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Scope of Quasi Turbine:A Review Analysis

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ABSTRACT

Piston engine is the main power supply of all kinds of mobile equipment's, and its power density directly affects the performance of mobile equipment. Compared with electric motor and gas turbine power, the piston engine has a smaller volume, simpler structure, and larger power density etc., therefore it becomes the most common source of power. Present paper provides the review analysis for the Quasi Turbine including its comparison, design analysis and future scope of work.

Keywords – ***Quasiturbine, Rotory Engine***

I INTRODUCTION

Rotary piston engines have the basic characteristics different from traditional piston engine which is that under pressure torque, its piston rotates around the output shaft instead of reciprocating motion in the cylinder. The working process of the cylinders, although in some points it has its own characteristics, is almost simile as the original reciprocating work cycle in nature. On the one hand, it is freed of the reciprocating inertia force for the privilege of high speed, and on the other hand, to a certain extent, it keeps the economy of traditional piston engine. So, its emergence is the major technological changes on the structure of internal combustion engine [1]. Over the years, like this rotational structure, many kinds of solutions were put forward. By now in addition to Wankel rotary engine, others did not become a formal product

1.1. About Quasi Turbine

The QT (QT) is the most compact 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 (Quasi Turbine) 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 object of this invention is to provide a new engine concept making use of a four degrees of freedom rotor, connected inside an internal housing contour Wall, constituting a hybrid piston-turbine engine Where the rotor acts alternatively and similarly as a compressor turbine and a power turbine, unifying in one, both of the turbines in a conventional gas turbine engine.

Another object of this invention is to provide a low noise, perfectly balanced, zero vibration, low rpm engine, making use of a more efficient and less NO_x productive asymmetric pressure cycle, giving less time to compression and exhaust stroke, and allowing more time and volume to the intake and combustion stroke. A further object of this invention is to provide a fast accelerating, zero dead time engine, and to provide an engine almost universal in relation to energy sources, which can run efficiently on pneumatic, steam, hydraulic, liquid and gas fuel internal combustion, and due to its short pressure peak and cold intake area characteristics, is as Well suitable for photo-detonation mode and pure hydrogen fuel combustion. Another further object of this invention is to provide a high Weight and volume density engine, compressor or pump, without need of any valve, check valve or obstruction, and with neither a crankshaft nor a wheel.

The QT can handle large volumes of air or steam. The rotor is 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.

It saves energy in several ways. The Quasiturbine has several intrinsic efficiency characteristics which add up, and reduce the engine energy lost in several ways:

- Because it does not have internal accessories to drive, like the piston cam shaft and valve train, additional energy is available to the end users.
- Because of the shaping of the volume pressure pulse, the thermodynamic of the Quasiturbine can be far superior.
- Because the engine weight is about 1/4 that of a piston, energy saving can be substantial in many applications.
- Because the Quasiturbine is a high torque low rpm engine, much less or no transmission gears ratio are needed with corresponding efficiency increase.

- Because the Quasiturbine can be of large size, it is an efficient alternative to utilities for efficient energy conversion (steam) in electricity or from co-generation.
- Because the Quasiturbine (AC model with carriages) has the potential to run in detonation mode, it will not have the low power penalty of the Beau de Rocha (Otto) cycle, which can provide a 50% energy saving in transportation application (much superior to hybrid concepts).

II LITERATURE SURVEY

The basic principle behind any internal combustion engine is simple: If you put a tiny amount of air and high-energy fuel (like gasoline) in a small, enclosed space and ignite it, the gas expands rapidly, releasing an incredible amount of energy. The ultimate goal of an engine is to convert the energy of this expanding gas into a rotary (spinning) motion.

The Piston engine perhaps unquestionably, has been at the center of mechanical energy conversion for almost 2 centuries and as such, has been a pivotal technology in our development and transformation into a modern society. But why are piston engine replacement attempts representative of such a long sequence of failure? Is it so difficult to do better? In this vein, human intellect has managed to create at least 3 obstacles: First, sine wave crankshaft motion has been long assumed as the best way to convert linear motion into rotary motion, and was never questioned. Second, the historical record shows that early internal combustion engine concepts were first 70 ad hoc proposed and later built and tested, rather than being conceived for a specific solution (Otto engine historians may differ with this view). Third, our great theoretical physicists had a preference for atoms and cosmos, and they completely overlooked the need for engine theory and concept design guidelines.

Recent research efforts by the Saint-Hilaire family directed by Gilles Saint-Hilaire, a Ph.D. in thermo-nuclear physics, have followed a very different modern computer approach wherein conventional engine characteristics were mapped against optimum physical-chemical characteristics, and subsequently demonstrating that all considered present engine concepts were off optimum in some respects. The 80 Quasiturbine engine [1] conception has been developed from this optimum desirable characteristic table and has succeeded, at least theoretically, to optimize simultaneously the 14 most important engine parameters, including compatibility with the revolutionary photo-detonation mode (knocking) [2] which the piston cannot effectively tolerate. When taken together, these various improvements increase fuel efficiency, while simultaneously reducing exhaust emissions.

Hu Chen, Cunyun Pan, XiaojunXu, Xiang Zhang, HaijunXu studied that with increasing energy and environmental problems and limitations in development of traditional engines, world is moving towards rotary engines. The rotary piston engines are the most and most successful which include constant speed types, planetary types, and differential types. Piston engine is the main power supply of all kinds of mobile equipment, and its power density directly affects the performance of mobile equipment. After hundred years of improvement the traditional reciprocating piston engine is close to its limit and the possibility of improving its power density is small, so it cannot satisfy the demands of new mobile platform at present. [1]

Its characteristics are light weight, high efficiency, easy processing, and good sealing. It has two sets of rotors, a total of four pistons, which form four independent air chambers in the circular cylinder. Piston rings and seal rings are used for seal.

- George Marchetti and Gilles Saint-Hilaire proposed A Six-Stroke, High-Efficiency Quasiturbine Concept Engine with Distinct, Thermally-Insulated Compression and Expansion Components. The concept engine which uses methanol as fuel and separate compressor, combustion chamber and Quasiturbine expander. The six-stroke Quasiturbine concept engine described here is designed to overcome many of the limitationsinherent in the Otto cycle and bring the engine's operating cycle closer to Beau de Rochas' ideal efficiency conditions. [2]

To achieve the desired efficiency following proposals are made in the concept engine:

1. To minimize cooling surface, the proposed engine eliminates cooling system. Instead, cooling of the inducted fuel/air charge is achieved through the use of methanol.
2. Maximum rapidity of expansion can be achieved by increasing compression ratio. With high-octane fuels, such as methanol, premature ignition can be prevented while still increasing the engine's compression ratio.
3. Maximum pressure of ignited charge is achieved by insulating both compressor and expander separately.
4. Maximum expansion is achieved by increasing expansion volume over compression volume. This is done by separating the compressor and expander.

The engine components used in proposed concept engine are: Piston type compressor, Compressed fuel/airline, Holzwarth combustion chamber, Quasiturbine expander: The Quasiturbine consists of four rotor segments, two face plates, a stator and differential. [3]

- Comparison with other engines:

1. The QT engine provides power nearly 100% of the time, while each piston of the piston engine can provide power less than 20% of the time.

2. Unlike Wankel engine the hinging at the edges of rotor allows higher compression ratio and different time dependencies.

3. The Wankel is already known as a high-power density engine. At comparable power, the QT presents an additional reduction of volume.

4. Because of its quasi-constant torque, the use factor of the intake and exhaust pipes is 100% (still better than Wankel).

5. Unlike conventional turbines, the QT is a positive displacement machine and therefore can operate at very low RPM and over wide RPM range consistent with typical automobile engines. [4]

- Roxan Saint-Hilaire; YlianSaint_Hilaire; Gilles Saint_Hilaire; Francoise Saint-Hilaire presented a patent paper on Quasiturbine. A new type of rotary engine has been proposed that can:

1. Can replace the conventional gas turbine engine using a rotor(DOF=4) removing the piston-cylinder arrangement and crankshaft.

2. Provide low noise, perfectly balanced, zero vibration, low rpm engine, which is more efficient and less NOx productive.

3. Accelerate fast, has Zero dead time, and can run efficiently on pneumatic, steam, hydraulic, liquid and gas fuel internal combustion as well as for photo detonation and pure hydrogen fuel combustion.

4. Have high Weight and volume density engine, compressor or pump, without need of any valve, check valve or obstruction, and with neither a crankshaft nor a flywheel. [5]

II DESIGN OF QUASITURBINE

A rotary internal combustion engine comprises a four-segment hinged rotor assembly accommodated in a coaxial housing such that the rotor assembles deforms and continuously adapts to the housing internal profile during its rotation. The housing profile, required to accommodate a four- segment flexible, or hinged, rotor assembly at any rotational angle. The design of an Otto cycle (four-stroke) rotary internal combustion engine is employing the concept of a deformable four-segment hinged rotor assembly. The underlying principle consists of accommodating the four-segment equilateral hinged rotor in coaxial confinement housing such that the four vertices of this rotating equilateral parallelogram coincide with the confining curve (rotor housing internal contour) at any angle of rotation.

Now for designing the mechanism we have to decide the constraint to be applied on it, so that it could provide the desired mechanism. Being in sliding contact only, the mechanism is axially decoupled from the rotor assembly.

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Therefore, the rotor assembly is not subjected to any lateral (axial) load. Simple thrust wishers mounted on the mechanism shoulders may be employed to bear any axial load acting on that component, for instance load that may result from the clutch being depressed in automotive applications.

Now the final stage of designing comes i.e. assembly of all the parts we made. Fig. 1 showing the assembled parts, including track rollers and associated tracks. With one of the rotor segments in the top dead center position, illustrates the relationship between assembled engine components. The flat-plate side covers and attached tracks are removed for clarity.

III TURBINE COMPARISON

The word Quasiturbine literally means 'similar to turbine' and is so called because, like turbines QT is also capable of producing flatter torque. The primary energy output of the combustion of the fuel is the Pressure energy. QT, being a hydro-aerostatic device, directly transforms this pressure energy into mechanical motion. Conventional turbines are hydro-aerodynamic device which converts the pressure energy of the fluid into mechanical energy through an intermediate kinetic energy and hence its efficiency changes with variation in the flow velocity. (CAROL,2005)

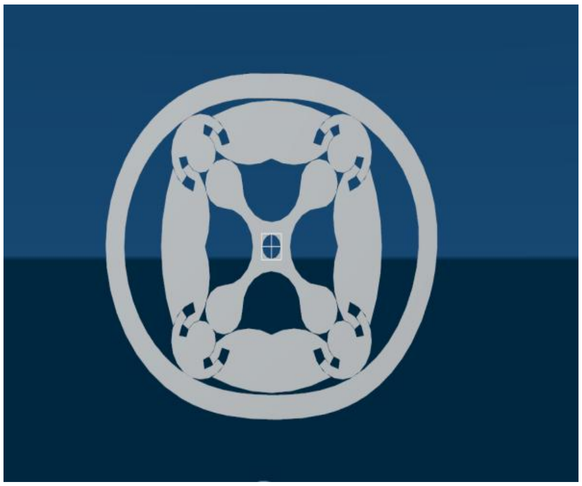

FIG. 1: Front view of Assembly

3.1 Piston Comparison

The piston engines being the most common engine reference, the QT research team has initially established a list of conceptual piston open for improvement. The QT concept is the result of an effort to improve the piston engine and indirectly other engines including Wankel.

3.2 Piston Deficiencies

All the processes are taking place in one single chamber. Hot process will destroy the efficiency of cold process and vice versa

- The piston makes positive torque only 17% of time and drag 83% of time
- The gas flow is not unidirectional, but changes direction with the piston direction
- The valves open only 20 % of the time, interrupting the flows at intake and at exhaust 80% of the time
- The duration of the piston rest time at top and bottom are without necessity too long
- Long top dead center confinement time increase the heat transfer to the engine block reducing engine efficiency
- The non-ability of the piston to produce mechanical energy immediately after the top dead center
- The proximity of the intake valve and the exhaust valve prevents a good mixture filling of the chamber and the open overlap lets go some un-burnt mixture into the exhaust
- The piston does not stand fuel pre-vaporization, but requires fuel pulverization detrimental to combustion quality and environment
- The average torque is only 15% of the peak torque, which imposes construction robustness for the peak 7 times the average
- The flywheel is a serious handicap to accelerations and to the total engine weight
- The valves inertia being a serious limitation to the engine revolution
- The heavy piston engines require some residual compressed gas before top dead center to cushion the piston return
- The internal engine accessories (like the cam shaft) use a substantial power.
- Complete reversal of the flows from intake to exhaust
- At low load factor, the intake depressurization of the Otto cycle dissipates power from the engine (vacuum pump against the atmospheric pressure)

3.3 QT and Piston Side by Side

Like the piston engine, the QT is a volume modulator of high intensity and acts as a positive displacement engine. Better torque continuity and acceleration: The crankshaft and the flywheel are the main obstacle to engine acceleration, and since the flywheel are unable to store energy at low rpm, the engine torque at idle is highly handicapped by the engine dead times. The piston of a 4-stroke engine works in power mode about 120 degrees / 720 degrees (2 turns), and thus constitutes a drag 80% of time, period during which the flywheel assumes a relative torque continuity. The Quasiturbine has jointed torque impulses, and presents a profile of almost flat torque characteristics, without the assistance of a flywheel. (CAROL ,2005)

Low revolution – Reduction of gearbox ratio: The gear boxes are evils necessary (expensive, complicated, delicate, and energy consuming). The RPM required by the human activity are generally lower that the performance optimum speed of the engines (e.g.: an automobile wheel generally does not rotate to more than 800 or 1000 RPM, which is 4 to 5 times less than the engine RPM). As the Quasiturbine turns 4 to 5 times less quickly than the other engines, the gear boxes can often be removed (amongst other things in the field of transport) with an increase in efficiency.

Continuous combustion with lower temperature: As the Quasiturbine strokes are jointed (what is not the case with the Wankel), the lighting is necessary only in launching, since the flame transfers itself from one chamber to the following. The thermalisation of the Quasiturbine by contacts with rollers is more effective, and prevents hot point. From the thermal point of view, the Quasiturbine does not contain any internal parts requiring coolant fluid (like oil).

Better overlaps: The intake and exhaust ports being at different ends of the combustion chamber, it is possible to do a better filling of the chamber by having a simultaneous open overlapping of the two ports, without risking that a portion of the intake gas goes into the exhaust, as it is the case with the piston engine.

3.4 Wankel comparison

Today's Wankel engines technology is well mastered, but the concept does still present major drawbacks. Because hundreds of experts could not pin point the exact reason for the poor Wankel combustion, they have "vaguely attributed it without proof" to the elongated shape (high surface to volume ratio) of the Wankel combustion chamber. (MYRON ,2003)

3.5 QT and Wankel Side by Side

- The Wankel engine uses a rigid three faces rotor with a crankshaft.
- The Quasiturbine uses a deformable four face rotor without a crankshaft.
- The Wankel engine shaft turns at three times its rotor RPM. The Quasiturbine rotor and main shaft turns at the same speed.

- The Wankel engine fires only once per shaft (not rotor) revolution (which means three times per rotor revolution). The Quasiturbine fires four times per main shaft revolution, producing strong and exceptional torque continuity.
- The Wankel compression and combustion stroke each last 120 degree of rotor (not shaft) rotation, of which only 90 degrees is effective (no chamber volume variation in the first 30 degrees of compression and in the last 30 degrees of combustion). Exhaust and intake strokes share together 120 degree of rotation in an excessive overlapping. In term of time management, the Wankel is even worse than the piston. All Quasiturbine strokes are of equal 90 degrees' rotor rotation (not necessarily duration), with useful volume variation (like piston) at all angles and without undesired overlapping.
- In the Wankel, 2/3 of the work is produced by piston like radial crankshaft force, while 1/3 of the work is done by pure rotational (tangential) force, which the crankshaft is not optimized to harvest (and for which a synchronization casing gear is needed). In the Quasiturbine, 100% of the work comes from tangential forces and movement, which the tangential differential harvests correctly. (Piotr,2010)
- The Wankel excessive engine ports overlap imposes to trunk the power stroke somewhat before the bottom dead center BDC, which results in some loss of efficiency. In the Quasiturbine, the power stroke extends until it is fully completed.
- When the Wankel engine rotor goes from one TDC (top dead center) to the next, the torque increases to a maximum value and starts decreasing right away. The torque generated by the Quasiturbine (accentuated on AC type) gets toward a plateau, and holds this maximum for a longer arc before decreasing, producing a better overall mechanical energy conversion rate.
- The center of mass of the Wankel triangular piston is moving in circle with the crank, and this whole triangular mass tends to bang the seals against the housing, requiring the protection of a housing synchronization gear. The Quasiturbine has no crankshaft, and its rotor center of mass is immobile at the center during rotation. Never the Quasiturbine seals need to oppose and constraint the whole rotor mass, the only force required being the one to transform a square into lozenge and back to square.
- The Wankel engine cannot operate in continuous combustion. While a full expansion stroke occurs (rotor revolution of 90 degrees), intake mixture compression is only partially initiated and not yet ready to be lighted (an additional 30 degrees' rotor rotation is required as a dead time). Quasiturbine mixture is completely compressed and ready to fire at the end of each expansion stroke, making possible a flame transfers for continuous combustion.
- Due to its one single firing per shaft revolution, and the dead time, the Wankel engine needs a flywheel. The Quasiturbine needs no flywheel, and consequently has faster acceleration.

- The Wankel engine is a "rotating piston engine" that is subject to a constant circular vibration. The Quasiturbine has a fixed center of gravity during rotation, and is a true zero vibration engines (like the turbine), since any weight movement is exactly compensated by symmetric mirror movement through the center.
- Since the main Wankel engine shaft rotates at three times its rotor speed, it is more suitable for high RPM end uses. The Quasiturbine main shaft (rotating
  at the same speed as its rotor) is more appropriate for lower revolution uses (e.g. airplane propeller at only 2000 RPM, generator, transportation, or to reduce gearbox ratio in current applications).

IV HYBRID COMPARISON

4.1 Hybrid Definition

Detonation and hybrid are two different means to harvest the low efficiency of reduced power piston engine, and both are compatible with efficient electrical (in-wheel) power train. Detonation engine is however a more direct and efficient way, and because the on board fuel is already a form of energy storage, detonation engine avoid to re-stock this energy electrically into batteries. The chemical energy stored in the fuel is degraded when chemically re-stored in batteries. (Vishnu,2011)

4.2 Quasiturbine Over Hybrid

Detonation and hybrid are two different means to harvest the low efficiency of reduced power piston engine, and both are compatible with efficient electrical (in-wheel) power train. Detonation engine is however a more direct and efficient way, and because the on board fuel is already a form of energy storage, detonation engine avoid to re-stock this energy electrically into batteries. The chemical energy stored in the fuel is degraded when chemically re-stored in batteries. The Quasiturbine has several intrinsic efficiency characteristics which add up and reduce the engine energy lost in several ways:

- Because it does not have internal accessories to drive, like the piston cam shaft and valve train, additional energy is available to the end users.
- Because of the shaping of the volume pressure pulse, the thermodynamic of the Quasiturbine can be far superior.
- Because the engine weight is about 1/4 that of a piston, energy saving can be substantial in many applications.
- Because the Quasiturbine is a high torque low rpm engine, much less or no transmission gears ratio is needed with corresponding efficiency increase.

- Because the Quasiturbine can be made of large size, it is an efficient alternative to utilities for efficient energy conversion (steam) in electricity or from co-generation.
- Because the Quasiturbine (AC model with carriages) has the potential to run in detonation mode, it will not have the low power penalty of the Beau de * Rocha (Otto) cycle, which can provide a 50% energy saving in transportation application (much superior to hybrid concepts).

Multi-fuel capability is also an important efficiency factor permitting to use the most pertinent local combustible. Hydrogen high compatibility is also of consideration for the future.

So, the Hybrid Concepts have been developed to harvest the low piston efficiency at reduced power. If a new engine does not have such a penalty at low power, the Hybrid Concept would be of no interest. This is exactly the objective of the Quasiturbine detonation engine use in transportation.

The development of a detonation engine provides a mean to avoid that low-power efficiency-penalty; maybe more environment friendly as it will require low octane additive-free gasoline or diesel fuel; maybe multi-fuel compatible, including direct hydrogen combustion; and may offer reduction in the overall propulsion system weight, size, maintenance and cost. For these reasons it could be better or competitive with hybrid car technology.

V CONCLUSIONS

The Quasiturbine is a pressure driven, continuous torque and 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, which makes it most suitable for land transportation and windmill systems.

- The Quasiturbine goes along the best modern engine development strategy, which is to get as many ignitions possible per minute, with a mechanical device rotating as slowly as possible.
- For the same shaft RPM as a piston 4-stroke engine, the Quasiturbine strokes are twice as fast and 8 times more frequent, for an impressive torque and power gain.
- By opposition to several new engine designs, the Quasiturbine is not a piston equivalent engine and notwithstanding its multi-mode (including steam and air motor) and multi-fuel capability, the foremost important characteristic is the fact that it does support detonation (HCCI [22]), where piston engine has not succeeded over the last decades.
- The detonation auto-ignites similarly to what happens in Diesel, but burns homogeneously, faster and cleaner. The size and weight advantages provide opportunities for tradeoff between engine sizes vs. efficiency that is not practical with other engine types.

- Because of the light weight, the QT would have significant advantages as the prime mover in a hybrid engine. Also, since the QT can be configured as either a pneumatic or steam engine, there is the possibility of combine a QT ICE engine with a pneumatic or steam QT to harvest the energy from the high temperature exhaust gases that have been treated with the catalytic converter. Several other options exist.
- The QT will require significant investment for application to the automobile industry just as would be required for a new piston engine design. But, the investment in development of the QT should provide a high yield on the investment dollars.
- Two or more QT can be easily combined into two stages which would be much smaller than an equivalent power piston engine. Thus, only two different size QT engine designs could provide many options. For example, 110 hp, and 160 hp designs could be combine in different ways to provide 110, 160, 220, 260, and 320 hp automobile models.
- The two stage engines could be easily implemented so that only one stage was active when the extra power wasn't needed. This concept has been used for piston engines but it was considerably more complex that two QTs would be.

The future of energy strategies involves resources, efficiency, distribution and mobility. As more efficient and detonation capable engines get on the market, small engines will become as efficient and as clean as large utility stations. Only then the distributed power generation will become reality and because of fuel mobility, specific energy and power advantages, efficient internal combustion engines like the Quasiturbine will then have almost no substitute. Considering fossil fuel depletion, is this technology coming too late? If the availability of fossil fuel becomes rationed, everyone will like to use the precious liquid left in the most efficient and clean engine possible. This is why it is important to develop better engines today regardless of the depletion of the fossil fuel, to attenuate the effect of the inevitable transition to synthetic replacement fuel, including hydrogen. The closer we will get to the end of the fossil era, the more highly efficient engines will be necessary and appreciated. The Quasiturbine is one more tool to tackle the energy and environment concerns.

VI SCOPE FOR FUTURE WORK

The Quasiturbine in Beau de Rocha (Otto) cycle (model SC without carriage) is a relatively simple technology which could be widely used within a few years with substantial efficiency benefits over piston engines in many applications. Large utility plants convert energy more efficiently than small distributed units and should be favored when possible, but on the long term, the Quasiturbine detonation engine is one of the very few means to match utility efficiency the distributed way, while being as chemically clean as possible.

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