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Quasiturbine Rotary Air Engine

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Abstract: *This paper discusses concept of Quasiturbine (QT) engines and its application in industrial systems and new technologies which are improving their performance. The primary advantages of air engine use come from applications where current technologies are either not appropriate or cannot be scaled down in size, rather there are not such type of systems developed yet . Examples are given showing cases where it is more cost effective (and efficient) to use steam engines including dispatched power, use of a lower grade gas turbine with a steam engine bottoming cycle especially in CHP applications with a large heat to power ratio, and in secondary heat recovery systems. For small systems, the steam turbine is not appropriate because of its small turndown ratio, sensitivity to steam quality, and high operating speeds. This results in available steam power being wasted. Steam engines scale down in size beautifully, work better with wet steam, and operate with very modest operating speeds.*

KeyWords- *Quasiturbine (QT) , Positive displacement rotor, pistonless Rotary Machine*

I.INTRODUCTION

A heat engine is required to convert the recovered heat energy into mechanical energy. Heat engines generally require compression and expansion of a working fluid. The QT (QT) is the most coampact and efficient tool currently available for compression and expansion of most working fluids. Therefore, the QT will be used for all examples involving use of heat engines for converting recovered heat energy into mechanical energy. The QT (QTurbine) is a positive displacement turbine alternative. Suitable as a double-circuits rotary motor or expander for compressed air, steam and other fluids. The QT is a compact, low weight and high torque machine with top efficiency, especially in power modulation applications.

The QT is a pistonless Rotary Machine using a deformable rotor whose blades (sides) are hinged at the vertices. The volume enclosed between the blades of the rotor and the stator casing provides compression and expansion in a fashion similar to the familiar Wankel engine, but the hinging at the edges allows higher compression ratio and different time dependencies, while suppressing the Wankel rotor dead time, and this without the complex rotor synchronization gears.

II. QT OVERVIEW

The QT or Qturbine is a pressure driven continuous torque deformable spinning wheel. It can be considered to be the crossroad of three modern engines – Inspired by the turbine, it perfects the piston and improves upon the Wankel. A Qturbine (in short) is thus a non-crankshaft rotary engine having a four faced articulated rotor with free and accessible center, rotating without vibration and producing high torque at low RPM. The rotor as an assembly is deformable and the four faces are joined together by hinges at the vertices. The volume enclosed between the blades of the rotor and stator casing provides compression and expansion in a fashion similar to the Wankel engine.The QT can be considered to be an optimization theory for extremely compact and efficient engine concepts.

2.1 QT Fundamentals

However, the QT is not an aerodynamic, constant pressure engine like the gas turbine. In the gas turbine, the combusted gases are directed through nozzles against the blading of the turbine rotor and are expanded to atmospheric pressure. The amount of work derived from the gas turbine engine is the difference between the work required to compress the air and the work obtained from the turbine. In the QT, there are no turbine blades. Instead, the high pressure of the combusted gases during the power stroke forces each rotor segment in the direction of rotation ("static pressure expansion").

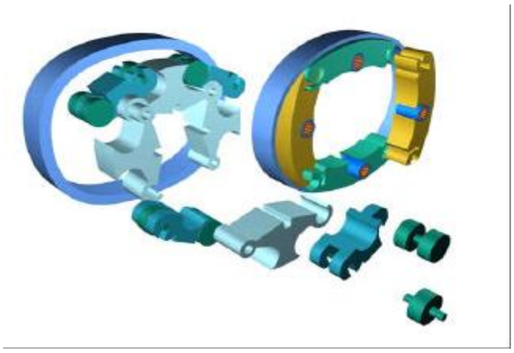

Fig. 1- The QT.

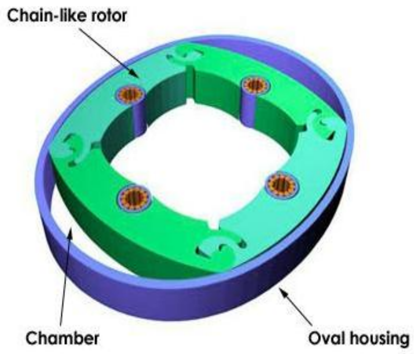

Fig.2 -QT Rotor.

Thus, the QT is a static pressure engine, not an aerodynamic, constant pressure engine. Moreover, the combusted gases do not “necessarily” expand to atmospheric pressure in the QT. Rather, the combusted gases only expand until the pressure at the exhaust port equals (or exceeds) the pressure of the compressed air charge at top dead center (TDC). Because the QT is a constant volume, static pressure engine, it can operate at pressures that exceed those which are normally practical for gas turbine engines and can reduce the work associated with air compression in a gas turbine because less air is required by the QT’s combustion process. Higher operating pressures and less negative compression work imply that the QT can, in principle, achieve efficiencies greater than those possible in a comparable gas turbine, if the combusted gases are ultimately expanded to atmospheric pressure.

The Canadians are working along similar lines with their Quaziturbine steam engine .In their base design, an oval housing surrounds a four-sided articulated rotor which turns and moves within the housing, trapping the working fluid into four chambers. As the rotor turns, its motion and the shape of the housing cause each side of the housing to get closer and farther from the rotor, compressing and expanding the chambers similarly to the "strokes" in a reciprocating engine. By selectively admitting and discharging steam, the four chambers of the rotor generate eight power "strokes" per rotor revolution which results in smooth operation at a large range of rotation.

III.CONFIGURATIONS OF A QTURBINE

3.1 Qturbine without Carriages

QT engine without carriages or in Simple configuration is very much similar to a conventional rotary engine. It has a rotor that revolves within the housing. The engine makes use of complex computer calculated oval shape stator housing, creating regions of increasing and decreasing volumes as the rotor runs. The rotor has four blades hinged to each other at their ends. The sides of the rotor seal against the sides of the housing, and the corners of the rotor seals against the inner periphery, dividing it into four chambers. The four strokes of an engine are sequentially arranged the housing.

Fig.3 without Carriage QT

3.2 Quasiturrbine with Carriages

QT with carriages is specially designed for a superior mode of combustion called as Photo Detonation which requires higher compression and sturdiness.

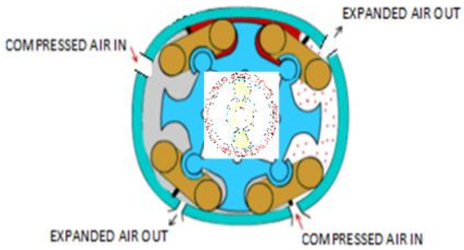

Fig.4 with Carriage QT

In this configuration, the rotor is composed of four pivoting blades which do a similar function as the piston. At one end of the pivoting blade, it has a hook pivot and on the other end a cylinder pivot. Each pivot sits intone of the four rocking carriages. Each carriage is free to rotate around the same pivot in such a way as to be continuously and precisely in contact with the housing. The filler tip on the blade is meant to control the residual volume in the chamber. The top of the filler tip is shortened to permit an adequate compression ratio. The traction slot on the other side of the blade is meant to couple it with an external shaft so as to draw the power generated. The wheels on carriages are made larger so that it reduces the contact pressure on the housing and also ensures a smooth motion of the rotor.The housing (stator) has a computer generated unique profile which is almost near to an oval shape and it is called “Saint-Hilaire Skating Rink”. The housing has four ports on it :

- An intake port -1
- An exhaust port – 1
- An intake port -2
- An exhaust port – 2

The housing is enclosed on each side by two covers.

3.3 Binary QT

The Brayton cycle requires at least two QTs - one for the compressor and one for the prime mover, with different displacements. The two different QTs could be cascaded together on the same shaft to satisfy the requirement. Cascading of two QT on the same shaft would not be not difficult, but a more cost effective and compact unit of two QTs could be designed which would integrate two independent QTs into a single package. This integrated package of two independent QTs will be called a binary QT.

IV]working

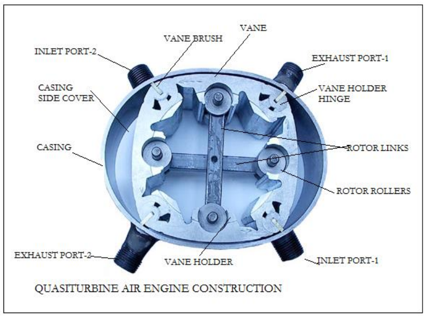

Fig.5 –Working of QT.

This model was designed for compressed air and steam applications. Other models are more suitable for internal combustion applications.

The QT can handle large volumes of air or steam. Figure shows the rotor in the top dead center position. The rotor consists of four blades which are identical. Each of the four blades produces two compression strokes per revolution which provides a total of eight compression strokes per revolution when used as a compressor. When used as an air or steam, eight power strokes per revolution are provided. The SC model has four ports. Starting with the upper right port we will number the ports clockwise 1234. Ports 1 and 3 are intake ports and ports 2 and 4 are exhaust ports. For one complete rotation of the rotor, the total displacement is eight times the displacement of a one of the chambers. Table 2 below gives the approximate theoretical sizing for QTs of different output horsepower. The theoretical values are based on a differential pressure of 500 psi with no cutoff and RPM of 1800.

4.1 Power Density

Here is a table comparing engines (order of magnitude only) on the basis of same combustion chamber volume and same rpm. QT model of series AC (with carriages) same chamber displacement, same rpm. High power density engine: The Wankel is already known as a high power density engine. At comparable power, the QT presents an additional reduction of volume. Integrated into a use, the density factor is even more impressive (no flywheel, less gear box ratio, optional central shaft...). Because of its quasi-constant torque, the use factor of the intake and exhaust pipes is 100 % (still better than the Wankel), implying tubes of smaller dimension, etc.
Same dynamic power range than piston engines: Just a word to recall that the conventional gas turbines are conceived for a precise aerodynamic flow, and do not offer a wide power range with reasonable efficiency. For its part, the QT does not use aerodynamic flow characteristic on the blades, and keeps its excellent efficiency on a wide power range. It is the same when the QT is propelled by steam, compressed air, or by fluid flow (Plastic QT for hydro-electric centrals, etc).
Same range of nominal power: As the piston engines, the QTs can be made tiny or huge. Due to concept simplicity and the absence of gears, the small units should be still more tiny than piston engines or Wankel. On the other hand, nothing limits the construction of huge QTs like for ship power, fix power plan stations, or large QTs for thermal power plan or nuclear, using steam or hydraulic.

4.2 Efficiency

More effective conversion into mechanical energy: Engines that use crankshaft generate sinusoidal volume impulses during which the piston stays a relatively long time at the top while it decelerates and reverses direction, and stays briefly at mid-course, which is contrary to the logic of a better engine (Compression impulses should be as short as possible, and the stay at mid-courses the longest possible for a better mechanical energy extraction). On the other hand, the QT is more effective because it has less engine accessories to operate (no valve, rocker, push rod, cam, oil pump)

4.3 Multi-fuel and Multi-mode

The QT can be fed (if adapted) by a whole fuel range going from methanol to Diesel oils, including the kerosene, natural gas and possibly hydrogen. The QT shows characteristics superior than the 2 strokes engine, with a quality of the exhausts better than the 4 strokes engine.

4.4 Mechanical

Robust and reliable construction: The QT does not present the critical sealing problem of the Wankel where the 3 seals at the top of a triangle (Apex) meet the housing profile with a variable angle around the normal (-60 degrees with +60 degrees). As the seals of the QT are assembled on a swivel carrier, they are almost normal (perpendiculars) to the perimeter profile in all time. The rotary engines are generally active between a robust external housing and a central shaft assembled mounted on good bearings, able to take the load on the shaft created by the pressure during combustion. For its part, the QT requires only one robust external profile, on which is also applied the load created by the pressure during combustion; the central shaft is optional and is only needed to transfer the torque when necessary.

V.QT APPLICATIONS

5.1 The Return of Steam Engine

Solar, geothermal, biomass, cogeneration and heat recovery are natural applications for the QT steam engine due to its simplicity, low price and low maintenance cost. Steam pressure less than 60 psi (often saturated steam) is generally much less regulated and most suitable for the QT. Flashing water (steam keep in liquid state in the supply line to ensure maximum heat transfer) into a hot QT is also a very safe technique removing the need of a boiler.

5.2 Engine Exhaust Heat Recovery

5.2.1 Heat Energy Available From Exhaust Gas

The energy from the fuel supplied to an internal combustion engine is balanced primarily by the energy converted to mechanical energy, the heat lost to the cooling system, and the energy carried away by the exhaust system. There are other heat losses, such as radiation loss, but these losses are small compared to the losses to the cooling system and that carried away by the exhaust system. The energy lost will be referred to as wasted energy. A rule of thumb has been that the wasted energy carried away by the exhaust and by cooling system is about equal for the ICE. Different engines and different operating conditions will cause some deviation from the "rule of thumb". The energy components carried away by the exhaust, are primarily results of incomplete combustion, incomplete expansion, sensible heat, and the latent heat of the water vapor created by burning of the hydrogen component of fuel. Most of the sensible heat can be recovered by a suitable heat exchanger located in the exhaust system. The latent heat can only be recovered by lowering the temperature of the exhaust gas below the dew point of the water vapor contained in the exhaust gas.

5.2.2 Brayton Cycle Implementation of Exhaust Recovery System.

Normally the Brayton cycle is associated with gas turbines or turbojet engines. The conventional turbine is traditionally used for these applications because of their large air handling capability and high power associated with the very high RPM. The QT has some properties that are similar to the conventional turbine and makes an excellent machine for use in applications such as exhaust heat recovery and many other applications. Unlike conventional turbines, the QT is a positive displacement machine and therefore can operate at very low RPM and over the wide RPM range consistent with the typical automobile engines. The many parameters involved with the exhaust recovery system change greatly with operating conditions. Therefore computer control would be necessary. Figure 6 is a block diagram of the QT implementation of the Brayton cycle.

Control signals from the computer are indicated by "C" and the sensor signals to the computer are indicated by "S". The mechanical coupling of the common shaft between the engine, the QT prime mover expander and the QT compressor is indicated by the dashed line. A shaft position encoder is also coupled to the shaft.

Computer controlled valves V1 and V2 are used at both the input and output of the compressor to control the volume temperature and pressure of the air delivered to the heat exchanger. The valves would be completely open or completely shut. Thus, there would be only minimum throttling effect. Valve 2 operates as a power controlled check valve. When the pressure at the compressor output was greater than the HE pressure, the valve would be open. V1 would normally be open, but when the demand for compressed air at the HE is satisfied, both V1 and V2 are closed. Exhaust gas passes through the heat exchanger. The temperature at both input and output are monitored by S5 and S6. Sensors, S2 and S3, send temperature and pressure signals for the compressed air entering and leaving the HE to the computer.V3 is the cut off valve. The computer sends signals to open and close V3 based on the shaft position, to provide the desired temperature, T4, of the prime mover exhaust. T4 is provided to the computer by sensor S4.

Table 2 (Theoretical value of QT scale-up)

Shaft Power	Rotor diameter	Rotor Thickness	Displacement/Revolution
70 HP	5 inches	2 inches	36.6 cu in
530 HP	10 inches	4 inches	293.9 cu in
4000 HP	21 inches	8 inches	2343.0 cu in

Note that the displacement increases in direct proportion to the rotor thickness and approximately the square of the rotor diameter.

5.2.3 Conversion of solar energy to electrical energy

The solar concentrator collects solar energy which is focused on a heat exchanger to heat water for the QT flash steam system By contrast, in the flash steam system, water is heated to the saturation point at a high pressure, but is not evaporated. Thus, most of the heat is captured while heating the flow of water in the liquid phase. To get the most heat transfer in flash steam system, high pressure maintains a liquid water state in the feed line that prevents evaporation as heat is added. Both evaporation and expansion take place after a small quantity of water is metered into the QT. The steam enters the QT in the saturated liquid state with zero quality, but after expansion at constant entropy, the steam quality will continue to increase until full expansion occurs. Thus, when the water is released into the QT and expansion takes place, the pressure is reduced and the water begins to evaporate.

VI .ADVANTAGES

1. The QT efficiency remains high over a wide power range without use of hybrid technology. (Efficiency of a piston engine falls off rapidly below rated engine power.)
2. The QT engine provides power nearly 100% of the time. (Each piston of a piston engine can provide power less than 20% of the time and creates a power drag more than 80% of the time.).
3. The QT engine would provide generally higher thermal efficiency and produces less pollution than the piston engine.
4. The QT's simple construction with many less moving parts would provide greater reliability at a lower cost than a piston engine. Also lower friction would further improve the efficiency.
5. The QT is a rotary engine, has no crankshaft, and parts do not have to reverse direction like in the piston engine; therefore, the QT engine produces has much less noise and vibration. The engine is balanced; therefore, no counter balances are required.

VII .CONCLUSION

The QT is thus a pressure driven engine producing continuous torque with a symmetrically deformable spinning wheel. It is a new engine alternative with some characteristics simultaneously common to the turbine, Wankel and piston, offering top efficiency power modulation capability. A review of the technology and possible applications of steam engines to industrial power and waste heat opportunities indicates that air engines are likely to be part of the energy engineer's portfolio as we move forward .The basic limitation of the QT engine at a present stage is that it is in its infancy stage. Though a lot of advancement has been made since its invention has been marked QT is a new technology probably unwelcome in the world of engine establishment.

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