TRICK CYCLE

PENTA CYCLE

TomahawkTurbine.com

TRICK-CYCLE TURBINE Ltd.

Creators of the world's first 4 & 5 PD COMBINED CYCLE CENTRIFUSION TURBINE ENGINES!

NOTE: ***TCT*** **& *PCT* ARE PROPRIETARY ENGINE DESIGNS IN EARLY-STAGE DEVELOPMENT. THEREFORE, CERTAIN DETAILS AND DRAWINGS CANNOT BE MADE PUBLIC AT THIS TIME. PLEASE HONOR THE COPYRIGHT AND DO NOT PUBLISH 4-25-2023 PATENTS PENDING**

"TRICK" IS DEFINED AS:

"AN ARTFUL WAY OF GETTING A RESULT"

TCT & PCT **ARE FULL 4-CYCLE & 5-CYCLE CENTRIFUSION TURBINE ENGINES THAT COMBINE THE BEST ELEMENTS OF THE ELECTRIC, PISTON, ROTARY & TURBINE ENGINES CREATING THE ULTIMATE HYBRID POWER PLANTS AND THE WORLDS MOST EFFICIENT ENGINE DESIGNS!**

TOMAHAWK TX ENGINE SPECS & TECH:

March 2024-NOTE: The ***TRICK-CYCLE TURBINE (TCT)*** was first conceived in November of 2020 and not inspired or encouraged by any other ongoing engine design project. What follows is the result, to date, of an exhaustive multi-year feasibility study, more concentrated in the last nine (9) months and focused on the ***TOMAHAWK TX (TTX)*** version of the ***TCT*** operating principle.

Great care has been expended to strictly adhere to that which can be reasonably accurately predicted based on the laws of physics, basic principles of ICE function and experience.

ENGINE TYPE: COMBINED CYCLE CENTRIFUSION TURBINE:
5-cycle (Positive Displacement (PD)) + Turbo Flux (afterburner) Exhaust cycle (Compression cycle does not occur in a separate chamber) all to a turbine effect.

DISPLACEMENT: Reference Displacement (= single displacement of all combustion chambers once) = **.761L** (46 CID); actual operational swept volume = active between **2.28L-7.5L** (over 360º rotation) & **6.84L-15L** over 720º rotation relative to standard 4-cycle ICE = **915** direct comparison CID (No internal cycle speed multiplier).

OPERATIONAL NOMINAL NON-BOOSTED INTERNAL AIR FLOW CAPACITY: = 11:1 divided by 3.67 (=faster cycle times) = 3+ X typical 4-valve ICE. The split design is a key factor in achieving this level of internal flow capacity.

(Example: If nominal 4-valve achieves max volumetric efficiency @ 5600 RPM (ie peak torque) The ***TOMAHAWK TX*** @ 3 times the flow ratio could be predicted to max out in a range of 15,000-17,500 RPM & peak HP would land in the 16,500-19,000 RPM range).

FIRING ORDER: = 18 firings per/rev = 3 simultaneous firings every 60° (No internal cycle speed multiplier).

PROJECTED PEAK POWER OUTPUT: = *8300* shp @ 12,500 RPM*
(11,000 shp @ 16,500 RPM)
PROJECTED PEAK TORQUE OUTPUT: = *3500* ft/lb @ 12,500 RPM*
(on 85 octane pump gas)

*** For comparison with a nine (9) + L supercharger @ 1.33 OD a top fuel (NHRA) dragster engine expands its reference volume to an Effective Swept Volume (ESV in liters) over 720° to 22L and produces 395 ft/lb/L of torque WITHOUT nitro-methane as a fuel (approx. 13% higher with nitro-methane) of which 60 ft/lb/l is consumed to power the blower leaving a net 335ft/lb/l. *TTX* is projected here to produce only 233 ft/lb/L of torque or 30% less (only 2.5 ft/lb/l consumed by the compressor) despite having a superior combustion energy conversion factor (BTE), an almost complete elimination of internal friction, no oil pump combined with a factional size fuel pump, and complete elimination of energy robbing reciprocating, oscillating or elliptical mass, Etc… Therefore, these power projections are in fact, conservative.**

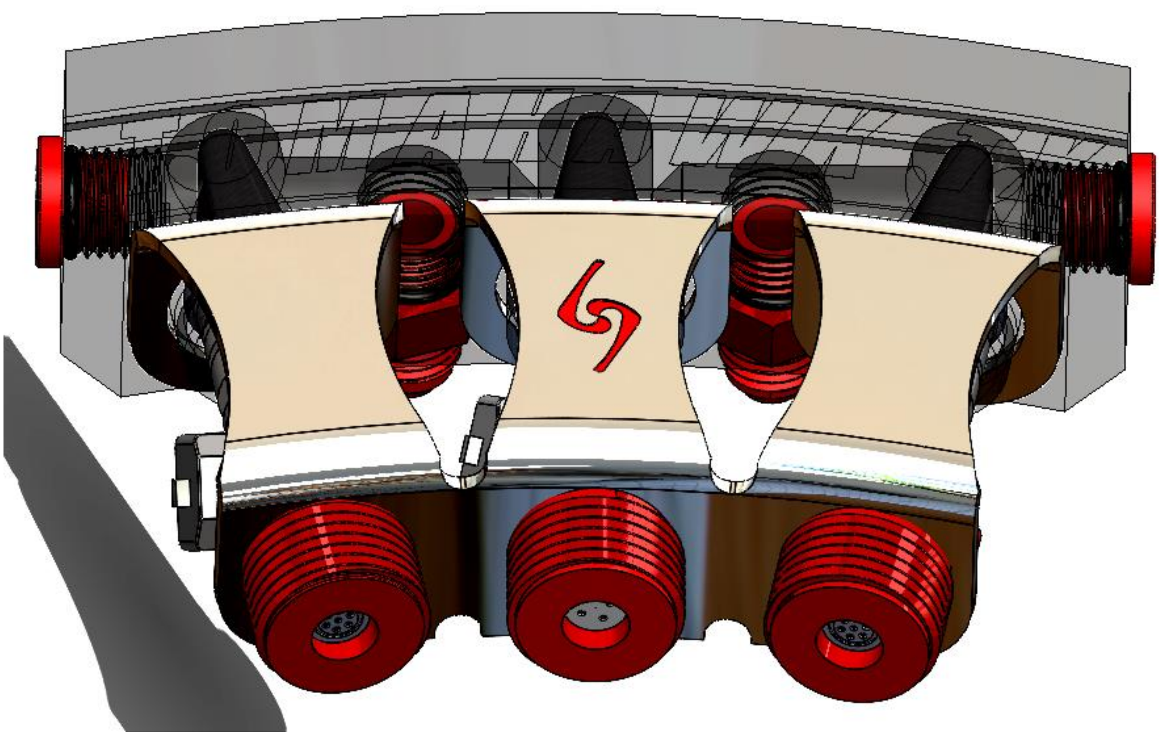
MAX PROJECTED BRAKE THERMAL EFFICIENCY (BTE): = 69%

COMPRESSION (expansion) RATIO (CR): Active between 11 & 26:1 (1 of many selectable ranges).

INDUCTION: Combination of active direct internal & integral positive displacement & internal & integral match speed Centrifugal Screw Supercharge X 6 (No separate dedicated induction charging system) with an effective max induction gauge pressure of 25-30 psi (1.7-2 bar).

EXHAUST: Four (4) stage in this optimal order: 1. Blow down, 2. Scavenge 3. Centrifugal charge out, AND 4. Positive displacement.

FUEL SYSTEM: Combination of direct & indirect EFI all @ low pressure (40-120 psi). 18 direct injectors (6 low & 12 high flow). Direct injectors not exposed to combustion pressures, temperatures or gases means less costly and more reliable port fuel injectors can be utilized in DI effectively. A liquid fuel vapor system can be adapted for low loads.



IGNITION: Drive shaft trigger direct = 4 iridium electrodes per combustion chamber (24 total) + 2 iridium afterburner electrodes per exhaust transfer circuit/chamber (12 total) fired by 18 dual alternating loop dual fire compact coil packs with active adjustable voltage input from 12-20V (allows for stable high energy spark of all 4 plugs up to 20,000 RPM & 2 plugs over 38,000 RPM), and/or glow plug type. The system is designed to facilitate extreme lean burn strategies.

NOTE: Due to the system's extremely high-speed cycling The ***TOMAHAWK TX*** is uniquely qualified to potentially utilize and perfect HCCI auto-ignition under higher load and speed conditions unlike any ICE cycling system known. This is in part because there is a greatly reduced time between the auto-ignition point and minimum volume and the optimal torque arm moment point (See also **"EGR/EGC System"** below). This is also why 85 Octane regular gasoline and/or hydrogen is expected to do well even in conditions of effective high CR & load. In HCCI mode the electronic ignition system can be shut off for max efficiency apart from the afterburner system which may be selectively run in combination where more peak power and high load emission control is desired or needed.

COOLING/WARM UP SYSTEMS: Thermostatically controlled air cooled, self-contained with no external fans. The system has a secondary function to act as an air-to-air intercooler during periods of high effective boost loading.

NOTE: High BTE efficiency up to **69%** = low probability of obtaining proper warm up under start-up & low loads in cold conditions. Therefore, The ***TOMAHAWK TX*** is designed with this challenge in mind. Two (2) Throttles are located deep in the center of the engine for several reasons, one being the ability to control air flow into the combustion chambers post compressor. During periods of start-up & warm up, idle and low loads, manifold pressure can be selectively increased to above atmospheric even while speed and load are under complete control. The higher manifold pressure forces the engine to silently work a little harder and part of that added energy warms the manifold air instantly improving combustion efficiency and reliability while lowering cold start emissions instantly upon start-up.

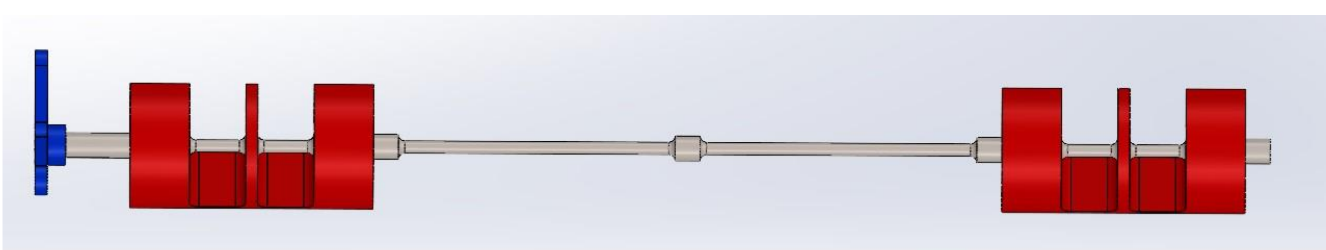
NOTE: ***TOMAHAWK TX*** combines a 50-66% reduction in heat rejection with a heat distribution factor more even from front to back, side to side & top to bottom than any other ICE design known. Despite these extreme design advantages keeping certain key internal components safe from overheating ONLY during periods of sustained full power & speed output may be a design & development challenge. This challenge is solvable, however.

EGR/EGC SYSTEM: EGR possible. ***TTX*** features a unique active Exhaust Gas Capture (EGC) system with a capture control range of ZERO (0) to 100%.

NOTE: While the ***TTX*** is capable of recirculating exhaust gases by means of a straightforward EGR valve system in which exhaust gases are pumped out of the combustion chamber and then a select portion is pumped (recirculated) back into the combustion chamber an Exhaust Gas Capture (EGC) system is far superior, when possible, for several reasons. As contemplated over three (3) years ago the ***TTX*** is uniquely well suited to make full use of an EGC system & method. In an EGC system exhaust gases are portioned out in each cycle allowing a select portion to remain captured in the combustion chamber. A small amount of fresh air & fuel is metered in and the captured EG fills the remaining space allowing for high CR to be maintained and greatly reducing low load negative pumping losses.

The ***TTX*** EGC system will measurably reduce part load negative pumping losses by a minimum of 96% to as high as 99.5% all while not increasing mechanical stress, friction & noise such as is common to the Diesel Cycle.

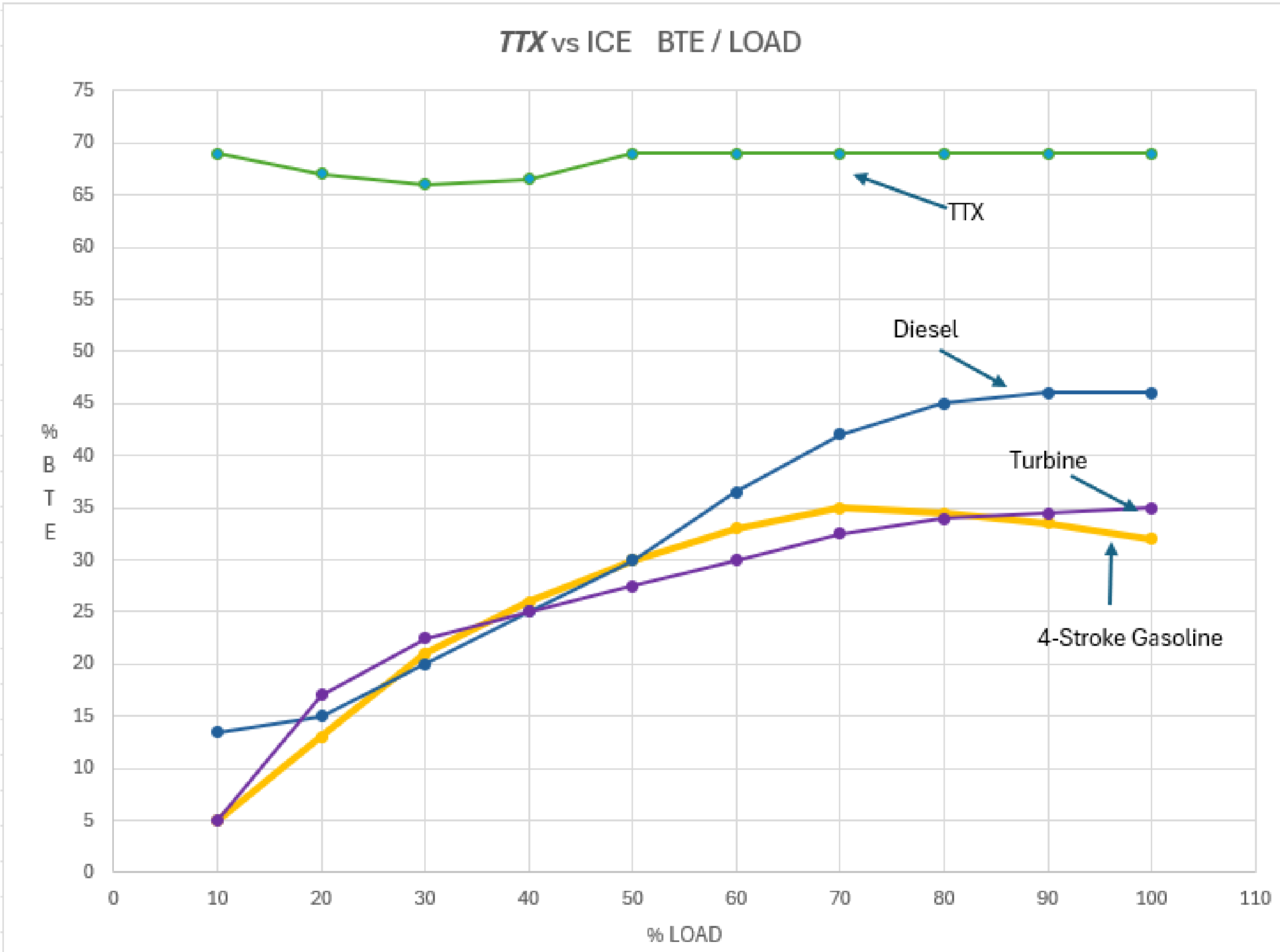
The ***TTX*** EGC system utilizes a specially designed constantly electronically variable static rotary exhaust flow control valve. This valve is not exposed to the extreme pressure and heat associated with most exhaust



valves. This fact, as well as others, allows for the proprietary design of a EGC system to facilitate a high level of sophistication of operation increasing both performance & efficiency @ all loads & speeds that belies its reliable simplicity & elegance. The ***TTX*** EGC system allows for effective VVT and yet is simpler than a comparable EGR system.

In combination with the elegant & simple complete active compressor control system the ***TTX*** will be able to make full use of low temp lean burn auto-ignition strategies across a broad range of operating conditions AND be able to adjust instantly to flex to a broad range of fuels.

This is a very important aspect of the development of the ***TTX*** because it allows it to achieve @ or near peak BTE @ all loads & speeds in contrast to all other types of IC engines as illustrated in the graph. This means that for applications that operate in constantly varying load & speed conditions the actual real world efficiency gains will be significantly higher than a simple comparison of the peak BTEs would indicate.



It would also mean that the gap between city & highway EPA fuel consumption ratings, for example, would close by 50% or more. Such a reality would make the cost, weight, complexity and maintenance of regenerative braking systems a less practical method of improving vehicle efficiency giving more flexibility to auto manufacturers to exceed all performance & efficiency goals cost effectively, in fact @ an overall cost savings.

NOTE: In February of 2022 The Mazda Corporation published a patent application U.S. patent (US 2022/0034265 A1) **in which a similar method is disclosed for use in a supercharged 2 stroke piston engine. It is projected that the method will allow for auto-ignition to be employed @ low loads and that it could increase part load BTE to as high as 50%. However, because the Mazda system involves the use of reciprocating poppet valves, speed is limited to the 4-4500 RPM range which will greatly reduce the power density potential. Further, it will be very complicated and difficult to control the poppet valve EGC system over a broad range of speed, load & atmospheric conditions because it necessitates a complex variable poppet valve timing system to meter the EGC actively on the fly. The Mazda system also requires a high cost, complex & high maintenance extreme high pressure Direct Injection (DI) fuel system operating @ pressures exceeding 700 bar or 10,000 PSI.**

FUEL: Active flex to, gasoline (85 Octane or less), diesel, ethanol, methanol, Jet A, JP-8, kerosene, etc. + adaptable to **hydrogen,** CNG or CPG, Etc.

NOTE: The extremely high projected BTE of The *TOMAHAWK TX* will present a unique opportunity to explore hydrogen as an alternative fuel. Current ICE systems contaminate hydrogen combustion with oil & oil vapor. That combined with the inefficient high heat rejected combustion (low BTE) can create limited NOX emissions. Further, currant ICE systems simply require too much passenger and/or cargo room to be dedicated fuel storage space to make hydrogen practical in most automotive applications. *TTX* would reduce that utility space requirement by 60-75%.

NOTE: It is critical IF a hydrogen infrastructure is to be built over decades that all hydrogen powered vehicles can seamlessly flex to gasoline & other fuels, which, expensive hydrogen fuel cells, cannot do, at all, let alone @ 69% BTE.

MAIN BEARINGS: Eight *SKF* "Super Precision" cylindrical hybrid roller. MAX speed = 28,000 RPM.

NOTE: The *TOMAHAWK TX* generates virtually ZERO (0) axial thrust shaft loading and/or cross axial shaft loading on the central master shaft because of the self-canceling effect of the tri-opposing combustion events. The slave power shafts likewise generate ZERO (0) axial thrust shaft loading but will experience 90° cross axial shaft loading. However, depending on the application, external G-Forces will produce very low-level axial thrust shaft loading. In such cases a very simple fully integrated centrifugal force pumping action will be used to effectively supply oil to a flat Babbitt style thrust bearing system somewhat resembling that used in many jet turbine engines.

TIMING GEARS: No separate timing gear set required.

NOTE: The split power rotor method allows for a 98+% reduction in the coefficient of friction that would be experienced by a .5” (13mm) wide dedicated timing gear set tasked with keeping all the rotors in proper angular relationship with each other under all conditions. Therefore, it is conceived that the rotor assemblies can double as their own timing gears especially where liquid fuels are injected. The ability to eliminate a separate dedicated timing gear crankcase filed with oil is very significant to the overall goals of the *TOMAHAWK TX*. Nonetheless the original prototypes will be outfitted with a separate gear set to protect the project and confirm this claim. Due to the projected significantly reduced friction & load that such gear set would experience it can be set up so that the only lubrication required is a small amount of specially selected grease. Centrifugal forces will be employed to constantly cycle & recycle the grease eliminating the need for a liquid lubricated crank case.

LUBRICATION SYSTEM: Sealed Centrifugal Feed (SCF)= no oil pump, no oil filter, no wet or dry sump = no regular oil changes.

TYPE OF OIL & CAPACITY: JASO GLV-1 ZEROW-8 ultra-low viscosity full synthetic. Total capacity = 1 Qt.

INTERNAL SEALING: Dynamic virtually zero friction Impregnated Carbon Graphite (CGI) light constant contact seals to control vertical (rotor OD) sealing only. Seals are very simple, use no springs, require no operationally supplied lubrication and yet are expected to last the life of the engine regardless of engine speed.

NOTE: Since all combustion chambers build the same pressure at the same time (unlike the Wankel, Liquid Piston & Omega 1, Etc.) a “Jam Seal” effect is created that reduces the potential blowby by 50% right off the top. Adding High cycling speed, low heat rejection and even heat distribution the *TTX* is uniquely capable of running efficiently without any constant contact seals especially @ speeds above 1000 rpm. Adding ceramics & centrifugal brush sealing makes the case even stronger. Not only does Silicon Carbide (SiC) have low surface friction but its thermal expansion rates are extremely low. Further It will greatly reduce the thermal expansion of associated

metal parts over what they would be even considering that Ti-811 has a thermal expansion rate 1/3 of AL. Ceramics will help maintain an even sealing surface as temperature increases. When this is combined with centrifugal brush sealing horizontal (rotor width) thermal expansion & contraction & blowby can be held to very tight tolerances throughout a wide range of operational temperatures and combustion pressures. Controlling vertical expansion & contraction would still present a bit of challenge however which is solved with another simple proprietary innovation allowing for idle speeds to drop to 200 rpm while increasing power density & BTE while reducing the ultimate production cost.

MINIMUM IDLE SPEED: 200 rpm

MODULAR: Yes

WEIGHT: 209 LBS (95 kg)W/HCCI/auto ignition, 220 LBS (100 kg) with full electronic spark ignition

HEIGHT: 29.5" (75 cm)

WIDTH: 19.8" (50 cm)

STARTER/ALTERNATOR/GENERATOR/HYBRID-DRIVE: Fully integrated Starter/Alternator/Drive. ***TOMAHAWK TX*** is capable of full integration of up to six(6) electric drive motors and/or generators capable of adding 480-720 ft/lb (650-975 Nm) of torque without increasing its outer spacial dimensions. Allows for instant start/stop, regenerative braking & hybrid drive. Eliminates any & all drive belts, gears and/or chains as well as separate high load bearings. Eliminates maintenance & replacement routine.

MAIN CONSTRUCTION MATERIALS: 6061-T6 & 7075-T6 AL, Ti 811, Silicon Carbide (SiC), Impregnated Carbon Graphite (CGI optional dynamic seal) (CG(NiCr) & TiN coated 15-5 PH SS (Zero (0) "rare earth" materials except for iridium spark plug electrodes).

MAINTENANCE: Zero (0) scheduled maintenance for first 5000 hrs = Iridium Spark Electrodes up to 5000 hr = no crankcase or crankcase oil + no distinct mechanical valve system = zero (0) oil changes = no liquid cooling system maintenance or weatherization = permanent self-cleaning air filtration = no replaceable air filter in and no separate space robbing air box required. No serpentine belts to adjust or replace.

COMBUSTION vs CYCLING SPEED: Combustion speed is a very important factor in the achievable power density and/or efficiency of high-speed cycling ICEs. When combustion speed begins to fall behind cycling speed it becomes necessary to advance the ignition point ahead of minimum volume or effective Top Dead Center (TDC). The ignition map[1] pictured here is a typical example of ICE ignition performance showing the effects of both speed & load on the required advance of ignition timing. Here one can see exactly how combustion speed progressively falls behind cycling speed up to 8500 RPM ranging from 0° to 31° BTDC.

"Maximum" Ignition Advance Angle Map in Degrees BTDC (1995 3000GT Spyder VR4)

RPM	500	750	1000	1250	1500	1750	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500
LOW	15	15	15	20	26	29	31	33	34	35	36	37	38	39	40	41	42	43	44	44
	15	15	15	20	26	29	31	33	34	35	36	37	38	39	40	41	42	43	44	44
	15	15	15	20	26	29	31	33	34	35	36	37	38	39	40	41	42	43	44	44
	15	15	15	20	26	29	31	33	34	35	36	37	38	38	38	39	40	41	42	42
	16	16	18	24	26	27	29	30	31	32	32	32	33	34	34	35	36	37	38	38
L	14	14	18	20	23	24	26	27	28	29	29	29	30	30	30	32	34	35	36	36
O	12	12	18	18	23	24	23	24	25	26	26	26	26	26	26	30	32	35	35	35
A	9	9	16	18	23	24	21	22	24	25	26	27	26	26	26	28	30	35	35	35
D	4	4	14	17	23	24	25	25	27	30	31	27	24	24	26	28	30	35	35	35
	4	4	14	17	19	18	21	22	24	30	31	27	24	22	26	28	30	35	35	35
	2	2	12	15	17	18	18	19	19	21	28	25	21	21	26	28	30	35	35	35
	1	1	10	12	12	12	12	14	14	13	18	20	17	20	26	24	30	35	35	35
	0	0	8	10	10	11	11	12	12	10	16	17	14	16	24	24	30	33	33	33
	0	0	6	8	8	9	9	10	10	9	13	14	11	16	24	22	28	31	31	31
HIGH	0	0	6	8	8	9	9	10	10	9	13	14	11	14	22	22	28	31	31	31

Back in the late 1960s Honda R & D engaged a research project to test the outer limits of cycling speed in a piston ICE. Based on the well documented combustion speed deficit many engineers at that time predicted that as speeds were pushed to well over 10,000 RPM and beyond combustion would continue to fall behind until the advance ignition timing required would be so high that it would prove to be the speed limiting factor. But to their surprise it was found that the higher flow and mixture energies and effective dynamic CR at higher speeds actually began to speed up the combustion so much so that cycling speeds as high as 25,000 RPM were successfully reached and mechanical limits became the limiting factor, not combustion speed **(See:** Yagi, S., Ishizuya, A., and Fujii, I., "Research and Development of High-Speed, High-Performance, Small Displacement Honda Engines," SAE Technical Paper 700122, 1970, https://doi.org/10.4271/700122).

All this information and experience is very important in the design and feasibility analysis of The ***TOMAHAWK TX.*** This information factored into the decision to split the power rotors around a central compressor and in facilitating four (4) spark plugs per main combustion chamber and two (2) for the exhaust transfer circuit/chamber. By doing so each main combustion chamber is reduced in size to 7.74 in³ (127cc). Four (4) spark plugs each combined with other factors will be able to ignite and consume the entire

[1] Source: Matt Jannusch & Jeff Oberholtzer

contents of the combustion chambers in the range of 11-25 X faster than a typical automotive type ICE. Higher operational compression ratios will also contribute to higher combustion speed.

The result is that projected speed limits can now be far in excess of 30,000 RPM. Further, any advance timing will be limited to a range of ZERO° - 8° (depending on fuel). With this monumental improvement it is likely that the need to advance & retard ignition timing will be eliminated altogether further simplifying operation of the engine. This represents the potential for significant improvement in BTE because negative combustion work is almost eliminated throughout the full operational range which will in-turn further reduce heat rejection.

Accordingly, record level efficiency of 69% BTE is projected.

CYCLING PROFILE: A typical IC piston engine spends approximately 60% of the compression cycle increasing the torque arm moment at the same time the cylinder pressure is increasing. Conversely it spends approximately 60% of the expansion cycle decreasing the torque arm moment as the cylinder pressure decreases.

The ***TOMAHAWK TX*** spends 100% of it's compression cycle decreasing it's torque arm moment at the same time pressure in increasing. It results in an improved mechanical advantage against the negative pressure which reduces the negative work. Conversely, it spends 100% of the expansion cycle increasing the torque arm moment as pressure decreases. This increases the positive work conversion coefficient. Since there is no associated increase in friction, etc. this combination is projected to increase cycling efficiency by 12-18%, which will correlate directly in increased BTE of approximately the same value.

Additionally, other unique cycling features improve cycling efficiency such as increased dwell time around effective TDC, max torque arm moment AND trick thermal conservation, Etc.

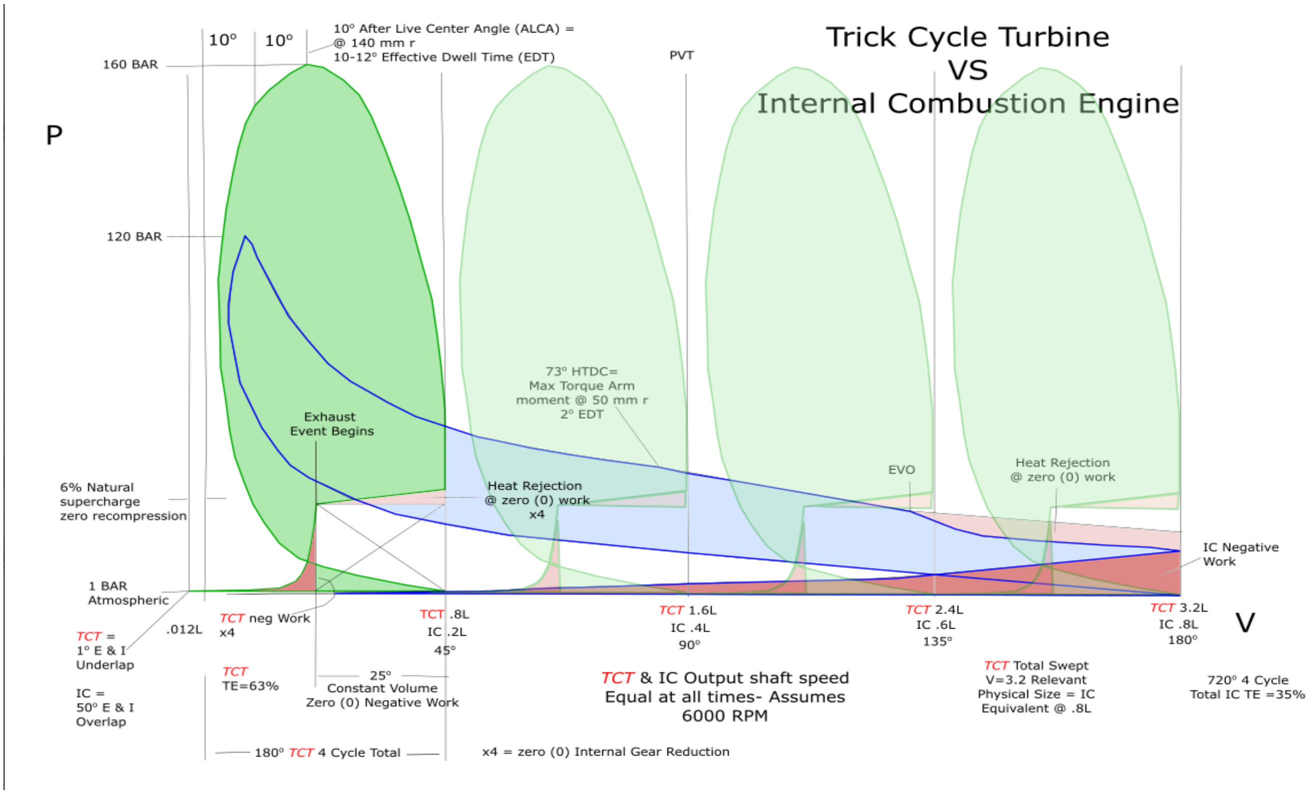
POWER DENSITY FACTOR:

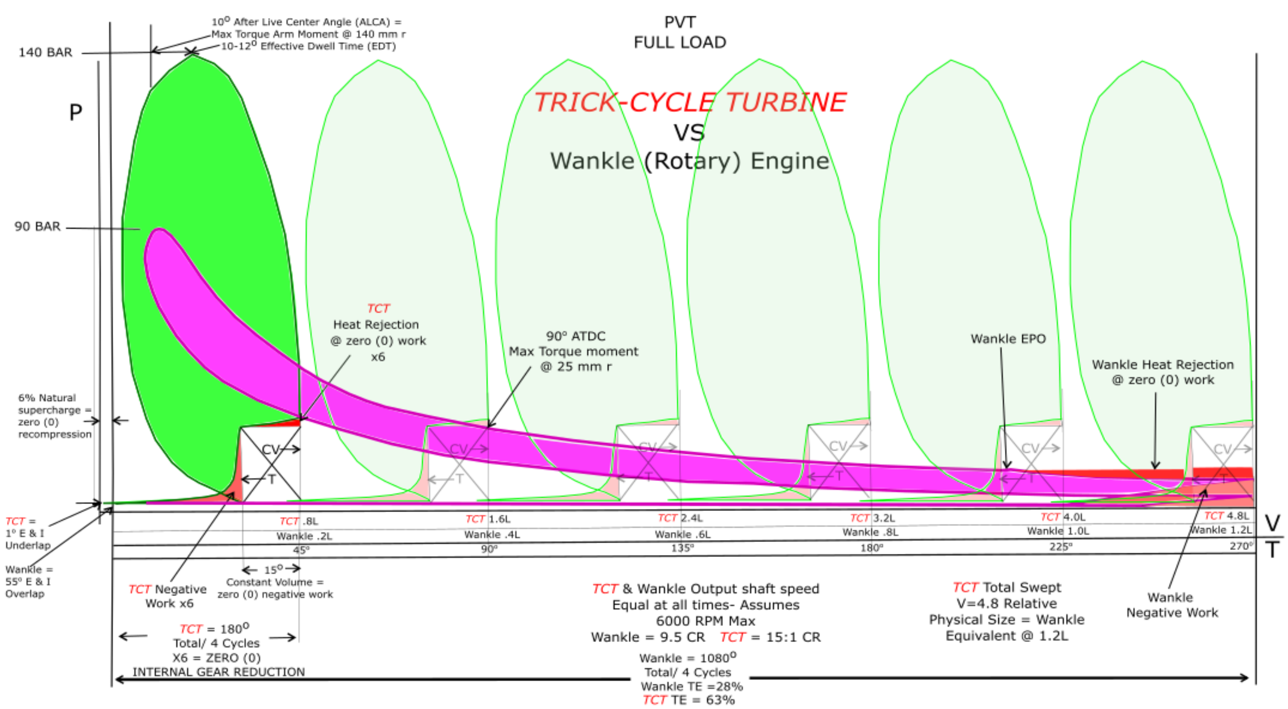
A key indicator of the potential for higher power density is the total swept volume (displacement) to the reference volume (displacement) ratio. The higher the ratio the higher the potential power density (as one of many factors). It could also be described as the Cycle Timing Ratio or CTR.

CTR is a simple comparison of a single displacement stroke, ie "reference volume" vs the number of full displacement strokes supporting a firing event that occur in one (1) 360º rotation of the final drive shaft WITHOUT any internal or external actual or effective gear reduction, ie "swept volume". This number is not controlled by (for example) the number of cylinders. Therefore a single cylinder 4-stroke engine has the same CTR as a V12.

Here are some CTRs of common and not so common IC cycling systems in comparison to The ***TOMAHAWK TX:***

4-STROKE:	.5:1
MILLER CYCLE:	.5:1
MODERN ADAPTATION OF ATKINSON CYCLE:	.5:1
WANKEL ROTARY:	1:1
2-STROKE:	1:1
OMEGA 1:	1:1
SPLIT CYCLE:	1:1
ATKINSON CYCLE:	1:1
LIQUID PISTON:	1:1
TOMAHAWK TX	3:1 (NOTE: = six (6) X typical automotive engine)


Trick Cycle Turbine
VS
Internal Combustion Engine
10°
10°
10° After Live Center Angle (ALCA) =
@ 140 mm r
10-12° Effective Dwell Time (EDT)
PVT
160 BAR
P
120 BAR
73° HTDC=
Max Torque Arm
moment @ 50 mm r
2° EDT
Exhaust
Event Begins
6% Natural
supercharge
zero recompression
Heat Rejection
@ zero (0) work
x4
EVO
Heat Rejection
@ zero (0) work
IC Negative
Work
1 BAR
Atmospheric
TCT =
1° E & I
Underlap
.012L
TCT neg Work
x4
TCT .8L
IC .2L
45°
TCT 1.6L
IC .4L
90°
TCT 2.4L
IC .6L
135°
TCT 3.2L
IC .8L
180°
V
IC =
50° E & I
Overlap
TCT
TE=63%
25°
Constant Volume
Zero (0) Negative Work
TCT & IC Output shaft speed
Equal at all times- Assumes
6000 RPM
TCT Total Swept
V=3.2 Relevant
Physical Size = IC
Equivalent @ .8L
720° 4 Cycle
Total IC TE =35%
180° TCT 4 Cycle Total
x4 = zero (0) Internal Gear Reduction


10° After Live Center Angle (ALCA) =
Max Torque Arm Moment @ 140 mm r
10-12° Effective Dwell Time (EDT)
PVT
FULL LOAD
140 BAR
P
TRICK-CYCLE TURBINE
VS
Wankle (Rotary) Engine
90 BAR
TCT
Heat Rejection
@ zero (0) work
x6
90° ATDC
Max Torque moment
@ 25 mm r
Wankle EPO
Wankle Heat Rejection
@ zero (0) work
6% Natural
supercharge =
zero (0)
recompression
CV
T
TCT =
1° E & I
Underlap
Wankle =
55° E & I
Overlap
TCT .8L
Wankle .2L
45°
TCT 1.6L
Wankle .4L
90°
TCT 2.4L
Wankle .6L
135°
TCT 3.2L
Wankle .8L
180°
TCT 4.0L
Wankle 1.0L
225°
TCT 4.8L
Wankle 1.2L
270°
V
T
15°
Constant Volume =
zero (0) negative work
TCT Negative
Work x6
TCT = 180°
Total/ 4 Cycles
X6 = ZERO (0)
INTERNAL GEAR REDUCTION
TCT & Wankle Output shaft speed
Equal at all times- Assumes
6000 RPM Max
Wankle = 9.5 CR TCT = 15:1 CR
Wankle = 1080°
Total/ 4 Cycles
Wankle TE =28%
TCT TE = 63%
TCT Total Swept
V=4.8 Relative
Physical Size = Wankle
Equivalent @ 1.2L
Wankle
Negative Work

TOMAHAWK TX AVIATION:

The ***TOMAHAWK TX*** presents a potential alternative to the application of the jet turbine &/or turbo-fan jet turbine engines used predominately in aviation for the following reasons:

1. ***POWER DENSITY:*** The ***TOMAHAWK TX*** is projected to have a shaft HP (shp)-to-weight ratio @ 3 times higher than a jet turbine engine and thus capable of producing higher thrust to weight ratios in all configurations (Most notably the ducted fan configuration).
2. ***FUEL EFFICIENCY:*** The ***TOMAHAWK TX*** is projected to have a BTE well over two (2) times higher % as a typical jet or turbo-fan jet engine. Combined with the higher projected power density, which will reduce total aircraft weight & the reduced weight of the fuel load, this will result in a 50-60% improvement in overall fuel efficiency while increasing payload capacity.
3. ***EMISSIONS:*** With the higher fuel efficiency there will be a corresponding drop in total emissions. However, in addition, the reduction in the universally recognized harmful emissions would be reduced further to a small fraction of that of a typical jet engine.
4. ***NOISE:*** Engine noise levels produced, especially during takeoff, are projected to be measurably less than typical jet engines in the range of 25-40%. This could improve takeoff route options and even where and how future airports can be constructed at potential large savings in overall air travel efficiency.
5. ***COST:*** The overall cost to both produce and maintain The ***TOMAHAWK TX*** Engine is projected to be a small fraction of typical jet turbine engines.
6. ***SAFETY:*** The ***TOMAHAWK TX*** is projected to be a much safer turbine engine design which will be far less vulnerable to compete loss of power due to bird strikes, Etc.

Note: These factors would also have a huge impact on other significant politically driven "climate" policy immune ICE dominant markets such as marine, heavy-duty trucking, heavy duty agriculture, stationary & mobile power generation and high-end racing of many forms, Etc.

GUARANTEE FIRST PROTOTYPES WILL RUN AND PRODUCE PUBLISHABLE DATA:

As discussed herein there have been several new engine concepts over the years, including recently, such as the "Liquid Piston" and the "Omega One", that have captured the imagination of many but have failed to produce either any running prototypes at all or have produced running prototypes whose performance and efficiency is less than that of current production ICE engines.

The common theme is that these engines are somehow uniquely adaptable to run on Hydrogen (they actually are not) and therefore produce "zero emissions" and/or are uniquely adaptable to some form of "Homogeneous Charge Compression Ignition" (HCCI) (they actually are less adaptable to HCCI than current engine designs in production because of inefficient long cycle times, Etc.) and will somehow magically solve that illusive puzzle and then the BTE will suddenly rise to record high efficiency. But, after years of work and 10s of $Millions spent somehow that day just never comes. The main problem is that these engines all have inherent & discernible flaws in the base design that are not fixable as such in much the same way as the Wankel Rotary Engine proved over some 6 decades of development.

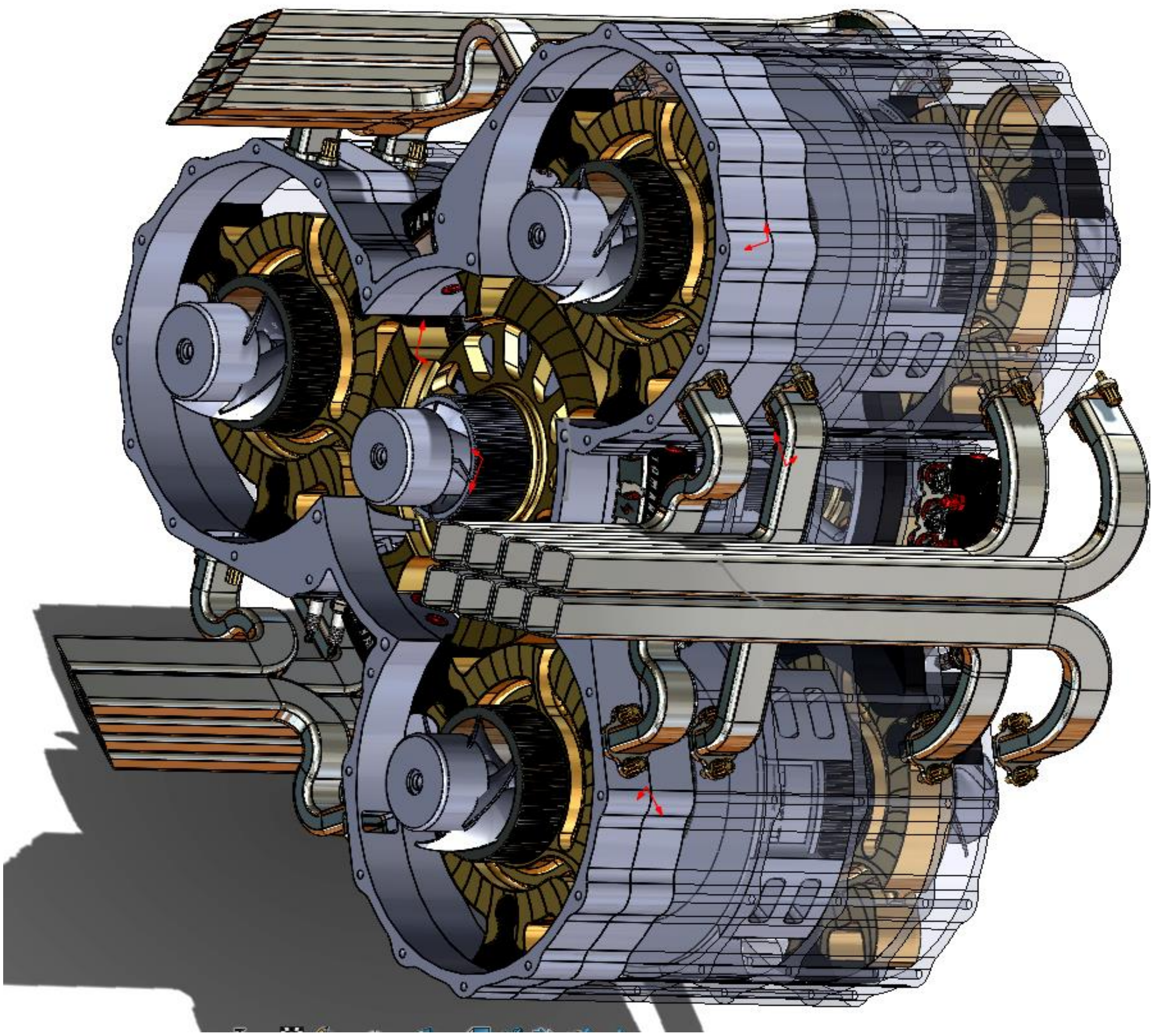
At ***TCT*** we do things differently. We have a specific plan from the beginning to guarantee that not only will the FIRST set of prototypes produce actual running prototypes, capable of producing their own measurable power without any assist, BUT, that they are guaranteed to produce extremely impressive repeatable & publishable data.

PART of the way this is done is by designing tremendous adaptability, adjustability & tunability from the beginning, some of which is described in the engine specs section above. Another part has to do with the symmetry and balance of the engine combined with the complete absence of any reciprocating, oscillating or elliptical mass.

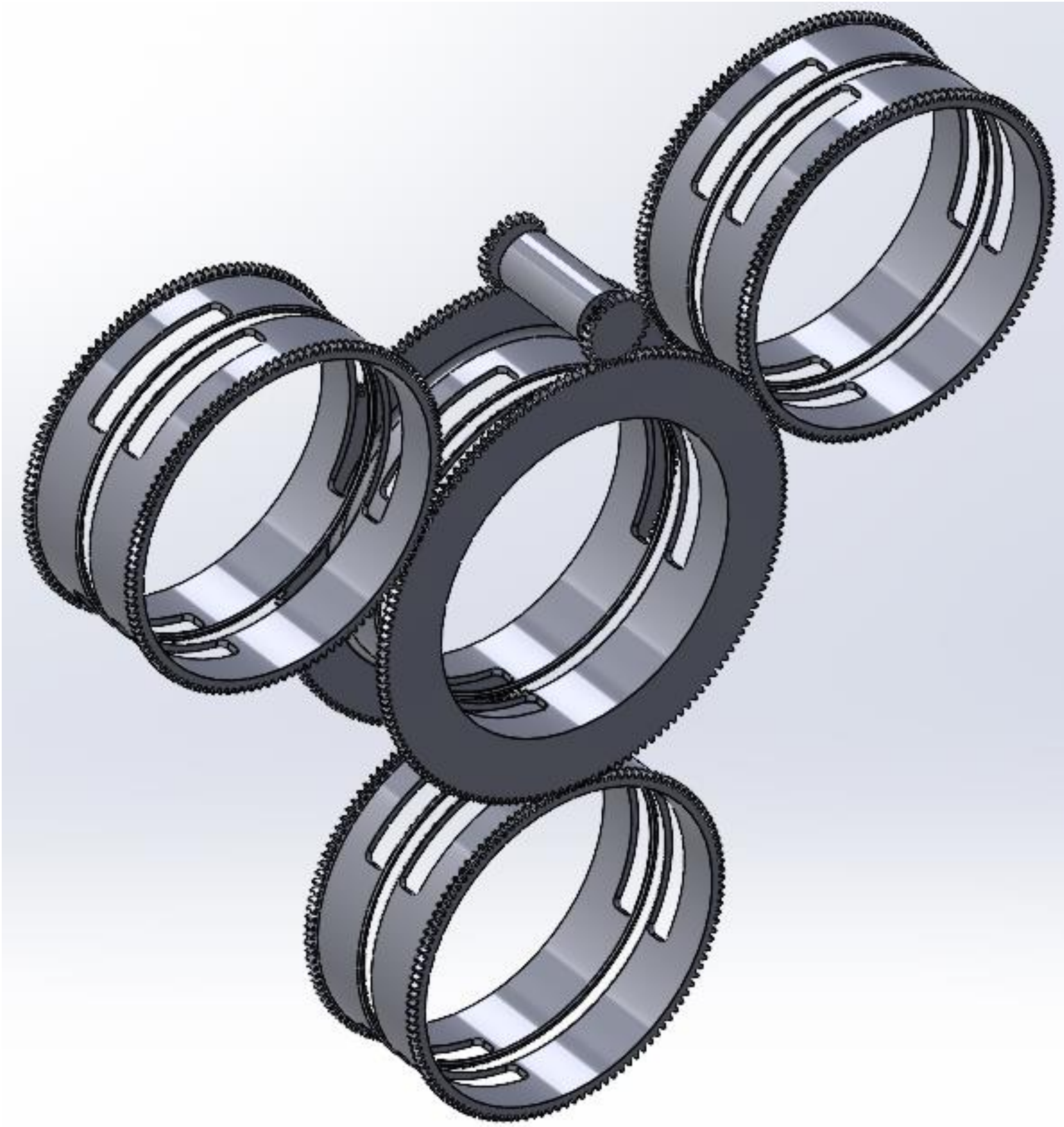
It is noteworthy that the production Mazda rotary engine has a large amount of elliptical mass which is an improvement but not a complete illumination of reciprocating mass and yet those engines have shown much higher RPM capability while almost eliminating catastrophic failure even in the highest stress/load & speed circumstances. Therefore, the

TOMAHAWK TX will have the lowest probability of catastrophic failure @ speed & load possible.

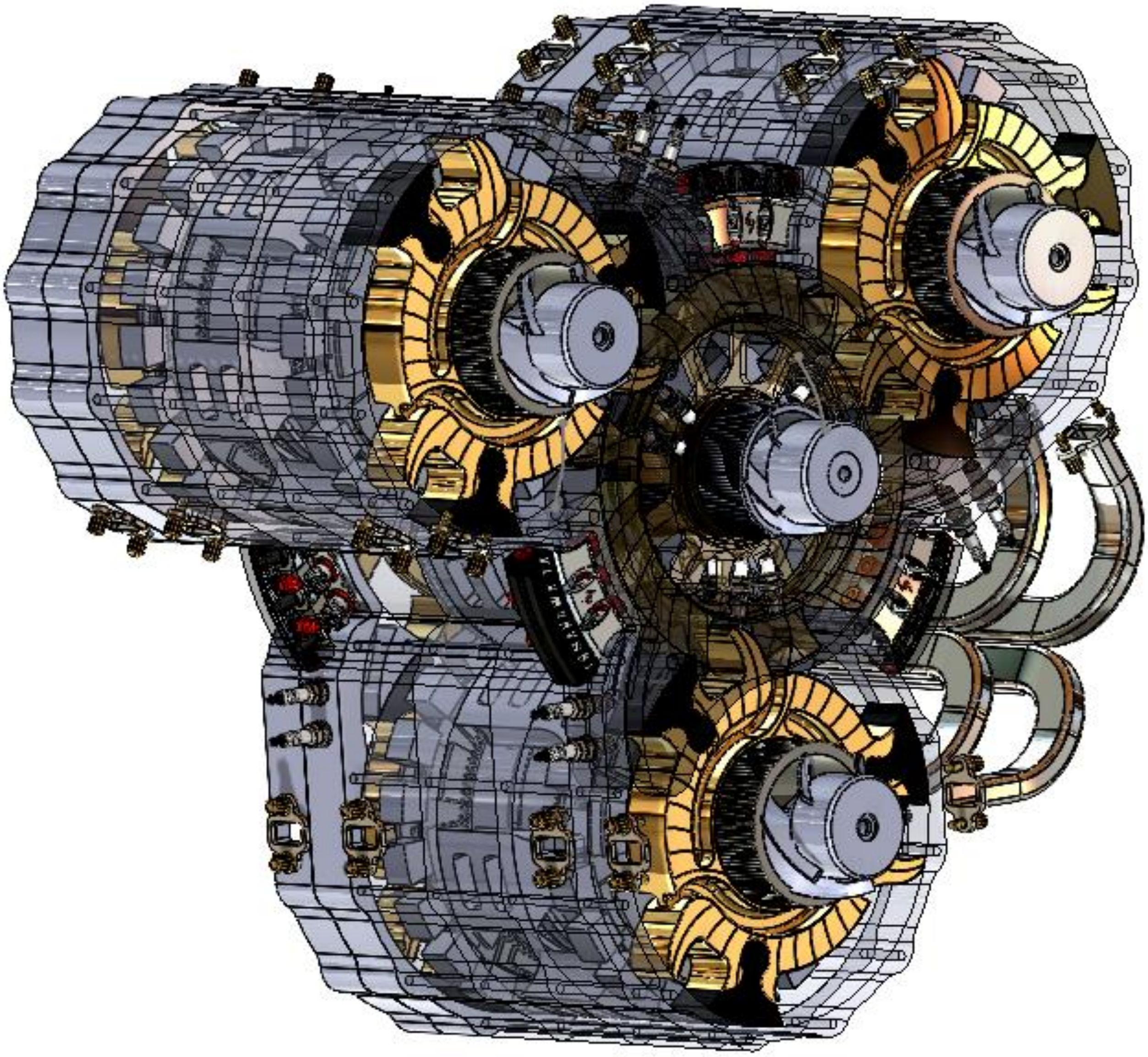
In addition The ***TOMAHAWK TX*** has no valve train or high stress components &/or springs requiring pressurized oiling and/or oil splash cooling, in fact, pressurized oiling is not required anywhere in the engine. When this is combined with the mathematically definable extremely high levels of internal air flow capacity (See above), extremely high speeds can be explored without serious risk of destroying the engine under load and/or before data can be extracted. What this means is that even if the engine produced sub-record power density @ normal ICE engine speeds it can confidently be pushed to higher speeds until the power output is pushed into record useful power density and therefore will be highly publishable AND marketable.



MANY PATENTS PENDING

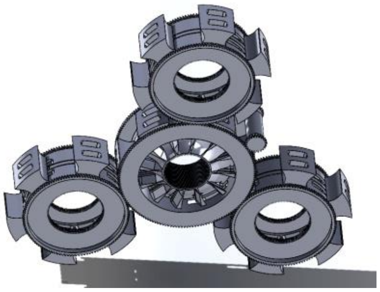


ELECTRONIC CENTRAL COMPRESSOR CONTROL SYSTEM = FULL MANIFOLD PRESSURE CONTROL
ELIMINATING NEED FOR WASTE GATE SYSTEM AND CAN DOUBLE AS A THROTTLE CONTROL



FULLY INTEGRATED HYBRID DRIVE/GENERATOR/RE-GENERATOR

TESLA: "When I get an idea, I start at once building it up in my imagination, I change the construction, make improvements and operate the device in my mind. It is absolutely immaterial to me whether I run my turbine in thought or test it in my shop. I even note if it is out of balance. There is no difference whatever; the results are the same."



"MY TURBINE!"