Exploring the Power Balance of Main Rotor Primary Control

In most cases a designer refers to the primary control system power consumption the discussion focuses on the rating of the hydraulic system i.e. pumps, boosters, auxiliary gearbox pickup, etc. In contrast, it is rarely acknowledged that this part is only one element and does not represent the total power which has to be invested for (primary) control. If we could trim the aircraft, clamp the swashplate und cut off any power flow to the primary control boosters we would have to accept that in practically all flight conditions power has to be applied to pitch the blades. This portion of power cannot be traced back to the motion of the boosters but is “stolen” via the swashplate from the rotor shaft torque. This paper uses simplified mechanical models which allow to apply measured loads and control motions to trace back these power paths from and to the rotor. The different power contributions are compared and related to the over-all rotor shaft power. When moving to more advanced swashplate-less architectures with individual pitch actuation at each blade root, the mechanical connections transferring power between the single blades or from/to the rotor shaft are lost. Therefore, any electric control
system should in some way or the other replicate the inter-blade power exchange. Alternatively it has been proposed to use trailing edge servo flaps for primary control. While it might be possible to reduce the actuation power, it is obvious that such flaps add a considerable amount of aerodynamic drag to the blades. The resultant increase of rotor shaft power falls in the same category of an indirect, hidden component. Estimates of this portion are compared to the power balance of the conventional control system architecture. Finally, individual blade control (IBC) systems allow introducing of higher harmonic control (HHC) which in certain flight conditions can favorably change the blade torque – rate relations even to a point where the average power demand is reduced despite the additional blade pitch motions.

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