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Operational Performance Parameters of Engine Inlet Barrier Filtration Systemsfor Rotorcraft

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1 Abstract

Inlet Barrier Filter systems (IBF) are an essential piece of hardware in the operation of helicopters to and from unprepared landing sites. They are installed ahead of the engine in a variety of configurations, determined by the engine-airframe integration and mass flow requirements. On single or light twin-engine rotorcraft the filters are located within the intake plenum, or are flush with the airframe; on larger rotorcraft they may constitute an external, box-like structure. An example of the latter is given in Fig. 1, which depicts a Sikorsky UH-60 in operation, fitted with an IBF system at its intakes.

Figure 1: Sikorsky UH-60 Blackhawk with main engine barrier filter system fitted. (The US Army, 2009)

The necessary employment of IBF or other such airborne particulate removal systems is best exemplified by anecdotal evidence of engine damage. Severe erosion during the Vietnam War led to engines being withdrawn after just 100 hours of service (A Hamed, 2006). More recently during operation in the first gulf war, unprotected Ch-47 Chinook helicopters required engine overhauls after as little as 25 hours of service life (Stallard, 1997). The damage occurs through the ingestion of sand and dust particles, which are disturbed from the ground and lofted into the air by the rotor wake. This creates a dust cloud that engulfs the helicopter in the event of the dust mass concentration exceeding $1.177 \cdot 10^{-3}$ kilograms per cubic metre of air. This condition is generally known as *brownout* (Taslim and Spring, 2010), although the term is more generally appropriated to all situations of dust cloud generation. Based on this figure, an unprotected engine with a mass flow of $12.5\,kgs^{-1}$ could ingest around $7\,kg$ of particulate after just ten minutes in such a dust cloud. Given the statistics, it would appear a wise decision to employ some form of engine protection.

There are several types of sand-filter available. For a full review see Filippone and Bojdo (2010). IBF systems represent one type of particle removal device. The system comprises one or more filter panels, through which engine-bound air must pass. Particles that fail to navigate the tortuous path through the filter pores are deposited, as cleaner air continues to the engine. While IBF efficiently remove particles, a side effect of their employment is an associated loss in total pressure, analogous to a reduction in intake efficiency. The loss is initially in the region of $600\,Pa$; but rises fivefold before a filter cycle is complete (Stenberg, 2009) due to the contribution of the captured particles. The process of particle accumulation on and within the filter that gives rise to this transient state is known as *clogging*. With many contributory factors, filter clogging is not a simple process. The local conditions are especially influential in the evolution of the clogged filter, in particular the incident flow direction, the size of the particles and concentration of the dust cloud. Hence the IBF temporal pressure drop and therefore the variation in engine performance is very much dependent on the rotorcraft operational environment. It is the objective of the current work to investigate the role of local conditions in filter clogging, and provide insight into the temporal variation in pressure drop across IBF filters in order that the effect on the engine may ultimately be predicted.

References

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