but not limited to, platinum, so that any pollutants formed by incomplete combustion during the combustion operation may be converted to less polluting substances.