FREEDOM MOTORS

Rotapower® Engine Development Timeline

2001

- Undertook a cost analysis where we tested diamond dust particles in a nickel-plating process.
- Developed a stratified charge fuel ingestion system while exploring the use of the Ficht fuel injection nozzle to accomplish this. This is a major undertaking because it required substantial changes to the rotor housing and the development of a unique control algorithm for the fuel and ignition system.

2002

- Undertook alternative fuel studies using:
  - Natural gas
  - Alcohol-water
  - Alcohol
  - Gasoline-water
  - Diesel
- Developed high pressure fuel injection system for diesel fueled Rotapower® engine. This was a nine-month program.
- Single rotor 530cc installed in an all-terrain vehicle (ATV)

2003

- Designed metric 650cc engine.
- Began non-metric 650cc series engine development for licensee RotaMax.
- Developed 150cc series metric engine (funded by investment from RotaMax).
- Began development of diesel fueled 530cc Rotapower® engine.
- Two-rotor 530cc engine installed in jet-boat.

2004

- Developed two-rotor test nacelle for testing ducted fan version of the Rotapower® engine. Carried out tests over a one-year program.
- Explored intake and exhaust tuning on dyno to provide dynamic intake charging leading to a 15% boost in power.
- Several contracts underway during this period.
- ATV engine design (single rotor).
- Auxiliary diesel engine for trucking industry (single rotor 450cc engine).

2005

- Beta production run of 530cc, 1060cc, and 1590cc Rotapower® engines.
- 650cc and 1300cc engines entered beta production by licensee RotaMax.
- Designed 150cc engine, prototype nearing testing.
- Design and development of 27cc underway.

2006

- Dyno testing of 150cc engine underway.
- Carried out extensive emission tests using different fuels.
- Research program continued into less expensive wear coating (ceramics, iron-moly, etc.)
- Modular form of 530cc engine developed.
- Compound engine design being explored.

2007

- 530cc compound engine developed and tested in year-long program (patentable).

2008

- Began beta production of 150cc engines.
- Optimization studies of compound engine underway.
- Letters of intent to purchase engines reached 900,000 engines.
- Three-rotor 530cc engine installed in Jet-boat and thoroughly field tested.
- Developed high power 1060cc Rotapower® engine for Skycar® (208 hp and 65 lbs.).

2009

- Developed a 15 Kw gen-set capable of providing variable frequency and viable voltage. Weight was 20% of competing gen-set.
- Produced a specific 27cc engine under contract from Ryobi and integrated it into a weed-wacker.

2010

- Second compound engine version developed and tested.
- One-way valve critical to compound engine developed and endurance tested (patentable).

2011

- Developed and tested entirely new cooling path through rotor that improved rotor cooling by 30% (patentable).
- Developed and tested fuel injection directly into rotor that improves fuel economy by timing fuel charge to be richer near plug (patentable).

2012

- Developed a magneto ignition required for aircraft use of our engine.
- Redesigned the rotor housing to use two side-by-side spark plugs in place of following and leading plug. This arrangement improves fuel consumption by 8%.

2013

- Developed water injection phase change cooling system for rotor that allows sufficient cooling to enable doubling the power output through turbo charging (patentable).
- Quantified our discovery that we could use diesel fuel in the Otto cycle in a proprietary (trade secret) combination of engine displacement, engine RPM and brake mean effective pressure BMEP. This greatly simplifies the use of diesel in smaller engines.
- Letters of intent reaches 3.5 million.

2014

- Developed a motor scooter compatible 150cc engine and installed it in a charger scooter under a $600,000 contract from ALIFE Automotive in Singapore. This was a year-long program of design, development, and testing.

2015

- Developed an engine and integrated into a three-wheel vehicle for ALIFE Automotive.
- Redesigned engines for Neuera 200 including integrating sound attenuating system, new starter and direct fuel injection system in place of carburetors.
- Developed new fan/hubs to fit engines.

2016

- Designed layout in newly leased facility to fit the R&D needs.
- Designed compound version of 27cc engine.
- Completed moved to newly leased facility.

2017

- Developed mobile dynamometer and began testing of Rotapower® engine operating on biogas. Explored this application as a new business opportunity.

2018

- Developed a way to use alcohol fuel alone to cool the rotor in a way that provide a supercharging effect (patentable). This development should allow our 530cc engine to produce at least 125 Hp per rotor or 20% higher than the previous three horsepower per pound.