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New Trends In IC Engine

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ABSTRACT: *The Wankel rotary engine is a type of internal combustion engine, invented by German engineer Felix Wankel, which uses a rotor instead of reciprocating pistons. This design delivers smooth high-rpm power from a compact, lightweight engine. A rotary engine has an ignition system and a fuel-delivery system that are similar to the ones on piston engines. A four-stroke piston engine makes one combustion stroke per cylinder for every two rotations of the crankshaft (that is, one half power stroke per crankshaft rotation per cylinder),while each combustion chamber in the Wankel generates one combustion stroke per each driveshaft rotation, i.e. one power stroke per rotor orbital revolution and three power strokes per rotor rotation. Thus, power output of a Wankel engine is generally higher than that of a four-stroke piston engine of similar engine displacement in a similar state of tune and higher than that of a four-stroke piston engine of similar physical dimensions and weight. Wankel engines also generally have a much higher redline than a reciprocating engine of similar size since the strokes are completed with a rotary motion as opposed to a reciprocating engine which must use connecting rods and a crankshaft to convert reciprocating motion into rotary motion. The neat thing about the rotary engine is that each of the three faces of the rotor is always working on one part of the cycle -- in one complete revolution of the rotor, there will be three combustion strokes. The output shaft spins three times for every complete revolution of the rotor, which means that there is one combustion stroke for each revolution of the output shaft.*

Keyword: *The data refers to salient features of wankel type rotary engine and four cylinder two stroke reciprocating engine.*

I. INTRODUCTION

The wankel radial engine is a fascinating beast that features a very clever rearrangement of the four elements of the Otto cycle. The **Wankel rotary engine** is a type of internal combustion engine, invented by German engineer ***Felix Wankel***, which uses a rotor instead of reciprocating pistons. This design delivers smooth high-rpm power from a compact, lightweight engine. In 1951, Wankel began development of the engine at NSU (NSU Motorenwerke AG), where he first conceived his rotary engine in 1954 Considerable effort went into designing rotary engines in the 1950s and 1960s. They were of particular interest because they were smooth and very quiet running, and because of the reliability resulting from their simplicity,

A rotary engine is an internal combustion engine, like the engine in your car, but it works in a completely different way than the conventional piston engine.

In a piston engine, the same volume of space (the cylinder) alternately does four different jobs -- intake, compression, combustion and exhaust. A rotary engine does these same four jobs, but each one happens in its own part of the housing. It's kind of like having a dedicated cylinder for each of the four jobs, with the piston moving continually from one to the next.

The rotary engine (originally conceived and developed by Dr. Felix Wankel) is sometimes called a **Wankel engine**, or **Wankel rotary engine**.

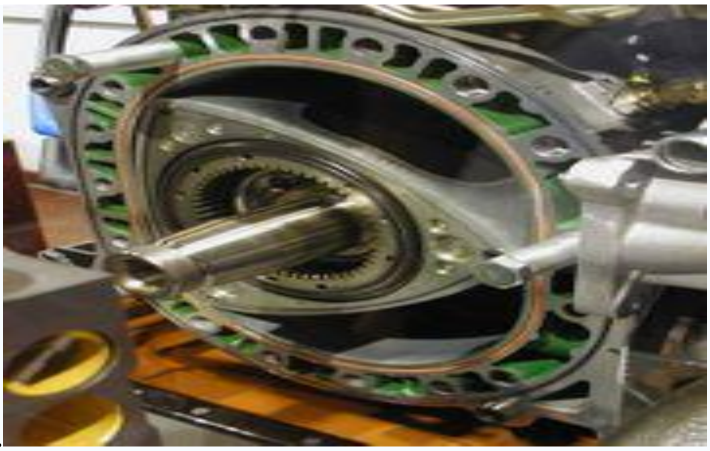

Fig 1. Wankel engine, or Wankel rotary engine.

II. PRINCIPLES OF ROTARY ENGINES

Like a piston engine, the rotary engine uses the pressure created when a combination of air and fuel is burned. In a piston engine, that pressure is contained in the cylinders and forces pistons to move back and forth. The connecting rods and crankshaft convert the reciprocating motion of the pistons into rotational motion that can be used to power a car. In a rotary engine, the pressure of combustion is contained in a chamber formed by part of the housing and sealed in by one face of the triangular rotor, which is what the engine uses instead of pistons. The rotor follows a path that looks like something you'd create with a Spirograph. This path keeps each of the three peaks of the rotor in contact with the housing, creating three separate volumes of gas. As the rotor moves around the chamber, each of the three volumes of gas alternately expands and contracts. It is this expansion and contraction that draws air and fuel into the engine, compresses it and makes useful power as the gases expand, and then expels the exhaust. In the Wankel engine, the four strokes of a typical Otto cycle occur in the space between a somewhat triangular-shaped rotor and the inside of a housing as shown in fig 2 . In the basic single-rotor Wankel engine, the oval-like epitrochoid-shaped housing surrounds a three-sided rotor The central drive shaft, also called an eccentric shaft or E-shaft, passes through the center of the rotor and is supported by bearings. The rotor both rotates around an offset lobe (crank) on the E-shaft and makes orbital revolutions around the central shaft. Seals at the corners of the rotor seal against the periphery of the housing, dividing it into three moving combustion chambers. Fixed gears mounted on each side of the housing engage with ring gears attached to the rotor to ensure the proper orientation as the rotor moves a fuel-delivery system that are similar to A rotary engine has an ignition system the ones on piston engines.

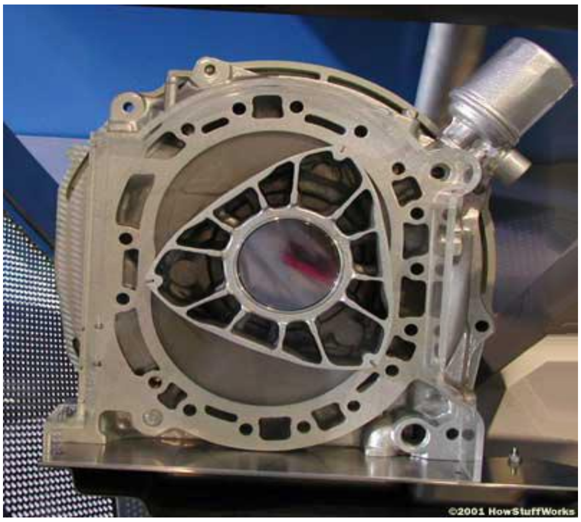

Fig 2.The rotor and housing of a rotary engine from a Mazda RX-7: These parts replace the pistons, cylinders, valves, connecting rods and camshafts found in piston engines.

III. THE PARTS OF A ROTARY ENGINE

Rotor

The rotor has three convex faces as shown in fig 3, each of which acts like a piston. Each face of the rotor has a pocket in it, which increases the displacement of the engine, allowing more space for air/fuel mixture.

At the apex of each face is a metal blade that forms a seal to the outside of the combustion chamber. There are also metal rings on each side of the rotor that seal to the sides of the combustion chamber

The rotor has a set of internal gear teeth cut into the center of one side. These teeth mate with a gear that is fixed to the housing. This gear mating determines the path and direction the rotor takes through the housing.

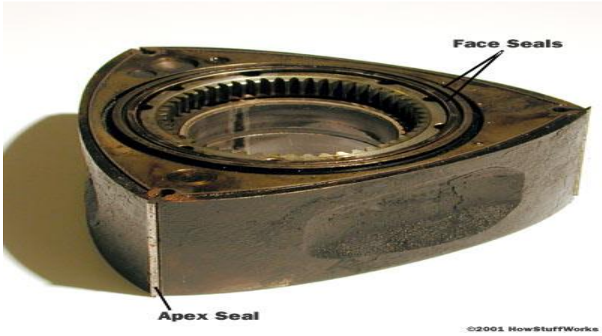

Fig 3. ROTOR

Housing

The housing is roughly oval in shape, it's actually an **epitrochoid**. The shape of the combustion chamber is designed so that the three tips of the rotor will always stay in contact with the wall of the chamber, forming three sealed volumes of gas.

Each part of the housing is dedicated to one part of the combustion process. The four sections are:

- Intake
- Compression
- Combustion
- Exhaust

The intake and exhaust ports are located in the housing. There are no valves in these ports. The exhaust port connects directly to the exhaust, and the intake port connects directly to the throttle.

Output Shaft

The output shaft as shown in fig 4 has round lobes mounted eccentrically, meaning that they are offset from the centerline of the shaft. Each rotor fits over one of these lobes. The lobe acts sort of like the crankshaft in a piston engine. As the rotor follows its path around the housing, it pushes on the lobes. Since the lobes are mounted eccentric to the output shaft, the force that the rotor applies to the lobes creates torque in the shaft, causing it to spin.

Fig 4.OUTPUT SHAFT

Now let's take a look at how these parts are assembled and how it produces power.

Rotary Engine Assembly

A rotary engine is assembled in layers. The two-rotor engine we took apart has five main layers that are held together by a ring of long bolts. Coolant flows through passageways surrounding all of the pieces. One of the two end pieces of a two-rotor Wankel engine is shown n fig 5.

The two end layers contain the seals and bearings for the output shaft. They also seal in the two sections of housing that contain the rotors. The inside surfaces of these pieces are very smooth, which helps the seals on the rotor do their job. An intake port is located on each of these end pieces.

The next layer in from the outside is the oval-shaped rotor housing, which contains the exhaust ports. This is the part of the housing that contains the rotor.

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The center piece contains two intake ports, one for each rotor. It also separates the two rotors, so its outside In the center of each rotor is a large internal gear that rides around a smaller gear that is fixed to the housing of the engine. This is what determines the orbit of the rotor. The rotor also rides on the large circular lobe on the output shaft.

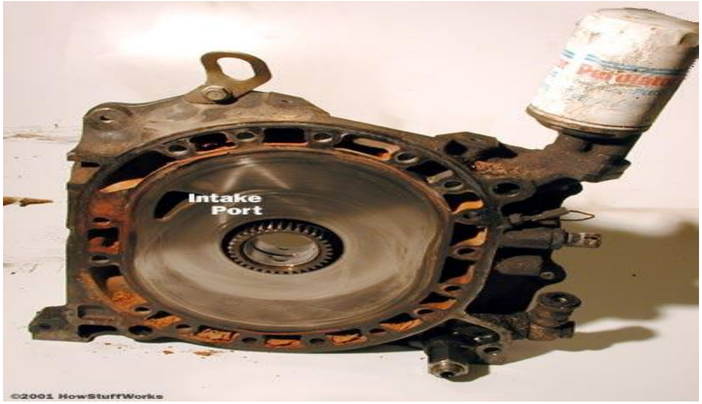

Fig 5. One of the two end pieces of a two-rotor Wankel engine

Rotary Engine Power

Rotary engines use the four-stroke combustion cycle, which is the same cycle that four-stroke piston engines use. But in a rotary engine, this is accomplished in a completely different way.

The heart of a rotary engine is the rotor. This is roughly the equivalent of the pistons in a piston engine. The rotor is mounted on a large circular lobe on the output shaft. This lobe is offset from the centerline of the shaft and acts like the crank handle on a winch, giving the rotor the leverage it needs to turn the output shaft. As the rotor orbits inside the housing, it pushes the lobe around in tight circles, turning *three times* for every one revolution of the rotor.

IV. WORKING

Intake

The intake phase of the cycle starts when the tip of the rotor passes the intake port. At the moment when the intake port is exposed to the chamber, the volume of that chamber is close to its minimum. As the rotor moves past the intake port, the volume of the chamber expands, drawing air/fuel mixture into the chamber. When the peak of the rotor passes the intake port, that chamber is sealed off and compression begins. Fig 6 shows this

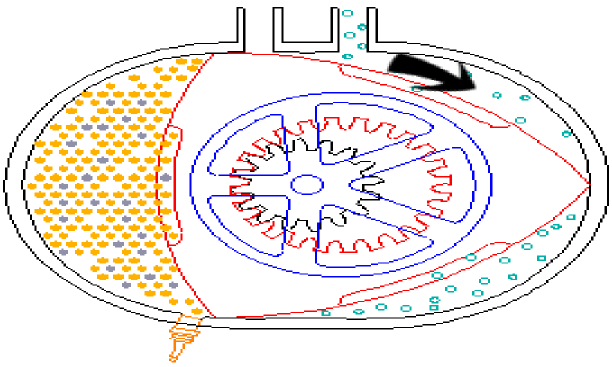

Fig 6 .Intake

Compression

As the rotor continues its motion around the housing, the volume of the chamber gets smaller and the air/fuel mixture gets compressed. By the time the face of the rotor has made it around to the spark plugs, the volume of the chamber is again close to its minimum. This is when combustion starts. Fig 7 shows this

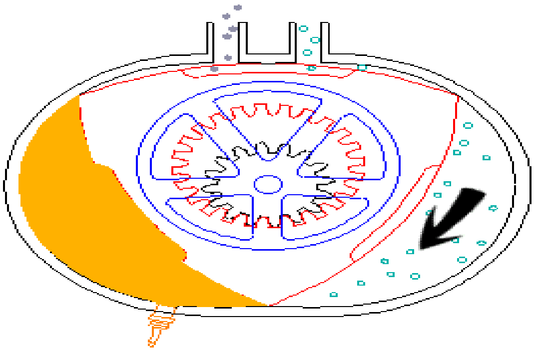

Fig 7 . Compression

Combustion

Most rotary engines have two spark plugs. The combustion chamber is long, so the flame would spread too slowly if there were only one plug. When the spark plugs ignite the air/fuel mixture, pressure quickly builds, forcing the rotor to move.

The pressure of combustion forces the rotor to move in the direction that makes the chamber grow in volume. The combustion gases continue to expand, moving the rotor and creating power, until the peak of the rotor passes the exhaust port. Fig 8 shows this

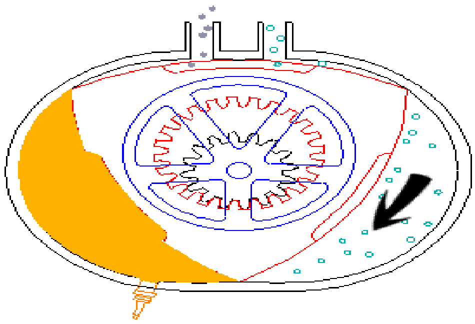

Fig 8 . Combustion

Exhaust

Once the peak of the rotor passes the exhaust port, the high-pressure combustion gases are free to flow out the exhaust. As the rotor continues to move, the chamber starts to contract, forcing the remaining exhaust out of the port. By the time the volume of the chamber is nearing its minimum, the peak of the rotor passes the intake port and the whole cycle starts again. Fig 9 shows this

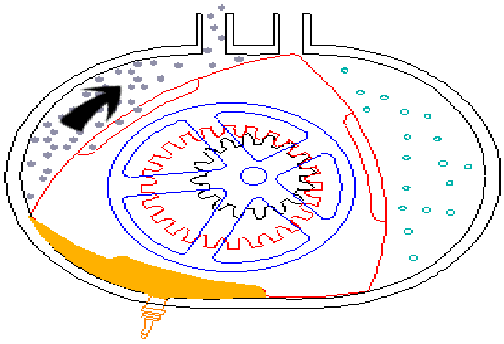

Fig 9 . Exhaust

The rotory motion is transferred to the drive shaft via an eccentric wheel (illustrated in blue) that rides in a matching bearing in the rotor. The drive shaft rotates once during every power stroke instead of twice as in the Otto cycle.

The neat thing about the rotary engine is that each of the three faces of the rotor is always working on one part of the cycle -- in one complete revolution of the rotor, there will be three combustion strokes. But remember, the output shaft spins three times for every complete revolution of the rotor, which means that there is one combustion stroke for each revolution of the output shaft.

V. ADVANTAGES & DISADVANTAGES

a. ADVANTAGES

- A far higher power to weight ratio than a piston engine (it is approximately one third of the weight of a piston engine of equivalent power output)
- It is approximately one third of the size of a piston engine of equivalent power output
- No reciprocating parts
- Able to reach higher revolutions per minute than a piston engine
- Operates with almost no vibration
- Not prone to engine-knock
- Cheaper to mass-produce as the engine contains fewer parts
- Superior breathing, filling the combustion charge in 270 degrees of mainshaft rotation rather than 180 degrees in a piston engine
- Supplies torques for about two thirds of the combustion cycle rather than one quarter for a piston engine
- Wider speed range gives greater adaptability
- It can use fuels of wider octane ratings
- Does not suffer from "scale effect" to limit its size

b. DISADVANTAGES

- Rotor sealing. This is still a problem as the engine housing has vastly different temperatures in each separate chamber section. The different expansion coefficients of the materials gives a far from perfect sealing. Additionally, both sides of the seals are being exposed to fuel, and the design does not allow for a dedicated lubrication system, as in two-stroke engines. In comparison, a piston engine has all functions of a cycle in the same chamber giving a more stable temperature for piston rings to act against; additionally, only one side of the piston in a (four-stroke) piston engine is being exposed to fuel, allowing for oil to lubricate the cylinders from the other side. To overcome the differences in temperatures between different regions of housing and side and intermediary plates, and the associated thermal dilatation inequities, the use of a heat pipe, transporting heat from the hot to the cold parts of engine, has been shown to reduce, in a small displacement, charge cooled rotor, air-cooled housing RCE, the maximal engine temperature from 231 °C to 129 °C, and the maximum difference from a hotter to a colder region of engine, from 159 °C to 18 °C.
- Apex seal lifting. Centrifugal force pushes the apex seal onto the housing surface forming a firm seal. Gaps can develop between the apex seal and troichoid housing in light-load operation when imbalances in centrifugal force and gas pressure occur. In low engine-rpm ranges, or under low-load conditions, gas pressure in the combustion chamber can cause the seal to lift off the surface, resulting in combustion gas leaking into the next chamber. Mazda has identified this problem and have developed a solution. By changing the shape of the troichoid housing, the seals remain flush to the housing. This points to using the engine at sustained higher revolutions eliminating apex seal lift off, in applications such as an electricity generator. In vehicles this leads to series-hybrid applications of the engine.
- Slow combustion. The combustion is slow as the combustion chamber is long, thin, and moving. The trailing side of the combustion chamber naturally produces a "squeeze stream" that prevents the flame from reaching the chamber trailing edge. Fuel injection in which fuel is injected towards the leading edge of the combustion chamber can minimize the amount of unburnt fuel in the exhaust. Kawasaki proposed a triangular tail extension of the plug hole, pointing to the combustion chamber trailing side to solve this.

VI. CONCLUSION

The Wankel Rotary Engine is a very interesting and well thought out engine. There is a lot of history behind it and also some very interesting facts about it. It has many advantages as well as many disadvantages. I think that this engine could become more popular because of its reliability and simplicity. I think that I would think about buying one of these engines because of the performance as well as the efficiency. The Wankel Rotary engine is going to nothing but become more popular and become even more efficient. I would recommend buying a vehicle with this engine in it.

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