Rotoliptic Geometry

Rotoliptic Technologies Inc. *

1 Introduction

In the search for high efficiency positive displacement pumps there is a desire to maximise flow rates and minimize envelope size, but there has been little deviation from the standard PCP ideal and geometry in the industry. In order to create a novel pump that utilizes metal rotors and stators to perform well in thermal applications that provides maximum efficiency, we must look beyond the standard PCP architecture. One way to expand the rotor and stator shapes beyond a general PCP is to look at cyloids and trochoids, which are generally formed by rolling a circle inside or outside another circle.

There are many types of related curves that are generated by a point P on a circle of radius r that are rolling, without slip, round a stationary circle of radius r_0. Four of these curves are the epitrochoid, hypotrochoid, epicycloid, and hypocycloid, and are defined by the orientation of the rolling circle with respect to the stationary circle, and the relative position of the point P. Hypotrochoids and hypocycloids are generated by a circle that is rolling on the interior of the base circle, whereas the epitrochoid and epicycloid curves are generated by a circle rolling on the exterior of the base circle. The differentiation between trochoid and cycloid curves comes from the locus of the point P where a distance d can be defined for this point relative to the center of the rolling circle; if $d = r$ and the point P is on the outside of the rolling circle then the resulting curve will be a cycloid curve, else a trochoid curve is generated.

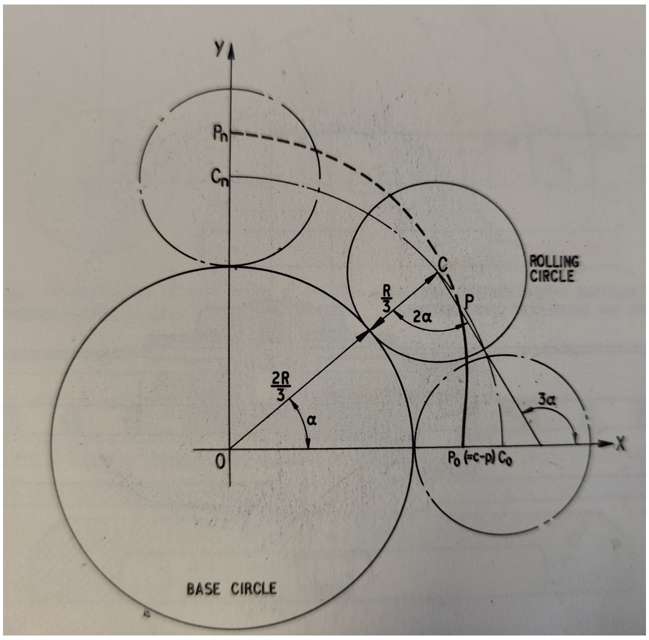

Figure 1: Epitrochoid generation with an outer rolling circle (Ansdale, 1968)

1.1 Trochoid and Cycloid Generation

The ratio between the radii of the two circles, the rolling and the stationary, generate different trochoids and cyloids dependent on the number of times the point P meets the base circle. Trochoid and cycloid configurations generated by different radii are shown in Fig.2, where the resultant curve is drawn here with an accompanying inner or outer member.

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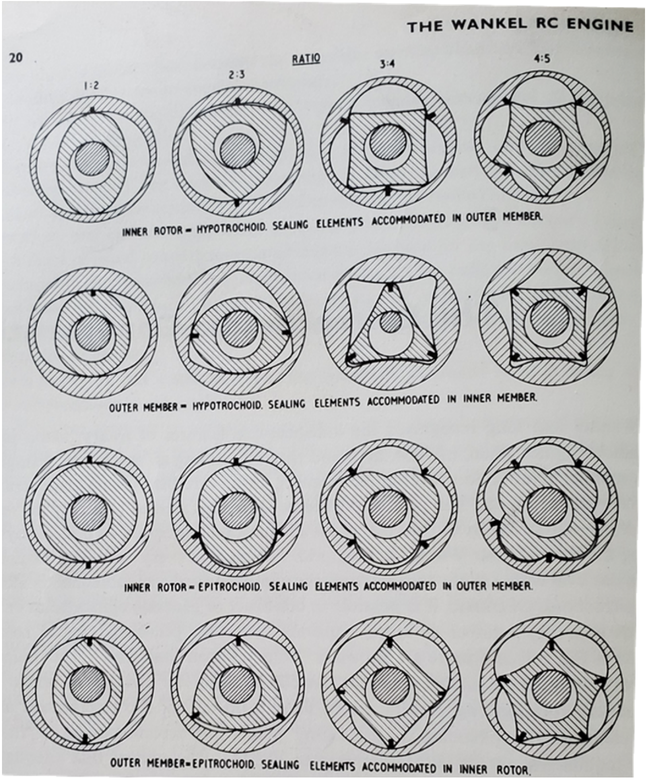

Figure 2: Hypotrochoid and epitrochoid rotor and stator pairs (Ansdale, 1968)

1.1.1 Two-lobe hypotrochoid

In the following section, we will define the configuration of a two-lobe hypotrochoid. We start with a base circle radius as:

$$r_0 = 2r \tag{1}$$

where r_0 = base circle radius and r = rolling circle radius, the relationship between these being what defines the number of lobes in the resulting hypotrochoid. We can use the distance d as the generating point from the centre of the rolling circle and the following:

$$r_0 + r = 3r = R. \tag{2}$$

Using (2), we can define the major and minor diameters of the hypotrochoid as:

$$D_{maj} = 2(R + d) \tag{3}$$

$$D_{min} = 2(R - d). \tag{4}$$

The resulting ellipse is shown in the top left of Fig.2., the hypotrochoid inner member with a ratio of 1 : 2.

1.1.2 Rotoliptic Geometry

The Rotoliptic rotor geometry utilizes a two-lobe hypotrotroid bore defined in the above section. There are multiple methods to generate the Rotoliptic geometry; the one considered above uses a circle of half the radius of the base circle that it is rolling inside in order to generate an elliptical shape, and this is used to determine the geometry of the stator.

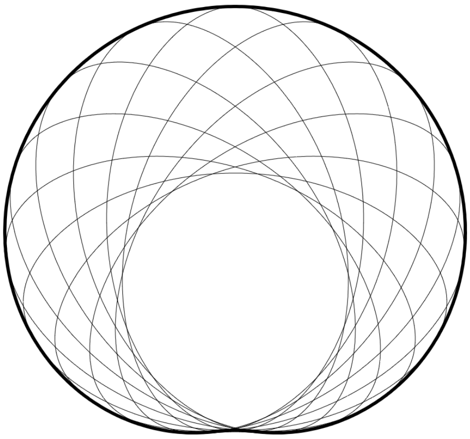

Figure 3: Stator geometry creation

Fig.3. shows the formation of a 2-dimensional drawing of the RTI stator with multiple rotor profiles inset, which is formed when the elliptical rotor undergoes planetary motion about its center. This cardioid is the inner envelope of the stator, and this sits inside an arbitrary circular tube of outer diameter S_{OD}. The resulting 2-dimensional rotor and stator pairing can be transformed into a helical structure whereby the helical axes are the centers of each respective component, a distance of e from the other center, where e = eccentricity of the rotor ellipse. The rotation periods in this 3-dimensional hypotrochoid is determined by the number of lobes in the trochoidal curve and the ratio of the radii of the rolling/base circles; in this case, the axial distance for one full rotation of the rotor is $\frac{1}{2}$ the axial distance for one full rotation of the stator. When this geometry is translated to a pump, the RTI technology works similarly to a standard PCP, but is unique in its maximization of flow area, near neutral axial loading, sealed cavities allowing for seamless pressure generation, and a larger through-bore hole for a series of connecting rotors.

1.2 References

Ansdale, R.F. (1968) "The Epitrochoidal Configuration," in The Wankel RC engine. London: Iliffe Books.