



Engineering Systems for Rotorcraft Icing Operations – Where Next?

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Status of Ice Protection Systems (1)

- Many different systems and components need protection - engines, intakes, rotors, windscreen, tailplane, sensors, weapon systems, etc
- Focus for many years on rotors - fundamental for safe flight but also the most challenging engineering problem
- Primary focus for last 3 decades on electro-thermal de-icing systems for rotors but also some prior history of others such as fluid / chemical anti-icing.
- Numerous rotor protection systems now in production/ service, e.g.
 - EH101 (Merlin, Cormorant etc)
 - Super Puma
 - S92
 - NH90
 - V22
 - Apache
 - Blackhawk
 - Many Russian helicopters

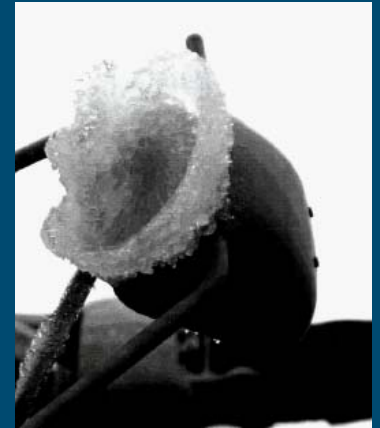


Status of Ice Protection Systems (2)

- Relatively little operational experience
- Relatively little uptake of available systems by military and civil operators
- Operators' perspective (military and civil):
 - Questionable operational need
 - Systems heavy, expensive
 - General concerns over system reliability
- Cost and time to achieve certification to a reasonable level of confidence
- However, military operators now beginning to appreciate the benefit of a true IFR all weather capability
 - Interaction with emerging technologies for Day-Night / All Weather operations (sensors, vision systems, displays etc)
 - Operational benefit of IFR capability e.g. for efficient self deployment over long ranges.

Ice Protection Systems – Future Challenges

- Extended periods of exposure to icing made possible by effective rotor protection will bring new issues:
 - Fuselage accretion: mass, drag, hazards of shed ice
 - Sensor protection (optical, radar etc)
 - Weapon system protection
- Continuing need to find more time and cost-effective routes to qualification / certification
 - More efficient conduct of icing trials
 - Complement by analysis, physical simulation etc
- Continuous growth of confidence levels through in-service experience



Exploitation of evolving technology (1)

- Materials
 - Novel forms of electro-thermal de-icing heater mat
 - High thermal conductivity polymers
 - Hydrophobic and ice-phobic surfaces
 - Rotor protection: need for compliance with all other design drivers such as erosion resistance, bending strain, lightning strike.
- Basic data on physical properties of accreted ice – Young's modulus, UTS, adhesive/cohesive strength

Exploitation of evolving technology (2)

- Advances in computational power
 - More powerful analytical tools for design and certification
 - Accretion, thermal anti- & de-icing, aerodynamic degradation, shedding, shed ice trajectories, impact damage etc.
 - On-board systems e.g. continuous monitoring (and display?) of aircraft status (rotor Δ -torque).
- Electronic systems
 - More refined control of anti- and de-icing systems
 - Novel ice removal systems: ultrasonic, ...
- HUMS / FDR
 - Continuous reduction of risk / building of confidence in icing certification through recording and analysis of in-service experience.

Other issues (1)

- Icing standards
 - Should we aim for a probabilistic representation of the atmosphere or a design specification?
 - Do the current standards over-specify the requirements e.g. do we need to design for operation at -30°C or would -15°C be good enough and ease the design problem?
 - Need for continuous gathering of evidence (e.g. through HUMS or FDR).
- Instrumentation
 - Current meteorological instruments adequate for trials use for OAT, LWC and Drop Size
 - No quantitative instruments for mixed conditions, snow, freezing rain
 - In-service instruments for LWC and OAT acceptable. Are they sufficient for the future?
- Training
 - Need to represent icing operations in crew training simulators
 - Merlin Mk3 simulator at RAF Benson includes icing simulation
 - Need for further refinement as experience evolves.

Other issues (2)

- Small helicopters
 - Most current rotor protection systems have been applied to medium or large helicopters
 - Scaling to smaller helicopters exacerbates design problems
 - Need for innovative approaches leading to systems at acceptable weight / cost / complexity.
- Mission decision support systems
- DNAW systems
 - Introduction of advances in technology to extend capability for flight in visible moisture must be complemented by icing protection if operations are not to be temperature limited.



So, what next?

- Considerable advances in system design and introduction to service, particularly for rotor systems
- What next?
 - Need to accumulate in-service experience?
 - Need to address the issues of prolonged icing flight?
 - Need to address solutions appropriate for smaller rotorcraft?
- What are the advances in technology which can be used to advantage in future design, certification and operation?

