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NASA TECH BRIEF

Ames Research Center

Swashplate Feedback Control for Tilt-Rotor Aircraft

Tilting prop/rotor aircraft are subjected to blade loads, hub forces, and moments because of the non-axial flow which occurs in all phases of operations. Steady loads such as occur in scheduled flight operations may be trimmed out by the application of cyclic loads, but when the aircraft is subjected to gusts or other transient conditions, some sort of automatic system must be used to apply the compensating cyclic loads. Additionally, large rotors mounted on a flexible airframe may give rise to instabilities at some flight conditions when oscillations of the airframe couple with blade motion; consequently, an automatic control system could also be used to suppress structural oscillations as well as to augment aerolastic stability. Conventional stability-augmentation systems effectively provide static margin and damping augmentation in the pitch, roll, or yaw degrees of freedom of the aircraft; unfortunately, the conventional systems respond slowly and cut off at frequencies significantly below 1 Hz.

It has been shown that automatic systems utilizing rotor swashplate feedback control with greater frequency response effectively reduce blade vibratory loads and damp oscillatory structural modes of the airframe and rotor system. The swashplate control motions are activated by signals originating in the structure or in the airflow relative to the structure.

In the system which was designed and built to demonstrate load alleviation, changes in the angle of attack were sensed indirectly by gages which responded to strains induced in the wing structure. Output signals were amplified, filtered, and used to activate the swashplate actuators. The system provided significant reduction in blade loads and desirable changes in hub forces and moments.

The structural stability augmentation/modal suppression system uses an accelerometer mounted at the wing tip to sense airframe oscillations; the signal is conditioned, using filters, then amplified and used to drive the swashplate actuators in such a way as to make the oscillation decay. The results of the tests have shown that increases in damping up to 500% are possible under normal operating conditions, and that an instability region at overspeed rpm's is completely eliminated.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single copy at cost
   (or microfiche $0.95)
   References:
   NASA CR-114600 (N73-30011), V/STOL Tilt Rotor Aircraft Study: Vol. VII, Tilt Rotor Flight Control Program Feedback Studies. NASA CR-114664 (N74-15711), V/STOL Tilt Rotor Aircraft Study: Wind Tunnel Tests of a Full Scale Hingeless Prop/Rotor Designed for the Boeing Model 222 Tilt Rotor Aircraft.
2. No additional documentation is available. Specific questions, however, may be directed to:
   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B74-10174

Patent status:

NASA has decided not to apply for a patent.

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under contract to
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Category 06