Bell Boeing V-22 Osprey:

Can A New Rotor Blade Save The Project?

Yes.

Makes The Tiltrotor King Of The Sky.

Reports used to make the post:

https://www.pbs.org/newshour/politics/**watch-live-house-oversight-panel-explores-v-22-osprey-safety-concerns**

For a fuller story there is also a “Related” column on the same page, with the list of the earlier reports.

Key statements accessed through the “Related” column:

“The Marine Corps is planning on using the Osprey through 2050, while Air Force Special Operations Command has already begun to talk publicly about finding another type of aircraft to conduct missions”

“None of the services is planning on new production orders of the V-22, . . . The Army has contracted with Bell Flight to buy the Osprey’s successor, the Bell V-280 Valor, which is a tiltrotor like the Osprey but smaller. . .”.

Business motives

Termination of the production of an aircraft like the V-22 Osprey is impossible to complete without causing huge losses in both jobs and investment. Unfortunately - according to the press - that is what will happen.

Magnitude of the wealth about to be scrapped may be a reason to consider alternatives. Theoretically at least.

Technical options

In the above documents some important technical details have been clarified. First of all the failures of the clutch and gearbox units named earlier as the causes of some of the V-22 crashes, have not been the root cause. The root cause is still kept secret by the investigators.

Which is an open secret for many engineers. Essence, discussed in an earlier **post** can also be found on the chart below. The problem is related to the basic aerodynamics of the proprotors.

Accepting this assumption (i.e. about the aerodynamics of the proprotors) a positive plan of action can be drafted to keep the V-22 in normal production and to avoid further losses.

Chance to turn defeat into victory

As a first step, it is important to recognize that the whole V-22 aircraft has only one single component that is at fault. It is the rotor blades. By a straightforward reason.

Rotors and propellers with stiff blades (practically all devices being in use today) always have some speed limits, which are way below the sonic barrier that equals roughly 0.8 Mach. Engineers know too that the actual rotor/propeller-limit can be moved up, closer to the 0.8 Mach value by making compromises in the region of low speeds. "Low speeds" also mean takeoff, landing and hover. By sacrificing part of efficiency (or, in the case of VTOLs, flight-stability(!)) in this region, the top axial speed of the rotor or propeller can get closer to the upper, sonic limit. In the case of the V-22 this sacrifice historically turned out a little too big.

The root cause of the V-22 accidents presently under investigation, may include full or partial stall of the proprotor blades. New patent No. US 2022-0402594 A1 addresses issues linked to rotor blade stall in general. More detailed explanations (which can be found at the stallfreepropellers.com website) show that implementation is possible as a rotor blade upgrade keeping the existing pitch control system (including also cyclic control) practically unchanged. Prototyping of the new blade is necessary, which may involve extra costs. In return the accidents will just stop. (Clutch problems too must disappear.) Range of the normal regime of operation will significantly be widened (improved vertical lift and hover performance, even higher top cruising speed, lower noise and vibrations etc.). Due to the improved efficiency of the new proprotors the aircraft also will experience a power-upgrade while working with the same engines as before. Service time of the V-22 Osprey can be extended indefinitely.

Variable twist of the rotor/propeller blades – demystified

Composite materials have been getting widespread within mechanical engineering for decades now. Thanks to this, we know, many new morphing structures are adopted for aviation too. Mechanical solution of a morphing propeller blade structure, therefore, must not cause great sensation. Questions can be asked however about the geometry to be followed in the process of morphing of a blade surface. How can we make sure it is correct? Or can a "simple" replacement of the blades really help? What will happen to the existing control and actuation systems etc.

The GIF series in the last **post** holds most of the answers. Aerodynamic models of rotor/propeller blades have been charted with the classic Blade Element Theory (BET) for propellers in mind. Basic triangle of airspeed vectors (axial speed, tangential speed and resulting speed) of the BET is built for multiple radius values to construct a skeleton for the ideal propeller blade.

To get a meaningful GIF the axial speed value was varied intensively – in a way not really natural. RPM of the propeller was kept constant in the meantime. All this helped us to see more of the twisting behavior of the resulting speed vectors. (They constitute the "twisting vector field" mentioned in other posts on this topic.) Movements of parts of the skeleton were triggered by intensive changes of the axial speed value, which caused similarly vigorous changes of the resulting speed.

We can see vectors of the resulting speed outline a twisting surface along the radius. This surface is the one to be followed by the surface of the ideal propeller blade. Meaning – we have the geometry of the ideal blade surface analytically. (Or, in other words we have all the formulas.) Also, we can make sure the proposed mechanical blade structure (see to check at the **website** or in the **patent**) meets the above requirement.

How about the existing blade control and actuation?

GIFs featuring "AOA errors" in the last **post** clearly indicate that today's variable blade pitch control is nothing but a poor quality blade twist control. This is important; therefore better be repeated:

today's variable blade pitch control is but a poor quality blade twist control.

Present day's control and actuation works to ensure alignment of the blade surface with the resulting wind (+AOA) at the 75% point of the propeller radius. At this point we have perfect alignment for all speeds. Unfortunately, at all speeds different from design speed traditional blades will have a "non-zero AOA error" condition at all radius positions – except the 75% section.

Hence - a good point of potential blade replacement - when the new blades with good quality variable twist solution are installed, AOA errors disappear automatically. (!) To answer the question in the subtitle, here is an analogy.

When you install new, good-quality tires on your car there is no need to replace the engine or the gearbox as well. The car just will run better, and that's all. Same must be true for a potential rotor blade upgrade on the V-22. Of course, good engineering care throughout the process will be indispensable. Rewards, however, are going to be huge.

Graph of the benefits

Potential improvement of the Osprey envelope is enormous. **Rotor efficiency graphs** reflect the quality jump an upgrade can bring about. Proposed new name for the V-22 is

OSPREY++