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Quasiturbine Rotary Engine Stator Confinement Profile Computation and Analysis

Gilles Saint-Hilaire Ph.D.[1], Roxan Saint-Hilaire MBA[2], Ylian Saint-Hilaire M.Sc.[3], Françoise Saint-Hilaire M.Let[4]

[1]Quasiturbine Académie, Montréal, Québec, Canada

Abstract: ***Among the most frequent questions asked about the Quasiturbine « QT » are: Why is a central differential needed? And how is the stator confinement profile calculated? These are strategic elements reluctantly discussed by the inventors in the past 20 years. Many are convinced that computing the correct confinement profile of the Quasiturbine rotor is not simple task, and the purpose of this paper is to help understanding the matter and the underling characteristics. Unaware of the real difficulty, some are reporting elementary solution attempts, but missing ways to control their exactitude, they are so far neither reliable, nor precise enough. Quasiturbine confinement profile is discussed in a USA patent, and exact solutions are graphically presented as the « Saint-Hilaire skating rink profile » (named after the physicist who first made exact calculations) by analogy to well-known sport skating rink. As a first hint, notice that ellipses are not acceptable solutions, which are far from unique due to undetermined nature of the Quasiturbine rotor. Contrary to circular constraints of piston engine and conventional turbine, the asymmetrical « multi degrees of freedom » concept of the Quasiturbine offers a wide variety of underlying innovative design options, and working characteristics.***

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

Keywords: Quasiturbine; Rotary engine; Steam engine; Air engine; Rotary pump

1. Quasiturbine rotor description

The QT rotor is a deformable chain of 4 interconnected blades by pivoting hinge at their ends [1], [2]. As such, there is no rotor constraint or limitation to its square and lozenge shape, and holding it by hands reveals a feeling somewhat like a mechanical Jell-O! [3]. This rotor can be placed within a close fit circular confinement, where it can rotate freely in square configuration. Notice the 4 constant and equal volume chambers between each pivoting blade and the internal circular wall, which then does not suggest much interest to the device. Now imagine the closed fit circular confinement profile (stator) being squished in a bench vice (or anvil) and permanently deformed, then outer blades chambers would have different sizes during rotation (assuming it would rotate), while opposed chambers across the rotor center would have same volumes.

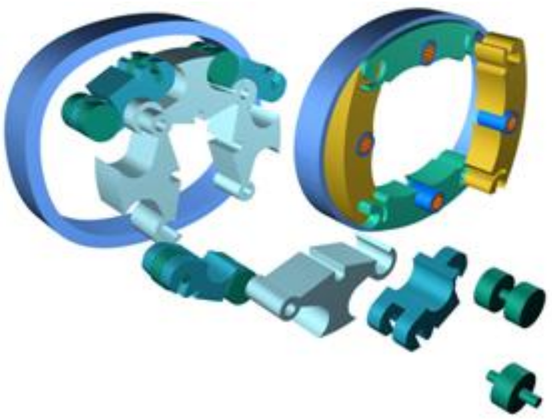

Photo A – The Quasiturbine « QT » with carriages rotor arrangement www.quasiturbine.com base on optional manufacturing design.

2. Understanding the rotor geometry

2.1 Rotor is not confined

Opposed pivots are co-linear with the center of the rotor, and always at the same distances and move in and out the same way. Both sets of opposed pivots moves along orthogonal axis crossing at the rotor center, and stay at 90 degrees apart at all time and for all configurations (simplifying calculations).

During a rotation, the rotor becomes either in square or full diamond configurations 8 times, which defined 8 reference points and curve sections of 45 degrees each, of which 2 will need to be fed by seed curves (see below) for complete contours.

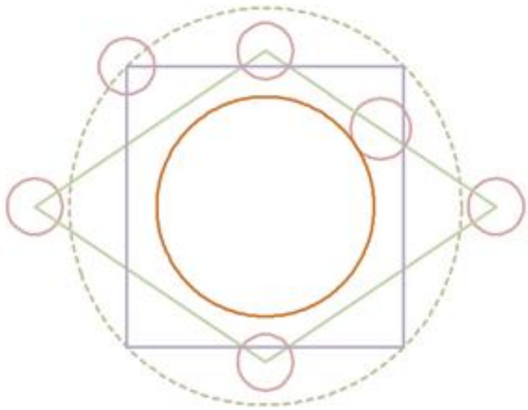

Figure 1: The Quasiturbine rotor becomes either in square or full diamond configurations 8 times per rotation, defining 8 points of reference and sections for contour. Notice the top and bottom pivots moved inward in diamond configuration, in contrast with the square configuration and its circle broken line (PivEcc = 1). The central circular track supporting the mid blade roller is shown in the first quadrant.

The pivots have a substantial physical size, and consequently the pivots' center itself cannot be in contact with the stator confinement wall. It is the pivot outside circle (or its contained seal) which touches the stator confinement wall.

No matter the degree of rotor deformation (configuration), its center of masse stays immobile at the center of the rotor. It is said to be perfectly balanced at all angle and rotational speed.

Not confined, this rotor geometry is unstable in rotation: It could be initially stable in square configuration, but as soon as a set of opposed pivots moves a bit away from the rotor center, centrifugal force will expel these 2 pivots outward, while the orthogonal ones will sort of implode inward.

While rotating, an external force (from the stator confinement wall or elsewhere?) will be needed to guide the rotor back toward the square configuration. One could further conceive a central mechanical device to guide the pivots in respect to the stator wall, but this would not be relevant to the present calculation method of the stator confinement profile.

While rotor is confined
Close elliptic-like stator fit is necessary to confine the rotor and provide contour guidance forces to pivots' outside diameter (and its contained seal) to bring back the rotor from 4 diamond-to-square configurations, 4 times per rotation.

While rotating, the overall QT rotor size changes as the loz-enge configuration (deformation) and the seals angle touching the stator confinement profile, which could means variations in the blades' pivots circuit. Smooth stator confinement profile does not guaranty smooth needed movement of the relatively massive blades and their blades' pivots. Consequently, calculations will have to determine first the smooth blades' pivots circuit, which will provide by enlargement the shape of the stator confinement profile.

Photo B – The Quasiturbine medallion offers a simple view, while hiding underlying complexity and characteristics

From the rotor characteristics, the stator confinement profile must be symmetrical point by point only through the rotor center, which means that the rotor shape is not necessarily symmetrical through the X and Y axis. Said otherwise, the stator shape in any 180 degrees arc can be identically copied 180 degrees forward or half, which does not mirrored it across X or Y axis.

3. QT rotor size, limit and guidance

Prerequisites: Blade length, 2 seed curve sections and eccentricities

As detailed below, the contour shapes are marked by 8 reference points 45 degrees apart, defining 8 contour sections, 2 of which being feed by seed curves. During rotation, most parameter values change continuously at all time, but the following are kept constant:

- For the rotor, the designed blade length « L » extending from one pivot center to the other (a dimensional number), which define the sizes of the circular (Eccentricity = 1) blades' pivots circuit (square lozenge circle broken line on graphs) and everything else; and
- The blades' pivots circuits « eccentricity form factor » (Ecc, a pure number), which from circular (Ecc = 1) blades' pivots circuit (square lozenge circle broken line, on graphs) dictates the longest X axis (proportional to (L x Ecc) / sqrt(1 + Ecc^2)), and the minimum Y axis (proportional to L / sqrt(1 + Ecc^2)), two derived dimensional numbers useful when comparing several blades' pivots circuits to one another. There is equivalence between square lozenge circle deformation (delta R = %) and blades' pivots circuit eccentricity (PivEcc).
- The 8 reference points 45 degrees apart.
- For the stator confinement profile, distinct size and eccentricity (ConfEcc) result directly from enlarging the blades' pivots circuit to take into account the pivot diameter, the contour seals and their geometric orientation during rotation.
- The two selected seed curves (not necessarily symmetrical), one in each interlaced group.

These parameters determine the computation needs for all points of reference, and elsewhere in-between points as univocally defined by seed curves (see below). Notice that the stator confinement profile will have its own (ConfEcc) eccentricity.

In order to have a smooth running machine, one must consider the movement of the masses within the rotor. The best way to insure smooth movement of the QT pivoting blades is to insure smooth movement of the blades' pivots circuit.

- The **criteria for smooth blades' pivots circuit** movement (where the masses are) will require careful monotone progression, and geometric continuity in between seed curves sections, both simultaneously in position in tangential angle. This smoothness may have some impacts on the stator confinement profile due to minor rotor size variation during rotation.
- This criteria imposes the matching points between blades' pivot circuit sections to fit both in radially and also angularly. Furthermore, as considered design eccentricity

increases, the stator profile will initially look like a sort of ellipse, but pass over a certain PivEcc limit, the stator will have an inflexion zone at its shorter diameter ends (like 2 ellipses stretching apart), which may require special attention in several applications.

- A **criteria on eccentricity inflexion limit** in order to locate an inflexion of the stator confinement profile, a zone of constraint that not all mechanical designs may consider.
- Finally, the 8 reference points of the blade's pivot circuit are not sufficient to determine the intermediary curve sections (and consequently the stator confinement profile).
- To raise the indetermination of the blades' pivot circuit, one needs to **provide 2 seed curve sections**. Designers are free to impose these curves sections in-between reference points to meet their own design characteristics. These seed curves do not have to be symmetrical nor identical, and by seed definition are exact blades' pivot circuit solutions, once selected.

No such seed curves are needed for the stator confinement profile, as it is determined by the blades' pivot circuit. This **indetermination** is an important asymmetrical **« multi degrees of freedom »** particularity of the Quasiturbine concept to permit a wide variety of underlying innovative design options and working characteristics, this is in addition to mechanical dimensions and proportions freedom shared with the well-defined geometric circular constraints of piston engine and conventional turbine.

About the pivot design

Once the rotor is taken apart, the blades are obviously more massive at one end (the « HEAD » in preferential direction of rotation, where the seal is located) and less heavy on the other end (the « TAIL » while rotating). Once assembled, the complementary pivot geometry makes all the pivots having the same weights and balance. The HEAD side (with the seal) may at first look as the male hinge, but its under harm is definitively a female receptacle. Reciprocally, the TAIL side appears as the female hinge, but its under faced is definitively a male insert. Both ends of the blade have simultaneously male and female characteristics for most symmetrical design, providing robustness and leak-proof options.

4. Establishing the reference points

Observations on the blades' pivots circuit

During rotor movement, the pivots move along an ellipse-like circuit, where two extreme rotor geometry configurations occur alternatively: One being the full diamond rotor extension, and the other the perfectly square rotor arrangement.

While in full diamond extension, 4 exact pivots positions of the rotor are easily determined from the imposed eccentricity PivEcc of the blades' pivots circuit (stator radius being enlarged by pivot circle diameter and seals), allowing determination of a distinct eccentricity ConfEcc for the stator confinement profile.

While in perfect square configuration, 4 exact pivots positions are straight forward at the pivots corners of the square lozenge (on circle in broken line).

Be careful, **coordinates of 8 exact reference points** are known for the blades' pivots circuit, but without any in-between circuit detail information. Who will provide the detail movement in-between the reference points? The designers themselves, as they are free to impose (not one but 2, and no more) curve sections, in-between points of the blades' pivots circuit, which do not have to be symmetrical, nor identical, and such seed curves are by definition exact solution. Notice that rotor contour seals are not involved in the blades' pivot circuit calculation, but are in the stator confinement profile.

Observations on the stator confinement profile

No seed curve is needed for the stator confinement profile, as it is determined by the blades pivots circuit. During confined rotation, the pivots diameter (ot its containd seal) moves in contact with an ellipse-like stator profile, as full diamond rotor extension and perfectly square rotor arrangement.

While in perfect square configuration, 4 exact stator positions are straightforward from the pivot diameter at the corner of the lozenge in square arrangement.

In full diamond extension, 4 exact stator contact reference points are easily determined from the imposed eccentricity of the blades' pivots circuit (by radius addition of pivots diameters and seals), allowing determination of a different eccentricity ConfEcc for this stator confinement profile.

At this point for the stator confinement profile, coordinates of 8 exact reference points are known, and detail information in-between will be provided from the blades' pivot circuit once its calculation is completed.

For both blades' pivots circuit and stator confinement profile, coordinates of a **total of 16 reference points** are known which are most valuable before initiating exact detail computation. The coordinates of these reference points are exactly symmetrical, both across rotor central point, and mirror across X and Y axis. It is the in-between seed curves that make de blades' pivot circuit, and consequently (with seal orientations add up) the stator confinement profile not mirror symmetrical.

Off-radius seal orientation:

An additional rotor confinement profile asymmetry comes from the seals orientation in relation to the local radius, which results from the fact that each pivoting blade holds a seal at only one end. This large pivot diameter contains a nearly immobile stator contour seal, which seal extend exactly radially only in the rotor square configuration (where the rotor has its maximum overall dimension). In diamond rotor extension, one can notice on the drawings that the seals touch the stator slightly off the X and Y axis (contact axis being in counter rotation to one another), while these seals are exactly co-linear at 45 degrees diagonal in square configuration.

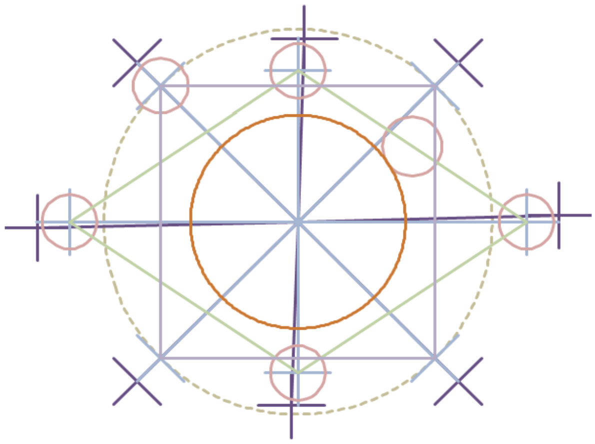

Figure 2: Pivots coordinates of the rotor blades are shown in square and extended diamond configuration. 8 reference points for the blade's pivot circuit, and as many for the stator confinement profile by enlargement. Notice that these reference points are symmetrical, both across center and X and Y axis, while the seed curves and calculated solutions are not necessarily mirrored symmetrical
Circular central supporting track for mid-blade roller is shown in quadrant I. The circle broken line is the exact no eccentricity (PivEcc = 1) circular blades' pivot circuit.

Depending of the blade orientation during the rotation, the seal off-radius orientation reduces overall rotor size by leading ahead the movement (in large radius profile section) and lagging behind the movement (in short radius profile section). The effect of this « off-radius seal orientation » generates small sizes radius reduction within the stator wall (none at 45 degrees, maximum at 0 and 90 degrees) spreading asymmetrically over 90 degrees each. Consequently, there is a relatively **small preferential direction of assembly** of the rotor within the stator. Once properly paired, the QT rotor can turn indifferently in both directions.

5. Modified Ellipse MOD8 to Fit 8 Points

Comment on parametric trigonometric ellipse formula
Trigonometric parametric ellipse equation looks simple:
X = Rx * sin(tau) and
Y = Ry * cos(tau)
(tau) being the parameter (not the actual point angle)

This is rigorously true for cycle where Rx = Ry, (tau) being then the angle of the R radius. As the eccentricity increases, the Radius angle is not (tau) any more. All parameters (tau) provide coordinate of points which are on the perfect ellipse, but such points are not at the (tau) radius angle. Phase out between true Radius angle and tau may reach 5 to 8 degrees (increasing with eccentricity) in the range of simple QT solutions. Providing careful radius angle correction, this method is fine to get the perfect ellipse coordinates and shape. For each eccentricity an equivalence table of radius angle versus the tau parameter can be calculated with sufficient precision by 4 or 5 iterations only.

Does ellipse fit through 8 known symmetrical points?
It would be great if the geometrical properties of the blades' pivots circuit would coincide with ellipse geometrical properties, otherwise ellipse shape will only fit through a set of 4 symmetrical points. As obvious from previous Quasiturbine disclosures, early attempt shows that ellipse cannot fit the blades' pivots circuit, neither the stator confinement profile. Fit can be pretty close at small eccentricity, but becomes rapidly useless for design purpose.

Modifying the perfect ellipse to fitting 8 symmetrical points
Ellipse can easily be made to pass by the ends of the long and the short diameter axis, but offers no flexibility to reach any other arbitrary symmetrical coordinates midway. Drawing shows that the Quasiturbine rotor characteristics do not match the ellipse characteristics. Practically, perfect ellipses do not extend far enough in their 45 degrees corners areas to fit any QT rotor solution; unless forcing the ellipse to pass by the X45, Y45, and R45.

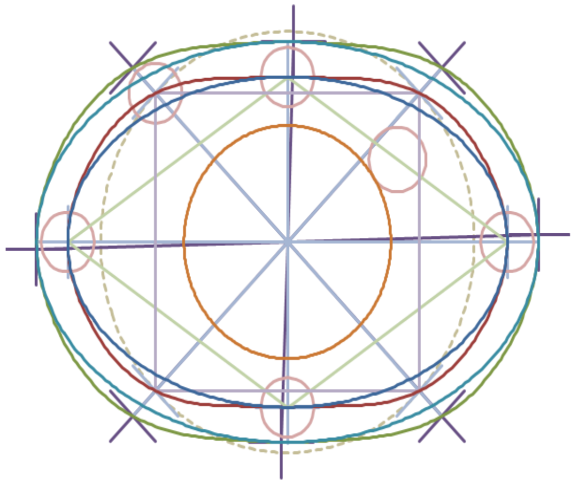

Figure 3: Even for most simple case, perfect ellipse is shown to be unable to simultaneously fit at once 8 reference points, while the MOD8 modified ellipse does (without detail in-between reference points). An extra pair of parameters « PivC(X;Y) » must be introduced into the ellipse equation, to stretch the ellipse corner shape while preserving it near the X and Y axis. Will also fit the stator confinement profile with appropriate » ConfC(X;Y) » parameters.

To better fit (approximate) the Quasiturbine blades' pivots circuit needs, an extra pair of parameters « PivC(X;Y) » could be introduced in the perfect ellipse equation (the C(X) ; C(Y) being the axis amplitude of the pivot circuit corrections, possibly in the form of $\sin^3(4 \text{ x theta})$ or otherwise). If the correction match is done along the 45 degrees radius, then PivC(X) = PivC(Y), usually in the range between 0 to 3 % of the radius, to stretch the ellipse corner shape (while preserving the full diamond main axis coordinates), and to allow fitting at once through the entire 8 reference points coordinates of the blades pivots circuit. The same MOD8 ellipse approximation function would also fit with the stator confinement profile, providing an appropriate set of « ConfC(X;Y) » parameters is used. MOD8 ellipse offers exact fit of reference points, but no exact curve in-between. Exact blades' pivots circuit and stator confinement profile computation will have to provide solution in-between these exact points matched by MOD8.

MOD8 limitation to near symmetrical and no inflexion

MOD8 is a very valuable analytical tool for the most obvious (and current) QT cases. As the perfect ellipses, the MOD8 ellipses are mirrored through X and Y axis, and consequently symmetrical. They could be useful approximations where the 2 seed curves are complementary symmetrical one another, and generate near symmetrical blades' pivots circuit and stator confinement profile. They are not recommended to approximate more advanced and complex asymmetrical and inflexion QT geometries.

MOD8 ellipse is no attempt to get an exact Quasiturbine blades' pivots circuit, nor the stator confinement profile, but is a simple mathematical approximation for purpose of understanding and discussion. In symmetrical cases considered in this paper, the modified MOD8 ellipses radiuses in the 45 degrees area are exact ellipses values extended by no more that 5 %. Notice that the modified MOD8 ellipse shape and pair parameters for blades' pivot circuit are much different for the stator confinement profile.

6. Blades' Pivot Circuit - Symmetrical Seed Curves

Imposing seed curves to 2 groups of interlaced sections

The set of 16 reference points is not sufficient to determine details solution in-between the points. Where are the in-between detail data available? This is part of the **Quasiturbine multi-degrees of freedom concept** not to provide these details, and it is left to the designer to make his own choices. Therefore, before initiating any computation at the blades' pivots circuit level, two inter-points « seed curves sections » must be imposed, one and only one within each of the 2 interlacing groups. Each proposed curve section will be copied by symmetry across the rotor central point (no mirror across X or Y axis), and later used by the mathematical rotor pivots transform function to map the corresponding orthogonal segments, for a total of 4 sections in each interlaced group. Same will be done with the second interlacing group, to complete the blades' pivot circuit calculation.

Notice that impose seed curve sectors are by definition exact solution. Furthermore, this example shows that solutions are far from being unique, but as many as you can propose seed curves. Notice that these reference points are symmetrical, both across center and X and Y axis, while seed curves and seals orientations spoil the in-between mirror symmetry.

Comment on eccentricity versus circle deformation?

The eccentricity is a necessary upfront value before proceeding to exact calculation. Using an analytical function like MOD8 to seed the Blades' pivots circuit provides upfront eccentricity from the equation. Another way to feed the seed sections is to modify the (PivEcc = 1) pivots lozenge circle (broken line on the graphs), by adding a radial perturbation on it, in which case only the long X axis is imposed, and not the short Y axis (needed to determine the eccentricity). Fortunately, this shorter Y axis can be easily calculated upfront by the rotor geometry in full extended diamond configuration. This provides equivalence relation between square lozenge circle deformation (delta R = %) and blades' pivots circuit eccentricity (PivEcc).

7. Rotor Pivots Transform Function

The rotor configuration change must occur simultaneously along two orthogonal X and Y axis. For every two opposed points coordinates set on the blades' pivots circuit, the rotor define two coordinates set on its orthogonal axe, which are the mapping of the first set. This is the « **rotor pivots transform function** » one needs to determine the exact blades' pivot circuit in the top and the bottom area of the graphs. Notice that this function is reversible from the mapped coordinates set to the original coordinates set, and that the rotor pivots transform function returns 2 coordinates set (one up, one down), both along the actual orthogonal axis.

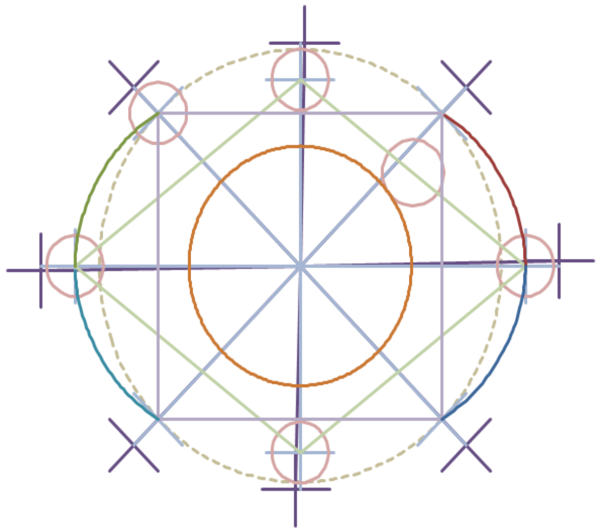

Figure 4: For the blades' pivot circuit, a simple set of 2 seed curves which could be from MOD8 ellipse (not anymore an approximation once seed selected), shown with their symmetrical copy across the center. The QT multi-degrees of freedom concept leaves designer with « seed freedom of choice ». All done now for initiating the top and bottom blades' pivot circuit calculation through the mathematical rotor pivots transform function. The circle in broken line is the exact no eccentricity (Ecc = 1) circular blades' pivot circuit

8. Exact Blades' Pivot Circuit Computation

Exact blades' pivot circuit solutions will require computation through the mathematical **« rotor pivots transform function »**, where movement of the pivot along some curve sections will be imaged (mapped) in another section to entirely defined the current blades' pivot circuit. Previous observations established a set of 8 exact reference points coordinates that pivots circuit must go through, and similarly for the stator confinement profile, for a total of 16 control reference points, most valuable before initiating exact detail computation. Rotor contour seals are not involved in the blades' pivot circuit calculation, but will later in the stator confinement profile.

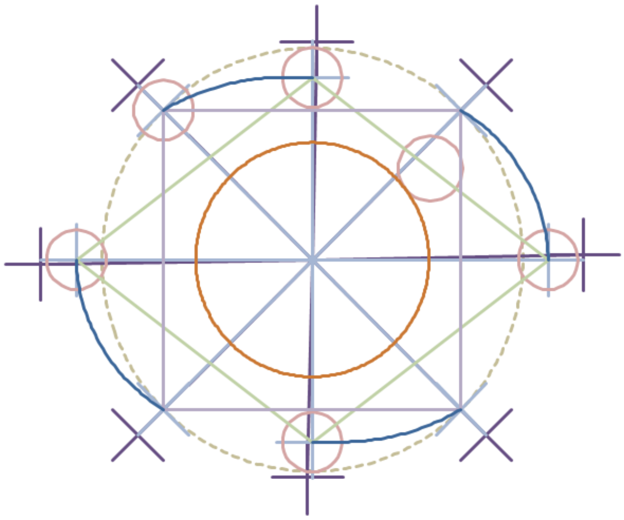

Figure 5: Shows half of the exact blades' pivot circuit calculated result for one seed curve (here from the modified MOD8 ellipse Quadrant I), and its symmetrical through center (Quadrant III), with its rotor pivots transformed (Quadrant II), and the symmetrical solution (Quadrant IV). The other interlaced group seed curve can be imposed in any of the free interspace, and calculated the similar ay, for a complete blades' pivot circuit. Notice that exact solution goes strictly through the 8 reference points. The circle broken line is the no eccentricity (PivExc. = 1) circular circuit.

One must first get the solution for the blades' pivots circuit. The 8 in-between sections of the blades' pivots circuit form 2 groups of 4 interlaced curve sections each; where in each group, one in-between section must be seed by a proposed seed curve. By definition, all proposed seed curves and their symmetrical across the rotor central point are part of the exact blades' pivot circuit solution. From one seed curve section, the three other sections can be determined. Similar procedure applied to the second group of interlaced sections, where seed curve (or part thereof) can be on any still available group.

Two sections (and their symmetries) are left to be computed for the blades' pivots circuit? Each **group of 4 in-between** curves has 2 known as the seed curves and their symmetrical across the rotor central points; the 2 sections left are also symmetrical, so only one in-between curve needs to be computed by the **rotor pivots transform function**. Similar computation needs to be carried on the second **group of 4 in-between curves**. Consequently, the « rotor pivots transform function » need to be applied only twice (once per group) for the blades' pivot circuit.

9. Exact Stator Confinement Profile Computation

Stator confinement profile

Once the blades' pivot circuit is known, there is no need to apply the **« rotor pivots transform function »** to get the stator confinement profile, as it is mainly an enlargement. Also, practical consideration imposes the contour seal tip to extend somehow (10 to 20 % of pivot radius) outside the large pivot diameters.

Off-radius seal orientation

Not only asymmetries come from the non-symmetrical seed curves, but some seals asymmetry also results from the fact that each pivoting blade holds seal at one end only, where a larger pivot diameter contains a nearly immobile stator contour seal [4], [5], which seal extend exactly radially only at the rotor square configuration (where the rotor has its maximum overall dimension).

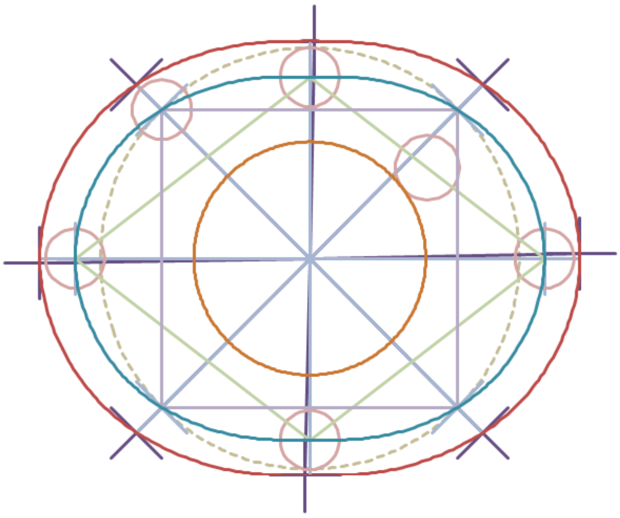

Figure 6: With the seed curves (again from the modified MOD8 ellipse), here are the calculated exact blades' pivots circuit and stator confinement profile (as an enlargement of the blades' pivots transforms). Due to off-radius seals orientations, notice the contact point of the seals with the stator are not exactly at 0 and/or 90 degrees, radius being slightly closer to one another in quadrant I and III.

Depending of blade orientation during the rotation, the seal off-radius orientation reduces overall rotor size by leading ahead of movement (in large radius profile section) and lagging behind the movement (in short radius profile section). The effect of this off-radius seal orientation generates small size reductions within the stator wall, each centered on zero and 90 degrees area.

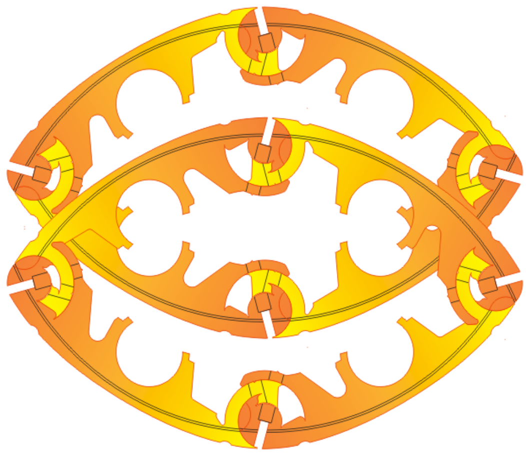

Figure 7: Even with perfectly symmetrical blades' pivots circuit, flipping the rotor shows blades' seal orientation asymmetries that a stator cannot fit both at once. Clockwise rotation of the stator and the rotor must then be properly paired to allow the QT to turn indifferently in both directions.

Preferential direction of rotor assembly

It is obvious that the QT rotor can turn indifferently in both direction, but does the rotor have a preferential direction of assembly in relation to the stator? In full diamond rotor extension, one can notice that the seals touch the stator slightly off the X and Y axis (contact axis getting closer to one another), while these seals are exactly co-linear on the 45 degree diagonal in square configuration. This is because the QT pivoting blades carry asymmetrically a seal at only one end, stator symmetry being perfect only at 45 degrees. These off-radius seal orientation corrections on the stator impose a small preferential direction of assembly of the rotor within the stator, even for the perfectly symmetrical blades' pivots circuit and while barely noticeable on the graph. This is further true for all complex stator shapes, but once correctly paired within the stator, the QT rotor can turn indifferently in both directions.

Important to notice that the seal orientation stator radius reductions, each spread around 0 and 90 degrees, are stator shapes adjustment that the seals must follow to insure that the pivots stay on the optimum circuit in the most smoothly matter. These seal orientation are significant enough to impose a preferential direction of assembly. Consequently, the rotor and the stator need to be paired accordingly for the rotor to turn freely in both directions.

10. Quasiturbine QT.6LSC Circuit and confinement comparaison

Referring to the small 1.5 kW Quasiturbine manufactured as air-steam motor under the model QT.6LSC, here are the parameters comparison for exact solution of the blades' pivot circuit and the stator confinement profile. Notice the modified MOD8 ellipse different pair parameters for each best fit. Parameters are given for both the blades' pivots circuit on the left, and the stator confinement profile on the right:

- Notice that the maximum stator radius (on the right) is the maximum blades' pivots circuit radius (on the left) increased by the pivot circle radius and the needed seals space tolerance.
- Eccentricity of the blades' pivots circuit of PivEcc = 1,301 is reduced to ConfEcc = 1,251 on the larger stator confinement profile.
- MOD8 ellipse modification pair parameters goes from PivC(X=3,470 %; Y=3,470 %) for the blades' pivots circuit to ConfC (X=1,700 %; Y=3,440 %) for the stator confinement profile.

				Comparaison patielle avec QT.6LSC?			
Calcul : Profil de confinement du Stator				Confinement QT.6LSC construit avant 2020			
X	Y	R	10,34%	X	Y	R	10,34%
3,419	0,058	3,419	= ConfGrRx	3,406	0,000	3,406	= ConfGrRx
0,000	2,736	2,736	= ConPtfRy	0,000	2,656	2,656	= ConPtfRy
2,750%		Confin. Excen. =	1,251	2,750%		Confin. Excen. =	1,251
0,0275	0,0275	= Correc. ÉiipMod8Conf		0,0275	0,0275	= Correc. ÉiipMod8Conf ?	
2,193	2,193	3,102	= Rloz+Joint	2,193	2,193	3,102	= Rloz+Joint

11. What if eccentricity is further increased?

This would offer still **more options for innovation** and specific challenges. Then, the blades' pivot circuit and the stator confinement profile show an inflexion in the shortest diameter area. Computation method does still apply, however the inflexion point may become in itself an obstacle to the passage of the pivoting blades, surface of which may need to be depleted in concave shape in order to make room for the blade to move across the stator inflexion area, somewhat as the Wankel engine (Similarities end there!). Central blade supporting track and rollers may also be design in an appropriate way.

Modified MOD8 ellipse (even if it still does go through the 8 reference points) will not fit correctly the inflexion contour. However MOD8 is far from being useless, as it can provide interesting seed curves options, which are part of the exact solution by definition. Exact circuit and profile computation become however an absolute necessity for practical application.

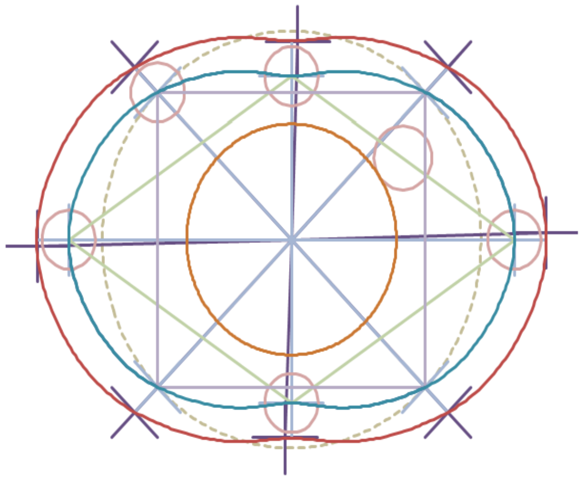

Figure 8: Modified MOD8 ellipse is non-reliable in-between reference points at such a high eccentricity, but provides interesting seed curves options, which are part of the exact solution, once selected. Notice that a pivoting blade concave surface is needed to transit across the inflexion. The computation method is still valid at high eccentricity. Notice that Wankel rotary engine cannot avoid this inflexion, while QT can!

12. Complex Seed Curve and Asymmetry

The square lozenge circle (broken line on graph) is the spherical trivial solution for the blades' pivots circuit. A symmetrical deformation of this basic circle leads to ellipse-like type of situation. To illustrate the effect and results, a set of 2 different seed curves are here considered next one another (they do not have to be symmetrical, nor identical), in the extremities area of the maximum long axis. For comparison, these 2 seed curves are selected to produce the same eccentricity at blades' pivot circuit level, as well as equivalent at the stator confinement profile level (remember that seed curves are exact solutions by definition):

Symmetrical Seed curve Case-1:
A section of the lozenge circle Radius increased up to 12 %, by the $\cos^3(2 \times \text{théta})$ function.

Asymmetrical Seed curve Case-2:
A section of the lozenge circle Radius is increased up to 12 %, by the $\cos^1(2 \times \text{théta})$, and made asymmetrical by the +/- (80%) $\sin^2(4 \times \text{théta})$ function (+ in an interlaced group, - in the other).

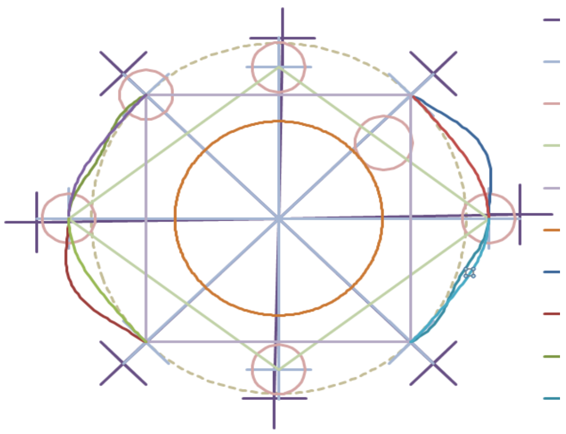

Figure 9: To illustrate the seed curves freedom of choice, and corresponding possibility, here are 2 examples of blades' pivots circuit seed curves (not from MOD8 this time) with same 8 reference points. Notice that one is highly asymmetric. Stator confinement profile being an enlargement, it does not need seed curve of its own. The circle in broken line is the exact no eccentricity (PivEcc = 1) circular blades' pivot circuit

Notice that these seed curves do not come from an analytical equation like MOD8 (where eccentricity is known), but are perturbations imposed on the pivots lozenge circle (broken line on the graph) fixing only the long X axis (small Y axis need to be calculated from de rotor full diamond configuration to provide eccentricity). The second proposed seed curve is an asymmetric case showing that computed solution may potentially extend the circuit further than the maximum large X axis diameter, while the maximum diameter is not considered for stator eccentricity (see 22 degrees area). It does confirm that any combination of seed curves (say in the positive Y) can be selected with any combination curves in the negative Y.

Several other curve types can be used for alteration of the lozenge circle, like linear and or quadratic deformations. This kind of asymmetric profile could offer different physical characteristics of the Quasiturbine at intake compared to exhaust. So many different solutions are possible, each with their own physical properties.

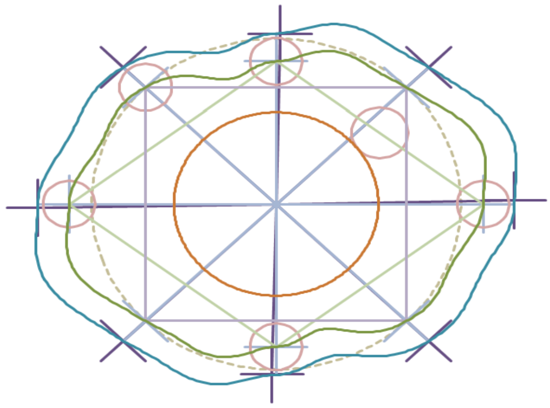

Figure 10: The exact solution of the asymmetric Case-2 is presented to illustrate the complex asymmetrical seed curves effects, with the 8 reference points for the blades' pivots circuit, as well as those for the stator confinement profile. Asymmetry can generate off-X axis large oblique non-orthogonal diameter (look the 22 degrees area).

This example shows again that ellipses are not compatible solutions, and that solutions are far from being unique. In complex case, the surface of the blade may limit the clearance of its own stator while moving within the said stator. Furthermore, this example shows that solutions are far from being unique, being as many as one can propose seed curves!

The complex blades' pivot circuit seed curve is a way to modify the geometrical Quasiturbine characteristics, but one may also consider modifying the size and proportion of the blade's supporting track, rollers and external blades' pivots diameters, as described in a previous patent. Present calculation method still applied.

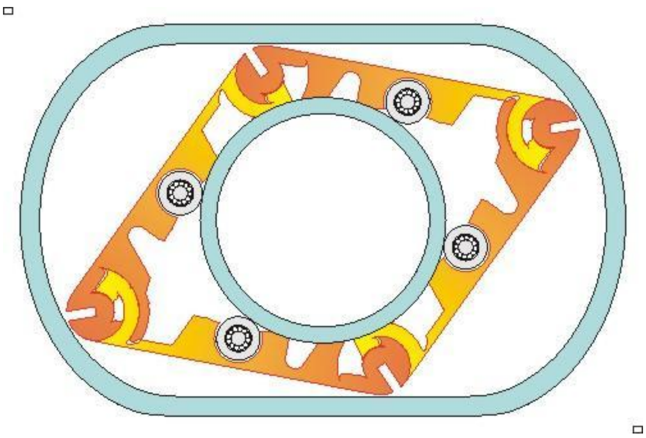

Figure 11: Modifying the blade's supporting track, rollers and external blades' pivots diameters are other geometrical alternatives to explore different Quasiturbine characteristics. Knowing that the QT pumps 8 chamber volumes per rotation (4 on each side), here is an example where the flow per revolution exceeds the size of the machine! This stator shape well fit the name « Saint-Hilaire skating rink profile ».

13. Applying Computation to Torque and Power

The present method is a general tool to explore numerous Quasiturbine design parameters. While having the geometric characteristics on hand, why not go on further? [6] Calculation of internal chamber volume would lead to compression and expansion ratio and to fluid flow across the machine. Assuming constant fluid pressure within the Quasiturbine, radial and tangential forces could be calculated providing torque and power output. This calculation method is also suitable for design component sensibility analysis, and can help to select proper intake and exhaust ports positioning, as well as the location of side contour seals location, and stator contour bolts positioning, as well as central differential design insertion.

Photo C: Sample of a Quasiturbine stator executed from the computation results

14. Conclusion

It is far from intuitive that the general Quasiturbine solution requires 2 independent seed curve sections; accept asymmetrical profile; makes the rotor turn as a perfectly balanced rotary device at all angles and speeds; and imposes a preferential direction of assembly of the rotor within the stator. One of the reasons the Quasiturbine has not been developed a century ago is probably due to difficulty to determine valid stator confinement profile shapes, as today computer can do. The objective of this paper is not to suggest or propose any specific stator confinement profile, but to offer means to achieve exact solutions. This paper shows that ellipses are not compatible solutions, but are nevertheless useful to assist seed curves selection, and that solutions are far from being unique, each with their own physical properties.

Contrary to the well determined circular constraints of piston engine and conventional turbine, the seed curves asymmetrical **« multi degrees of freedom »** concept of the Quasiturbine offers a wide variety of underlying innovative design options and working characteristics. It is a fairly new concept hiding a large amount of unexpected turnout, and toward which extrapolating conventional practices, analysis and explications often constitute an unfair QT potential limitation. This paper objective is to address one of the apparently minor QT difficulties, to show how correct understanding open up the diversity of designs and technology alternatives.

The Quasiturbine stator is an important component, and it is essential to characterize it properly to guide correct manufacturing and reach expected performances. The present method is a general tool to explore numerous Quasiturbine design parameters into applications. Unless it is well documented, the Quasiturbine presumption of simplicity can turn out wrong, and shortcut barely leading to correct conclusion.

Worth to mention, the fact that the QT concept solicits every designer for a « free-choice of seed curves », opens up to endless suggestions, arguments and personal claims, that many may hear about for years, until an « **optimisation seed curve theory** » comes to clarify it all.

References

[1] Search Quasiturbine Papers on Google at https://scholar.google.ca/scholar?q=quasiturbine+engine+journal+paper&hl=fr&as_sdt=0&as_vis=1&oi=scholart
[2] http://www.quasiturbine.com
[3] Automotive Design 1999 http://http://quasiturbine.promci.qc.ca/EADSept99.html
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Author Profile

Gilles Saint-Hilaire Ph.D. Paris, Thermonuclear physics, Roxan Saint-Hilaire MBA Berkeley, Microchips design, Ylian Saint-Hilaire M.Sc. Montréal, Meshcentral principale, Françoise Saint-Hilaire, M.Let. Sorbone, Documentation, are all in Quasiturbine Académie, Montréal Québec H2K 4J9 CANADA

Definition / Abbreviations
PIV - PIVOT OF ROTATING BLADES
CONF - CONFINEMENT PROFILE

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