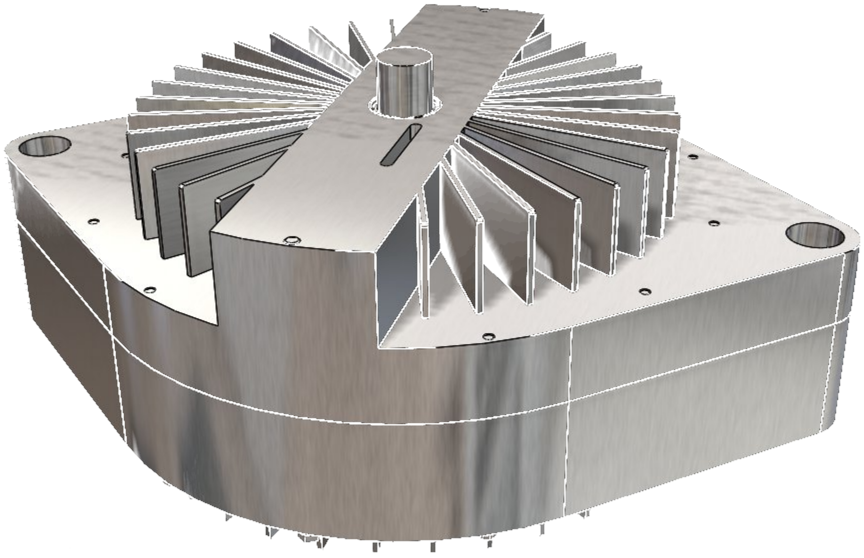


Pentt

RADIAN ENGINE

Compact, low emissions, continuous high torque engine.

Rotary gasoline or hydrogen internal combustion engine for extended range power generation applicable in electric vehicles.

CONTENT

Design background

The current design of the ICE internal combustion engines with reciprocating pistons is inherited from the first steam locomotives. This design consists of an irregular engine body where the compression and combustion processes are carried out in the same chambers. These processes use heavy-weight pistons inconveniently positioned on the upper part of the engine’s shaft line that reciprocate at thousands of revolutions per minute. This piston configuration produces low torque and high vibrations, so they must be balanced with counterweights. These engines must also rotate at thousands of RPM to be able to generate the desired power.

It has taken more than a hundred years to create dozens of mechanisms seeking to increase mechanical and thermal operation efficiency of this design.

The electric motor is undoubtedly one of the most remarkable inventions in human history, with far-reaching implications across countless industries and powering a vast array of devices. Its inception in the early 19th century marked a turning point, as it harnessed the power of electricity to convert electrical energy into mechanical motion. Since then, the electric motor has undergone significant advancements and found critical applications in various sectors, including the automotive industry. This essay will delve deeper into the operating principles, development, and challenges faced by the electric motor in the automotive sector.

Electric Motor Operating Principles:

1. Electric Motor Parts: The electric motor comprises two essential components: the stator and the rotor. The stator, the stationary part of the motor, houses the windings made of copper or aluminum wire. The windings are carefully wound around the stator core, creating electromagnetic fields when energized. The rotor, the rotating part, consists of permanent magnets or electromagnets. When electric current flows through the stator windings, it generates a magnetic field that interacts with the magnetic field of the rotor, resulting in rotational motion.
2. Assembly of the Stator Windings: The assembly of the stator windings is a crucial aspect of electric motor design. The windings are meticulously arranged in a specific pattern to create a rotating magnetic field. By adopting a three-phase configuration, the motor can generate a rotating magnetic field that propels the rotor. The precise alignment and placement of the windings optimize motor efficiency and performance.
3. Natural Position of the Stator and Magnets: The strategic positioning of the stator and magnets is another key factor in electric motor design. By placing the magnets at a certain distance from the shaft, the motor capitalizes on the physical principle described by the equation $\tau = r \times F$. The torque (τ) produced by the motor is proportional to the distance (r) between the magnets and the axis and the force (F) exerted. This design choice allows electric motors to naturally develop high torque, enabling them to deliver impressive performance.
4 Instant Torque Delivery: One of the standout features of electric motors is their ability to provide instant torque. Unlike internal combustion engines, which require time to build up torque, electric motors deliver torque immediately. This is attributed to the precise control of electric current flow through the windings. By adjusting the current, the motor can respond promptly to input signals, resulting in instant acceleration and responsiveness. This characteristic makes electric motors highly suitable for automotive applications where quick and efficient torque delivery is essential for performance and safety.

Radian Rotary Internal Combustion Engine: Innovation in the Face of Electric Motor Challenges

In response to the current challenges of the electric motor, a group of talented engineers has dedicated themselves to developing an innovative alternative: the Radian rotary internal combustion engine. Inspired by the advantages of the electric motor in terms of efficiency, instant torque, and high torque, these engineers have created an engine that seeks to offer these same benefits without the sustainability problems associated with battery production and disposal, as well as the dependence on fossil fuels for electricity generation. The Radian engine is based on similar physical and mechanical principles as the electric motor but with additional advantages, such as low manufacturing cost.

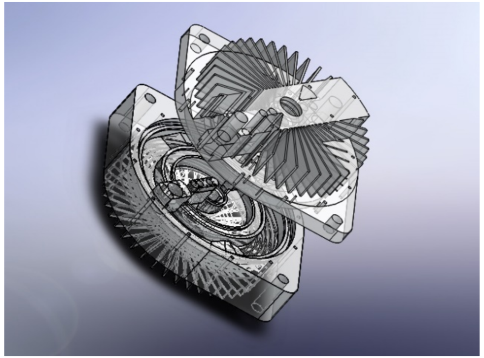
Operating Principle of the Radian Engine: The Radian engine operates through internal combustion and utilizes a rotary design. Like the electric motor, it consists of two essential component groups: the first group consists of the compression tracks near the axis and the combustion tracks away from the axis. These elongated and rectangular combustion tracks generate the propulsive force, similar to the stator of the electric motor, but instead of relying on electromagnetic induction, it is due to expansion that drives the rotary motion of cam profiles placed at a certain distance from the engine axis. The second group consists of the rotor, the rotating part, which firmly holds these cam profiles, similar to the electromagnets of the electric motor. When expansion occurs in the combustion chamber or chambers, a rotary motion is generated with torque similar to that delivered by the electric motor because, in both systems, the propulsive force is located away from the engine shaft.

Comparison with the electric motor: The Radian engine shares several characteristics with the electric motor that make it an attractive alternative. Like the electric motor, the Radian engine is capable of providing instant torque. Unlike conventional internal combustion engines that require time to build up torque, both the electric motor and the Radian engine deliver torque immediately. In the case of the Radian engine, this is due to the presence of a regular supply of pressurized air from the compression tracks near the axis, where the air is stored before being supplied to the injectors. This pressurized air is dosed into the combustion chamber, allowing the Radian engine to deliver almost instant torque, resulting in immediate acceleration and efficient response. This feature is especially valuable in automotive applications, where the quick and efficient delivery of torque is essential for performance and safety. The force and efficiency of thrust are largely due to another advantage provided naturally by the rotary design of the compression chambers, which are also rectangular, elongated, and concentric but now close to the axis, compressing the air with great force.

Advantages of the Radian Engine over the Electric Motor: The Radian Engine offers several advantages over the electric motor. Firstly, it addresses one of the main challenges of the electric motor: the weight of electric vehicles due to batteries. Although battery technology has improved energy density and reduced weight, electric vehicles still tend to be heavier than conventional vehicles. This additional weight can affect aspects such as maneuverability, braking, and overall vehicle efficiency. The Radian Engine offers a lighter alternative, helping to mitigate these problems. Additionally, the Radian Engine can operate with synthetic fuels or e-fuels, and even if it were to operate with traditional fuels such as gasoline, the engine would have much lower pollutant emissions than conventional engines due to its high operating efficiency.

Furthermore, the Radian Engine stands out for its lower manufacturing cost compared to the electric motor. Its simple design and reduced number of moving parts make it more cost-effective to produce. This can contribute to greater economic viability of vehicles equipped with Radian engines, making them more accessible to a wider audience.

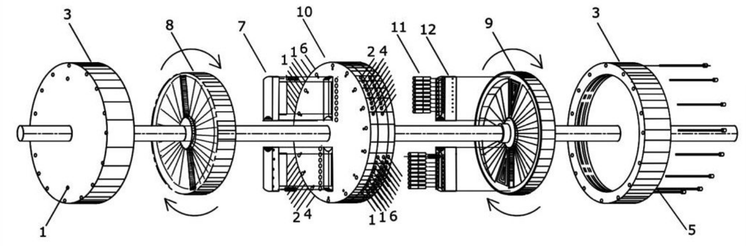
Conclusion: The Radian rotary internal combustion engine represents an innovative solution to the current challenges of the electric motor. By combining the physical and mechanical principles of the electric motor with additional advantages such as low manufacturing cost and the possibility of using more sustainable fuels, the Radian Engine seeks to offer an attractive and efficient alternative. The Radian Engine represents a step forward in the search for more sustainable and efficient solutions in the transportation industry.



About the project

The design of the Radian rotary internal combustion engine offers great advantages that are not found in any other ICE design in the world. Its operating principle is different from that of conventional reciprocating motors since, unlike these: 1.- It generates high torque and power continuously and constantly. 2.- It has a high use of the fuel energy to transform it into mechanical impulse (efficiency >60%) 3.- It operates at low RPM and generates high power. 4.- It does not require conventional valves or distribution chains mechanisms. 5.- The intake chambers, air compression and the combustion and expansion chambers are not the same for each process, which allows air-fuel mixtures from 15:1 to 68:1 6.- It is made up of fewer parts , is symmetrical, light, compact and naturally balanced.

Characteristics: 1.- The force generated in the combustion is applied on a large lever arm to the motor shaft, generating ample torque. 2.- It carries out the thermodynamic processes of admission, compression, combustion, and exhaust at multiple points at the same time and continuously in each rotation. 3.- The compression of the intake gases is conveniently carried out in several stages, achieving high compression levels (>20:1). 4.- The parameters of RPM, the quantity of fuel, and the volume of intake air are optimized, always keeping them constant. 5.- Generates high levels of work and power. 6.- It works at constant RPM. 7.- It generates minimum levels of polluting gases NOx, CO, or Hc, and 8.- Its ideal application is to powerfully drive an EV vehicle electric generator in a SUPER-extended range, eliminating the need for large batteries or having to plug it in to recharge it.



1.-Cold oil inlet.
2.-Air intake.
3.-Engine body.
4.-Fuel inlet.
5.-Hot oil outlet.
6.-Gas exhaust.
7.- Intake/ Compression Radiano
8.-Intake / Compression Rotor.
9.-Combustion /Expansion Rotor.
10.-Central disks engine body.
11.-Fuel Injectors.
12.-Combustion /Expansion rotor.

Exploded view of TWIN ROTOR Radian engine.

About the design

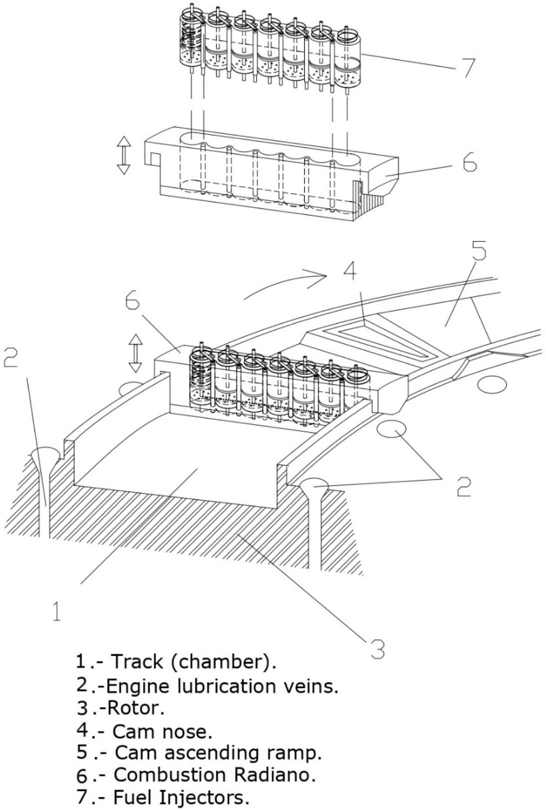
The patent (WO2015012677A8) shows the design of the Radian Engine. This is a circular internal combustion rotary engine that performs a split 4-Processes (strokes) thermodynamic cycle. The intake gases are compressed in one part of the engine and then transferred to a second part of the engine where the combustion chambers are located. The engine has circular, disc-shaped rotors attached to its shaft that also serve as flywheels. Their rotors are characterized by having a certain number of concentric circular tracks with a rectangular section on one of their circular faces. These tracks have a cam profile that causes the axial rise/fall of rectangular 2 parts radial telescopic gates called Radianos, which are attached at one end to the engine body. This results in the formation of elongated hermetic chambers in front of and behind said gates, where the thermodynamic processes of intake, compression, combustion and exhaust take place.

The moving parts in this engine are the rotating rotors attached to the engine shaft and the telescopic gates called Radianos. The rectangular 2 parts bodies of the Radianos are joined at one end to the engine body itself and the other end moves axially in a reciprocating manner following the contour of the concentric circular tracks. The Radianos have a downward/upward motion that is caused by a cam profile attached to the bottom of the tracks. These telescopic gates additionally function as valves since, through them, the gases are conducted between the tracks, and both compressed air and fuel are released inside said tracks.

¿How it works?

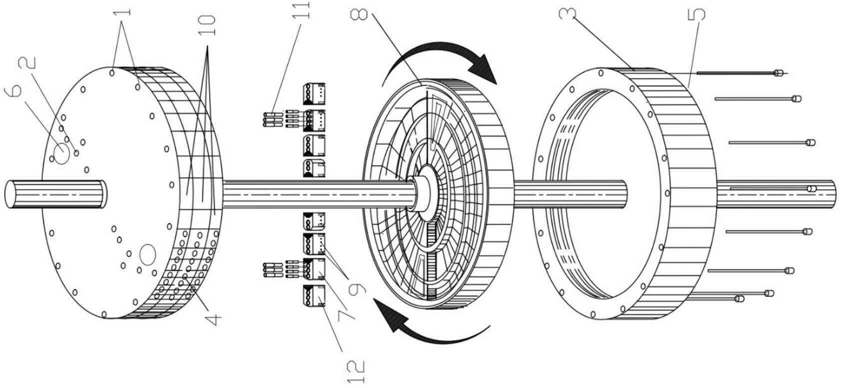
The thermodynamic processes of intake, compression, combustion, and exhaust in the Radian engine are carried out simultaneously and without interruption. The tracks farthest from the motor shaft (which have a greater lever) are used for combustion and those close to them (which have a greater torque) for compression. This latter process is conveniently carried out in several steps since gases are continuously transferred between its tracks. The intake gases compressed in the first step are transferred to the next track (concentric) closer to the axis for a second compression process, performing this process uninterrupted. The process continues until large compression ratios (>20:1 bars) are effortlessly achieved to finally transfer the highly compressed air to the combustion chambers through ducts inside the engine body.

In each Radiano of combustion, the fuel is consumed in the front chamber to them, and residual gases are released (exhaust) by the rear chamber. At each compression radian, the air is admitted into the front chamber and compressed into the rear chamber.



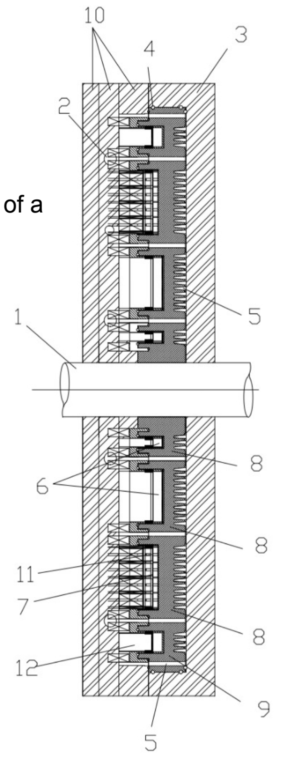
Detail of the assembly of the combustion Radiano in the Rotor Track

Exploded side view of single rotor Radian engine.



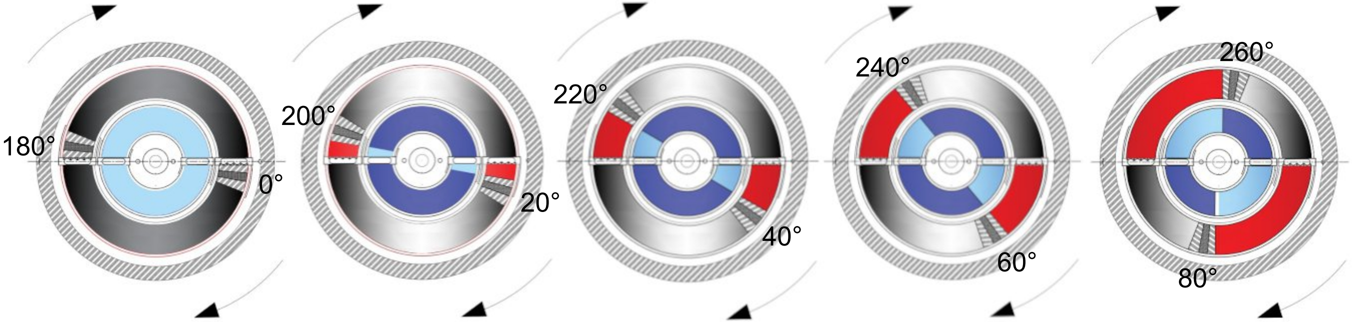
1.-Cold oil inlet.
2.-Air inlet
3.-Engine body.
4.-Fuel inlet.
5.-Hot oil outlet.
6.-Gas exhaust.
7.-Intake/Compression Radiano.
8 .-Rotor
9 .- Air/Fuel outlets.
10 .- Central disks engien body.
11 .- Fuel Injectors.
12 .- Combustion / Expantion Radiano

Diametrical cutaway of a single rotor Radian engine.



1.- Engine shaft.
2.- Engine seals.
3.- Engine body.
4.- Ball bearings.
5.-Engine lubrication veins.
6.- Tracks (chambers) of compression.
7.- Intake/Compression Radiano.
8 .-Rotor in compression zone.
9 .- Rotor in combustion zone.
10 .- Central disks engine body.
11 .- Fuel Injectors
12 .- Combustion /Expansion Radiano.

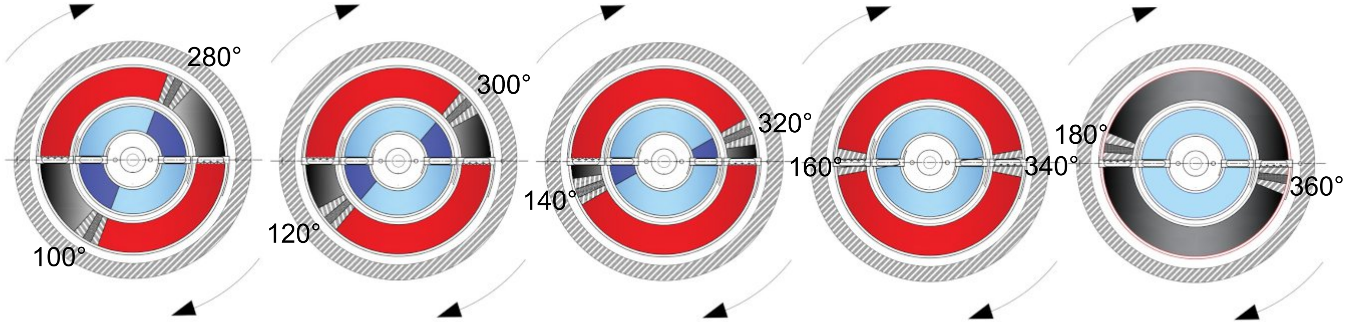
Thermodynamic cycle of a Radian Engine with one rotor/two tracks that shows operation mechanical principle (shown in video).



Combustion/Exhaust Track (Red)
Admission/Compression Track (Blue)

	Dead point				
Shaft grades (Rotor)	0°/180°	20°/200°	40°/220°	60°/240°	80°/260°
Combustion Radiano (Position)	Down	Down	Down	°Down	Down
Spark	No	Yes	No	No	No
Compressed air outlet	No	Yes	Yes	No	No
Fuel output	No	Yes	Yes	No	No
Combustion/Expansion	No	Yes	Yes	Yes	Yes
Torque (Strength) %)	0	100	90	80	70
Combustion chamber size %	0	10	20	30	40
Exhaust Camera Size %	100	90	80	70	60
Gas outlet	No	Yes	Yes	Yes	Yes
Compression Radiano (Position)	Up	Down	Down	Down	Down
Air inlet (Intake)	No	Yes	Yes	Yes	Yes
Air compression %	0	10	20	30	40
Transfer of compressed air to tank	No	Yes	Yes	Yes	Yes

Combustion/Exhaust Track (Red)
Admission/Compression Track (Blue)



					Dead point
Shaft grades (Rotor)	100°/280	120°/300	140°/320	160°/340	180°/360
Combustion Radiano (Position)	° Down	° Down	° Down	° Down	° Up
Spark	No	No	No	No	No
Compressed air outlet	No	No	No	No	No
Fuel output	No	No	No	No	No
Combustion/Expansion	Yes	Yes	Yes	Yes	No
Torque (Strength) %)	60	50	40	30	0
Combustion chamber size %	50	60	70	80	100
Exhaust Camera Size %	50	40	30	20	0
Gas outlet	Yes	Yes	Yes	Yes	No
Compression Radiano (Position)	Down	Down	Down	Down	Up
Air inlet (Intake)	Yes	Yes	Yes	Yes	No
Air compression %	50	60	70	80	0
Transfer of compressed air to tank	Yes	Yes	Yes	Yes	No

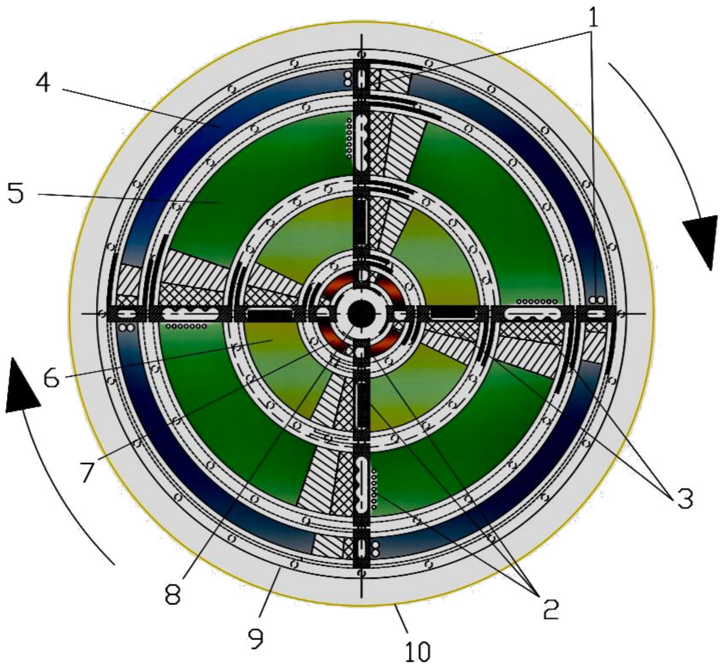
Four track Radian Engine thermodynamic cycle for a defined application.

The Radian engine performs the 4 thermodynamic processes at the same time and continuously. The high torque generated is always constant.

The top view exemplifies the design of a Radian engine composed of 4 combustion tracks (#4) and 3 compression stages (#5, 6, 7).

Components:

1.- Radiano (gate) of Combustion/Exhaust.
2.- Radiano (gate) of Admission / Compression.
3.- Cam profile crest of the rotor tracks.
4.- Combustion/Expansion Track.
5.- First track (initial stage) of Admission / Air compression.
6.- Second track (intermediate stage) of Air compression.
7.- Third track (final stage) of Air compression.
8.- Engine shaft
9.- Engine rotor
10.- Engine Body



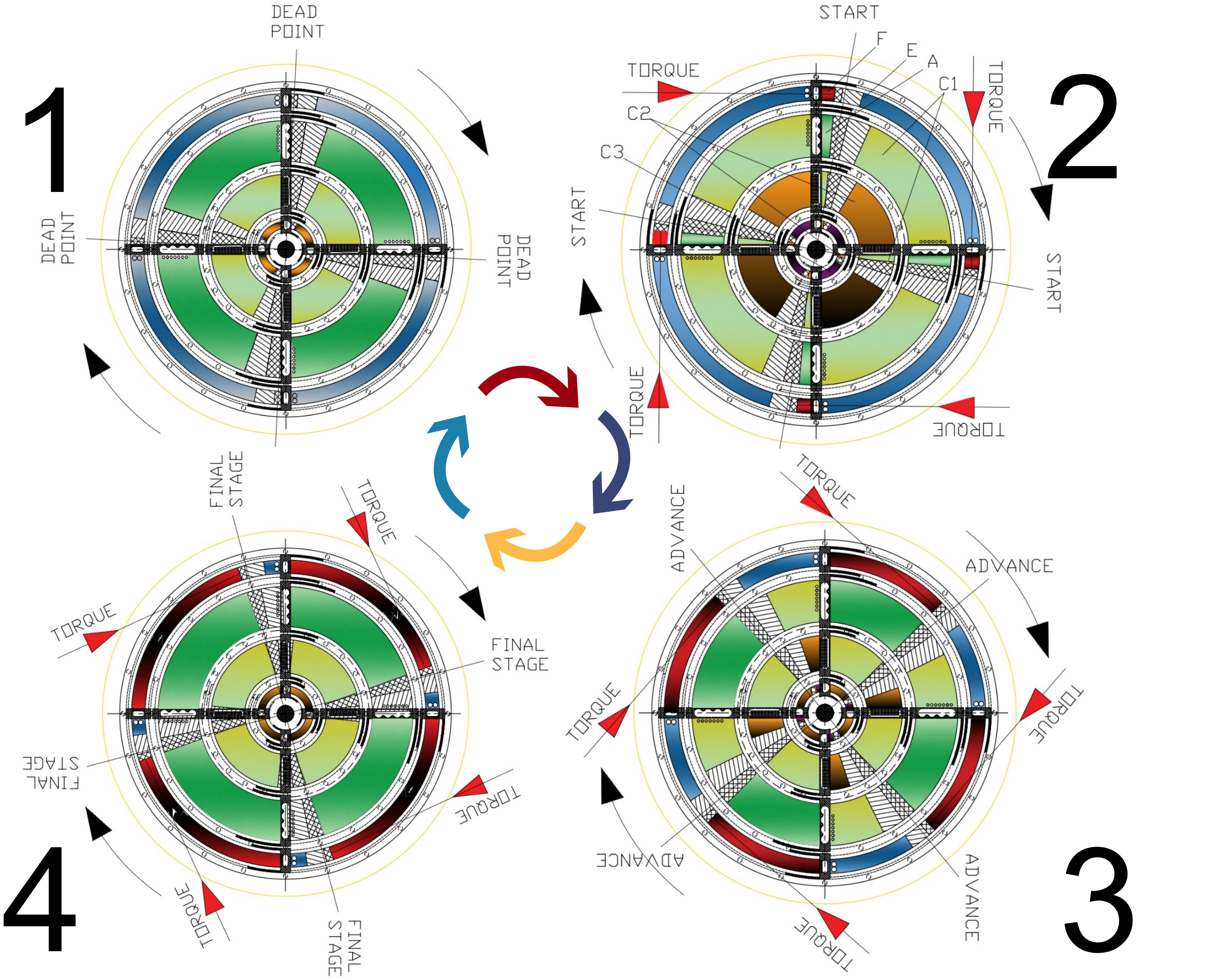
The hatched sections with diagonal and grid lines represent tracks cam profiles that provide the up-and-down movement of the Radianos (gates)

Continuous thermodynamic cycle of the 4-track Radian engine.

The top view that exemplifies the design of a Radian engine composed of 4 combustion tracks (F) and 3 compression stages (C1, C2, C3)
Elementos:

A= Air intake.
C1= The Compression system in stage 1.
C2: = The Compression system entered phase 2.
C3= The Compression system in its final phase.
F= Combustion/Expansion
E= Exhaust or outlet of combustion gases.

The hatched sections with diagonal and grid lines represent the cam profiles that provide the up-and-down movement of the Radianos (gates)



Main Advantages

Summary

01

GOOD EFFICIENCY

The Radian Engine achieves a thermodynamic efficiency greater than 60% due to:

Complete combustion

Complete combustion of the fuel mixture is carried out by having elongated chambers.

High compression ratio

3 compression stages that easily achieve high compression ratio in intake gases, improving engine efficiency.

10x torques

A greater torque is generated than current engines by having the impulse farther away (greater distance) from the engine axis.

Cooling

The rear faces of the rotors are cooled by oil in a differentiated way to obtain more cooling in the combustion tracks and less cooling in the compression tracks, varying the number of cooling veins in each case.

Even more…

02

Low RPM (500 RPM)

This engine runs at a constant RPM and performs optimally as a mechanical drive for an extended-range electric generator in hybrid cars.

03

Zero toxic gas emissions

Using hydrogen as fuel and increasing the air-fuel ratio, 68:1 becomes an engine with zero toxic gas emissions.

04

Efficiency in force transmission

It has a high efficiency in the transmission of force to the engine shaft, since it always acts on a constant lever arm unlike current engines where only a part of the combustion force is used since it is transmitted indirectly (through the connecting rods) to the engine shaft.

05

Combustion efficiency

The elongated combustion tracks (chambers) and constant low RPM (500), allow to achieve a complete combustion of the air-fuel mixture.

06

The chemical energy of fuel.

It takes advantage almost entirely of the chemical force of combustion, due to:

Mix dosage

The precise and fast dosing of fuel and compressed air to obtain the correct mixture to be burned in the combustion chamber.

Camera design

The design of the elongated combustion chamber thus takes advantage of the chemical energy of the combustion gases for a longer time.

Gas compression

A high compression ratio of intake gases (>20:1 bars)

Even more…

07

Gas expansion

The expansion of the Radian engine's flue gases can be fully exploited due to the elongated chamber design and the possibility of expansion using different tracks (stages).

08

Compression and combustion chambers

The compression and combustion chambers are fed by taking advantage of the radial dimension of the rectangular gates called Radianos (which also serve as valves). These Radianos have enough space to house multiple pressurized air and fuel inlets and outlets that optimize the dosing in the tracks (chambers), carrying out this operation quickly and accurately.

09

Multi-fuel

The Radian Engine can be conceived to work with a wide range of liquid and gaseous fuels. In the case of hydrogen as fuel, incorporating a second rotor (Radian twin-rotor engine) would facilitate the admission of a more significant amount of air required to form mixtures from 34 to 68:1 (mass), a characteristic that no other ICE engine can offer.

10

Efficiency of the thermodynamic cycle

Radian engine generates high indices of compression of the intake air, performing it in stages, thus improving the global thermodynamic efficiency. It uses a spark or hot element to start combustion.

Even more…

11

Fuel temperature

The fuel previously circulates in the engine, which naturally preheats it before being dosed into the combustion chamber.

12

Multiple mechanical injectors

It has multiple air and fuel injectors inside the Radianos (gates). In addition to achieving a homogeneous mixture, this engine does not have mixture pre-ignition problems, due to this novelty engine configuration.

13

It is autonomous

Its operation is autonomous and directly generates the rotary movement of the axis (unlike current engines that require connecting rods). Some of the forces applied through these connecting rods will not provide rotational moment which will (additionally) require valves and cam mechanisms, leading to efficiency losses.

14

Angular momentum of gyroscopic effect

It has a large angular momentum of gyroscopic effect that can be very useful when used to give a vehicle handling stability.

And finally…

High spot power

This engine performs a very high punctual power in combination with electric generators since the (electrical) energy needed at a certain moment is generated and stored before it is required (and not at that precise moment as is currently the case with reciprocating piston engines).

Circular engine of few parts

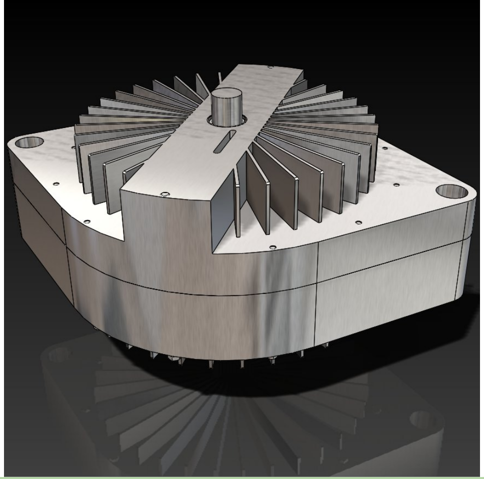
It is an engine made of few parts (light), economical, scalable, and easy to manufacture, which requires 60% of the weight of a conventional reciprocating engine to obtain the same power.

Power curve graph

The Radian motor stands out by reaching its maximum power in a significantly shorter time compared to the electric motor and the reciprocating internal combustion engine. Power increases linearly from zero to its peak, reaching it´s operative speed of 500 RPM. In contrast, electric motors used in automotive applications and other conventional motors reach their maximum power at around 7,000 to 8,000 RPM approximately.

Outstanding feature

One outstanding feature of the Radian engine is its ability to start without needing a conventional starting system, such as an electric starter motor. This is possible because it incorporates a regular reservoir of pressurized air, sourced from the compression tracks, where air is stored before being supplied to the injectors. This pressurized air is dose into the combustion chamber by the pressurized air injectors inside the Radianos, allowing the motor to have an almost instant response similar to that offered by electric motors. Additionally, when the Radian engine is stopped, the air reservoir remains charged with pressurized air, which is utilized when starting it again, enabling combustion in the designated tracks.



Lubrication, Cooling, and Sealing of the Radian Engine.

Lubrication, Cooling, and Sealing of the Radian Engine.

Lubrication and Cooling: The Radian engine features a symmetrical design assembled in pancake-like layers, enabling its manufacture using high-precision laser cutting machines with increased productivity. The entry of lubricant and coolant is facilitated by a highly flexible design, allowing for the placement of veins of any shape between each level to direct the lubricant or coolant to the desired areas for lubrication or cooling. It is possible to individually cool each level (pancake) or create an axial flow from one end to the other of the engine. To achieve cooling, a conventional subsystem circulates chilled water from the engine's cover (or even radially through the layers) to different parts of the engine, enabling targeted removal of heat from combustion chambers and lesser cooling of compression chambers. Moreover, the rotor features concentric circular tracks with axial perforations that allow the circulation of oil from the engine's cover to the base of the rotor. At the rotor's base, an oil mirror dissipates heat and lubricates the bearing system supporting the rotor. Bearings are placed between the engine's cover, rotor, and engine body to facilitate the rotor's rotational movement while minimizing friction. The aforementioned lubrication system allows oil to reach these points initially through the rotor's concentric channels and then via axial perforations, traversing from the engine's cover to the opposite end of the motor, where it exits for filtering and cooling treatment.

The geometric design of the Radian engine grants access to any lubrication or cooling point by utilizing the levels, layers, or pancakes used in its construction. This applies to both lubricating the rotor and the Radianos, which constitute the only moving parts within this engine.

Chamber Sealing: Hermetic chambers are formed within the rotor's concentric rectangular tracks with cam profiles when the **Radiano** descends to its bottom dead center. To achieve a reliable seal, two excellent alternatives are available:

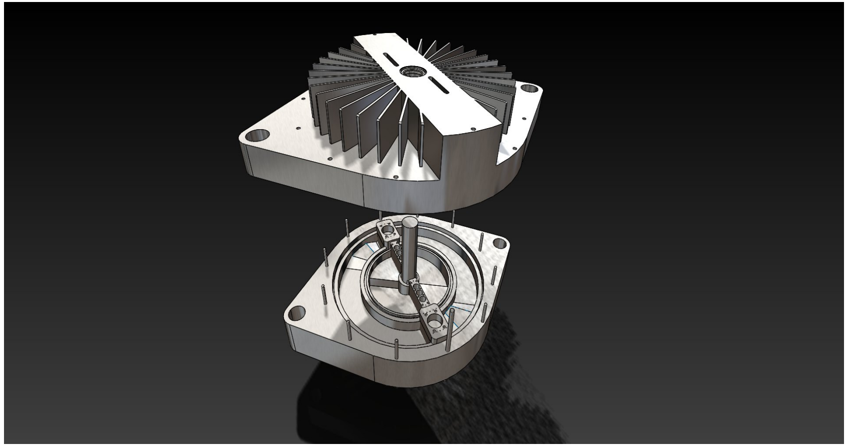
1. The utilization of conventional metallic or graphite/aluminum alloy seals placed in various parts of the rotor, which are lubricated using the previously explained system. Given the presence of separate compression and combustion chambers, a small subsystem ensures the filtration of compressed air before its dosing into the combustion chamber. While the installation of filters leads to a loss of flow (rather than pressure), this can be compensated by using larger filters or initially increasing the supplied air quantity. Comparatively, this engine would require fewer linear centimeters of metallic seals compared to a reciprocating piston engine.

2. An innovative and universally applicable proposal capitalizes on the engine's geometric design and the large "contact" areas between the moving parts (Rotor, Engine Cover, and **Radianos**). By achieving high manufacturing precision in the production of these components, it is possible to attain a high level of hermeticity without the need for seals or the introduction of oil that might eventually enter the combustion chamber. In an alternative version, the same engine can generate counterpressure in the "contact" zones, further enhancing the sealing efficiency of these chambers. For this option, tungsten carbide can be employed as the material for manufacturing the Rotor, Engine Cover, and **Radianos**, leveraging its high hardness, precision, and minimal thermal expansion coefficient, as well as its remarkable resistance to hydrogen when used as a fuel.

The designs described above are not applicable to reciprocating piston engines. It is the exceptional design of the Radian engine that enables this unique approach to lubrication, cooling, and chamber sealing.

This innovative approach to lubrication, cooling, and sealing in the Radian engine demonstrates its ability to leverage the engine's distinctive geometry and suitable materials, thereby achieving optimal performance and efficient hermetic sealing. These advancements represent a significant step forward in the efficiency and reliability of internal combustion engines. With careful design and the application of advanced technologies, the Radian engine offers a promising solution in the field of rotary engines.

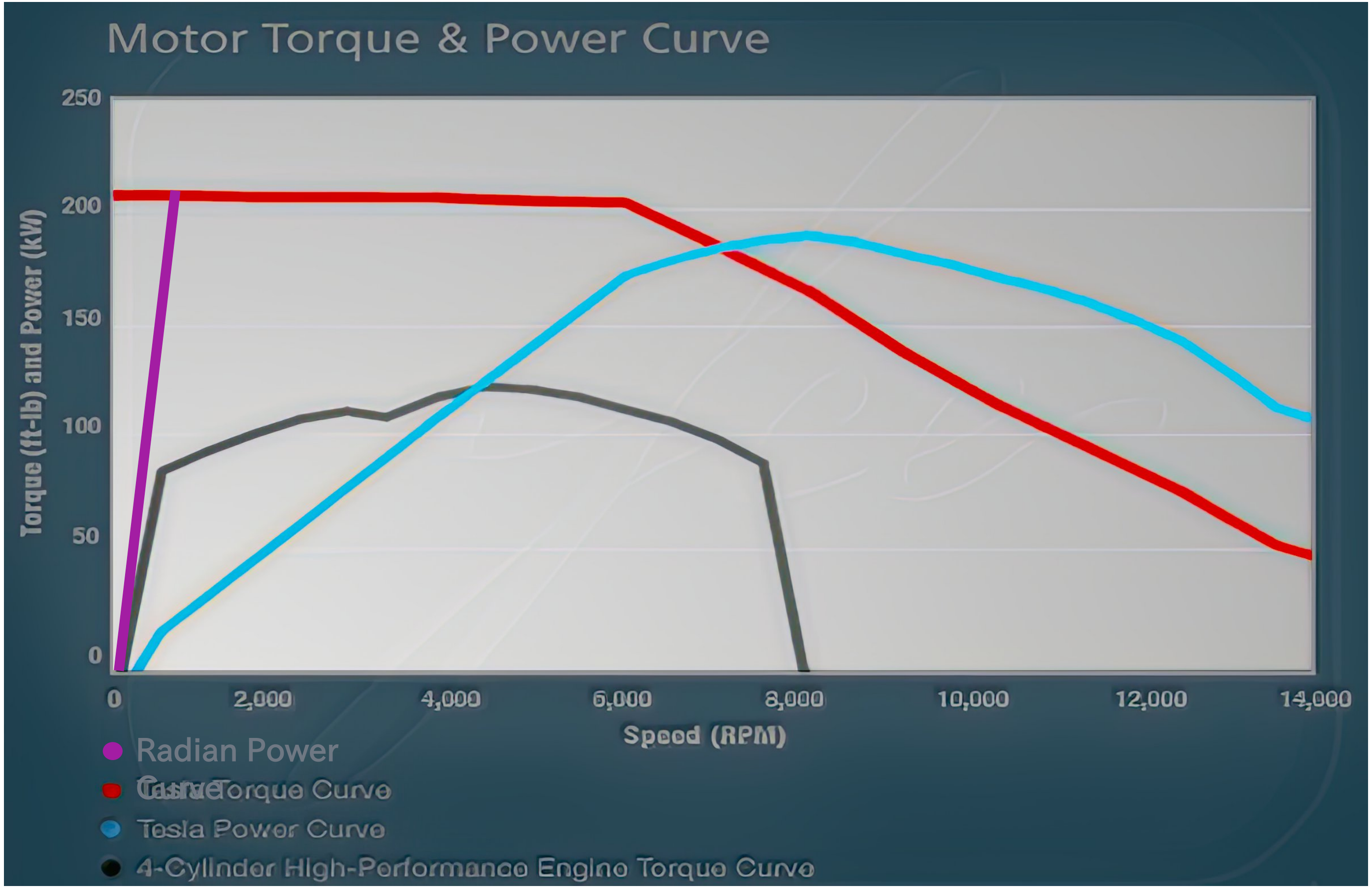
By implementing a symmetrical pancake-like layer design, the Radian engine ensures precise manufacturing using high-precision laser cutting machines. The engine allows for flexible lubricant and coolant flow, thanks to its unique geometry. Veins can be strategically placed between each layer to direct lubricant and coolant to specific areas, enabling targeted cooling of individual levels or axial flow from end to end. A conventional subsystem circulates chilled water from the engine cover, or alternatively, it can access the layers radially, providing differential cooling to different parts of the engine. This approach effectively removes heat from combustion chambers while minimizing cooling in compression chambers. Furthermore, the rotor incorporates concentric circular tracks with axial perforations, allowing oil circulation from the engine cover to the rotor base. An oil mirror at the rotor base dissipates heat and lubricates the bearing system, supporting smooth rotor movement. The engine employs ball or tapered bearings placed between the engine cover, rotor, and engine body, reducing friction. The lubrication system utilizes the rotor's concentric channels and axial perforations to ensure oil reaches the bearings, allowing oil flow from the engine cover to the far end of the motor. From there, the oil undergoes filtering and cooling treatments.



COMPARISON CHARTS

Radian engine, EV engine, ICE engine Comparison chart

FEATURES	RADIAN ENGINE	ELECTRIC MOTOR	RECIPROCATING PISTON ENGINE
Engine/Motor weight + auxiliary systems	158 kg	95 kg	195 kg
Weight batteries + fuel tank	55 kg	370 kg	55 kg
Power	218 HP/163 Kw	260 HP/194 Kw	177 HP/130 Kw
Torque	3,116 Nm	340 Nm	221 Nm
RPM (max. power)	500	8,000	7,000
kWh consumption	40	20	160
CO2 emissions	175 grms/mile	225grms/mile (+175 grms/mile (coal) +50 grms/mile (baterry))	350 grms /mile
NOX ≈	.03 grms/mile	0.34grms/mile	0.07grms/mile
HC ≈	.002grms/mile	0	.004grms/mile
CO v	0.13%	0	0.5%


Motor Torque & Power Curve
250
200
150
100
50
0
Torque (ft-lb) and Power (kW)
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Speed (RPM)
Radian Power Curve
Tesla Torque Curve
Tesla Power Curve
4-Cylinder High-Performance Engine Torque Curve

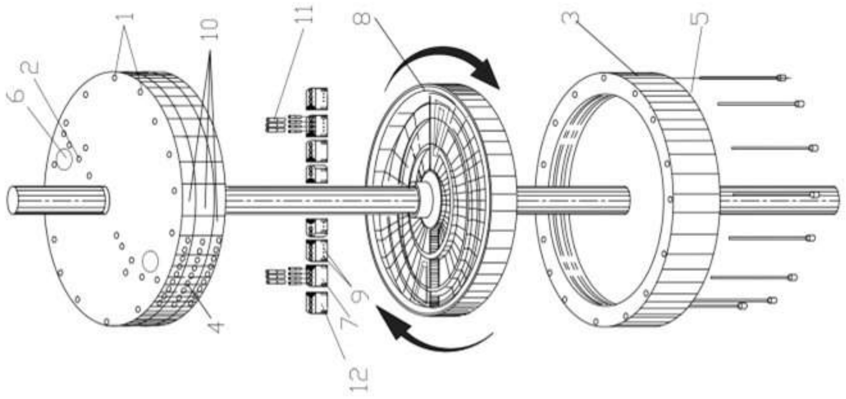
Comparison chart of the Radian engine with different fuels

Features	Gasoline Radian	Hydrogen Radian
Toxic emissions	Low	Zero
Aspirated air and fuel ratio	Up to 20:1 (mass)	Up to 68:1 (mass)
Rotors	One or more	Two or more

Comparison chart between Radian engine and conventional engine

	CHARACTERISTICS	RADIAN	RECIPROCATING PISTONS
1	Harnessing the chemical power of combustion	High	Low
2	RPM	Constants (500)	Variables (> 700)
3	Torque	High	Low
4	Pre ignition	No	Yes
5	Thermodynamic efficiency	> 60%	30%
6	Engine ballancing / Vibration	Straightforeard	Complicated
7	Combustion chamber	Elongated	Short
8	Combustion vs Explosion	Combustion	Explosion
9	Air compression process through several stages	Yes	It's not possible
10	Manufacturing Cost	Low	High
11	Wear and year	Very low	Regular
12	Supporting elements of parts that drive engine shaft	Ball/Nedle bearing	Metal bearings
13	Cooling	Straightforeard	Complex
14	Scalability	Straightforeard	Very complex
15	Gas expansion process through several stages	Yes	It's not possible
16	NOX produced by temperature peaks	Non-existent	Continuous
17	Octane required in gasoline	>65	>87

	CHARACTERISTICS	RADIAN	RECIPROCATING PISTONS
18	Mechanical logistics in design	Friendly	Complex
19	Lubrication	Straightforward	Complex
20	Maintenance	Straightforward	Complex
21	Cam train mechanism	Not required	Required
22	Valve Mechanism	Not required	Required
23	Number of pieces	Few	Many
24	Power lost by reciprocal moving parts	Very low	Very high
25	Weight	Low	High
26	Possibility to be converted to multifuel	Straightforward	Complicated to impossible
27	Power lost in air compression process	Low	high
28	Compression ratio (bars)	20:1	10:1
29	Symmetry	Symmetrical	Complex
30	Fuel injection system	Straightforward	Complex
31	Electronic system to manage engine performance according to geographic altitude	Not Required	Required
32	Power transmission to engine shaft	Direct	Indirect through connecting rods
33	Average Speed of Radianos / Pistons	10m/s	100m/s



Tech Specs

Radian Engine Base Model

Design and Technical Specifications for the Radian Engine Base Model

Abstract: This document presents the detailed design and technical specifications of the Radian rotary internal combustion engine. The base model of the Radian engine consists of two cross-radial axes and the use of four concentric tracks on the rotor axis: two tracks for compression and two tracks for combustion. The construction characteristics, performance, and capabilities of the engine are described, including information on materials, weight, torque, power, dimensions, fuel consumption, air-fuel mixture, compression ratio, Radianos operation, pollutant generation, and part support, among other important aspects.

1. Introduction: The Radian engine is a rotary internal combustion engine designed for specific applications. It is based on the configuration of two cross-radial axes and utilizes four concentric tracks on the rotor axis, enabling efficient operation and optimal performance. In this document, we present the technical specifications of the Radian engine's base model, along with the obtained performance results.

2. Technical Data: The Radian engine features the following technical characteristics:

2.1 Construction: The engine is primarily constructed using steel, aluminum, and tungsten carbide, materials that ensure strength and durability. This material combination contributes to reducing the overall weight of the engine.

2.2 Weight: The total weight of the Radian engine is 138 kg, making it a lightweight option compared to other engines in its category. This characteristic facilitates installation and optimizes the overall system performance.

2.3 Continuous Torque: The Radian engine offers a continuous torque of 3,116 Nm, providing high responsiveness and efficient performance under various load conditions.

2.4 Power: The Radian engine generates 218 HP of power, which is approximately equivalent to 163 kW. This power output ensures suitable performance for a wide range of applications.

2.5 Exterior Dimensions: The engine has a diameter of 62 cm and a height of 170 mm, making it compact and easy to integrate into different systems and structures.

2.6 RPM: The Radian engine operates at a constant speed of 500 RPM, guaranteeing stable operation and optimal efficiency in the working cycle.

2.7 Fuel Consumption: The fuel consumption of the Radian engine is estimated at 4.86 liters per hour, considering that this value is less than 25% compared to current reciprocating internal combustion engines. This improvement in efficiency contributes to a significant reduction in fuel consumption and emissions of polluting gases.

2.8 Air-Fuel Mixture: The Radian engine utilizes an air-fuel mixture ratio of 18 to 1, enabling efficient combustion and increased energy efficiency.

2.9 Compression Ratio: The compression ratio of the Radian engine is 14 to 1, optimizing thermal performance and overall work cycle efficiency.

2.10 Compression and Expansion Stages: The Radian engine employs two compression stages and two expansion stages, ensuring efficient combustion and optimal energy transfer.

2.11 **Radianos** Operation: The Radianos, axial actuators used in the Radian engine, ensure smooth and precise operation, contributing to overall stability and performance.

2.12 Pollutant Generation: The Radian engine achieves a significant reduction in pollutant generation compared to current reciprocating engines. The total pollutant generation is estimated at 10% in relation to conventional engines. Specifically, the generation of nitrogen oxides (NOX) is less than or equal to 900 parts per million (ppm), carbon monoxide (CO) generation is less than or equal to 400 ppm, and hydrocarbon (HC) generation is less than or equal to 25 ppm.

2.13 Part Support within the Engine: The Radian engine utilizes both spherical and tapered bearings for supporting internal parts. These bearings ensure smooth operation and extended engine life.

2.14 Sealing of Moving Parts: The Radian engine achieves the sealing of moving parts without the use of mechanical seals. This sealing is accomplished through precise fitting of parts, with a tolerance of 2 to 3 thousandths of an inch, and the generation of counterpressure to redirect combustion gases, preventing leaks and improving overall efficiency.

2.15 Cooling: The Radian engine employs a cooling system that uniformly distributes water in both the axial and radial directions. This water distribution ensures efficient and controlled cooling of critical engine parts.

2.16 Lubrication: The Radian engine features a lubrication system that distributes lubricant through specific veins. This proper lubrication ensures smooth operation and extended lifespan of the engine's moving parts.

3. Results The Radian engine provides a total output torque of 318 kg, equivalent to 3,116 Nm. Additionally, it is estimated that the engine consumes approximately 49 million cubic centimeters of air per hour, which is equivalent to 60 kg. Regarding fuel consumption, it is estimated at 3,401 grams per hour, equivalent to 4.86 liters. Finally, the Radian engine generates a power of 218 HP, equivalent to 163 kW.

*performance data measured at sea level

Conclusions: The Radian rotary internal combustion engine exhibits outstanding technical features, such as its lightweight construction, high power and torque, low fuel consumption, and reduced pollutant generation. Its innovative design, utilizing cross-radial axes and concentric tracks, along with the utilization of Radianos as axial actuators, ensures efficient performance and smooth operation. These specifications and results demonstrate the potential of the Radian engine as a promising alternative in the internal combustion engine industry.

FEATURE	VALUE
Construction	Steel, Aluminum, Tungsten Carbide
Weight	138 kg
Continuous torque.	3,116 Nm
Power.	218 HP
Exterior dimensions.	Diameter 62cm, Height 170mm
RPM	500
Fuel consumption	4.86Lts/hr. (≤25% vs Reciprocating ICE)
Mix combustible air	18:1
Compression ratio.	14:1
Steps for compression	2
Steps for expansion	2
Operation of the Radianos.	Axial actuators (Radianos are not hit or touched by cam profiles in tracks)
Pollutant Generation/Km	≤10%. (vs. current reciprocating engines)
NOX generation	≤900 ppm.
CO generation	≤400 ppm.
HC generation	≤25 ppm.
Support of moving parts inside the engine	Bearings (balls and conic rods)
Sealing of moving parts	Achieved without mechanical seals, adjusting manufacturing parts within 50 microns and generating counter pressure by redirecting combustion gases.
Refrigeration	Uniform distribution of axial and radial cooling water.
Lubrication	Distribution of lubricant fluids through veins.

*performance data measured at sea level

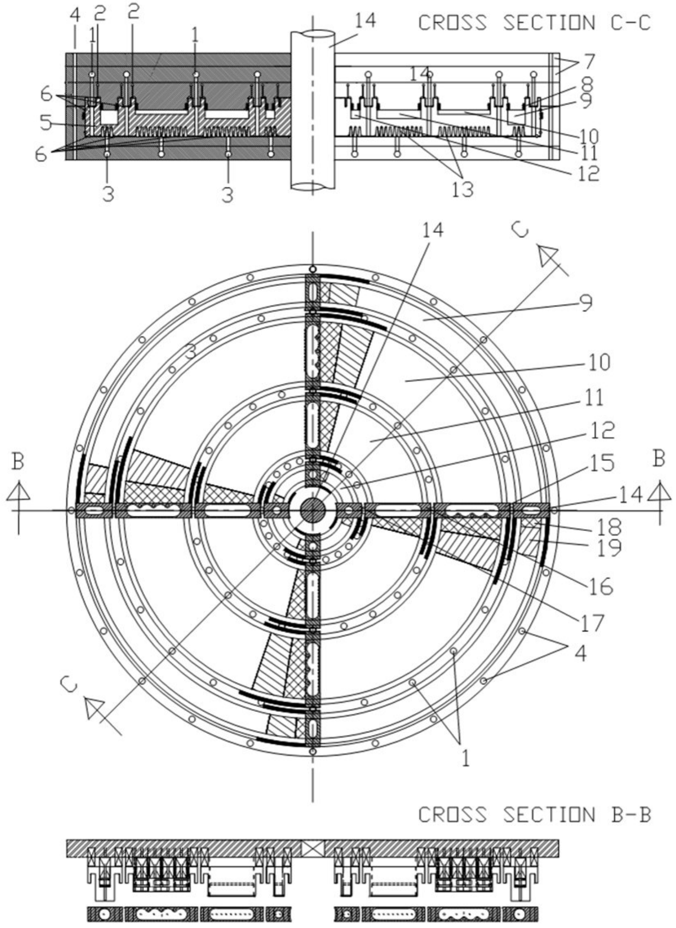
	The name of the track	Radiano Measurements Width x Height (cm)	Distance to axis (mm)	Track volume cm3	Pressure Req. Kg/cm2	Torque output, kgm
T1	Compression track 2	3x4	45	58.5	-10.5	-22.7
T2	Intake and compression track 1	5x4	103	410	-4.6	-38.0
T3	Combustion track	7x2	180	410	+25.0	+252
T4	Expansion track	4x7	253	840	+4.5	+127
	Total torque output					318

Engine Torque: It is calculated by adding and subtracting the torques necessary for compression and those obtained by combustion and expansion of flue gases. The pressure at each step is shown in the 5th column, multiplying this value and the Radian face areas (in the 2nd column) gives the torque output (6th column), adding these values we get the torque output as follows: Torque = 318 kgm= 3,116 Nm.

Air Consumption: Is calculated multiplying air volume in Track 2 (admission) per rotation (column 4th) by 500 RPM : Air consumption per hour: 49 million cm3= 60 Kg of air.

Fuel Consumption: Knowing the RPM and how much air is admitted into Track 2 per hour, and establishing that the air-fuel mixture has 20% more air (to avoid temperature spikes) and knowing the required constant stoichiometric air/fuel mixture (14.7: 1), the fuel consumption is obtained. Fuel consumption = 60,000/(1.2 x14.7)= 3,401grms of fuel, multiplying by a density of 0.7kg/lt we obtain a fuel consumption of 4.86 Lts

Power: Knowing RPM and Torque, using formula Power= Torque x RPM, we obtain HP as follows: HP = 163kw = 218HP



1	Oil inlet for lubrication and cooling
2	Counter pressure inlets
3	Oil outlet for lubrication and cooling
4	Cooling water inlet
5	Rotor
6	Support bearings
7	Pancake type engine body plates
8	Expansion track
9	Combustion track
10	Admission-compression track 1st step
11	Compression track 2nd step
12	Mechanical Seals (optional)
13	Rotor cooling veins
14	Radiano (expansion)
15	Radiano (combustion)
16	Radiano (intake-compression 1st step)
17	Radiano (compression 2nd step)
18	Flat ridge of the cam profile
19	Cam profile rise ramp

Radian engine for EV (range extender)

FEATURE	VALUE
Construction	Steel, Aluminum, Tungsten Carbide
Weight	78 kg
Continuous torque.	1,030 Nm
Power.	73 HP
Exterior dimensions.	Diameter 33cm, Height 170mm
RPM	500
Fuel consumption	2.4 Lts/hr. (≤25% vs Reciprocating ICE)
Mix combustible air	18:1
Compression ratio.	14:1
Steps for compression	2
Steps for expansion	2
Operation of the Radianos.	Axial actuators (Radianos are not hit nor touched by cam profiles in tracks)
Pollutant Generation/Km	≤10%. (vs. current reciprocating engines)
NOX generation	≤900 ppm.
CO generation	≤400 ppm.
HC generation	≤25 ppm.
Support of moving parts inside the engine	Bearings (balls and conic rods)
Sealing of moving parts	Achieved without mechanical seals, adjusting manufacturing parts within 50 microns and generating counter pressure by redirecting combustion gases.
Refrigeration	Uniform distribution of axial and radial cooling water.
Lubrication	Distribution of lubricant fluids through veins.

*performance data measured at sea level

The Radian Engine

A Promising Option for Clean Internal Combustion

The Radian Engine: A Promising Option for Clean Internal Combustion

The automotive industry is undergoing a significant transformation with a push for cleaner and greener technologies. To meet this demand, stricter emissions regulations, such as the Euro 7 norm, have been implemented to reduce nitrogen oxide (NOx) emissions. However, recent bans on the implementation of Euro 7 by countries like Germany and Italy have raised questions about the future of emissions reduction in the industry.

Synthetic fuels or e-fuels are being suggested as an exemption to address this problem. These fuels are made by combining renewable energy with captured carbon dioxide (CO_2) from industrial processes, and they can be used in internal combustion engines without modifications. The Radian engine is ideally positioned to take advantage of this development as it can use e-fuels without compromising power or torque.

The Radian engine's high thermodynamic efficiency, over 60%, is significantly higher than any other internal combustion engine currently in production. This feature means that the engine requires less fuel to generate the same amount of power, resulting in fewer emissions. The elongated combustion chamber design of the Radian engine allows for a more efficient combustion process, reducing unburned fuel released into the atmosphere and further lowering emissions. Its straightforward mechanism also allows for precise combustion process control, enabling optimal efficiency and reduced emissions.

Another advantage of the Radian engine is its use of ball and needle bearings instead of bronze bearings, reducing wear and tear and increasing its lifespan. The engine's scalability, low weight, and symmetrical design also make it an attractive option for a wide range of vehicles, from small cars to heavy-duty trucks.

New technologies to produce e-fuels as a new source of energy that internal combustion engines would use, hinder the efforts of the EU to opt for 100% electrification of the vehicle fleet. The potential of EV's to significantly reduce emissions in both urban and rural areas is questionable..

In summary, the Radian Engine is a unique and efficient internal combustion engine that can address some of the challenges posed by emissions regulations. Its ability to use e-fuels and maintain high thermodynamic efficiency while producing fewer emissions and reducing wear and tear makes it a valuable tool in the fight against climate change while supporting the automotive industry's sustainability.

Thanks!

www.penttsys.com
alvaro.bricio@penttsys.com