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Numerical Analysis of Bird Strike Resistance of Helicopter Searchlight

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Abstract

Bird strike is a major threat to aircraft structures, as a collision with a bird during flight can lead to serious structural damage. For helicopters the windshield, forward airframe structure, rotor blades and all exterior equipment parts are exposed to the risk of bird impact. Consequently, aviation authorities require that such structures need to prove bird strike resistance before they are allowed for operational use, which primarily had to be demonstrated in full-scale bird impact tests in the past. Today, as numerical simulation techniques have evolved and proven accuracy, compliance can more and more be shown by sufficiently validated numerical analyses. This study shows such an example of successful simulative demonstration of bird strike resistance of a searchlight and its pod as external equipment of a military helicopter. The finite element model was built up and validated step by step according to the building block approach from coupon level up to the full-scale structural level. The focus was on the accurate non-linear constitutive modeling of the different aluminum alloys and mechanical fasteners of the target structure. The searchlight pod as well as its internal electrical components and attachments were modelled with a high level of detail in order to allow for accurate results evaluations. A validated smoothed particle hydrodynamics (SPH) bird impactor model was used to simulate different load cases and impact positions of this fluid-structure interaction scenario with a water-like soft body projectile. Although plastic deformations and partial fracture of the outer housings of the structure were observed, no critical failure mode, detachment of critical parts or loss of structural integrity occurred. These analyses were accepted by the authorities as means of compliance and demonstrate today's progress in airworthiness certification by simulation.

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1. Introduction

Bird strike is a major threat to aircraft structures, as a collision with a bird during flight can lead to serious structural damage. For helicopters the windshield, forward airframe structure, rotor blades and all exterior equipment parts are exposed to the risk of bird strike. Consequently, the aviation authorities require that such structures need to prove a certain level of bird strike resistance before they are allowed for operational use. These requirements are compiled in the Federal Aviation Regulations (FAR) and in the Certification Specifications (CS) of the European Aviation Safety Agency (EASA). For large rotorcraft with a maximum take-off weight of more than 7000 lbs. and >9 pax seats the FAR/CS 29§631 regulation requires safe flight and landing after impact with a 1 kg bird. The classical approach to prove the bird strike resistance to the authorities is a full-scale physical impact test with a real bird. However, sufficiently validated numerical simulations are also accepted today as means of compliance, more and more replacing physical tests due to ethical reasons and monetary efficiency.

The focus of this current study is on the external searchlight that was developed by RUAG in the framework of the TH06 ISR upgrade of the AS 322 Super Puma helicopters of the Swiss Air Force (Fig. 1). While the searchlight itself is a third-party component, the searchlight pod, which is attached to the helicopter airframe and houses the electronic components is a development of RUAG. Since the customer requires the demonstration of bird strike resistance according to FAR/CS 29 of this component, a numerical analysis study was conducted to simulate the bird strike loading at different relevant impact positions.

2. Searchlight and pod specification

The searchlight, which can rotate around two axes for adequate utilization flexibility, is mounted to a searchlight pod, which itself is attached to specific external mounting points at the helicopter airframe. The searchlight pod is completely made of lightweight aluminum alloy. It basically consists of a base plate made of AA2024 with all electrical components and helicopter mounts connected to it, and a TIG-welded housing made of AA6061. All parts are connected by conventional aerospace-grade bolted joints.

3. Load case specification

The bird impact load case is derived from FAR/CS 29§631 as mentioned above. The projectile is a bird with a mass of 1 kg and an impact velocity of 167 kts = 85.9 m/s. The specific most critical impact position is not known at the beginning of this study and shall be identified in the framework of the numerical analyses by a systematic variation of impact positions and searchlight rotational configurations. Successful bird strike resistance is achieved as long as the external searchlight equipment maintains structural integrity and no major parts of the searchlight pod housing are detached, which could then, under aerodynamic lift, hit the tail rotor and lead to a critical flight situation. The searchlight itself must not detach from the pod or the pod must not detach from the helicopter, as the vertical fall would pose a risk to people or items on the ground.

Fig. 1. Swiss Air Force Super Puma helicopter with highlighted external searchlight (photo copyright & permission: VBS).