Feasibility Study of a Load Alleviation Strategy on a Compound Helicopter Using Redundant Controls

Laurent Declerck
Flight Performance & Propulsion

The compound helicopter concept is reviving as operational needs push rotorcraft capabilities beyond the current standards. The compound helicopter can be seen as a mix between a fixed-wing aircraft and a conventional helicopter. It features both a fully controllable rotor as well as wings, elevator, ailerons, and a push propeller near the tail. This concept can increase agility because of its unique combination of controls and increase flying speeds by unloading the main rotor lift and redistributing it over the fixed wings. However, flying faster at higher load factors comes at a cost! High loads in the main rotor hub and blades are expected.

As the compound helicopter can control its rotor as well as auxiliary push propeller, wing flaps and elevator, some control inputs can be seen as redundant. This means multiple combinations of control inputs can achieve a (near-) identical helicopter state. This unique configuration comes with the opportunity of using the redundant controls for structural load alleviation purposes. Next to the primary function of executing manoeuvres, the controls are given a second objective: reducing loads.

The U.S. government together with the U.S. rotorcraft industry initiated a joined program: "Rotorcraft Handling Qualities Requirements for Future Configurations and Missions" by the US Army’s National Rotorcraft Technology Centre [1]. Within this program, new mission task elements are proposed. The thesis research will focus on the new break-turn mission task element executed by a wing and thrust compound version of the UH-60A Black Hawk. The break-turn is an evasive manoeuvre where the rotorcraft makes an aggressive 90° heading change at high flying speeds. Flight tests on conventional rotorcraft show the link between critical main rotor hub loads and high flying speeds in combination with high load factors. These critical conditions are expected during the execution of the break-turn.

The thesis research will investigate the feasibility of using the redundant controls of a compound UH-60A Black Hawk to alleviate loads in the main rotor hub and blades during the execution of the break-turn mission task element. An active load alleviation system strives to reduce the rotor hub and blade loads over their operational life-time. This cuts maintenance costs and improves component reliability. Theoretical studies in literature show the potential of using redundant controls to successfully alleviate loads at an acceptable degradation of handling qualities on conventional helicopters. The richer variety of redundant controls of a compound helicopter configuration is expected to alleviate loads in much more extreme conditions at a lower cost of handling quality performance.
