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NUMERICAL SIMULATION OF HIGH-SPEED IMPULSIVE NOISE OF THE PZL W-3A "SOKÓŁ" (FALCON) HELICOPTER MAIN ROTOR IN FORWARD FLIGHT

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The paper presents result of the numerical simulation of the flow and acoustic field of the PZL W-3A "Sokół" (Falcon) helicopter (fig. 1) main rotor in forward flight conditions based on the URANS approach and chimera overlapping grids technique (fig. 2). The high-speed (265 km/h) case reveals two main problems of modern helicopters: compressibility effects (high-speed impulsive noise) due to strong shock-wave boundary layer interaction on the advancing side and separation leading to dynamic stall on the retreating side of the rotor. Usually, the first approximation is to abandon the influence of the fuselage and tail rotor and to isolate the main rotor blades. The elastic deformation due to airloads is neglected in the overall picture as well. Still, the remaining task is computationally very demanding.

Fig. 1 PZL W-3A "Sokół" (Falcon) helicopter

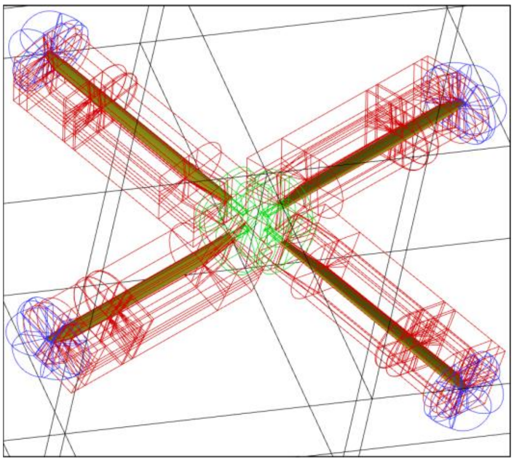

Fig. 2 Chimera overlapping grid topology

The PZL W-3 "Sokół" (Falcon) is a polish medium-size, twin-engine, multipurpose helicopter manufactured by PZL-Świdnik (now AugustaWestland Świdnik). This first helicopter fully designed and serially built in Poland is still in service since 1987. The original main rotor design has served for more than 25 years and is still operating in hundreds of machines sold all over the world. The increasing significance of the fuel consumption and noise emission restrictions forces the design of an improved version of the helicopter with increased performance and reduced fly-over noise. A completely new, 4-bladed main rotor (based on the ILH family of profiles [1]) for the modernized W-3A "Sokół" (Falcon) helicopter is designed, constructed by the "PZL Świdnik" S.A. company, verified experimentally through scale model wind tunnel tests by the Institute of Aviation (Poland) and tested numerically by the Institute of Fluid-Flow Machinery (Poland). The unrestricted work described in the article contains aerodynamic (fig. 3, [2]) and aeroacoustic (fig. 4, unpublished) results of a numerical simulation of the original, 4-bladed NACA rotor in high-speed forward flight.

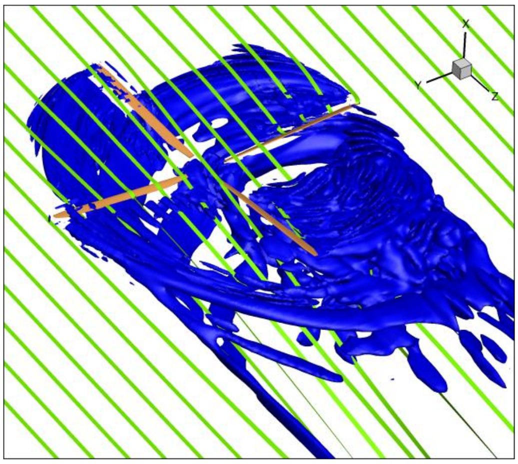

Fig. 3 Rotor wake in high-speed flight

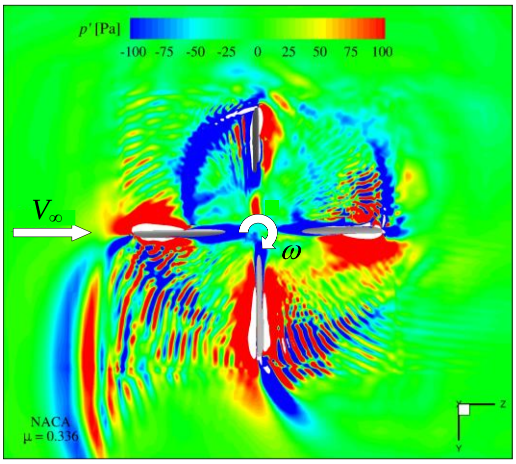

Fig. 4 Acoustic pressure field in high-speed flight

It has already been shown in [2] that a numerical simulation of the flow past the isolated rotor of PZL W-3A "Sokół" (Falcon) helicopter in high-speed forward flight leads to overprediction of the mean thrust and power by ~20 % compared to flight test data of a complete helicopter. Due to lack of detailed aerodynamic test data for the PZL W-3A helicopter (i. e. recorded blade pressure distributions) the numerical model has been additionally validated against a more extensive data set obtained in high-speed forward flight of AH-1G helicopter leading to similar deviations in aerodynamic performance.

A refined CFD model (40+ million of volumes, 600+ blocks chimera grid) was designed to resolve the flow-field together with the acoustic pressure in the near-field of the rotor blades. The full, 3d data was recorded for a quarter of the rotation period (approx. 2 TB) allowing exceptional insight into physical mechanisms initiating the occurrence and development of the high-speed impulsive noise phenomenon.

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