QUASI TURBINE
THE ADVANCED ROTARY COMBUSTIONI ENGINE

ABSTRACT

In this paper working of Quasi-turbines is discussed. It is a rotary combustion engine generating rotary motion through the combustion of the fuel, unlike the piston which convert reciprocating motion. These devices directly generate the rotary motion avoiding sine wave crank shaft conversion. This paper reveals a high efficiency, low emissions combustion process called *Photo Detonation* which is superior to thermal ignition process like Spark Ignition, Compression Ignition ,Homogeneous Charge Compression Ignition.

The main principle behind this Quasi-turbine is to generate rotary motion through the combustion of fuel in the four combustion chambers only in one revolution involving the general four strokes Suction, Compression, Expansion and Exhaust. Complex set of valves and camshafts which use substantial amount of power, valve inertia ,intake depressurization and detonation are the major problems associated with the reciprocating piston engines. Though these problems can be solved by Wankel Rotary Combustion, the problems of low efficiency, poor combustion, high emissions, starting trouble made this ineffective. So these Quasi-turbines can overcome both the problems of piston and Wankel engines.

The Quasi-turbine consists of four combustion chambers associated with carriages, are semi-spherical in shape and inturn are sealed perfectly from each other. In all the combustion chambers all the four events occur per

each revolution. The expansion stroke in each CC makes the Quasi-turbine to rotate. Each carriage is connected to the shaft. In this combustion namely photo-detonation, the combustion is initiated by a short strong pressure pulse.

Since there is no necessity to convert reciprocating motion to rotary motion there will be no mechanical losses. As high compression ratios can be maintained we can have high thermal efficiencies and low SFC s. Here dead times and reallocating times are totally absent. As the surface / volume ratio is very high Detonation is extremely low. It can generate high powers even at lower RPM s. Cooling can be easily provided. Combustion is very clean. Unburnt HC s and CO s are extremely less. As the residence of N2 in CC is reduced Nox emissions are reduced a lot.

INTRODUCTION

The Piston engine perhaps unquestionably, has been at the center of mechanical energy conversion for almost 2 centuries and as such, has been a pivotal technology in our development and transformation into a modern society The things supporting the piston technology are

- Sine wave crankshaft motion has been long assumed as the best way to convert linear motion into rotary motion.
- The internal combustion engines has became the part of the common man's life.

But the Quasiturbine engine which is a internal combustion rotary engine is more advantageous than ordinary reciprocating piston engines.In these Quasiturbines we can use a special type of combustion technique called photodetonation,which the piston can't tolerate effectively.By using this photodetonation mode we can save half the gasoline now consumed by vehicles and also it is ecofriendly.A recent March 2003 MIT report reached the following conclusion: "Improving gasoline and diesel engine is the way to go. The Hydrogen car is no environmental panacea: The hydrogen fuel cell will not be better in terms of total energy use and greenhouse gas emissions by 2020". With photo-detonation, the internal combustion engine is likely to become most fashionable again.

The difficulty of the Quasiturbine is in its concept, not its construction. Unlike the Wankel rotary engine, the Quasiturbine has a four-face deformable rotor which solves the theoretical Wankel flaws. Several proof of concept Quasiturbines have already been built and pneumatic educational prototypes are already marketed by Quasiturbine Académique Inc.

BACKGROUND

These Quasiturbines producing high efficiencies with extremely low exhaust emissions are no doubt,power advanced hybrid vehicles and stationary power systems.Through the use of most advanced combustion process, photodetonation ,the knocking is completely reduced. The Quasiturbine is also compatible with the Otto and Diesel modes, with substantial benefits over current piston engines.It can also be used in steam engines,cold injection,hot injection and steam locomotives etc.

By using four faced deformable rotor,it can perform 16 cycles in only one revolution there by getting high efficiencies even at low speeds of the order of 1800 rpm.Even at this speed it can give high power output about 200MW.

Quasiturbine Definition

The Quasiturbine (Qurbine) is a no crankshaft rotary engine having a 4 faces articulated rotor with a free and accessible center, rotating without vibration nor dead time, and producing a strong torque at low RPM under a variety of modes and fuels. The Quasiturbine design can also be used as an air motor, steam engine, gas compressor or pump. The Quasiturbine is also an optimization theory for extremely compact and efficient engine concepts.

BASIC PRINCIPLE

It is a rotary internal combustion engine having a deformable four faced rotor which enables to create four different chambers inside the engine. The charge is allowed to enter through the inlet port into the combustion chamber.Then this charge is subjected to Compression,Combustion and Expansion processes.Then the residual gases are sent through the exhaust port.The same sequence of processes happens in the other three chambers.Thus we can get ***8 – power strokes*** out of two revolutions.The power strokes in each combustion chamber will rotate the shaft due to the peculiar geometry of the rotor.

COMBUSTION PROCESS

PRINCIPLE

This combustion process uses detonation or knocking which is undesirable in piston engines.Because of the detonation short pressure pulse is created.It mkes the temperature to increase by far all ignition points.This creates a black body type laser like radiation.This makes the entire charge to burn spontaneously,homogeneously and completely.Here the pressure pulse is so short that the combustion is homogeneous.The combustion is just like a paper burning under a focal lens projected by sun light.

WORKING

Photo-detonation combustion mode is the fastest and the cleanest way, driven by volumetric black body radiation density, alike a powerful laser beam. Reference to laser light is a good way to see it; an other way is to remember burning a piece of paper at the sun focal point of a lens. It require no anti-detonation fuel additivesThe road to photo-detonation goes through some deflagration, some thermo-ignition auto lit, some threshold detonation and some supersonic detonation, all adding to radiation process, and finally radiative combustion driven photo-detonation. This mode is almost independent of the shape of the combustion chamber and accept almost any type of fuel. Photo-detonation can be considered to be the best of Otto and Diesel modes. It is homogeneous combustion without having intake manifold vacuum load.The research work is going towards the "piston thermal ignition control",(possibly involving the ultra high intensity spark concept) which is not the way of the Quasiturbine. Because of its significantly shortened pressure pulse (especially for the model with carriages), the Quasiturbine compression temperature increases mainly and rapidly at the pressure tip to exceed, by far, all ignition and combustion parameters (it is little affected by the engine wall temperature or otherwise in such a short time...). The combustion is then driven by the intense radiation in the chamber and does not welcome anti-knocking fuel additives but some additives which absorb the radiation and increase the octane index are added. The photo-detonation occurs at slightly higher pressure than the thermal ignition designated as "Homogeneous Charge Compression Ignition" (HCCI) combustion. The thermal and photonic ignition control in the piston is still an unsolved problem, but one that the Quasiturbine does overcome by better pressure pulse shaping. The piston is not designed for such a violent (knocking) aspect of combustion as photo-detonation, therefore, a successful machine solution must get rid of the crankshaft sine wave piston volume variation.

ADVANTAGES

- Quasiturbine photo-detonation of the homogenous fuel/air charge eliminates the electronic ignition requirement for most fuel.
- Photo-detonation completely combusts the fuel in the fuel/air charge because of the short, but powerful, pressure pulse and because of the fast nearly linear variation of the Quasiturbine's maximum pressure zone, which rapidly closes and re-opens the combustion chamber.
- The Quasiturbine (unlike the diesel) is therefore a "clean homogeneous combustion" engine. It has virtually no emissions other than the standard products of combustion, e.g., CO_2 and H_2O. "Clean combustion"also implies that the Quasiturbine engine is more fuel-efficient than the diesel. - Photo-detonation in the Quasiturbine occurs rapidly at top dead center.
- The combustion in Quasiturbine can have a very simple cooling mechanism, such as air-cooling. The principal difference between the Otto and the photo-detonation Quasiturbine is the mechanism of fuel ingestion, ignition and combustion.
- The Otto mode Quasiturbine uses a spark ignition, while the photo-detonation Quasiturbine eliminates the need for spark plugs and an electrical ignition system. In photo-detonation mode, the fuel/air charge autoignites with a *short powerful pressure pulse* in the Quasiturbine's combustion chamber.

ENGINEERING CONFIGURATION

CONSTRUCTION

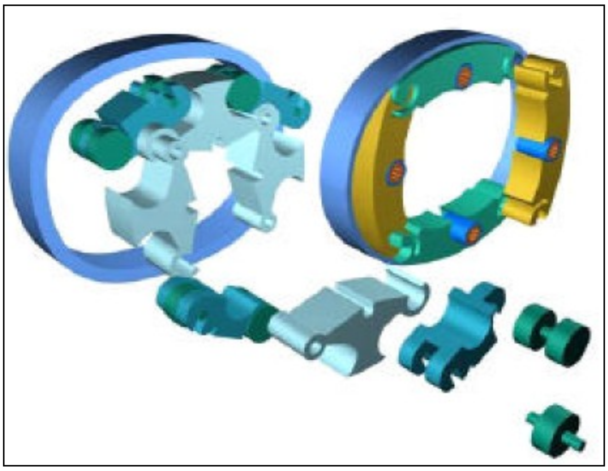
It is a rotary internal combustion engine.It is either circular or elliptical.It is constructed in two ways. QT-AC(with carriages)& QT-SC (without carriages).

QT-AC(with carriages)

The rotor is made up of simple mechanical linkages which enables deformable volumes.In this there will be four carriages.Each carriage is connected to the shaft through a peculiar geometrical shape.The rotor turns on the inner periphery of the stator through the dumb-bell shaped linkages.It has a fixed inlet and exhaust ports.The compression and expansion processes in the QT depend on the movement of the carriages.If the carriages move inwards it the charge is compressed and if the carriages move outwards the pressure decreases.

QT-SC(without carriages)

The rotor is made up of simple oval shaped lobes.In this there will be four lobes.Each lobe is interconnected to each other.Whenever the rotor rotates on the inner periphery of the stator the volumes of the chambers will be changed.The stator is elliptical in shape.So that depending on their geometry the compression and the expansion occurs.The each combustion chamber is sealed from the adjacent ones by perfect ceramic coatings.

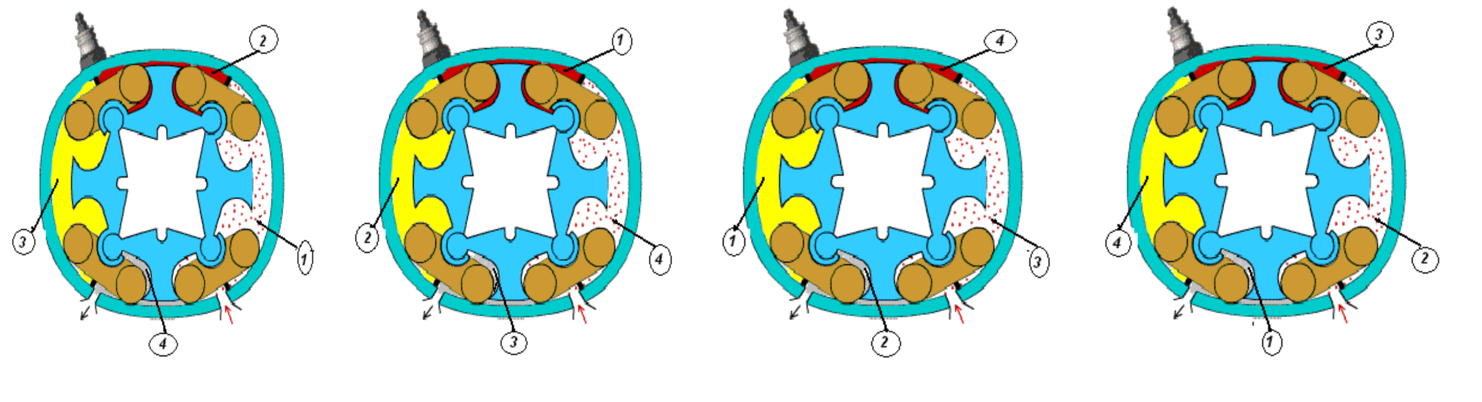


QT-AC (with carriages) & QT-SC(with out carriages)

WORKING

It is a rotary internal combustion engine having a deformable four faced rotor which enables to create four different chambers inside the engine. In each combustion chamber the normal four strokes happens.

Let us observe the chamber 1 in all the following figure.



1 → *Suction* ***Compression*** ***Expansion*** ***Exhaust***

Suction : The charge(fuel and air mixture) is allowed to enter the combustion chamber because of the outard movement of the carriages leading to reduction of pressure than the atmospheric pressure.

Compression : The charge is compressed due to the inward movement of the carriages to a high pressure and temperatures because of high compression ratios.

Combustion : The combustion takes place as decribed above.

Expansion : The high thermal energies released in the combustion chamber are converted into mechanical energies generating mechanical forces which pushes the carriages outwards there by rotating the rotor.

Exhaust : Because of the inward motion of the carriages all the exhaust is sent out through exhaust ports.

ADVANTAGES

- Because it does not have internal accessories to drive, like the piston cam shaft and valve train, additional energy is available to the end users.
- Because of the shaping of the volume pressure pulse, the thermodynamic of the Quasiturbine can be far superior.
- Because the Quasiturbine is a high torque low rpm engine, much less or no transmission gears ratio are needed with corresponding efficiency increase.
- Because the Quasiturbine can be of large size, it is an efficient alternative to utilities for efficient energy conversion (steam) in electricity or from co-generation.
- Because the Quasiturbine (AC model with carriages) has the potential to run in detonation mode, it will not have the low power penalty of the Otto cycle, which can provide a 50% energy saving in transportation application (much superior to hybrid concepts).
- Atmospheric gas pollution - Having a reduced combustion confinement time, the NO_x are are produced in lower concentration.
- Thermal pollution - Having an early mechanical extraction capability, less thermal energy is released in the environment.
- Noise pollution - Having 4 combustions per rotation, and due to a longer gas relaxation chamber, noise is reduced by a factor of 20 or more ! The Quasiturbine is a vibration free engine
- Oil free engine - Lubrication is source of pollution. The Quasiturbine has potential to be an oil free engine.
- Hydrogen compatible - Hydrogen fragilises steel, and degrades all oils. The Quasiturbine has a cool and stratified intake area most suitable for pure hydrogen engine (lubricant free) combustion.
- Photo detonation compatible.
- An high performance anti-pollution system (non catalytic), giving considerably more reduction of the NOx level than conventional system.

- A densification system, reducing by more than 50% the engine-flywheel-shaft-gearbox assembly volume, which leaves more space in the vehicle for other uses.

ENVIRONMENTAL BENEFITS

Regardless of the method of ignition and combustion,the Quasiturbine is a uniquely "clean combustion"engine. The pollution-related products of commercially available internal combustion engines include carbon monoxide, other un-combusted hydrocarbons and oxides of nitrogen. Carbon monoxide and un-combusted hydrocarbons are the result of incomplete combustion of the fuel in the engine. Oxides of nitrogen are formed because of the relatively long high pressure and temperature ,residence time of nitrogen in the combustion chamber which does n't happens in Quasiturbine . With respect to carbon monoxide and un-combusted hydrocarbons, the Quasiturbine's combustion chamber movement, which is near linear, favors uniform ignition of the fuel/air charge to all areas of the chamber. Another advantage of the photo-detonation engine is temperature limitation. The Quasiturbine has the potential to be an oil free engine as required by hydrogen of the future. Because it has no dead time, it has a specific power density at least 4 times higher than the piston engine. A faster reduction in the combustion chamber of the temperature, the pressure and the confinement time leads to less NOx production. Excess air in the photodetonation mode also helps to reduce the combustion temperature while achieving a more complete combustion.

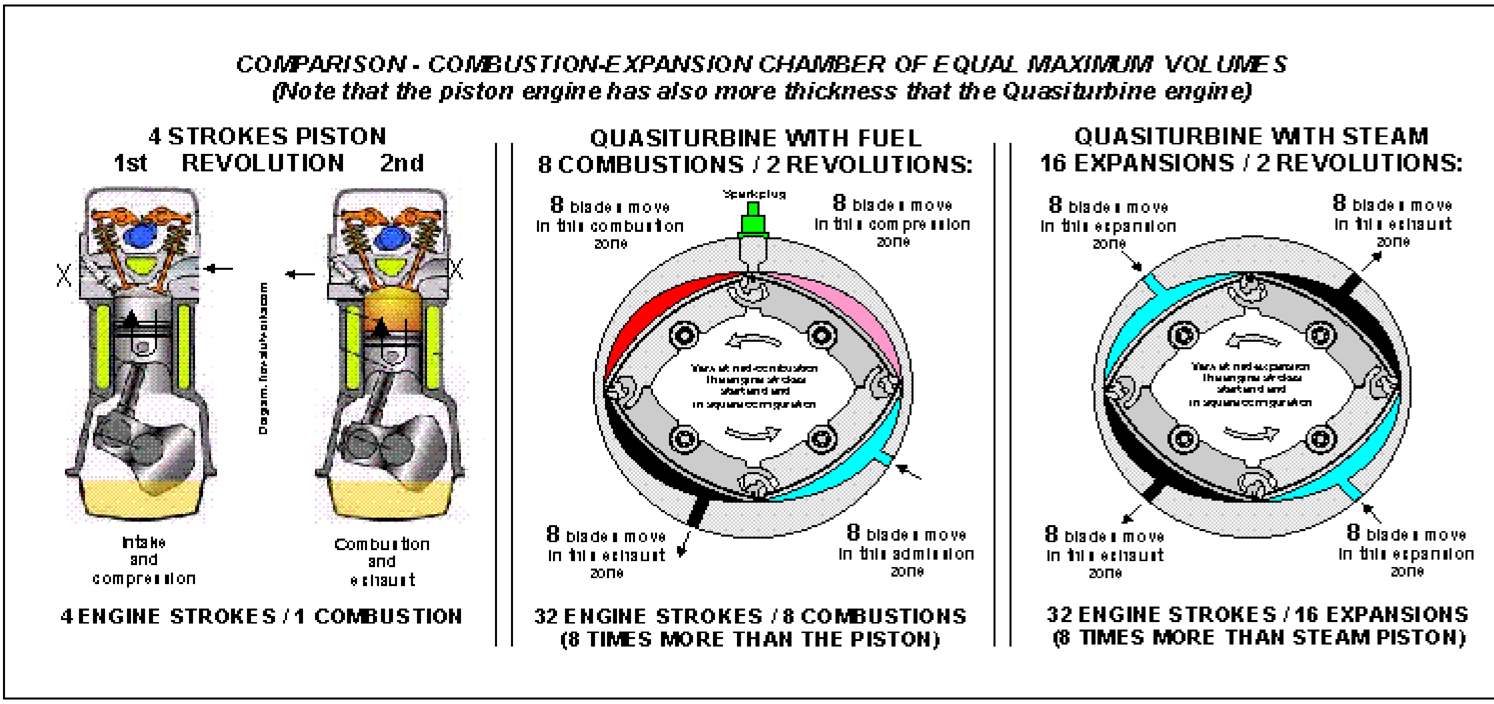
Now let us see which reasons make us to avoid pistons and be adopted to Quasi turbines.

PISTON ENGINE LIMITATIONS

The piston engine has served us well over the years and deserves our respect even when compared with new, potentially more efficient, concepts. The following list outlines the main conceptual deficiencies which tend to limit future prospects for enhanced piston efficiency even with advanced control technologies: [2]

1. The 4 engine strokes should not be of equal time duration.
2. The 4 stroke piston makes positive torque only 17% of the time and drag 83% of the time.
3. The gas flow is not unidirectional, but changes direction with the piston direction. While the piston descends, the ignition thermal wave front has a hard time trying to catch the gas moving it in that same direction.
4. The valves open only 20% of the time, interrupting the flows at intake and at exhaust 80% of the time.
5. The duration of the piston rest time at top and bottom are unnecessarily too long which increases the heat transfer to the engine block, thus reducing engine efficiency.
6. The proximity of the intake valve and the exhaust valve prevent a good mixture filling of the chamber and the open overlap allows some un-burnt mixture into the exhaust.

7. The average torque is only 15% of the peak piston torque, which requires enhanced construction robustness for a peak 7 times the average.
8. The flywheel needed to smooth out the torque gaps and protect the crankshaft is a serious handicap to acceleration and to the total engine weight.
9. The connecting rod gives an oblique push component to the piston, which then requires a generous lubrication of the piston wall.
10. The need for a complex set of valves and camshaft which use substantial power.
11. The valves inertia being a serious limitation to the engine revolution.
12. The heavy piston requires some residual compressed gas at exhaust top dead center to cushion the piston return.
13. A design inherent difficulty in addressing noise level and vibration which is called ***detonation***
14. At low load factor, the intake depressurization of the Otto cycle dissipates power from the engine (vacuum pump against the atmospheric pressure).



QUASI TURBINE – WANKEL DIFFERENCES

- The Wankel engine uses a rigid three faces rotor with a crankshaft.
  The Quasiturbine uses a deformable four face rotor without a crankshaft.
- The Wankel engine shaft turns at three times its rotor RPM.
  The Quasiturbine rotor and main shaft turns at the same speed.
- The Wankel engine fires only once per shaft (not rotor) revolution (which means three times per rotor revolution).
  The Quasiturbine fires four times per main shaft revolution, producing a strong and exceptional torque continuity.

- The Wankel engine has a dead times. A complete rotor (not shaft) revolution is composed of three relaxation strokes of 90 degrees each, separated by a 30 degree rotor dead time.

  The Quasiturbine strokes are consecutive, with no dead time, allowing continuous combustion by flame transfer.
- The Wankel engine has a negative excess volume during its relaxation stroke, which lowers efficiency, and is responsible for some unburnt hydrocarbons.

  The Quasiturbine has no excessive volume during expansion, for maximum efficiency, and minimum HC unburnt.
- Due to its large residual chamber volume near the TDC, the Wankel can not easily be operated in Diesel mode.

  The Quasiturbine has no compression ratio limitation and can run in diesel mode.
- Due to its one single firing per shaft revolution, and the dead time, the Wankel engine needs a flywheel.

  The Quasiturbine needs no flywheel, and consequently has faster acceleration.
- The combustion chamber at top dead center of the Wankel is elongated and thin, and the relative contour wall and piston movements dragging the mixture into an unwanted rolling movement in a referential moving with the chamber, turning down the combustion at the chamber extremes.

  The Quasiturbine chamber is located in a tangential median cut in the rotary blade filler tip such that at top dead center, it is squeezed between the 2 carriage rollers.
- The Wankel needs 2 sparkplugs because of the gas rolling effect and the thin flat combustion chamber shape.

  One sparkplug is sufficient in Quasiturbine.
- The Wankel engine radial seals are at equidistant and at fix distances.

  The Quasiturbine (AC model type) seals are at variable angular and linear distances, giving relative geometric enhancement to intake, compression, and gas expansion.
- The Wankel engine is a "rotating piston engine" that is subject to a constant circular vibration.

  The Quasiturbine has a fixed center of gravity during rotation, and is a true zero vibration engine (like the turbine)
- The center of the Wankel engine is part of the oil pan, and contains the mandatory main crankshaft.

  In the Quasiturbine, there is no crankshaft, and the central main shaft is optional. The center of the Quasiturbine can be empty, and available for electrical components, fan blades, or other devices.
- Since the main Wankel engine shaft rotates at three times its rotor speed, it is more suitable for high RPM end uses.

  The Quasiturbine main shaft (rotating at the same speed as its rotor) is more appropriate for lower revolution end uses (e.g. airplane propeller at only 2000 RPM, generator, transportation, or to reduce gearbox ratio in current applications).

- Due to its geometry, the Wankel exhaust and intake ports overlap extensively, opening much before the expansion stroke is over, and closing much after the intake stroke has begun.
  The Quasiturbine does not impose such a wide overlap detriment to efficiency.

comparision table of piston-wankel-quasiturbine engines

PISTON - WANKEL - QUASITURBINE

(Theoritical values not experimentally verified)

	Volume of each chamber (Prototype 1999)	Number of expansions (combustions) in every " 2 " revolutions	Power multiplyer (substained pressure)	Relative power (same RPM)
Piston 4 strokes (gazoline)	50 cc	1	1	1
Piston 2 strokes (gazoline)	50 cc	2	1	2
Wankel 4 strokes (rotor - not shaft)	50 cc	6	0.4 to 0.7	4
Qurbine 4 strokes (gazoline)	50 cc	8	1.2	10
Qurbine 2 strokes (gazoline)	50 cc	16	1.2	20
Qurbine (Steam / pneumatic) (500 psi)	50 cc	16	2.5	40

CONCLUSIONS

- Direct generation of rotary motion leading to high mechanical efficiencies.
- Superior combustion process i.e.,*Photo Detonation* is followed which is easily controllable.
- Detonation(pinging) is almost completely reduced .
- No intake depressurization.
- Unlike conventional IC engine producing 1 power stroke per two crank revolutions this can produce 8 power strokes per two revolutions.
- Frequent usage of combustion chambers.
- Providing cooling is very easier.

- Less unburnt HC and CO emissions.
- Very less Nox emissions as very low temperatures are maintained and less residence time.
- It can generate high power densities even at lower RPMs.

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