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Tomahawk TX Turbine Assessment[1]

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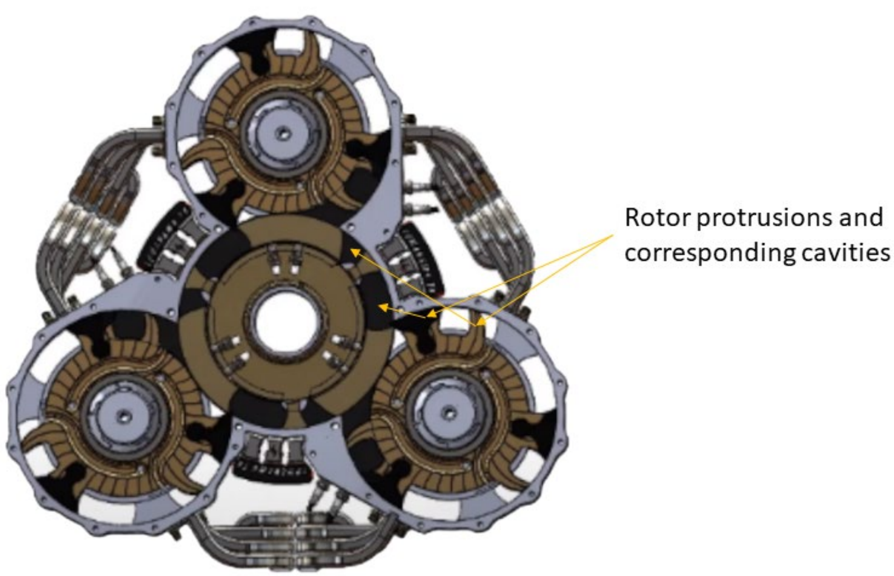
Technology: The Tomahawk TX Turbine can be described as a multi-shaft, circumferentially distributed, mechanically linked, quasi reciprocating rotary internal combustion engine, wherein 3 satellite rotors [circumferentially arrayed about a single radius] are mechanically geared to a central timing and distribution rotor with all axes of rotation parallel with the central axis, similar to the arrangement of planetary gears. It both borrows from the principles of single shaft rotary engines and is redefined by novel geometries and synergistic use of thermodynamic principles and subsequent mechanics to potentially increase torque and power density for internal combustion engines.

Mechanical Function: Through tangentially synchronized rotation of each satellite rotor with the central timing and distribution rotor, the protrusions designed within each cylindrical satellite rotor, per rotational timing, along with the corresponding rotationally distributed cavities of the central rotor and the containing system of housings and slotted partitions provide the necessary relative motion to accomplish the physics of change in pressure and resultant changes in flow rate and thermal state. The "Tomahawk" and "Hook" protrusions combined with the correspondingly timed central rotor cavities produce both a momentary quasi-radial compression and subsequent tangential combustion expansion force as rotation progresses thus producing a torque at the radial boundary of each rotor (Figure 1). Combined with two additional satellite rotors and 3 "chamber" pairs per rotor there is opportunity for 9 combustion pulses per rotation.



[1]This review is strictly technical in nature and does not provide opinion or review of market viability.

*Concern of note to be mindful of during development that effects optimization and not root function

Figure 1

Initial Assessment: This novel approach to the internal combustion engine appears to make great use of mechanics to potentially increase torque and power output per unit mass making it suitable for aerospace and marine applications. However, certain aspects of the design would create challenges for use in ground vehicle applications, such as solid particulate air contamination, and high g irregular vibrational load tolerances respectively due to the required clearances between the components of the rotors. The rotary design by nature makes efficient use of mechanical inertia to decrease momentum losses thus increasing mechanical efficiency and decreases internally produced vibration. However, with a triple rotor design and virtually independent ignition for each "combustion chamber" the concern* becomes the potential difficulty in optimizing the timing and fuel/air distribution cycle with reference to a differential in torque from one rotor to another.

Observed potentials:

- This design has the potential to produce higher torque and power per unit mass of the engine as seen with similar single rotor mechanisms. However, it has a greater potential for power by virtue of 3 simultaneous pulses per rotor alignment and 3 sequential pulse sets per rotation. This is essentially equivalent to a 9-cylinder engine with 3 sets of 3 simultaneously firing cylinders per revolution.
- This design has an opportunity to drastically reduce internally produced vibration relative to reciprocating designs thus potentially increasing longevity of the motor and its moving parts. There appears to be very little contact throughout the design as it appears to rely heavily on close tolerance fits and clearances to act as dynamic gap seals, which will be defined in observed challenges.
- This design appears to have potential to improve thermodynamic efficiency of the rotary internal combustion engine by virtue of a contacting central heat mass and its resultant retention of thermal energy for distribution into the combustion mixture. This would allow for the use of higher energy fuels and a cleaner more efficient combustion cycle.

Observed challenges:

- Tolerances: The design aspect of close tolerances and non-contact sealing with close relationship to timing of multiple components, is difficult and expensive to manufacture, as well as sensitive to particulate contamination due to internal or external sources of debris both macro and microscopic. Over time it could potentially degrade the performance of and imbalance the system of the timed rotors with respect to their own individual output torque. This could potentially generate torque differential induced oscillations and resultant internal stressors. This of course will be noted during laboratory testing.

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- Timing: As mentioned above, any significant torque disparity will have an affect on the dynamics of the rotor system in terms of torque ripple, and differential loading of the combining shafts. A mismatch of non-mechanical ignition and injector timing between the adjacent rotors could potentially produce adverse effects.
- Thermal management: It is unclear how heat will be effectively removed from the central rotor and housing and rejected from the assembly. Additionally, it appears there are currently no measures for maintaining the small clearances during expansion and contraction of the rotors with respect to the housing. Close attention should be given to differences in thermal expansion due to material type and thickness. This is especially apparent in the interface between rotor and external housing wall with respect to the relative location of each axis to adjacent axes.

Conclusion:

The reviewer sees clear potential to increase the power and perhaps efficiency over current combustion engine designs. The function of the engine system appears feasible from a design and thermodynamic perspective. However, certain challenges appear to exist that will need to be addressed to ensure proper functioning in all conditions over the lifetime of the engine. The reviewer recommends a close adherence to critical design review to include DFMEA/PFMEA for this specific design and the practice of dynamic analog testing to address potential adverse effects of the outlined challenges as they present themselves throughout the development timeline. More data will be needed to determine if any of the anticipated potential challenges will prove to be problematic and to what degree.

Further study needs to be conducted on market viability and fit.

With this stated, it is the reviewer's professional assessment as aerospace research engineer with 20+ years experience, that this technology be further developed as it represents a potential performance improvement that outweighs the potential challenges to design and manufacture.

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