BATTERY-POWERED SAILPLANES

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SUMMARY

Based on two years flight experience with the first battery powered glider, the advantages and limitations of electric drive units as well as the practice of electric flying is discussed. Electric launch systems can offer a single quiet launch plus a reserve for cross-country flying before the battery has to be recharged. Using NiCd batteries, rapid charge allows several starts per day, at moderate costs and a very high reliability. Simple in handling and almost maintenance free, the electric unit is highly comfortable and a very suitable system for gliders. Due to its limited capacity, it does not offer retrieval from extended cross-country flights.

SYSTEM DESCRIPTION

Increased sales and use of gliders powered with retractable combustion engine systems has demonstrated impressively the advantages of self-launch and retrieval capability. At the same time, the high noise emission is not well accepted and has brought about negative reactions towards gliding by the public. Moreover, an airborne restart with combustion engines is not always reliable and has caused some avoidable accidents.

The electric, battery-powered drive unit appears to be one possibility to improve the described situation.

Compared to conventional motors, the electric drive has the following advantages:

- low noise
- high reliability
- low maintenance
- low running costs
- simple handling
- zero emission
- low energy consumption
- high public acceptance
- interesting new technology

The disadvantages of an electric drive are:

- limited running time
- limited availability of power at some airfields
- required charge time limited life of the battery
- high cost for initial investment.

With the development of the AE-1 Silent - the first battery-powered glider with retractable propeller- it became possible to evaluate these theoretical benefits of an electric system in practice. The AE-1 prototype has been flying for two years and was type certified in Germany in May 1998.

The main goal in the development of the electric drive for the AE-1 was to realize a simple, reliable and easy-to-handle glider that reduces the cost and time normally involved in gliding. For reasons of cost and availability, NiCd technology was chosen for the battery. NiCd offers the highest specific performance at moderate costs and is available to everyone. The temperature characteristic and rapid-charge capability allow high start frequency without overheating of the battery.

TECHNICAL DATA OF THE AE-1 SILENT

drive unit:		
motor:	performance:	13 kW
	efficiency:	88 %
	revolutions:	3400 rpm
	weight:	8.5 kg
propeller:	diameter:	1.92 m
	revolutions:	1300 rpm
battery:	weight:	40 kg
	energy	1.4 kWh
	standard charge:	40 min at 220V
	rapid charge:	20 min at 360 V
total weight of unit:		65 kg
glider:		
dimensions:	wingspan:	12 m
	wing area:	10.3m^2
	aspect ratio:	14
weights:	empty weight:	200 kg
	max weight:	300 kg
	max wingload:	29.2 kg/m^2
performance:		
retracted prop:	V-max:	180 km/h
	V-min:	65 km/h
	sink rates:	0.78 m/sec at 75 km/h
		2.0 m/sec at 150 km/h
	L/D	31 at 98 km/h
powered flight:	takeoff FAI:	300 m on grass
	takeoff roll:	160 m on grass
	max climb:	2.4 m/sec
	altitude range:	700 m (full power)
	distance range:	30 km (reduced power setting)

On the basis of flight experience with the AE-1 the above-mentioned advantages can be detailed as follows:

Noise: Presuming that a large propeller is installed, the noise of an electric powered glider is negligible. The AE-1 was tested for certification with 43 dB(A) at a full-power climb in 300m altitude. This is about the level of an airfield without traffic during daytime.

Reliability: There have been no failures of the electric system so far. Restart in the air is very reliable without the necessity for warm-up of the engine, the electric unit can thus be used for safety even at low altitudes. The full power is available immediately and at all environments. Take-off roll does not increase at high temperatures or altitudes. But as a pilot, one should keep in mind that no technical propulsive system can offer 100% reliability.

Maintenance: Brush check every 100 flights. It takes about 5 min and requires no special training.

Running costs: 2 kWh electric consumption ex outlet per flight. The battery costs are less than 5 DM for a complete discharge. Partial discharging increases life and decreases

costs over-proportionally.
Handling: Has proved to be very simple. Main fuse on, power control switch on, ready to start.
Emission: Related to the primary energy for the production of 2 kWh in a modern power plant if the power was taken from conventional non renewable sources. On the other hand, 1 m^2 of solar cells could produce more energy than needed for one glider yearly.
Energy consumption: Compared to conventional launch methods the energy consumed is greatly reduced. Even compared to other self-launchers the consumption is less due to the high efficiency of the system. The consumption is comparable with a modern dishwasher for one run.
Public Acceptance: The AE-1 was accepted to fly even from glider fields within residential areas normally restricted to winch-launched gliders.
New Technology: It has attracted great interest everywhere and is considered to be the coming way of launching.

DISADVANTAGES:

Running time: Approx. 5 min at full power climb or 20 min level flight. Retrieval from cross-country flights is therefore limited. The capacity of the battery reduces with lower temperatures. It can drop to 80% at very low temperatures.
Power supply: Not available at some Ultra-Light and glider airfields. Often 220V and 380V are available in Germany. Depending on the wind, the charge socket may be at the other side of the runway.
Charge time: The charge time is limited by the power supply. At 380V the max. charge time needed for fully discharged batteries was 22 min. At 220V charge time was double.
Battery life: With 300 discharge cycles and no loss of capacity so far the lifetime of the NiCd battery is expected to be 500 to 700 full cycles. Considering today's rate of battery development, one will most probably exchange the battery for a new model before the old one is finished.
Investment cost: The electric unit consists of motor, control and fuses, battery, charger. The cost for these systems are 50 to 100 % higher than a conventional unit.

Based on the experience with the AE-1, the following data can be used for performance calculation of other gliders with an electric launch system:

Motor: Weight including electronic control: 10-15kg
Performance: 13-22 kW
Efficiency: >85 %
Speed: 3500-5000 rpm

Battery: Specific energy: 35 Wh/kg
Specific power: 400 W/kg

A retractable launch system with NiCd batteries for a standard-class glider can be realized at 80 kg overall weight, 18 m class will be around 90 kg. Launch could then be to a height of 700m at full power, alternatively the distance range at a reduced power setting would be 35-45 km. The addition of water ballast will reduce the electric power performance.

Reducing the weight of the glider by 30 kg would allow 60% more battery capacity and range. Notice that the charge time increases with the capacity of the battery due to the restriction of the standard power supply (e.g. in Germany 16A at 220V).

FLIGHT PRACTICE WITH ELECTRIC SYSTEM:

Due to the natural self discharge of most battery systems charging is recommended immediately before take-off. The charge time has turned out to be 10-15 min on average at 380V power supply. Thus, the glider was regularly ready for re-launch 20 min after landing. It may well be used in clubs where several launches a day are the rule and a high start frequency is required. If the altitude range is critical, the first launch of the day can be used for a weather check and to preheat the battery, thus giving the max. capacity for the following flight.

The search for lift and the best glide path begins immediately after take off. Reduced power is used as soon as possible with the goal to consume as little energy as possible. If half of the capacity is used for the initial launch, the remaining energy leaves the possibility for a 15 km level flight or a climb to 350m. With this reliable energy source, the out-landing can be made much safer or in some cases even avoided.

The launch could also be with conventional methods leaving the full battery capacity for a second chance. For many pilots this will take away a lot of stress during cross-country flights and reduce the damage risk of out-landings to a minimum. As a result more pilots could be attracted to leave their home base and fly away.

A competition can be organized with little effort. Time measurement begins with self-launch, and the pilots will immediately go on course thus reducing the risk of crashes. To avoid a technical race there should be classes for NiCd and other battery technologies in addition to different wing span. For cost and handling reasons there could be a basic competition class with NiCd batteries, wingspan of 12m and 300kg max. weight. It would give new impulses to the development of small inexpensive gliders and keep the battery small enough to be recharged in a reasonably short time.

CONCLUSION

As demonstrated with the AE-1 Silent, the electric drive for gliders can be realized at relatively low cost and is an attractive alternative to conventional methods of launching. The technology has proven to be mature and is accepted by the pilots. It is clean and elegant but powerful way of getting in the air that is well suited to the quiet and dynamic characteristic of gliding. The energy is limited, but offers independence and reliability. At the same time it supports the sportive ambition of gliding to travel in the air with the highest efficiency and will thus add to the good reputation of our sport.