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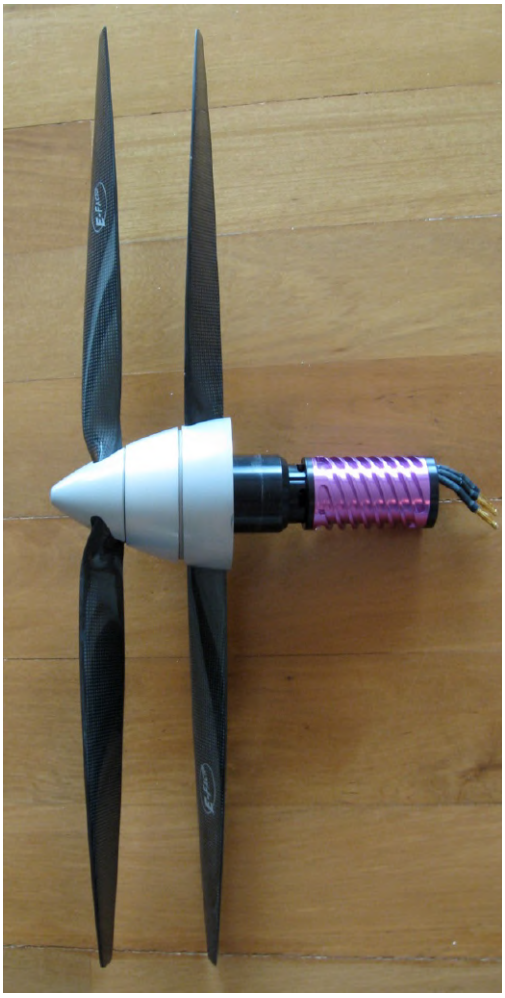
To compensate the assymetrical forces

Around the era of 1950 some single engine fighter planes were fitted with two contra-rotating coaxial propellers in order to compensate the serious troubles caused by the assymetrical forces of their extremely powerful piston engines, normally swinging just one huge propeller. Mostly the late production Spitfires, determined to operate from aircraft carriers, were powered that way and are a nice example for this development.



Forgotten completely

Although the concept could really resolve the problems it was aimed to in quite a few projects, success was limited to the insufficient rigidy of the complex gearboxes, while the tremendous forces caused by the two propellers plus the destructive vibrations from the piston engine just loved to shake such drives apart. Moreover at those times, jet engines were coming-up widely and high performance piston engines were dropped from the wish lists finally.The coaxial drive wasn't forgotten completely though, since in later years a few multi-engine aircraft employed contra rotating props combined with turbo-prop engines while taking advantage of the higher efficiency over single prop systems.Finally, contra rotating rotors are a quite popular answer to the specific requirements in helicopter design.

F3A Application

As an active F3A-competition pilot always eager for higher scores, technical refinements must help me to compensate what skill can't achieve. My experiences with electric drives in F3A finally lead to the idea to pick- up the contra-rotating propeller (coaxial drive) system with the target to improve in-flight appearance and to facilitate model airplane control as much as possible from the propulsion's side. In this article I avoid to bore readers with the full history of crucial experiences , the numerous hours invested in CAD-design, component machining and test flying with an almost uncounted variety of propeller combinations. Instead I will concentrate on the basical technique and significant properties of my coaxial drive system, named „E-Factor E-F-503".

Technical Set-up

One brushless electric motor (Hacker C50 modified) matched to a double stage gearbox

(E-Factor) with two coaxially positioned output shafts, driving two contra rotating propellers (E-Factor) of 22" diameter. System mass including two propellers and spinner (less ESC): 875 g Propeller rpm each at max. power static: 3.800 rpm Input current at max. power static: 85 A. With this fact in mind, it just seems logical to ideally seek for a propulsion which works as symmetrical as everything else is doing in F3A model airplanes: A coaxial drive propulsion. But does it really work symmetrically? Is the rear propeller able to produce the same thrust as the one in the front? And if so, do they rotate at the same or at least almost same rpm? All these questions can be simply answered with „yes". To explain a complicated and not linear science like aerodynamics is too much for here, but to imagine that the the front propeller accelerates or compresses the air in a spiral stream backwards and that the rear propeller runs right into that in the opposite direction, deliveres a vital coherence of the systems' function. Of course, the mechanical layout of the gearbox had to be designed to produce upon conditions and to sufficiently resist the forces created by the mighty 22" propellers and the powerful motor. Also, the drive had to be designed in a way the two propellers would not work against eachother, which would result in significant loss of efficiency.

Particular effects of a coaxial drive in aerobatic flight

Due to the equal share of torque between the two contra rotating propellers, no torque (or counter torque) is transferred from the motor to the model airplane.

Propeller Airstream
The spiral airstream around the longitudinal axis of the fuselage normaly created by a single propeller is compensated and straighted here by the second propeller. As a matter of fact, there is no side thrust necessary, the motor is installed absolutely straight into the fuselage. All that results in a smooth and straight propeller airstream, in parallell to the fuselage and delivering a practically symmetrical air flow as well as along fin and rudder.

Gyro Effect
When an airplane with a single propeller system is pulled or pushed into a loop the propeller's gyro forces yaws it to one side, applying some rudder resp. elevator deflection. With a correctly operating coaxial drive, the gyro forces from the two contra rotating propellers are compensated to zero.

P-Factor
In most flight conditions the model airplane doesn't head exactly in parallel to the environmental air movements, i.e. under crosswind influence or pull/push or yaw conditions. As a result, propeller blades going through one radial sector of the propeller disk work with a higher induced pitch than the blades going through the opposite sector at the same time. With a single propeller this creates an assymetrical pull force tending the model airplane to deviate from the ideal flight path. With a coaxial drive, this effect is compensated by the second propeller.

Airspeed Potential
To achieve best propeller efficiency, the diameter should be large and to achieve a high flying speed, especially in strong wind conditions, a high pitch is necessary at reasonable rpm. With a single propeller system the increase of diameter and pitch would simply increase all the upon mentioned disturbing assymmetrical influences, but with a coaxial drive the compensation of all the nasty propeller forces allows to employ much larger diameter and pitch.

Airbrake
The coverage of the propeller disk is doubled by the blades of the second propeller, and in combination with large propeller diameters this results in a significantly increased brake effect in vertical downlines. A very nice feature to achive a constant speed flying style.

Soft Sound
The combination of large diameter, high pitch propellers, operating at relatively low rpms produces a low and soft sounded propulsion, rather suggesting a multi cylinder piston engine installed than an electric.

The Coaxial Drive in F3A Competitions
The first time I used a prototype

of the E-F-503 coaxial drive set-up in the competitions to the German Championships 2006. It was installed in my unique „Excalibur", personally built by Günther Ulsamer for me. I was lucky to finish 8th, 12th, and 5th that year.
In 2007 I employed a refined prototype in an ZN-Line „Oxalys", however, flying was very limited that year due to my job committments.
Among the world's top pilots it was the Italian Champion Sebastiano Silvestri, who had smartly discovered the potential of my coaxial drive that same year and it was an exiting experience to have it installed in his SebArt „Angel" and to see him very successfully finish 5th at the 2007 F3A World Championship in Argentina.

What Came Next
Based on these great results, my cooperation with Rainer Hacker and Sebastiano Silvestri resulted in the production version of the E-F-503 and it is a pleasure to see the system being used by an increasing number of F3A competition pilots year by year. Meanwhile it helped Sebastiano and a number of other pilots to succeed splendidly in various competitions and championships like young pilots Marco Mazzucchelli or Robin Trumpp to finish German F3A Champion twice in 2012 and 2013 and settling among the top ten at the F3A World Championship in South Africa. F3A World Championship in South Africa.

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