KIRK ENGINES, INC.

PURPOSE

Kirk Engines, Inc., a Wisconsin-based S-corporation, was originally formed in 1981 for the purpose of developing prototype engine concepts. In addition, general mechanical engineering consultation is performed on a contractual basis.

PERSONNEL

The company is solely owned and operated by J. David Kirk, a graduate mechanical engineer. David has over 34 years of consecutive employment with five different major engine manufacturers. His background includes positions as Senior Staff Engineer, Research and Development Engineer, and Senior Project Engineer. David's expertise in the engine field comprises machines ranging from 2 to 4500 cubic inch displacement, both two and four-stroke operational cycles, and various ancillary and accessory sub-systems. Additionally, his knowledge of materials and manufacturing methods compliment his mechanical engineering background. David holds seven patents in the internal combustion engine field and is a member of the Society of Automotive Engineers, and American Society of Mechanical Engineers.

CONSULTATION SERVICES

The following are specific areas of expertise offered:

- Engines, general:
    - Reciprocating machinery balance analysis – all configurations
    - Bearing load and life analysis and prediction
    - Fuel systems, including carburetion and fuel injection, both direct and indirect
    - Kinematic analysis – all dynamic engine sub-systems
    - Induction and exhaust system design and optimization
    - Pressure charging system selection and optimization
    - Estimation of optimal engine architecture to meet application requirements
    - Construction of spread sheets or computer codes to model processes
    - Licensed user of "Virtual Engines" gas-dynamic modeling software by Optimum Power

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- Two-stroke engines:
    - Port time-area studies and optimization
    - Geometry configuration studies for specific applications
    - Exhaust system engineering for both intra-cylinder and reflected wave tuned systems
    - Induction system engineering, comprising analysis of reed, rotary, and piston-port induction systems

- Four-stroke engines:
    - Valve actuation machinery engineering – all phases of valve train design, analysis, and optimization utilizing highly sophisticated software
    - Air-cooled engine cooling system engineering
    - Lubrication system requirement and design details

- Stirling engines:
    - Gas circuit design and optimization, including sizing of heater, regenerator, and cooler
    - Mechanical configuration selection and detailing for specific application
    - Combustion burner design
    - Performance predictions

- Evaluations of new engine concepts or inventions:
    - Historical review to examine uniqueness of idea for patent consideration
    - Identify potential problem areas that could “make or break” the concept
    - Detailed engineering analysis and projected performance estimates
    - Honest appraisals with highest degree of confidentiality maintained

COMPLETED PROJECTS

A four-cylinder, two-stroke cycle, light aircraft engine was engineered, designed, and prototypes constructed. The engine met all target design goals of performance and running quality in a one-year developmental time frame. A U. S. Patent was awarded covering unique mechanical aspects of the design.

A Stirling engine-powered, 200-watt generator set was engineered, designed and prototyped as a proof-of-concept demonstrator. This unit performs up to expectations.

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A single-cylinder, two-stroke cycle, model airplane engine was engineered and designed by Kirk Engines, Inc. and produced by a local manufacturer. It has proven to be a very successful product for powering quarter-scale, radio-controlled, model aircraft.

SUMMARY

Knowledge, experience, enthusiasm, and honesty are foremost qualities offered to our customers. Please consider us for your next endeavor.

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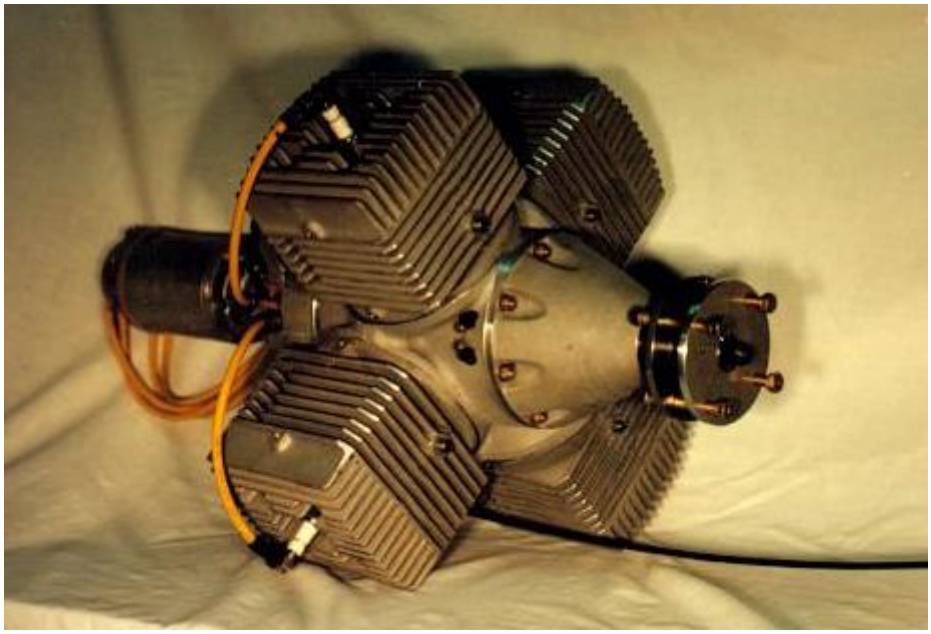
ACCOMPLISHMENTS OF KIRK ENGINES, INC.

Kirk X-4 Light Aircraft Engine



In 1981, a project was undertaken to design a small aircraft engine for both manned and un-manned aircraft applications. Prerequisites were compact size, simplicity of design and construction, low vibration, high specific output, and high reliability. In order to meet the target goals of 25 horsepower @ 5000 rpm with minimum weight, the two-stroke operational cycle was utilized along with a novel crank train mechanical system (scotch yoke). The configuration benefits by isolating the cylinder scavenge pumps from the crankcase to allow a full circulatory, dry sump lubrication system to be employed, unique to a two-stroke engine.

The initial design study, engineering calculations and modeling, plus full working drawings were done solely by David Kirk over a 3-year period as a spare-time endeavor. The components were machined by local machine shops in the area. A torque-measuring propeller test stand was also designed and constructed to evaluate the engine.

With very little development, the first prototype achieved the target power outputs, exhibited low vibration, and operated reliably for over 30 hours of testing. It generated a great deal of interest whenever a running demonstration was given. For more in-depth information on this engine, please see SAE Paper 851518, “Design of a Two-Stroke Cycle Engine Employing a Scotch Yoke

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Crankshaft Mechanism", available through the Society of Automotive Engineers. U.S. Patent 4,373,475 covers unique design features of this machine.

Stirling Engine-Powered Generator Set

A proof-of-concept engineering study was undertaken by Kirk Engines, Inc., to investigate the feasibility of a portable generator set powered by a Stirling-cycle engine. With the ever-tightening emissions regulations, noise standards, and increased demands on product durability, the Stirling engine deserves a fair and unbiased evaluation as a power plant for today's environment. Certain applications, such as a portable generator set, seem perfect devices for Stirling power. Such a generator would offer virtually silent operation, be environmentally clean with low emissions, offer low maintenance, combined with reliability and long product life.

The study consisted of a kinematic system selection that offered inherent simplicity with good mechanical balance, a materials selection for hot section components, a thermodynamic cycle analysis to size heat exchangers and predict performance, then production of working drawings. A prototype engine was then constructed around a currently-produced refrigeration compressor to minimize costs. The end result is an alpha-configuration, twin piston Stirling engine that is moderately pressurized and drives a 12-volt, 200-watt alternator at 1200 rpm.

This first prototype runs extremely well and demonstrates the potential of such a product. Running demonstrations are frequently performed with much interest being generated.

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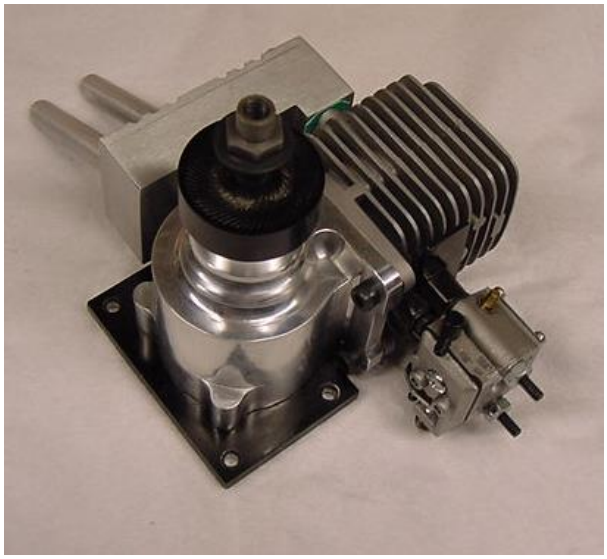
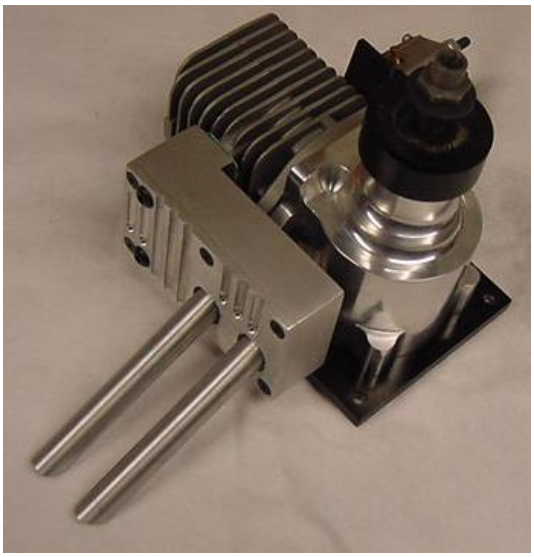
25cc Quarter Scale Model Aircraft Engine





A model aircraft engine was recently designed by Kirk Engines, Inc., and prototyped for a local manufacturer. The goal was to use a high production-volume string trimmer engine cylinder, piston, and crankshaft, thus taking advantage of lower costs for highly specific components. The crankcase, back-plate, propeller hub, connecting rod, and muffler were uniquely engineered and designed for the intended application. These parts are produced from billet aluminum on CNC machining centers resulting in components offering high strength, low weight, and attractive appearance.

As a spark-ignition, string trimmer engine, the stock unit produces approximately 1.3 bhp at 6000 rpm. Analysis showed that crankcase volume could be considerably reduced using a fully machined crankcase, thereby raising the scavenge pump compression ratio. A new muffler was designed for larger internal volume and less restrictive gas flow paths without incurring increased noise signature. A larger venturi carburetor was sized to the engine displacement commensurate with the predicted increase in airflow. An adaptor was designed for replacing the spark plug with commercially available glow plugs for use with alcohol-based model aircraft fuel. These changes resulted in a power output of 3.0 bhp at 7000 rpm, where the engine produces 18-lbf static thrust when turning an 18-inch diameter propeller. The complete engine, ready to run less propeller, weighs 3.0 pounds.

About 30 engines have been sold and owners are very enthusiastic with the performance, running quality, and reliability. This engine produces its peak power at a lower rpm than other competitive products in this class. The larger diameter, slower turning propeller adds a more realistic sound and appearance to

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the quarter-scale radio-controlled airplane. In addition, better propulsive efficiency is obtained.

Clients of Kirk Engines, Inc.

Martin Aircraft Company, 46 Curries Road, Christchurch, New Zealand.

Product – Jetpack Aircraft

Involvement – Provided consultation for initial engine configuration studies, establish general specifications, induction and exhaust system design, and engine balance evaluation.

Davis Engineering, N118 W19328 Bunsen Drive, Germantown, WI 53022

Products –
1) Seven Marine Outboard Motor
2) Neander "Shark" Diesel Outboard

Involvement –
1) Invented, designed, prototyped, and performed initial testing on a fuel delivery system that eliminates a vapor separator
2) Performed kinematic analysis of cranktrain geometry, engine balance, bearing loads, gas dynamic model created for performance predictions, sized turbocharger, lubrication system design, valve timing optimization and camshaft design, model effects of flywheel inertia on idle speed variation

Lycoming, 652 Oliver Street, Williamsport, PA 17701

Products – Piston Aircraft Engines

Involvement – Provided engineering consultation on the design of a two-stroke, three-cylinder, direct fuel injected, RPV (Remote Piloted Vehicle) engine. Contributions included configuration studies, balance and bearing load determination, gas dynamic modeling including inlet and exhaust system optimization, determination of cylinder porting layout and timings, muffler design including noise predictions, fuel system air compressor design