

Introduction

As society marches towards a world with the increased presence of unmanned aerial vehicles, it is becoming increasingly apparent to ensure these vehicles are designed with heavy lift capabilities. Moving past personal leisure and even competitive racing, these vehicles are vital to industrial applications ranging from military surveillance to the transportation of goods. To fulfill the rigor and the duration it takes to complete the activities within these applications, the solutions tend to involve the implementation of contra-rotating motor - powered propellers. This technical review briefly summarizes the commercial applications of contra-rotating motor-powered propellers, the functionality of these motors, and lastly the methods for implementing this technology.

Commercial Applications of Contra-Rotating Motor- Powered Propellers

Over the past few years, unmanned aerial vehicles or drones have been developed to now include the use of contra-rotating motor-powered propellers. Having strong origins in Germany, these vehicles have now migrated to the United States and now primarily dominate the design of most heavy lift specific drones. Contra-rotating motor- powered propellers that can be mounted to a DIY drone kit are the most popular and functional option currently available on the market.

Offering a higher thrust-to-volume ratio and low cost, the Himax CR6320A contra rotating outrunner motor sits as the most sought-after motor currently on the market. Designed for light weight, high efficiency, and high torque, the Himax Outrunner motor weighs 1250 grams and operates with a max power of 3200 watts [1]. Made for large size unmanned aerial vehicles weighing 15 to 30 pounds, this motor is still able to reach a max 10,000 RPM, with respect to the power/weight ratio applied to the vehicle. The motor with propellers included is listed currently at \$499.99 [2].

An alternative competing design is the DZP30 Contra-rotating Dual Brushless Motor with Dual three Blade Propellers. Designed for smaller unmanned aerial vehicles, the DZP30 motor weighs a mere 32g, has a max thrust of $280g \cdot 2 / 11.1v / 5.1A \cdot 2$, and has an idle current of $0.5A \cdot 2 / 11.1V$ [3]. In contrast to the forementioned motor, it includes 3 blade propellers and is listed currently at \$40.78 [4].

Technology of Contra-Rotating Motors

Basic Functionality

Investigating the technology of contra-rotating motors involves looking at the motors from a larger perspective. In terms of large, fixed wing airplanes, contra-rotating motors are typically installed in twin or multi-engine aircrafts. The name contra rotating refers to the installation by which two propellers are attached to the same engine, with one propeller attached immediately behind the other. The motor then powers the propellers to rotate in opposite directions around the same axis, which refers to the term contra-rotate. Contra-rotating motors are used to recover the energy that is lost as a result of the motion of the air in the slipstream of the forward propeller and allow an increase in power without a corresponding increase in propeller diameter [5].

Functionality within UAVs

Regarding unmanned aerial vehicles, contra-rotating motors have recently began to replace more traditional motor configurations of fixed, rotary and flapping wing. Contra-Rotating configurations within UAVs have specifically shown to transfer tangential flow into increased thrust while simultaneously mitigating it to provide a more linear flight, resulting in overall increased thrust and elimination of potential instability [6]. There is also an advantage in contra-rotating motors in the compensation of torque. Contra-rotating motors compensate for torque by enabling two torque forces ,generated in opposite directions, to complement each other perfectly at any airspeed. This is advantageous because other motor configurations typically only optimize torque at a single airspeed.

Implementation of Contra-Rotating Motors into Unmanned Aerial Vehicles

The implementation of contra-rotating motors into unmanned aerial vehicles requires a understanding of power and motor systems to ensure the successful motion of propellers in the desired motion. It also requires an in-depth understanding of force, pressure, and flow-field measurements to ensure flight and heavy lift capabilities are possible with the given vehicle. Purchasing a Rotor Riot Cinewhoop UAV kit, in addition to the forementioned Himax CR6320 outrunner motor, would provide a team of individuals the opportunity build the UAV component by component. This totals to be approximately \$1,789.99 [2,7]. Building the vehicle this way ensures the team has ample opportunity to separately assess and test each component to get optimal or desired outcome. Although the implementation mainly consist of hardware principles, some software could be implemented to possible simulate various flight aspects before actually placing the vehicle in an real environment to ensure the contra-rotating motors successfully propel the vehicle correctly.

References

- [1] Maxx Products International LLC. , Himax CR6320A Contra Rotating Brushless Outrunner Motor Specification Sheet. Feb. 2012. [Online]. Available: <https://www.maxxprod.com/pdf/CR6320A.pdf> [Accessed : October 6, 2020]
- [2] Max Products International LLC., Himax Pricing Information. [Online] Available: <https://www.maxxprod.com/mpi/mpi-266.html> [Accessed : October 6, 2020]
- [3] Banggood Inc., DZP30 Contra-rotating 1500KV Dual Brushless Motor with Dual 3 Blade Propellers 32g for Fixed Wing Plane RC Airplane Aircraft Specification Sheet March. 2013. [Online]. Available: <https://usa.banggood.com/DZP30-Contra-rotating-1500KV-Dual-Brushless-Motor-with-Dual-3-Blade-Propellers-32g-for-Fixed-Wing-Plane-RC-Airplane-Aircraft-p-1599932.html> [Accessed : October 6, 2020]
- [4] Banggood Inc., DZP30 Contra-rotating 1500KV Dual Brushless Motor with Dual 3 Blade Propellers 32g for Fixed Wing Plane RC Airplane Aircraft Pricing Information [Online] Available: https://usa.banggood.com/shopping_cart.html [Accessed : October 6, 2020]
- [5] Skylibrary, “Contra-Rotating Propeller” Nov. 15. 2015 [Online]. Available: https://www.skybrary.aero/index.php/Counter-Rotating_Propellers [Accessed : October 6, 2020]
- [6] W. Ong, S. Srigrarom, H. Hesse, “Design Methodology for Heavy Life Unmanned Aerial Vehicles with Coaxial Rotors” AIAA Scitech Conference, 1-3 January 2019 pp 1-13. [Accessed : October 6, 2020]
- [7] Rotor Riot Inc., Roto Riot Cinewhoop DIY Build Kit With Air Unit Goggles and Transmitter Pricing Information Oct. 6 2020 [Online] Available: <https://rotorriot.com/collections/build-your-own-fpv-drone/products/rotor-riot-cinewhoop-diy-build-kit?variant=31566528053322> [Accessed : October 6, 2020]