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STUDY ON SPHERICAL BALL FREE PISTON ENGINE

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Abstract

This study contains the technical facts about the spherical ball free piston engine and the description about the working principles and the benefits during practical application. Beside this its new concept which reduces the total engine friction.Useful power is available at the output shaft.
The spherica ball piston engine is a new concept in high efficiency power machine. Although the basic geometry was invented by individuals, the concept has been subsequently studied and developed by scientists and professional engineers. The machine concept is attributes to simplicity. Having only a small number of moving parts, the design implements a modified version of the tried and proven thermodynamic otto cycle when use as a engine. Although the small parts count an important advantages, other than the spherical ball free piston engine will give future engineers new found freedom in tailoring the combustion processes.

INTRODUCTION

The ball free piston engine is an attempt to combine the high thermal efficiency of a reciprocating engine with high power/weight ratio of a rotary turbine. It is a combination of a reciprocating engine and a rotary turbine.

The new design concept utilizes kinematic design to completely eliminate inertial loads that would contribute to sliding friction. Also, low leakage is maintained without piston rings by using a small clearance on the ball piston, resulting in choked flow past the ball. These features provide the potential for an engine with higher efficiency than conventional piston engines. The engine design utilizes existing recent technology to advantage, such as silicon nitride ball pistons, so a large development effort is not required.

The quest for increased power from a given cylinder size has resulted in a long process of development. Important steps in this process of development are improvements in the fuels used and in the design of various components for higher efficiencies and lower cost and weight. However, a different approach in the

direction of using different cycles of operation or modifications of existing cycle, has also been pursued with great interest.

The simple engine was at first supercharged to get increased power and this was possible only after the development of better fuels, materials, and improved design of engine components. Further improvements in the supercharged engine resulted in turbocharged engines which utilize heat of exhaust to drive the supercharger with the help of an exhaust turbine. This idea of using exhaust energy has matured and, now, has culminated to its logical end in a ball free piston engine which is a highly supercharged diesel cylinder using its exhaust into a gas turbine for producing power, whereas the whole output of the diesel cylinder is used for compressing the air for its own supercharge. As no external power is available from the diesel cylinder and as it produces only high pressure gas for a turbine, it is known as a gasifier and the whole unit including the turbine is called a ball-free-piston engine.

OPERATION OF BALL FREE PISTON ENGINE

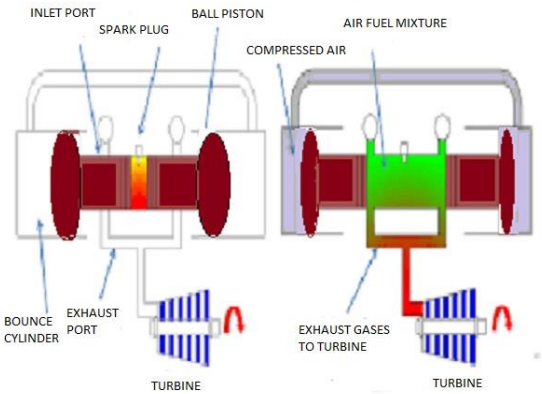

Fig:1 OPERATION OF BALL FREE PISTON

The operation of the ball free piston engine . The diesel pistons are brought together in the center by supplying compressed air to the bounce cylinder. During the inward stroke the air in the compressor cylinder, inducted through the intake valve during the outward stroke of the ball pistons, is compressed and delivered, at a pressure of about 3 bar, to the compressed air box which is also called a scavenging box. In the power cylinder this inward motion compresses the air to about 35 bar at the inner dead point. The fuel is then injected in the power cylinder as on a diesel engine, at a pressure of about 400 to 700 bar. Combustion starts and the pressure so developed forces the piston outwards. During the outward stroke, the air in the bounce cylinder is compressed, which is expanded in returning the piston back to the firing position in the next inward stroke; and in the compressor cylinder during the outward stroke the air is taken in through the intake valves. At the end of the outward stroke the exhaust ports are uncovered and products of combustion flow to the gas turbine through a receiver. Simultaneously the scavenging ports are also uncovered and the air from the compressed air box enters the power cylinder, which aids in the scavenging process. The excess scavenging air also passes to the gas turbine. The next cycle starts with the compressed air in the bounce cylinder returning the pistons in the inward stroke closing the exhaust and scavenging ports.

Due to excess scavenged air the exhaust of the gasifier contains about 80 percent of air. This cools the exhaust products and they enter the turbine, at about 450° C and 3 bar, to produce power.
Note that there is some loss of pressure due to scavenging as air goes from the compressor cylinder to power cylinder.

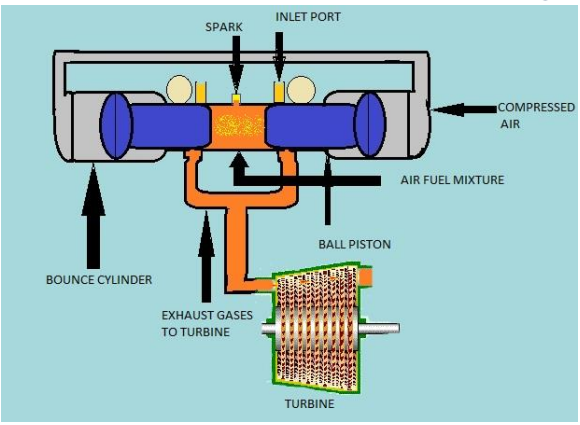

Fig: 2 SPHERICAL BALL FREE PISTON

COMPONENTS OF A BALL FREE PISTON ENGINE

1. Cylinder
2. Spherical ball piston
3. Connecting rod
4. Injector
5. Intake port
6. Exhaust Port

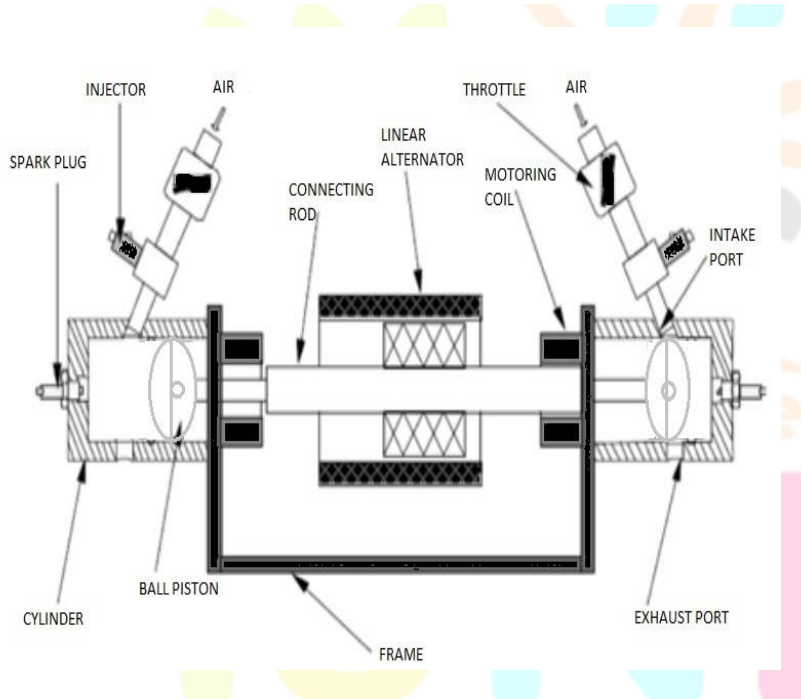

Fig:3 COMPONENTS OF A SPHERICAL BALL FREE PISTON ENGINE

7. Motoring coil
8. Linear alternator
9. Frame
10. Spark plug
11. Throttle

It consists of a gasifier and a turbine. The construction of the gasifier is like an opposed piston uniflow-scavenged two-stroke cycle diesel engine with compressor pistons directly attached to the diesel ball pistons. The pistons are not connected by links like connecting rods, etc., to crankshaft as in a conventional engine. The function of the connecting rod and crankshaft assembly, i.e., conforming the pistons to same motion pattern and transmitting the diesel piston forces to the compressor piston, is performed by directly connecting the pistons of compressor and the diesel cylinder and in addition to this, by providing a cushion or bounce

volume. This bounce volume acts as a mechanical spring which conforms the pistons to desired pattern of motion.
Thus the motion of the pistons is dictated by the gas pressures in the cushion volume, compressor space and the main diesel combustion chamber space and not by mechanical linkage. It is this freedom of motion from mechanical linkage which gives variable stroke according to load for which this engine is called free piston engine. However, it does not mean that there is no mechanical link at all between the two pistons. A light synchronizing linkage is provided to connect the two pistons, the purpose of which is to give symmetrical motion to these pistons even if there is any difference in friction which may occur between them. This mechanism may be a rocker arm or a rack and pinion arrangement. It should again be stressed that the driving forces are the pressures in different volumes of the gasifier and not these synchronizing links. The center pivot of the mechanism oscillates with the reciprocation of the piston and is used to drive the fuel pump and other auxiliaries.

The fuel is injected into the diesel cylinder and burnt in it. The exhaust from it is fed via a receiver to an axial flow or impulse turbine. This turbine is the source of external power output.

The stroke of the pistons in gasifier is variable and depends upon the amount of fuel injected. The gasifier is provided with a safety device for emergency stop in the case of overstroking which may occur due to loss of cushion cylinder pressure. The overstroking device shuts off the fuel supply and since there is no rotating component in the gasifier it immediately stops.

Advantages

The advantages of a ball free piston engine are as follows:

1. Simplicity. The inherently balanced configuration of opposed-piston unit results in reduced vibrations. The absence of crankshaft and connecting rods results in great mechanical simplicity.

2. Power to weight ratio. The power-weight ratio of a ball free piston engine is surpassed only by a simple gas turbine. However, to increase the efficiency, a simple gas turbine is modified by adding a heat exchanger which is very bulky and the power-bulk ratio of gas turbine with heat exchanger is not more than for a ball free piston engine.

3. Multifuel capability. The free piston engine has a characteristic of adjusting to the ignition requirements by changing its compression ratio. The compression ratio varies from about 25 to 50. This property allows it to utilize a wider variety of fuels than the conventional high speed diesel engine. It can run on low speed diesel fuels. Even fuels of 3000 SUS viscosity and high sulphur content have been successfully used without fouling the turbine blades.

4. Flexibility and reliability. Due to the fact that the gasifier and the turbine are not mechanically coupled, the free-piston engine arrangement has inherent in it certain flexibility of installation. This also allows it to work as a compressor alone, if needed. The use of multi-gasifiers feeding a single turbine gives increased reliability in that even if one or two gasifiers are out of order the plant will not stop and the effect on efficiency will not be much. The plant life for a free-piston engine is of the order of 20,000 to 25,000 hours.

5. Vibrations, noise and maintenance. Due to better balancing the vibrations and structure borne noise are lower than for the diesel engine. There is no piston side thrust, so lubrication requirements of bearing surfaces are reduced. (However, due to increased heat flux as a result of higher combustion rates this is partly offset). All these, along with lower operating temperatures, result in low maintenance requirements.

6. Starting and control. Due to variable compression ratio it is easy to start a free-piston engine. The air required for starting the free piston engine is less than that needed for a diesel engine of corresponding size.

The gasifier has little mechanical or thermal inertia and its output can be varied from full load to idling and back to full load within 15 seconds.

7. Waste heat recovery. Free piston engine is highly suitable for waste heat recovery, though steam at high pressures cannot be generated because the exhaust temperature of such a plant is low. The suitability of such plants for waste heat recovery arises from the fact that the heat drop and, hence, the temperature drop decreases with load, and though the temperature from the exhaust of the gasifier falls with pressure, the turbine exhaust temperature remains nearly constant and does not fall below 230°C even at idling. This nearly constant temperature coupled with the fact that the mass flow also does not vary much with load allows an efficient waste recovery equipment to be designed, giving a reasonably constant output under all loads.

8. Friction.Due to decrease in the contact area between the cylinder wall and the spherical ball piston, a single piston ring is used which helps to eliminate the sliding friction and higher the efficiency.

CONCLUSIONS

The terms of design and working shows that the spherical ball piston engine can achieve higher efficiency and does the troubleshooting of piston-cylinder internal combustion engines are facing. Differences and advantages relative to traditional piston internal combustion engines are discussed. Conventional carburation or induction and exhaust systems are being developed efficiently to increase the lifespan of the machine. If the engine is fabricated with all the design features, the concept of Ball Piston holds an immediate promise of high efficiency, and low cost, probably with a greater life span.

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