Quasiturbine Fundamental of Internal Components Behavior and Detonation Flash Compression for Early Energy Recovery

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Abstract: ***The deformable Quasiturbine relays on a nearly Homo-Kinetic perfectly balanced deformable Lozenge Rotor with no radial mass movement and nearly imperceptible contour seal extension, for High-Torque low RPM power density and efficiency. The present work analyses a Moderate Deformable QT-SC (without carriage) case study, with its design sequence starting from the physical component sizes, the selection of the (moderate) Maximum Rotor Deformation Ratio MRDR, and the stator confinement profile additional parameters input and calculation. From the basic properties of the Lozenge, the components behaviors are timely analyzed in position, volume, speed, and incremental Torque and Energy over an entire power stroke. It is shown that the Blades turn at tangential speed on a perfect circle at RPM speed +/- 30 %, with the Blade center points diverging sinusoidally +/- 8.5 degrees in agreement with simple differential corrections when using a central shaft. This confirms also the rotor inertia to be constant and acting as a conventional flywheel, and that centrifugal forces are no-issue in the Deformation of the QT Lozenge Rotor. Comparisons are presented using a 3R+/-1R static mathematical Piston model in expander mode at constant pressure. The work covers also the Detonation QT-AC case study (with carriages, having variable contour seals distances) which by opposition to the Piston handicaped by its poor fluidity of movement with components speed range and acceleration-deceleration variations, and where the fast Detonation occurs in a Piston rest zone, the near Homo-Kinetic Detonation Quasiturbine QT-AC has a set of Rotor Blades on carriages turning non-stop at +/- 30 % of the steady RPM, with the Detonation occurring in the fastest blade moving zone. The detonation is an efficiency issue also because modern fuels including hydrogen, tend to burn faster in some condition. A substantially different QT-AC chamber volume variation is also compared to a static mathematical Piston model.***

Note: This scientific disclosure does not constitute permission for commercial manufacturing.

Keywords: Quasiturbine; Rotary Engine; Steam Engine; Detonation Engine; Rotary expander

1. Quasiturbine in Paradigm Context

1.1 Introduction

The Quasiturbine QT is a 4 faces deformable Lozenge Rotor turning in an appropriate confinement Stator, which Stator has 2 sets of diametrally opposed chambers, one set with maximum volume at BDC and the other with minimum at TDC, producing a total of four complete 4-strokes cycles (16 strokes) per rotation, and suitable as pump, compressor, steam or gas expander, and engine, as reviewed in the engine literature [1]-[6]. In contrast with vane rotor where the Torque is produced by tangential pressure on an extended contour seal, QT contour seals do not move perceptibly, and the Torque result as the tangential component of the pressure exerted on the entire Blade surface (not the extended seals). Travelling along the inner Stator, each Blade visits in one revolution 2 minimum volume chambers at TDC, interlaced with 2 maximum volume chambers at BDC as describe in several technical papers [7]-[11] including by the present authors [12]-[15]. Numerous pertinent applications have been suggested and documented by innovators [16]-[20]. Finally, some specialized Public Magazines have done serious informative articles on the Quasiturbine technology [21]-[24].

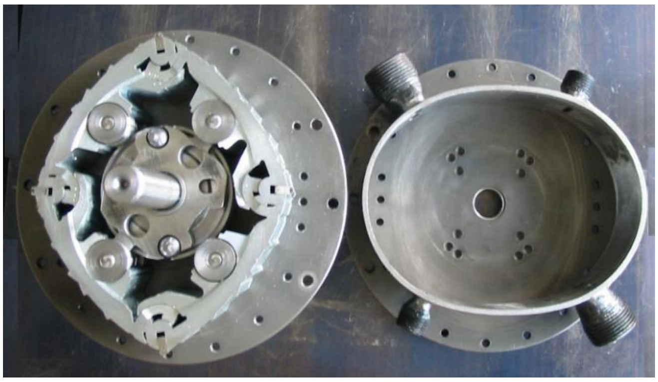

Figure 1: Quasiturbine Model QT-SC (without carriage) with 4 Blades Rotor, the Contour Seals, wheel-bearing Blade support, and a Shaft Differential [15]. Stator in Expander Mode with intakes and large exhaust ports, including side covers.

In the Quasiturbine QT-SC, the rotor gets in square configuration 4 times per rotation, and as many times in deformed (diamond) Lozenge shape, with the 2 sets of opposed Lozenge pivots forming an orthogonal referential system at all time, and this group of Pivots all rotates at a constant angular speed RPM, regardless of the continuously changing radius. Sort of reciprocally, each Lozenge side mid-point (Blade center Bc) moves along on a cercle of constant radius (no radial mass movement).

1.2 Quasiturbine: Beyond Centrifugal Dilemma?

Let's imagine a 4 faces Lozenge Rotor in square configuration spinning in free space (no Stator). The square Lozenge is simultaneously mirrored across its two Rotor diameters and both, the variation of the moment of inertia and the centrifugal force cancel simultaneously, but is this an UNSTABLE state if the Lozenge deforms slightly? The facts are that the Lozenge deformation will extend outward 2 opposed Pivots and retract inward the 2 other opposed Pivots. For sure, the centrifugal forces will tend to separate the Rotor in 2 parts along the longitudinal extended axis (which will be prevented by the Blade's hinges), but will the centrifugal forces accelerate the deformation of the Rotor or not?

Physic teaches to consider only the centers of rotation and the centers of mass, regardless of the shapes and orientation of the objects. The QT-SC Rotor is made of 4 Blades with their centers of mass Bc located simultaneously on the corners of a rectangle and on a circumference, at equal-distances from the center of rotation, forming 2 opposed pairs of mutually balanced mass regardless of the Lozenge deformation. The realistic answer is: STABLE. The deformation does not destroy the mirror symmetry across the Lozenge axis, it makes only the 2 axes of different lengths. Symmetry about the central point of rotation and constant radius are the only parameters to consider. If mass orientation is no object to the law of this physic, this same law has no effect on the object orientation. In this geometry, there are centrifugal forces, but the Lozenge deformation is not affected by centrifugal forces regardless the level of deformation, nor if it is within free space or in a Stator. Since the square Lozenge configuration is stable not only in free space, it becomes the stable reference for QT transitions between successive engine strokes. From "an impossible concept" to realty, the Quasiturbine offers its share of unique exceptional characteristics.

1.3 Properties of the Lozenge

The Quasiturbine Rotor is a deformable square shape (Lozenge) made of 4 sides (Blades) linked at their both ends by hinge Pivots, and where the Pivot may have a physical diameter around its center. Central diameters crossing from pairs of opposed Pivots Pc are of equal length only when in the square configuration. During Lozenge (Rotor) deformation, if one diameter increases, the other shortens, but most important: Both Pivots diameters stay orthogonal at all times no matter the level of Rotor deformation and their 4 square angles from the central intersection face a lozenge side. Similarly, the 2 pairs of opposed Lozenge corner angle are 90 degrees only in square configuration, and if one pair increases, the other decreases. When a pair of pivots is radially moving inward, the other pair is moving outward. The Lozenge internal mid-Blade Bc centers points do not form a Lozenge within the Lozenge, but rather a rectangle, which diameters are the central crossing arms, and are orthogonal only when in square configuration. As the Lozenge deforms, these mid-Blade centers Bc form the corners of a rectangle and are moving on a perfect circle, more practical that the changing radius Pivots for central shaft differential attachment to get constant smooth RPM with the Rotor.

In this geometry, there are centrifugal forces, but they have no effect in altering the rotor deformation, therefore there is no need to design QT with small and weightless Pivots sizes (see QT-SC hinge size Pivot), as no centrifugal force will risk to produce excessive pressure on contour seals at high RPM. Since all the Blades center of mass Bc rotate on a perfect circle and simultaneously on the corners of the Lozenge internal rectangle, there is no radial mass movement, and consequently no variation in centrifugal force. Seen otherwise, because the overall Rotor stays perfectly balanced at all time, there is no centrifugal issue. While in some Rotor areas the Pivots radius increases, simultaneously in other interlace area the Pivot radius reduces, which again cancels, and all Rotor Pivots Pc rotate at the same RPM angular velocity, while not at the same tangential velocity.

The QT Maximum Rotor Deformation Ratio MRDR is a fundamental QT design parameter which impacts the device total positive displacement, and the eccentricity of the Stator. For all level of Rotor deformation, the Lozenge presents a perfect symmetry simultaneously across the central rotor point, and across (mirror) each diameter. From Engine Rotor perspective, this means that all Pivots Pc rotate at the same angular speed (degrees/sec.) at constant RPM, but of course not at the same tangential speed (cm/sec.) as the pivots can be at different radius. Conversely to spin the Lozenge Rotor at constant RPM, it has to be done angularly at the Pivots Pc level regardless of their radial position. At least two orthogonal systems of references are needed to describe the Quasiturbine, both coinciding at the center of the device, one fix attached to the Stator, and one pivoting made with the diagonals of the Lozenge Rotor passing by their opposed pivots (always orthogonal no matter the deformation level of the rotor Lozenge) and rotating with the device central parts.

1.4 Quasiturbine Design Sequence

There exists no general QT rotor solution to fit in an arbitrary Stator contour form, and conversely the rotor alone does not determine a single Stator contour solution. At first, the rotor imposes its characteristics to an infinite sub-set of possible stator shapes, and later, it is the selected Stator solution which imposes it constrain to the rotor Blades external shape design for optimum compression ratio, or else.

Once the Rotor Blade length (Lozenge side Pivot to Pivot) is selected, the Blades-end Pivot size diameter, and the Maximum Rotor Deformation Ratio MRDR is defined (total positive device displacement), then a set of 8 stators points are automatically defined (4 at the two diagonals of the square Lozenge and 4 at the two diagonals maximum MRDR deformation of Lozenge Rotor). It has been demonstrated [13] that these 8 points are not on an ellipse, and the stator symmetry appends to be uniquely across the central point of the rotor (Careful, never mirror the Stator across X or Y axis!). Furthermore, these 8 rotor points allow to define 4 interlaced Rotor sections (branches) drafted by the engine designer, each symmetrical through the rotor center and imaged through the rotor transform function.

1.5 Need for Parting-Out Analysis

Quasiturbine versions suitable for Fuel-Engine are, the Combustion QT-SC (without carriage, having fix contour seals separation) and Detonation QT-AC (with carriages, having variable contour seals separation). In the past 20 years, the Quasiturbine characteristics have been extensively reviewed [1]-[7] with little attempt for parting-it out. Characteristics resulting of internal component behavior, are: No radial mass movement; Perfectly balance; Harmonic free rotation; Need no extra flywheel; Homo-Kinetic; Continuous combustion; High Power Density; Displacement exceeding its own engine volume; Light and compact; …

2. Quasiturbine QT-SC Autopsies

2.1 QT-SC Layout Case Study

This paper describes a reference case of QT-SC design, with moderate design parameter selection to offer sensible improvement in internal combustion engine, while it respects most concern for applications like pump, expander or compressor. In this work, the individual components of the QT-SC case study design are layout in 15 degrees interval of the "forward" Lozenge Pivot center angle in fig. 2. From the basic characteristics and properties of the Lozenge, the components behaviors are timely analyzed in position, volume, speed, and incremental Torque and Energy over an entire power stroke. Using a static 3R+/-1R mathematical Piston model in expander mode at constant pressure, comparisons are presented for a complete power stroke as chamber volume variation, incremental Torque and Energy conversion capability. The work presents also the Detonation QT-AC (with carriages) case study, knowing that the Piston is handicaped by its poor fluidity of movement with extreme components speed range and acceleration-deceleration stresses.

The mid-Blades center Bc from fig. 2 appends to move along a circle (nonphysical), while being the corners of the Lozenge internal rectangle. QT design and layout make intensive references to Lozenge "Forward Pivot center Pc" of consecutive fix 15 degrees, while "Mid-Blade center Bc" are at variable angular distance apart. Among the early design parameters selected:

- First the Maximum Rotor Deformation Ratio MRDR is the most fundamental to establish the positive displacement of the QT; it does also have direct impact on the eccentricity, the confinement shape having its own set of parameters for calculation [13].
- Second, the Pivot Pc hinge design which is not size and mass sensitive.
- Third, preserving free central Rotor space, if the designed Pivot Pc diameter is small enough not to reach within the Blade center Bc circle during the inward pivot movement (see Blade 90 at 270 degrees.).
- Quattro, will the rotor be driven at constant RPM by its Pivots Pc (which are at constant angular speed, but not at constant radius) or by a differential through the Mid-Blade center Bc (on a circle at constant radius, but at variable angular speeds); Possible perpendicular cross arms (half or full diameter) are shown attached to the Blade Bc points in fig. 6.

2.2 Major QT's Blade Pc-Bc Reference Points

For the discussion in fig. 2 and following, it is essential to focus on the position of two major QT's Blade reference points. First, at each Rotor Lozenge Pivots, and particularly for each Blade the "forward anti-clockwise" Pc Pivot center Pc (arbitrary selected, as tailing Pivot center could have been chosen with same valid presentation). The length of the Blade is the fix distance form Pivot to Pivot during rotation, while the Pivots radial positions keep changing individually in and out along the Stator shape.

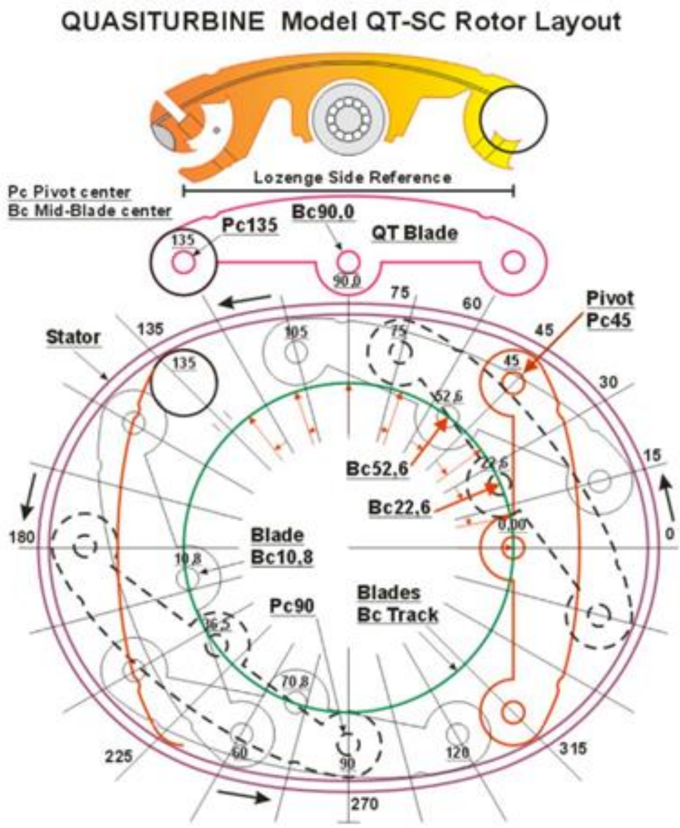

Figure 2: Quasiturbine QT-SC Internal Layout. Counter-clockwise, the forward Blade's Pivots Pc are shown in 15 degrees steps (For clarity, interlaced Blades shown on opposite wall, and Blade Pc135 is upward, off the Stator). The compression stroke from BDC Pc45 degrees. to TDC Pc135, is part of a total of 16 QT Strokes per rotation.

Also in fig. 2, the QT's mid-Blade Bc reference points are important. Contrary to the fix distances between sequential Pivots Pc, due to the Lozenge deformation the distance between two consecutive mid-Blade center points Bc keeps changing during rotation, which implies variations in the relative tangential blade speed, each opposed set being alternatively going slower and faster. However, these Blade center Bc points are the corners of the internal Lozenge rectangle and move along a Rotor concentric circle at a constant radius. The Bc distance along the circle not being constant, they are not part of an orthogonal axis system (The 4 mid-Blades Bc points being orthogonal only when the Lozenge gets in square configuration, 4 times per rotation).

2.3 Layout Description

The fig. 2 presents at the top, a QT-Blades of unity length from Pivot-to-Pivot, which Pivots have a circular diameter of 0.2 unity. Each Blade has 2 important noticeable reference points shown, their Pivots Pc, and its Blade's Center Bc. Several hinge designs are possible, the one shown is being simultaneously female and male, but not specific to the presentation. A set of 4 Blades are assembled to make a deformable Lozenge acting as Rotor, which Maximum Rotor Deformation Ratio MRDR (The small Lozenge pivots diam. over the large ones) was selected to be 0.752 for the QT-SC model. When adding the Pivot's diameter to the unit length, his MRDR dictates the Stator Diameter Eccentricity Ratio to be 0.779 (slightly different from the MRDR). The previous constraints are not sufficient to uniquely define the Stator contour shape, which further requires input of contour branches [13] conditioned by the target operational objectives of the device. The QT-SC was intended to have moderate Rotor and Stator eccentricity, with a Stator shape as close as possible to the ellipse (which cannot be an exact solution).

In fig. 2, a first Blade Pc45 has been positioned on the right-hand side in order to confine the largest chamber volume within the Blade and the contour wall, equivalent to the Piston BDC (Bottom Dead Centre). In counter-clockwise direction from Pc45, the chamber volume decreases until minimum at Pc135, the equivalent of Piston compression stroke to TDC (Top Dead Center). In between and for every 15 degrees "Forward" Blades Pc position, a set of complete Blade has been drawn (for clarity, missing Blades are positioned in the Stator opposite wall, and the Blade Pc135 has been translated upward outside the Stator).

In square Rotor Lozenge configuration, the layout shows a 45 degrees difference between Pc45 and Bc0.0, and the same between Pc135 and Bc135. However, this angle is not constant while Bc moves from 0 to 90 degrees, as shown by the set of small vectors this angle is different, retarding initially until Pc 45 degrees and catching up later when Bc reaches 90 degrees at Bc135. Detailed Bc movement reveals a rotational speed variation and phase difference in relation to the Pivots Pc, as detailed below. On the left of fig. 2, a Blade surface line from the Pivot circle Pc135 going downward allows to visualize the portion of the Blade tip Pt90 which exceeds the Rotor size in square configuration, which is of exactly one Pivot Pc diameter, and at which time in the rotation, the Pc90 tip is inward of the same amount. Simultaneously locating the Blades-ends in and out of Track #1 is an arbitrary designer choice (see fig. 6).

3. QT-SC Internal Behavior

3.1 Arbitrary conventions "Forward" Pivot and more

The direction to a Pivot is part of an orthogonal reference system which rotates at constant Rotor RPM. The counter-clockwise direction of rotation is arbitrary, as is the selection of "Forward" Pivot used to position the Blades within the Rotor. When in relation to the behavior of the QT components, the terms acceleration and deceleration refer to the Blades Bc within a Rotor spinning at constant RPM, and not to a speed variation of the Rotor itself. About expander and pump mode, when the Rotor is at rest exactly on the TDC and pressure is applied, the forward and backward Torque do cancel. Dividing the surface of the Blade by one or more successive little protuberances barely visible in fig. 1 will produce (at least to an applied pressure step) a half-Blade starting Torque from rest, proportional to the differences between the forward Radius less the Radius at mid-Blade. Not quite arbitrary but worth to mention.

3.2 Mid-Blade Center Point Bc

In fig. 2, the Blade Pc45 is vertical and has its Blade center Bc0.0 on the zero-degree X axis. Forward Pivot center Pc and the Blades mid-centers Bc are numbered by their angles position. From Lozenge geometrical properties, all Blade centers Bc are simultaneously the corners of the internal Lozenge rectangle, and move on a cycle. However, if all the "forward" Pivots Pc are at equal 15 degrees angular distances, the Bc angle intervals are not equal, except at Pc45 and Pc135. From the X-axis, Bc lag up to - 8.5 degrees at mid-stroke and recover + 8.5 degrees in the last leg, to target 90 at Pc135.

Naming and positioning the Blade with their forward Pivots Pt Angle Spacing make sure they are angularly and timely spaced according to constant RPM. However, another (and sometime more practical) way to position the blades on a diagram and discuss its characteristics is by referring to its mid-Blade center Bc Angles, which are not angularly equally spaced. All angles are measured form X-axis zero, and there is of course a bi-directional correspondence between Pc Angle and Bc Angle. One of the QT rotor challenges is to make a deformable rotor geometry to rotate at a constant smooth angular speed of the Rotor Pivots Pc. The Blade centers Bc move on a perfect cycle and look very practical, this is why knowing the correspondence between Bc angle and Pc angle is important for central components.

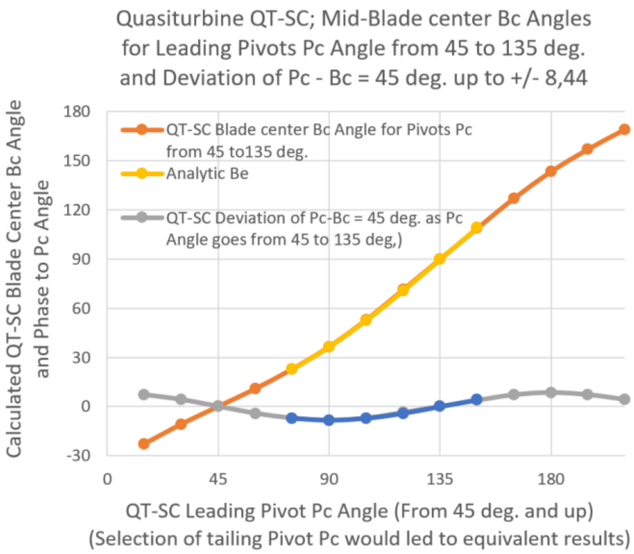

Figure 3: Quasiturbine QT-SC Blade Bc Angle from Pivot Pc Angle for half a rotation. The difference between Pc45 and Bc0.0 degrees is 45 degrees modulated in rotation by a phase shift up to +/- 8.5 degrees.

Because the Blade Bc points are not angularly equally spaced, the correspondence with the Pivots Pc angular speed is not linear as shown in fig. 3, which means that the individual QT Blade Bc instantaneous tangential speed vary during rotor rotation. Phase angle should not be confused with tangential speed. A few discrete points are sufficient for this paper explanation, but an analytical curve is useful when dealing with internal component like Central Power Crossing Arms for QT-SC Model: Corresponding to PcAngle:

BcAngle = (PcAngle – 45) – 8.5 * Sin (2 * (PcAngle - 45) * PI () / 180)

3.3 Blade Bc Tangential Instantaneous Speed

As the Rotor Lozenge Pivots Pc rotates at constant angular RPM, some Blades are slowing down while other are accelerating. This is also why knowing the correspondence between Bc and Pc angle is important for the analysis.

From fig. 4, in QT-SC, the difference (Pc – Bc) = 45 degrees deviates up to +/- 8.5 degrees because the Bc are not rotating at constant RPM.

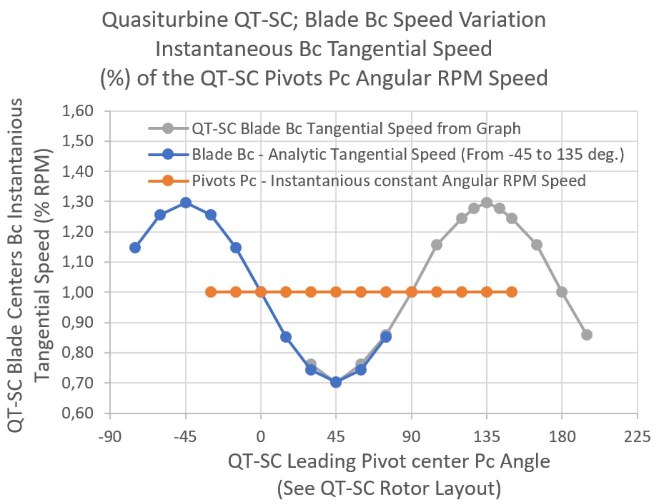

Figure 4: Quasiturbine QT-SC; Blade Bc Speed Variation comparison with Pc at RPM (at constant radius but at variable angular speed, deg. /min.). The Bc speed curve crosses RPM at MRDR configuration.

Analytic equation is:
Bc Tangential Speed Variation = 1 + (0.3 * COS (2 * (PcAngle + 45) * PI () / 180))

3.4 Rotor as Flywheel

Flywheel is a necessity for Piston because its Power Strokes are interlaced between two negative Torque Strokes (intake or exhaust). Even if it is not the case with QT, it is important to establish that the set of Blades act as a conventional flywheel. Referring to fig. 2, using an arbitrary 15 degrees steps, there are 24 positions to draw QT Blades within the Stator. If all mid-Blade centers Bc are on a circle, only the ones in square configuration (like Pt45 or Pt135) are facing the center of the rotor, the others are either slightly oblique to right or left. Since the Blade's mass stays centered on Bc, there is no radial net mass movement to prevent the set of 4 Blades to act like a conventional rigid flying wheel. Within the transition, compensation occurs when one opposed Blade set acquires a tiny more tangential Energy and the other loses an equal amount, making the overall rotor a smooth solid flywheel equivalent. Normal, as the masses are linked together and move on a circle with no radial center of mass movement, and if one accelerates in one direction, another decelerates across in the same direction for a constant average tangential speed. For this reason, no additional external flywheel is needed in many QT applications.

During rotation, every time the rotor gets into MRDR configuration, the 4 Blade's mid-points (centers of mass) move around all at the same tangential speed, which for a short instant is also equivalent of the 4 Blade's pivots angular speed. This occurs 4 times per rotation, and provides an equilibrium dynamic reference.

3.5 Polar Homo-Kinetic Advantage RPM +/- 30 %

Speed graph needs to be completed by a polar graph to show in which sector the Blade Bc speed is variating.

Constant rotor RPM is achieved because for 2 opposed Blades Bc at low tangential speed, there are 2 interlaced Blades Bc at high speed.

In fig. 5, in counter clock-wise direction, the Blade Bc acceleration zone from 0 to 90 degrees, and deceleration zone from 90 to 135 degrees. Notice that for internal combustion engine, the first quadrant would be a compression stroke at low pressure, and the second (or the third) quadrant the gas relaxation high pressure zone where the pressure guidance will have positive effect (See 4.4).

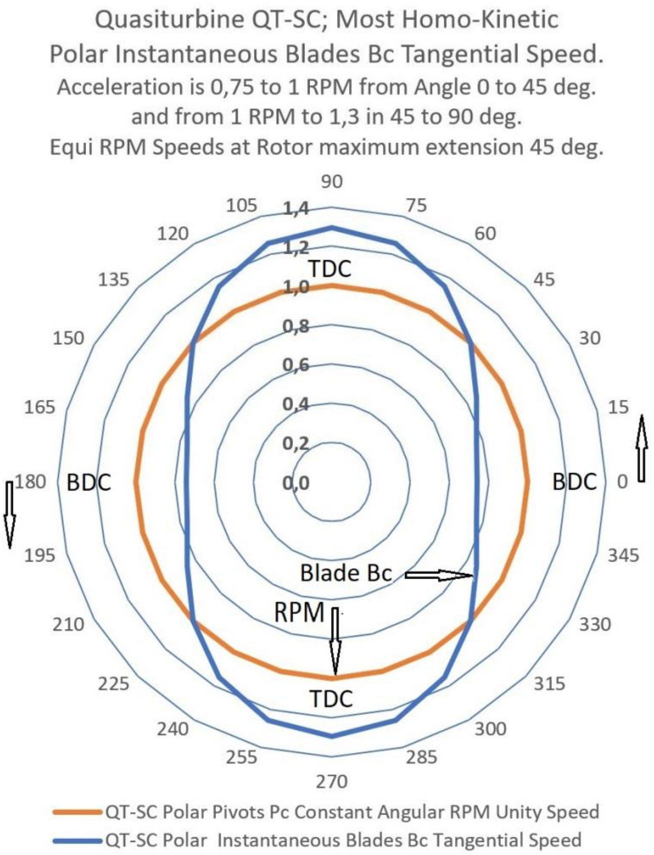

Figure 5: Quasiturbine QT-SC Homo-Kinetic Advantage RPM +/- 30 %**.** Polar Tangential Blade Bc speed, fast at TDC top and bottom, slow at BDC left and right. The resulting differential RPM is the Circle Pivot Pc speed, and central shaft output. In terms of component behavior, acceleration and deceleration refer to Blade Bc within a Rotor constant RPM.

Deceleration in second quadrant is consistent in accompanying the relaxation gas pressure also slowing down in speed and Energy. Every time the QT Stator gets in MRDR configuration (4 times per rotation) at the curve's intersections, the instantaneous 4 Blade Bc tangential speed gets the same as the RPM. In the transition between two successive square configurations, the Rotor gets its maximum deformation at a time where one set of opposed Blades Bc tangential speed is accelerating toward the small Stator diameter TDC area, while the other set is decelerating toward the large Stator diameter BDC area. Said otherwise, Blade Bc instantaneous tangential speed will get maximum in small Stator diameter area (TDC, top and bottom in photo), and minimum in large Stator diameter aera (BDC, left and right in photo).

The Blade Bc tangential speed reaches RPM speeds at every crossing of MRDR Rotor. Blade center Bc tangential speed variation is +/- 30 % of steady RPM, compared to Piston components velocity variation which goes from 0 to Max. Each of the QT Pivot Pc and Blade Bc spend equal time (angle) in high velocity sectors, and in the low-speed zone (right and left).

In the first quadrant, the QT Blade Bc acceleration is spread below and over the RPM from 0.7 to 1 RPM from Angle 0 to 45 degrees and from 1 RPM to 1.3 from 45 to 90 degrees, the strongest accelerations being near the 1 RPM circle, where the most part of the acceleration is done in the 30 degrees interval in-between 30 to 60 degrees, and same for the deceleration in the Stator.

4. QT-SC Support and Differential

4.1 QT Chamber Blade Pressure Load

From fig. 6, the pressure inside the QT Chamber can be considerable, and an underneath central Blade supporting system is necessary to prevent the Blade from collapsing toward the rotor central area. In the QT-SC this is assumed by wheel-bearing rolling on circular centered tracks, either fixed to each of the side covers, or on a cylinder-track part of the central shaft. As an alternative, the cross arms itself can be the supporting elements, providing they are robustly pivoting on the power shaft. Notice that the Detonation QT-AC uses no wheel-bearing, but transfers the load by the two adjacent vertical Blades directly to the opposite carriages. With knowhow of the QT Blades Bc angular movements, it is easier to review the whole QT-SC component behaviors in term of 4 distinct Tracks.

4.2 QT-SC Internal Tracks (fig. 6)

Track #0: The internal Stator wall is a fundamental track described elsewhere [13].

Track #1: Pivots of fix-square-Lozenge rotor in free space (square-Lozenge spinning with no deformation). This is the starting point of everything in QT: From this Track #1, a set of 3 arrows left and right show outward external deformation toward Track #2, while another set at top and bottom shows the inward deformation.

Track #2: Actual movement of the Rotor Pivots within the QT.

Track #3: Is not physical, but the geometrical perfect cycle followed by the Blade centers Bc, to which the differential Power cross arms can be attached.

Track #4: Physical surface circle attached to the QT side cover on which the wheel-bearing rolls while supporting the Blades under inward pressure. As an alternative, this track can be a cylindrical disk part of the main shaft, in which case the track rotates together with the wheel-bearing, which ones roll only a fraction of a turn alternatively forward and backward with minimal mechanical stress.

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4.3 Relative Sizes within the QT-SC Case Study

Notice on fig. 6 the forward Blade Bc270 being inside Track #1 at 270 degrees (dashed), while being on the outside at the left X-axis at 180, an interesting arbitrary decision of the designer. Simple but coherent dimensions make a case study still more interesting:

- The Lozenge side Pivot to Pivot is the unit of length, and the surface unit being a square of Lozenge side.
- Smallest Rotor diameter $((2.0)^{½} - 0.2) = 0.607$ is selected as the fix-square-Lozenge diameter of Track #1 less one Pivot diameter size.
- Largest Rotor diameter $((2.0)^{½} + 0.2) = 0.807$ is selected as the fix-square-Lozenge diameter of Track #1 plus 1 Pivot diameter.
- Maximum Rotor Deformation Ratio MRDR eccentricity (small diameter over large diameter) is = 0.753
- Small Stator diameter = $(2.0)^{½} = 1.414$ is selected as the fix-square-Lozenge diameter of Track #1.
- Large Stator diameter = $((2.0)^{½} + 2 * 0.2) = 1.814$ is selected as the fix-square-Lozenge diameter of Track #1 plus 2 Pivot size diameters.
- Stator Eccentricity (small diameter over large diameter) is = 0.779
- The Blade external surface cannot exceed the radius of Track #1 (see right Blade surface).
- Track #3 is nonphysical, but the Pivots diameter sizes are limited by the clearance of wheel-bearing Track #4 (see at bottom of fig. 6), or conversely, wheel-bearing diameter must be large enough to provide such a clearance.
- The Track #4 for rolling wheel-bearing can be either fixed to the QT side covers, or better on a cylinder part of the main shaft (preventing wheel-bearing to make several rotations per Rotor rotation by accompanying track #4.
- A relatively modest fraction of the Pivot size exceeds the Blade external surface as shown on the left of fig. 2.

4.4 Geometrical Rotor Pressure Guidance

Lozenge properties are most interesting particularly in presence of centrifugal forces, which counter balance themselves with no effect on the rotor deformation. The QT-SC does not require mechanical gear guidance, because re-shaping an extended X axis Lozenge Rotor to an extended Y axis, or further to an extended-X axis does not require any net Energy, not even much impulse, as Pivots Pc kinetic Energy keeps moving from one axis to the other. All 4 Pivots share an equal amount of kinetic Energy every time the Rotor gets in square configuration. In the QT, the Lozenge axis reversal occurs twice per rotation. This is a situation much different from the Wankel unbalanced triangular Rotor, which needs to be forced inward by Stator seals friction, or by a geared mechanism. For curiosity, a Lozenge can be brought back to square configuration by pressuring its center, but unfortunately, it would also require extra Energy to extend it.

Nevertheless, even if the QT-SC does not need mechanical guidance, in the Blade slowing tangential speed area of the stator (where some may argue seal stress?) the internal chamber pressure can be used to help pivoting Blade inward the Stator. As shown in fig. 6 at the down-right wheel-bearing by vector A and B, proper selection of wheel-bearing and rolling track diameter, the direction of the Blade supporting Forces is slightly move off center and the Blade forward part pushed by chamber pressure inward the Stator. This is because the contact zone of the wheel-bearing with the rolling track #4 becomes off center of the Blade. Be careful not to over design this off-balanced, which has double effects: what you take on one side, you remove it from the other which doubles the effects.

4.5 QT-SC Central Scissor Crossing Arms

Finally, fig. 6, layout suggests two central cross arms linked to their pair of diametrally opposed Bc points. These crossing arms are orthogonal only when the rotor gets in square configuration.

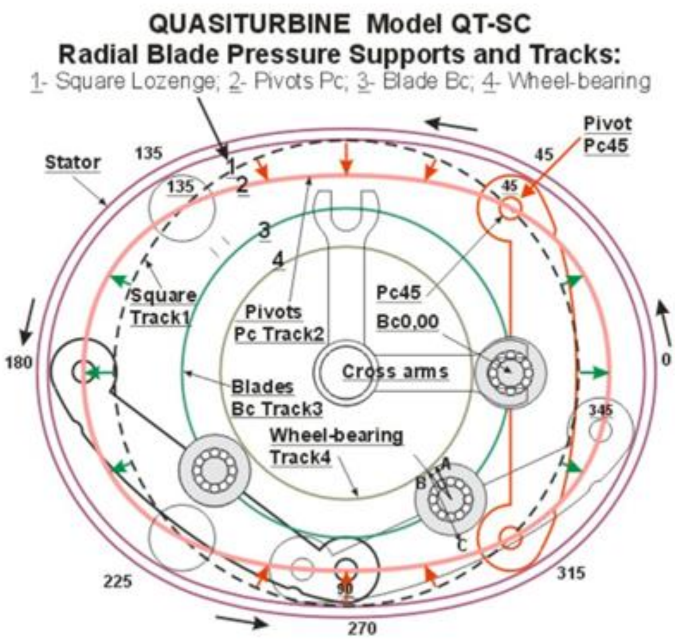

Figure 6: Quasiturbine QT-SC
Blade Pressure Support and Tracks.
Blades are supported by wheel-bearing rolling on Track #4.
Fix-square-Lozenge Pivot is Track #1,
and with Rotor Deformation the Track #2.
Mid-Blade center Bc are on circle (not physical) Track #3,
while simultaneously being the corners
of the Lozenge internal rectangle.

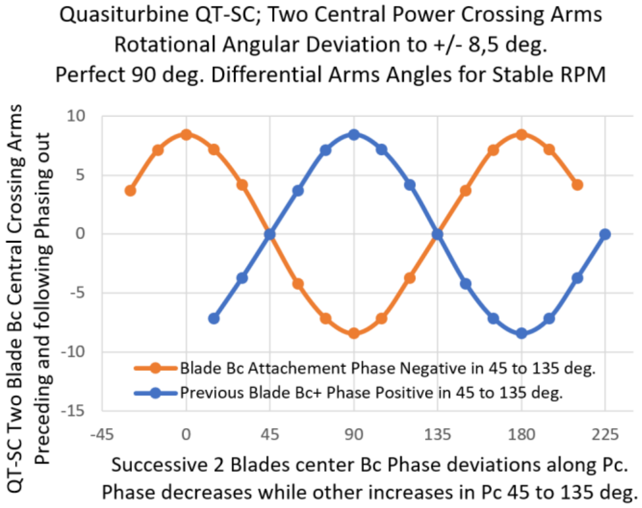

Figure 7: QT-SC Open Scissor-like Central Cross Arms. Oscillation and Differential cancellation to RPM. For 2 successive Blades Bc and Bc+ the phase differences do cancel, allowing the differential of the Crossing Arms to rotate at constant Rotor RPM.

From fig. 7, the movement of these 2 pairs of Bc points pertains to interlaced (successive) Blades with perfectly sinusoidal phase out, varying exactly in opposed direction and with the same amplitude, like two Central Open Scissor Crossing Arms.

Analytic equation:
Bc Cross arm Phase Amplitude = 1 + (0.3 * COS (2 * (PcAngle + 45) * PI () / 180))

The difference (Pc – Bc) = 45 degrees deviates up to +/- 8.5 degrees when away from the Pivot Pc 45 and 135 degrees, because the Blades Bc are not rotating at constant RPM. From fig. 7, however, for two successive Blades Bc and Bc+ the phases deviations do cancel, allowing the differential of the Crossing Arms to rotate at constant Rotor RPM. It is the role of any simple differential device to make this kind of average if linking the 2 open scissor crossing arms.

4.6 Central Differential

One of the deformable QT rotor challenges is to make the rotor geometry to rotate at a constant smooth angular speed. A single arm linked to a pair of opposed Blades Bc point cannot directly smoothly drive the central shaft. From any Lozenge Pivots Pc point of view, the angles variations appear to open or close symmetrically, the line between 1 set of opposed Blades Bc points is crossing the line of the other set at angle in the Rotor center, offering linkage shaft option. There are so many differential concepts adaptable to the QT power crossing arms, the matter is not included in this work.

5. Comparing QT-SC with Piston

5.1 QT versus Engine Comparison Options

The matter is about direct transformation of pressure into mechanical useful Energy. The valuable characteristics of the piston concept is its ability to reach most demanding high compression ratio, but with the inconvenient of intermittent flow and large axial movement. Numerous simple rotary engine concepts based on vane type pump can geometrically achieve only moderate compression ratio, while limiting radial movement to avoid problematic large seals extension. More complex rotary design can achieve higher compression ratio by moving radially a solid rotor in and out of a stator wall, a problematic radial movement of mass hard to counter-balance and making vibrations affecting lifetime of devices and its environment. In QT, it is rather the stator wall which gets closer to the rotor, as the QT rotor mass is not moving radially, Bc being on a circle. Conventional hydro-or aerodynamic turbines are unable to directly transform pressure to mechanical Energy without an intermediary step, which is to first transformed pressure in high velocity fluid. As the conventional turbine, the Quasiturbine (QT) is a perfectly balanced zero dead time device, but with low RPM and high Torque for rotary pump, expander and engine.

The Wankel Rotary is a hybrid engine in the sense that 2/3 of the power comes from crank shaft inward radial (piston like) movement, and 1/3 from tangential true rotary force. Its power shaft rotates at three times the rotor RPM to generate low Torque high RPM output. Furthermore, the Wankel challenge is attempting to achieve 4 strokes with overlapping 3 faces unbalanced rotor, which often are assembled in out of phase pair or trio (stages) to somehow mask the apparent vibration, but still being source of mechanical internal stress. A detail QT-Wankel comparison is not as straight forward as the Piston, but of limited interest here, suffice to mention that the Quasiturbine has a 4 faces rotor naturally suitable for non-overlapping 4 strokes cycles, and a rotor perfectly balanced that does not need to be assembled in engine pairs to cancel inexistant vibration. Furthermore, QT provides without high costly sensitive gearbox, the High-Torque low-RPM power output generally in demand by current applications. … Statements saying that QT looks like the Wankel is barely a compliment, but QT behaviors are totally different and the weaknesses attributed to Wankel over the years are irrelevant to the QT. These comparative concepts are interesting and valuable but do not target global objectives in regard to modern fuel, hydrogen use and detonation capability and efficiency.

5.2 Comparison Models and Data Sources

Most engine concepts can be statically compared to a simple single stage expander feed at the entrance by a compressible or incompressible fluid under constant pressure. The simplest expander is a long tube held at constant pressure at one end, with a piston free to move on Energy demand in the tube for any Delta Volume variation. In practice to shorten the tube, the moving piston position has to be periodically repositioned near the tube entrance, and that is what expander designs do. For this work, both QT-SC and Piston will be statically compared through reference with a single stage expander at constant pressure, without considering specific complex dynamic combustion or detonation cycle.

Piston is described by a simple theoretical 3R+/-1R model, having a connecting rod of 3 crankshaft radius, used as a single stage constant pressure expander (Expander mode at intake constant pressure – No fuel mixture):
Volume = Piston translation = (4 - 3R+/-1R) / 2 for R (Angle 0 to 180 degrees)
Torque = Crankshaft Tangential component (Angle) of Piston axial pressure force.
Delta Energy = Torque X Delta Vol.
QT-SC equivalent data are obtained from the Layout of fig. 2 for the expander mode under the same constant unit pressure:
Volume = Surface 2D Chambre Volume = 17 % of the square unit lozenge surface.
Torque = (Forward seal radius – Tailing seal radius) X Average Radius X Unit pressure
Delta Energy = Torque X Delta Vol.

For each Blade Bc at Pc angle position, tangential force producing the Torque is function of the Radius difference at extremities of each individual Blade, multiplied by this average radius lever and unit pressure. The QT layout of fig. 2 easily provides these data.

5.3 QT-SC versus Piston, Volume-Torque Comparisons

The volumetric profile is probably the most fundamental characteristic of any engine design. For the QT reference case arrangement (the QT-SC), it is determined by 4 design factors: The selected lozenge Blade length side Pivot-to-Pivot; The Pivots sizes (as a fraction of the blade); The Maximum Rotor Deformation Ratio MRDR selection; And the shape of 2 independent stator seed branches selected when calculating the rotor confinement profile. It is simple, but subject to considerable variations through the QT family of designs, not always obviously predictable.

To compare volume cycle curves in a single stroke, one must keep in mind that QT completes 16 strokes in every rotation simultaneously for both 2-X and 2-Y chambers, while Piston does 2 strokes per revolution. For comparison with adjusted time scale, both QT and Piston cycle have been made to coincide at maximum and minimum volumes on fig. 8. Power Strokes are interlaced in Piston by intake or exhaust Strokes of negative Torque, which stays negative before and after the Stroke of interest here. In contrary, power Strokes are sequential in all QT, and Torque stay positive before and after as shown as QT end-effect on fig. 8 and the same also applies for Delta Volume and Delta Energy of fig. 9 and fig. 10.

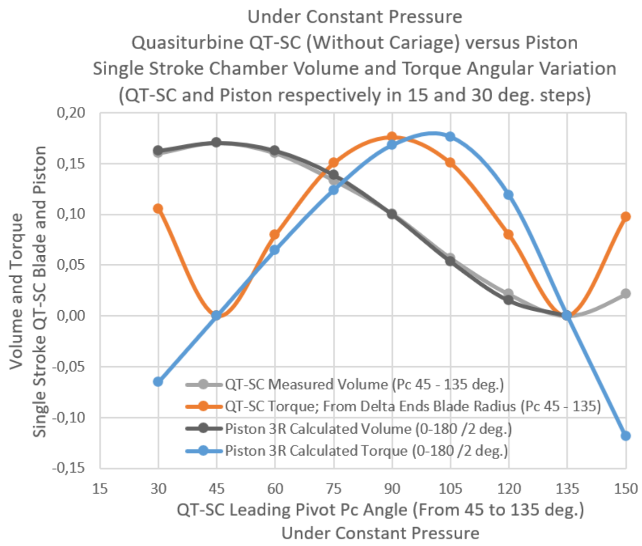

Figure 8: Quasiturbine QT-SC versus Piston, (Expander-pump mode at constant pressure – No fuel mixture). Comparison of Volume and Torque (shown positive) over a complete stroke. QT Chamber Volumes from Max to Min. are compared to the 3R+/-1R Piston Model

In fig. 8, the QT-SC and Piston variation are almost identical. The Torque, proportional to the Blades ends Radius differential presents symmetry somewhat surprising but resulting from symmetry in the QT Stator. The Torque, proportional to the Blades ends Radius differential, increases much faster than the chamber volume at BDC, and is symmetrical. As the Piston achieves volume variation with velocity varying from 0 to Max, the QT Blade Bc velocity varies smoothly in a much more limited range from only 70 to 130 % of the RPM. Nevertheless, QT-AC can achieve shorter and faster pressure FLASH pulse in demand for modern fast combustibles. While of another nature, the QT-SC rotor blades shows behavior similarities with Piston movement. It is not a weakness, but rather reassuring by establishing at least a point of convergence between both concepts, and thus enforcing the solid basis of the QT alternative.

5.4 QT-SC versus Piston, Volume and Delta Volume

In pump, expander and engine, the volume chambers are used alternatively as intake or exhaust, one being the other if the direction of rotation is inverted. On fig. 9 the movement from Pc45 to Pc135 is compressing as the chamber volume contracts, while the Pc135 to Pc225 would be in relaxation power zone as volume increases.

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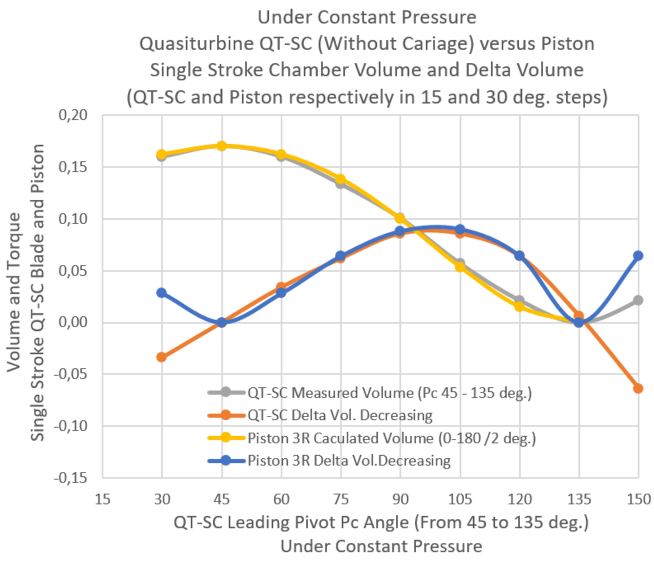

Figure 9: Quasiturbine QT-SC Delta versus Piston (Expander-Pump mode at constant pressure – No fuel mixture). From calculated Torque, a comparison of Volume and Delta Volume (shown positive) in an entire Stroke.

On fig. 9 is a comparison over a full stroke of the QT-SC and Piston for Volume variation and the Incremental Delta Volume per intervals of either 15 or 30 degrees (for Piston). Delta Volume values are said positive when chamber increases volume, and negative when chamber volume decreases. From previous and following interlaced Piston zero Torque strokes, Piston volume is not inverted positive as end-effect is as in fig. 8.

5.5 QT-SC versus Piston, Delta Volume and Energy

The Torque being known for any volume step increment (or decrement) in the chamber, this amount of Energy distribution (Power) over a stroke is presented in fig. 10.

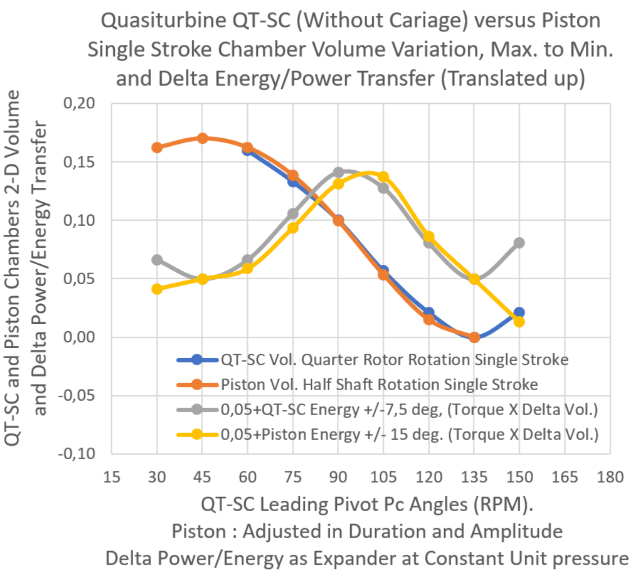

Figure 10: Quasiturbine QT-SC Energy versus Piston (Expander-pump mode at constant pressure – No fuel mixture). Comparison of Volume and Delta Energy increment (Derivative) (Curves translated up for clarity).

Delta Energy/Power = Instantaneous Torque X Delta Chamber Volume for both QT and Piston.

The object of this chapter analysis is on fig. 10, mainly about a Single Stroke Volume Cycle Comparison, which is not revealing on volume analysis alone, a fundamental difference between QT and Piston. This need explanations next.

5.6 Where are the QT / Piston differences?

From the Chamber Volume consideration, it appears that the QT-SC and the Piston are almost equivalent devices, which is not a negative observation, but fundamental differences are elsewhere from the internal component's behaviors. QT fires on Blade Bc moving at RPM + 30 % speed, while Piston fires at rest, and QT relaxation occurs in a Blade Bc deceleration down to RPM - 30 %, while Piston relaxation goes from rest, followed by acceleration and deceleration, and ends at zero speed. The fact that QT is much more Homo-Kinetic matches better the fluid flow within the device. Additional differences relate to Vibration, Displacement, Power Density, High-Torque at lower RPM, no extra flywheel, less gearbox needed… weight and overall rotary efficiencies, not forgetting manufacturing cost.

The 4 Blades concept makes QT capable to simultaneously intake and compress (or relax and exhaust) in two diametrally opposed areas of the stator, just like having two engines (or pressure circuits) in one. In two strokes application like in pump or steam expander, for each QT rotation one circuit intakes and exhausts 4 chambers volume (for a total of 8 strokes), while the other diametrally opposed circuit does simultaneously another 8 strokes, for a total of 16 strokes per rotation. For 4 strokes applications like internal combustion, the two circuits can be used in serial for completing 4 times the 4 strokes (Still 16 strokes) in a single rotor rotation. If the rotor is allowed to make a second rotation then 32 strokes are completed, exactly the same number as occurring in a 8 cylinders 4 strokes piston engine during 2 crankshaft rotations. Said otherwise, the two engines within a single QT permit to match much larger 8 cylinders engines.

Expelling fluid from the chamber is also an important step, and it is done differently as Piston starts from rest and ends at zero speed, while the QT starts the process from RPM less 30 % Blade Bc speed and ends at RPM plus 30 %. QT component fluidity offers a better follow up of the exhaust. Overall QT engine comparison has been done elsewhere [12].

6. Detonation QT-AC (with carriages)

6.1 Detonation versus Combustion

Detonation includes HCCI (Homogeneous Compression Combustion Ignition), Shockwaves and Photo-Detonation… excluding Diesel (Thermal ignition of conventional combustion). Because of its sinusoidal nature, the Piston is at rest near Top Dead Center TDC, and can deal only with relatively slow and partial combustion process, like thermal combustion front propagation. Light and radiation are like fluids and are concentrated by mechanical compression (similarly as a lens does), and can ignite a fuel mixture in a very fast shock wave or photo-detonation mode, not friendly compatible with slow piston. This is becoming an efficiency issue also because modern fuel including hydrogen, tends to burn faster in some environment. Detonation engine must ideally produce a short flash compression pulse, immediately followed by a rapid relaxation Energy recovery, characteristic not offered by Piston.

If large surface to volume ratio is not desirable in conventional combustion engine, it can become a precious attenuation pressure factor in a detonation chamber. The paradox challenge is to conciliate high compression ratio, while maintaining high surface to volume ratio. The QT-AC (with carriages, Seals at variable distances) is an opening toward Detonation Engine Challenge.

6.2 Detonation QT-AC Description

The QT-AC stator in fig. 11 looks rather rectangular shaped, and not as elliptical as the QT-SC. It is a sort of giant roller bearing! Blade pressure toward center is not supported from the central area as in the QT-SC does, but a force transfer is done through the interlaced vertical Blades and finally to the carriages. Consequently, it does not offer a geometrical Rotor square configuration guidance force from pressure applied to Blade surface, which is not needed as the carriages handle guiding. The geometry is consistent with High-Torque and low RPM nature of the QT.

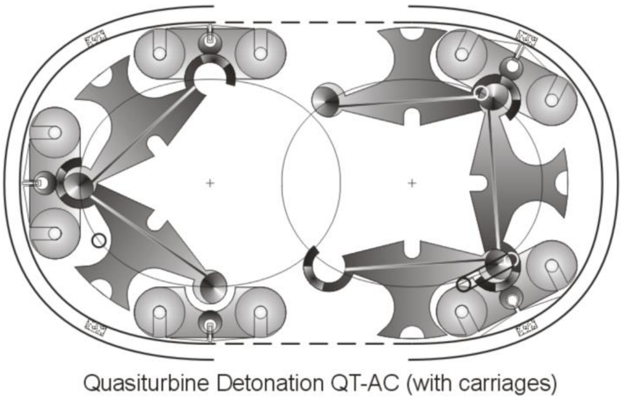

Figure 11: Quasiturbine QT-AC (with carriages, Seals at variable distances). On the left, two mid-stroke chambers. On the right, a maximum chamber volume at BDC, with top and bottom carriages being shared with minimum chambers volume at TDC. Hinges are different from the QT-SC design.

In detonation mode fig. 11, no effort is needed to reduce the surface to volume ratio of the carriages shape. Hinges friction, carriages rolling friction free on the contour confinement Stator, sealing laterally and at contour, may not be straight forward, but can all be tackled by standard solutions. The QT-AC Rotor has an exceptionally high degree of freedom which led to infinite number of geometry and as well Stator contour shapes to constrain the desired combinations.

6.3 QT-AC Volume Innovation versus Piston

Engine theory (with combustion and detonation in particular) must be based on the specific device behavior for appropriate analysis. Piston devices of sinusoidal crankshaft type, where the instantaneous speed of the piston is zero at minimum chamber volume TDC (top maximum pressure), do favor relatively slow-speed combustion fuel. Referring to the same simple static mathematical Piston 3R+/-1R model used for the QT-SC, an instantaneous QT-AC Volume and Torque comparison is shown in fig. 12 for constant pressure expander mode.

Details are presented in fig. 12 (Expander-pump mode at constant pressure – No fuel mixture), with decreasing chambers volume (compression stroke) from 45 to 135 degrees. Referring to piston volume curve from the BDC at 0 degree, the QT-AC initiates the compression much before the Piston from the 50 degrees zone and keeps compressing at the same Piston rate until the curves cross at 105 degrees where the chambers volume gets equal. Then the Piston keeps compressing faster before slowing down horizontally in the top pressure zone, while at contrary the QT-AC continues compressing slowly on a short plateau, before acceleration for a brief narrower flash pressure pulse compatible with detonation. The slopes of the volume curves in the 120 to 135 degrees are confirming the same. Symmetry of Torque curve is surprising but results from symmetry in the QT Stator.

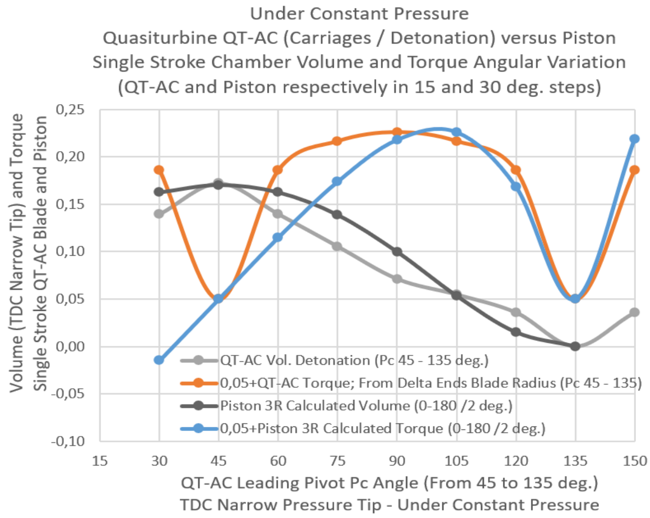

Figure 12: Quasiturbine QT-AC and Piston Chambers Volume (Expander-pump mode at constant pressure – No fuel mixture). Early decreasing Volume from 45 to 135 degrees, and crossing at 105 degrees followed by steeper flash compression slope at TDC. QT-AC Torque curve (translated up for clarity) is wider and slightly earlier than Piston (For better comparison, Piston is shown positive pass the TDC, while impossible in practice).

As seen on fig. 12, QT-AC has a very different Volume behavior from Piston, as the pivoting Blades tangential speed is maximal at top pressure and minimal in the Torque making before mid-stroke section, which favors relatively high-speed combustion fuel. The detonation originality shape-up in the 120 to 135 degrees where the compression slopes are very different, the Piston going horizontally at constant volume to the TDC, while the QT-AC waits and plunges making a flash short pressure pulse, initiating the detonation at the most convenient time. This shows the limits in improving a specific device like Piston for Detonation, and modern challenge needs device with very different behavior.

The fig. 12 shows a nearly linear QT-AC variation on both sides of the minimum TDC chamber volume at 135 degrees. Near TDC small effect on chamber volume has considerable effect on pressure profile, while this triangular tip characteristic at TDC can be attenuated or accentuated by selection of physical Rotor characteristics like the Pivot diameter, the diameter of the supporting wheel or the selection of the Stator confinement shape. Triangular volume tip reduces the mixture confinement time, which does favor fast burning mixture (leading to detonation). It does also prevent too high-pressure way before the TDC, avoiding catastrophic early self-detonation, while brief confinement time reduces the stress on the device. Furthermore, with this short pressure tip comes another important characteristic which is the ability to produce early Torque and mechanical Energy conversion. After detonation, pressure is all there ready for a rapid chamber volume relaxation in delivering pressure Energy. The Diagram of fig. 12 does not detail the expected substantial Torque improvement at TDC.

6.4 Carriages Effect on Chamber Volume

One of the reasons for introducing the carriages in the Detonation QT version was to vary the distances between the contour seals, which is fixed in the QT-SC. The rocking movement of the carriages extends the distance between seals at maximum chamber volume BDC, and shortens it reasonably at TDC. Referring to a QT-AC Lozenge Pivot-to-Pivot length of 1, the Seals distance at maximum chamber volume BDC measured along the inner Stator wall is 2.04 (1.66 in straight line), while the distance at TDC becomes only 1.03 (shorten by 35 to 100 %). Interestingly, the carriages separate the TDC chamber from two BDC, and while shortening the distances in TDC, they do increase them in neighbor BDC chamber. In term of volume %, the effect is considerable in TDC chamber, where it does also append the most rapidly to generate the short flash pressure pulse, or early Torque Energy conversion.

Why are the QT-AC and Piston Volume variation curves so different? The presence of the carriages QT-AC produces an early reduction of volume with effect right when quitting the maximum chamber volume at BDC at 45 degrees, and keeps its initial effect until the curves cross at 105 degrees. Then, from 105 to 120 degrees the forward carriage rocks in the opposite direction of the tailing one, which partially cancel the Volume variation, establishing a short nearly constant volume plateau. In the next final 15 degrees the compression in the chamber increases simultaneously from 3 directions, the Stator getting closer to the Rotor, and the two carriages pivoting closer to one another. These triple fast and localized actions are at the origin of the QT-AC flash pressure pulse at TDC.

If the carriages are responsible for the flash pressure pulse at TDC, they are also responsible for an ultrafast increase of the chamber volume just after the detonation. Carriages make the QT-AC able of early conversion of the detonation Energy in Torque action, while limiting the mechanical stress on the engine overall components. This is an ability the Piston does not have, and it is the reason for which detonation shocks are so damaging. Carriages are also responsible of large chamber surface to volume Ratio, which would be detrimental in a conventional combustion engine, but becomes an attenuating pressure pulse factor in detonation mode.

6.5 QT-AC Torque along power Stroke

On fig. 12, the capacity of the Piston to generate Torque (curve translated up for clarity) is asymmetric due to connecting rod angle on the crank shaft, but most favorable in the early third of the stroke following ignition, while the QT-AC Torque ability begins slightly earlier (which is critical due to detonation speed) and is quite steady and symmetrical throughout. Graph does not provide fine detail close to the flash compression pulse, but chamber volume slope variation favors the QT-AC, as the slope of the Torque build-up is steeper near top TDC.

6.6 QT-AC Detonation Advantage

Particularly for Detonation, the Piston is handicaped by its poor fluidity of movement with extreme components speed range and acceleration-deceleration stresses. In every rotation, the Piston and connecting rod beginning from rest, do accelerate, decelerate, stop, and re-accelerate, decelerate and return to rest again; unfortunately, the fast Detonation is occurring in a Piston stop zone. At contrary, the near Homo-Kinetic Quasiturbine has a set of Rotor Blades turning non-stop at mean RPM +/- 30 %, and better, the Detonation occurs in the fastest Blade moving zone. This support the argument that Detonation engine need a concept much different that the Piston device and so far, the QT-AC is the natural pretendant.

The QT-AC (with carriages, Seals at variable distances) is an open window toward the difficult Detonation Engine Challenge. Because of its sinusoidal nature, the Piston can deal only with relatively slow and partial combustion process, away from light and radiation fuel mixture ignition in very fast shock wave or photo-detonation mode. This is becoming an efficiency issue also because modern fuels, including hydrogen, tend to burn faster under most condition. The Detonation QT-AC engine produces this kind of needed short flash compression pulse, with a rapid relaxation Energy recovery. Furthermore, it offers a large surface to volume ratio as an attenuation pressure factor. Interestingly, QT-AC conciliates high compression ratio, while maintaining high surface to volume ratio at TDC.

7. QT-SC Internal Design Options

7.1 Rotor without Lateral Friction Seal

QT side cover seals are not much different from other rotary seal design. Friction seals maybe best, but in some pump/expander applications close wall contact can be sufficient at moderate RPM.

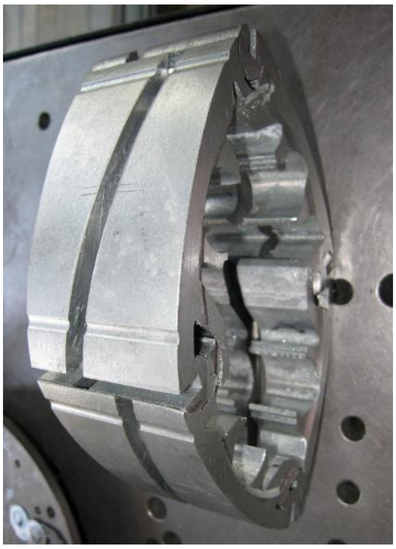

Figure 13: Quasiturbine QT-SC obliquely Split Rotor Blade allows to substitute lateral friction seal by a peripheral (no friction) expansion spring seal, in some moderate RPM application

In an effort to make things simple and less expensive, fig. 13, shows one way to substitute fragile side friction seals by oblique splitting the Blades to insert a peripheral spring seal (no friction) pushing the blade part against the side covers. If the Blade contact zones with side covers are near the top surface and if in contrary the seals are somewhat under the Blade surface, the chamber pressure can add a positive force pushing further each half piece against their respective wall. This is possible while keeping the deformable Lozenge Rotor together as a single component, because oblique cut allows the hinges to match off center rotor plane, and ensure that both Blade sides keep moving together at the same speed, and prevents the rotor to fall apart during technical service.

7.2 QT Scalable

QT is fully scalable up and down providing simple standard fluid flow rules. Displacement goes up as the cube of the QT linear dimensions, such that the port section needs to increase more than the square, and needs additional sectional surface increases to keep down the flow velocity at a fraction of the sound speed. In all cases, QT expander efficiency measurements must be done at the immediate entrance and exit, excluding any portion of the feed line.

7.3 Air or fluid cushion hinges

The Rotor must have some provision to allow a little more Deformation that the theoretical maximum MRDR deformation required by the stator. Permitting some pressurized gas or fluid infiltration in the QT Blade hinge system (together male and female and/or the carriages) makes film cushion and reduces friction.

8. Conclusions

This work is about detailed description of Quasiturbine internal components, their behaviors and the comparison with Piston device. In addition to the perfectly balance Lozenge geometry, every QT Rotor Blade moves on a perfect circle without any radial mass movement, and it is rather the static stator wall which gets close to the Blades to modulate the volume. The QT Lozenge Rotor has 3 noticeable properties: no radial mass movement for perfect balancing; the centrifugal forces have no net effect on the deformation; and its inertia is equivalent to solid flywheel. QT is able of high compression ratio, and have excellent intake and ventilation flow cycle, while being largely scalable up and down. QT appends to be two engines in one (two areas of compression and relaxation) for high power density, where total engine displacements can practically exceed its external device volume, making it suitable for very compact power unit running smoothly without vibration. Moderate QT-SC engine parameters selection allows the use of the device as an efficient engine, but also as a pump, compressor, expander, steam, hydraulic, flow-meter, etc. General introductions are available at [21]-[24].

When compared to Piston, the QT-SC chambers volume variations match almost perfectly over a full stroke (confirming at least a basic equivalence), while the Torque and Energy tend to be more uniformly spread in QT-SC within the stroke time frame. However, the components behaviors are very different in moving the masses, the QT being a perfectly balanced vibration free device, while the linear Piston geometry is not (Immobile center of mass is impossible in Piston device). Another major behavior difference is about the components speed and their role; while the Piston reaches maximum speed in between resting piston at top and bottom, QT has exceptional Homo-Kinetic proprieties with rotor components speeding nonstop at +/- 30 % of RPM. Still more contrasting in the combustion engine, the mixture fires when the piston is resting at TDC, while in QT it appends when the Blades reach their maximum tangential speed.

However, the Piston chamber volume variation does not compare at all when considering the Detonation QT-AC (with carriages, Seals at variable distances), which is an opening toward the difficult Detonation Engine Challenge which is becoming an efficiency issue, because modern fuel including hydrogen tends to burn faster in some environment. The QT-AC detonation engine produces the needed triggering short flash compression pulse, and is capable of rapid relaxation Energy recovery. Interestingly, QT-AC conciliates high compression ratio, while maintaining high surface to volume ratio as an attenuating chock-pressure factor. Because of its sinusoidal nature, the Piston can deal only with relatively slow and partial combustion process. Particularly for Detonation, the Piston is handicaped by its poor fluidity of movement (Piston at rest) with extreme components speed range and acceleration-deceleration stresses, and unfortunately, the

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fast Detonation needs to occur in a Piston rest zone, while in the Detonation QT-AC (as the combustion) it occurs in the fastest Blade moving zone.

Contrary to the 4-strokes combustion Piston, which power strokes are interlaced with intake (negative Torque neutralized by flywheel), QT power strokes are sequential and uninterrupted, with the Rotor acting as conventional solid flywheel, with no addition required. The QT Low RPM High Torque requires less costly gearbox in many applications. The perfectly balanced and vibration free QT are not only convenient, but help robustness and live extension of engine. A small number of critical pieces in QT design is always attractive, limiting the vulnerability and reducing the manufacturing and maintenance cost.

The objective of the present paper is to expose the non-obvious behavior of QT internal components, and situate the place of the QT devices in the world of modern engine, including with Combustion and Detonation today achievements. Present QT-SC and AC are cases studied with moderate rotor deformation, and with regular Stator shapes, but the Quasiturbine parameters spread is much wider than current engines like Piston, and may offer a number of possibilities not yet explored.

References

[1] P. Sankar Subbaiah. “Scope of Quasiturbine-A Written Analysis “. IJRAR, Vol.5, Issue 2, 2018 https://ijrar. org/papers/IJRAR1CBP046.pdf
[2] Akash Ampat, Siddhant Gaidhani et al. “A Review on Application of the Quasiturbine Engine as a Replacement for the Standard Piston Engine “. International Ideas in Mechanical Engineering (ICIIIME 2017) IJRITCC Vol.5, Issue: 6, 2017 http://www.ijritcc. org
[3] Pranjal Yadav, Amit Tiwari et al. “Scope of Quasiturbine: A Review Analysis “. IJARSE Vol.06, 2017 https://www.researchgate. net/publication/326676184_Scope_of_Quasi_Turbine A_Review_Analysis
[4] Yogesh Khedkar, Sushant Pande. “Review of Quasiturbine Engine “. IJIRSET Vol.5, Issue 10, 2016 http://quasiturbine. promci. qc. ca/QTPapiers/2016IJIRSETKhedkar Review of Quasiturbine Engine.pdf
[5] Patil Shital, Rananavare et al. “Review of Quasiturbine Rotary Air Engine “. IJRME Vol.3, Issue 2, 2015 https://iaeme. com/MasterAdmin/Journal_uploads/IJRME/VOLUME_3_ISSUE_2/IJRME_03_02_005.pdf
[6] K. M. Jagadale, Prof V. R. Gambhire. “A New Trend in Turbine Technology-Quasiturbine Rotary Air Engine”, International Journal for Technological Research in Engineering IJTRE, Vol.1, Issue 12, 2014. http://quasiturbine. promci. qc. ca/QTPapiers/2014IJFTRJagadaleTrendQuasiturbineAirEngine.pdf
[7] Chris VS Cars. “Quasiturbine, a Different take on the Rotary Engine “. (Video 5 min.), 2021 https://www.youtube. com/watch?v=NJrr6CxWQTc
[8] AM Gambelli, M Filipponi et al. “Performance analysis of a small-size CAES Quasiturbine system “. *AIP Conf. Proc.*2191, 020086, 2019 https://aip. scitation. org/doi/pdf/10.1063/1.5138819
[9] Pankaj Dahiya. “Study of Working and Construction of Quasiturbine Engines in Vehicles “. M. Tech. (Civil Engg.), CBS Group of Institutions, Jhajjar, Haryana https://docslib. org/doc/7733251/study-of-working-and-construction-of-quasi-turbine-engines-in-vehicles
[10] Kaushik Shailendra Bajaj, Shrikant U. Gunjal. “A Review on Six Stroke, High Efficiency Quasiturbine Engine “. Vol. No.2, Issue 03, 2016. http://ijirse. com/wp-content/upload/2016/02/401N.pdf
[11] K. M. Jagadale, Prof V. R. Gambhire. “Low Pressure High-Torque Quasiturbine Rotary Air Engine “. JIRSET Vol.3, Issue 8, 2014 www.ijirset. com https://docslib. org/doc/356643/low-pressure-high-torque-quasi-turbine-rotary-air-engine
[12] Saint-Hilaire et al. “Quasiturbine High Power Density Pump-Expander-Engine with Displacement Exceeding External Device Volume “. International Journal of Science and Research IJSR, Vol.11 Issue 7, 2022 https://www.ijsr.net/getabstract. php?paperid=SR22704112446
[13] Saint-Hilaire et al. “Quasiturbine Rotary Engine Stator Confinement Profile Computation and Analysis “. International Journal of Science and Research IJSR, Vol.10 Issue 3, 2021 https://www.ijsr.net/getabstract. php?paperid=SR21313004008
[14] Saint-Hilaire et al. “Quasiturbine Low RPM High-Torque Pressure Driven Turbine for Top Efficiency Power Modulation “. Turbine Institute and ASME-American Society. Review paper, 2007. http://quasiturbine. promci. qc. ca/QTPapiers/ASME2007QTMontreal.pdf
[15] Quasiturbine “Website “. http://www.quasiturbine. com
[16] B Castellani, E Morini et al. “Small-scale CAES compressed air energy storage Quasiturbine application for renewable energy integration in a listed building “. Energies 2018, *11* (7), 1921, 2018 https://doi. org/10.3390/en11071921
[17] G. Manfrida, R. Secch. “Performance Prediction of a Small-Size Adiabatic Compressed-Air Energy Storage System (2 kW Quasiturbine) “. International Journal of Thermodynamics (IJoT) Vol.18 (No.2), 2015
[18] Mohammed Akram. “Quasiturbine Rotor Development Optimization “. Thesis. UTHM 2014 http://eprints. uthm.edu. my/1537/1/24p%20MOHAMMED%20AKRAM%20MOHAMMED.pdf
[19] Kadam A. N., Mr. Jadhav S. S. “Quasiturbine Rotary Air Engine ”. IOSR Journal of Mechanical and Civil Engineering.2008 http://quasiturbine. promci. qc. ca/QTPapiers/2013IOSR-JMCE Jagadale Quasiturbine Rotary Engine Density.pdf
[20] Harry Valentine. “Using the Quasiturbine to Regulate Natural Gas Pipeline Pressure and Flow-rate “. Energy Central, 2005 https://energycentral. com/c/gn/using-quasiturbine-regulate-natural-gas-pipeline-pressure-and-flow-rate

[21] Brian Cowan. (Article) “Quasiturbine: Unusual Engines-Turbine Tale “. Engine Technology International Magazine, and the Stuttgart Engine-Expo Messe, Germany.2009 http://quasiturbine. promci. qc. ca/Presse/EngineTechIntl0609. htm
[22] William Harris. (Article) “How Quasiturbine Engines Work “. HowStuffWorks, 2005 https://auto. howstuffworks. com/quasiturbine. htm
[23] David H. Bode. (Article) “Quasiturbine Engine: Designated the 21st century engine “. Diesel Progress USA Magazine, 2000 http://quasiturbine. promci. qc. ca/DieselUSA0004.html
[24] Mark Fletcher. (Article) “Quasiturbine Engine: Designated the 21st century engine “. Europea Automotive Design Magazine, 1999 http://quasiturbine. promci. qc. ca/EADSept99.html

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Definition / Abbreviation

QT-SC Without Carriage
QT-AC With Carriages
MRDR – QT Max. Rotor Deformation Ratio
TDC-Top Dead Center (Piston)
BDC-Bottom Dead Center (Piston)
Pc-Pivot center (QT Pivot)
Bc-Blade center (QT Blade)

NOTE: This scientific disclosure does not constitute permission for commercial manufacturing.