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Maxwell Propulsion's PSRU

What is Torsional Vibration?

According to Wikipedia, torsional vibration is angular vibration of an object—commonly a shaft along its axis of rotation. Crankshaft torsional vibration is a concern in the crankshafts of internal combustion engines because of several factors.

- Alternating torques are generated by the slider-crank mechanism of the crankshaft, connecting rod, and piston.
- The motion of the piston mass and connecting rod mass generates alternating torques often referred to as "inertia" torques
- The cylinder pressure due to combustion is not constant through the combustion cycle.
- The slider-crank mechanism does not output a smooth torque even if the pressure is constant (e.g., at Top Dead Center there is no torque generated)
- There is inherently little damping in a crankshaft to reduce the vibration

If torsional vibration is not controlled in a crankshaft it can cause failure of the crankshaft or accessories being driven by the crankshaft (typically at the front of the engine, the inertia of the flywheel normally reduces the motion at the rear of the engine).

What torsional vibration control system is used in the MX1?

The MX1 has eight Lord Corporation elastomeric bushings. This approach to handling torsional vibration ensures that the resonant frequency of the engine coupled to the propeller is not in the normal RPM operating range. The elastomeric bushings between the engine and PSRU have a low enough spring rate to lower the resonant frequency significantly.

What tests were done on the MX1?

The first elastomeric coupler from Lord Corporation was a single-piece *doughnut*. Testing of this included vibration analyses conducted using procedures described in Steve Boese's Contact![1] article. Unfortunately, our analysis demonstrated harmonic frequencies that were outside the acceptable range described by Mr. Boese. Disappointed, we contacted Lord Corporation for their input on appropriate next steps in the development process. Their first advice was to investigate whether the engine mounting was a contributing factor to the observed vibrations. To do this, the original mounting bushings were replaced with different density materials and vibration readings obtained. The end result was that, while there was some minimal change to the results observed after each of four different density bushings, the primary source of the vibration was determined to be in the elastomeric coupler.

To address this issue, the MPS engineer worked with the engineering staff at Lord Corporation to analyze the vibration data. The proposed remedy was to use eight J-6250 rubber bushings and run another series of vibration tests. The results of the tests demonstrated that all observed vibrations fell below or within the acceptable range.

Ground testing was completed in January 2008 after 140+ hours run on the test stand. Since that time SportCopter International has been flight testing it on their new SportCopter II. In addition, by the time N787MX – The Maxwell *Dream Liner* arrives at AirVenture 2008, it will have logged approximately 70 hours.

[1] Steve Boese, *A Vibration Study of a Mazda 13B Installation in a Van's RV6A; Contact! Issue 90 Pages 22-29.*

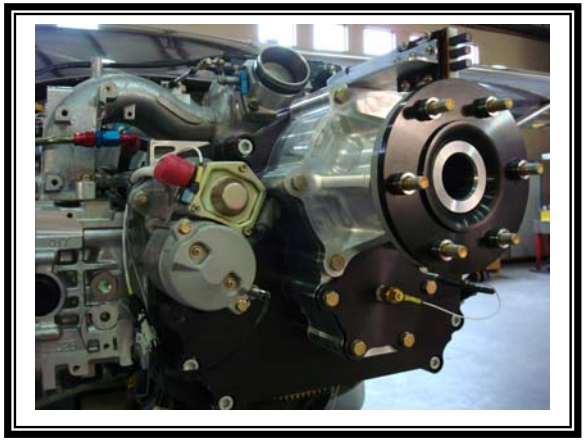
Advantages

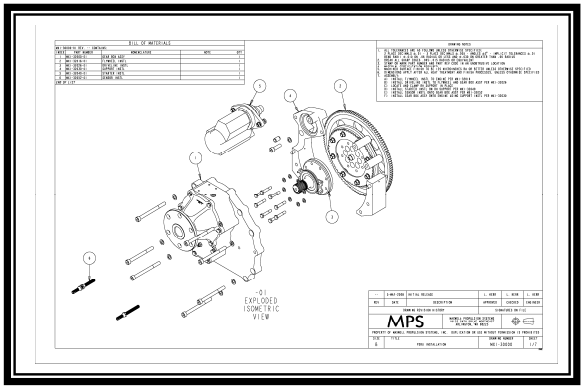
- Direct Drive
- Ease of Maintenance
- Professionally Engineered
- Scientifically Tested
- SAE 2 Prop Flange
- Multiple Prop Application
- AGMA Quality 10 Gears
- Helical Cut Spur Gear
- New 1.2 KW Starter

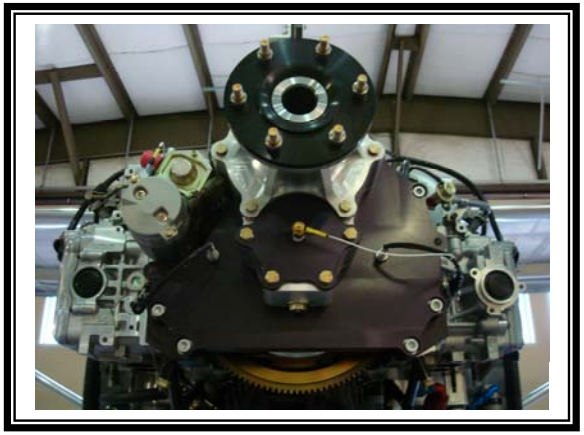
Features

- Anodized Aluminum Billet
- Cadmium Plated Flywheel
- Lord Elastomeric Bushings
- Dual Ignition Pickups
- 60 -2 Trigger Wheel
- Gear Ratio 2.13:1
- Offset 4.41”
- Length 10.5”
- Weighs 72 Pounds
- 500 cc Valvoline 80w-90 Oil
- Magnetic Drain Plug
- Oil Temp Sender
- TBO @ 1500 Hours

Maxwell Propulsion Systems, Inc.
MX1 PSRU







What vibration dampening devices are commonly used in an aircraft?

A typical way to ensure that the engine’s resonant frequency coupled to the propeller is outside the RPM operating range is to add an elastomeric coupler between the engine and PSRU. These devices have a low enough spring rate that it lowers the resonant frequency significantly.

One Torsional Vibration Myth

The subject of torsional vibration is surrounded by mysticism. One myth is that any level of torsional vibration will inevitably lead to a catastrophic failure of the prop shaft, gears, or other flight critical component. In truth, as long as the level of vibration is kept below the fatigue strength of each system component, there will not be a failure due to torsional vibration. It is the responsibility of the engineer/designer to incorporate appropriate safety factors into the design, and then test the finished product, to ensure the level of reliability one expects in an aircraft.

What were the MPS goals for their new PSRU?

Since the early days of converting automotive engines to experimental aircraft use, a variety of PSRU designs have been used to the dampen torsional vibration between the engine and PSRU. These included gears, belt drives, clutches and elastomeric systems. To our knowledge, despite the fact that many systems experienced mechanical and/or structural failures, there has been little scientific testing and analysis of the affects of engine vibration on a PSRU. In Fall 2006 Maxwell Propulsion Systems, Inc. made the decision to develop a new geared propeller speed reduction unit (PSRU). Our goal was to bring into the experimental aviation marketplace a professionally-designed and scientifically-tested system that would address the critical issue of fatigue and/or early failure resulting from torsional vibration. The design requirements included a projected TBO of at least 1500 hours.