World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:18, No:08, 2024

Prediction of the Aerodynamic Stall of a Helicopter's Main Rotor Using a Computational Fluid Dynamics Analysis

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Abstract : The purpose of this research work is to predict the helicopter from stalling by finding the minimum and maximum values that the pitch angle can take in order to fly in a hover state condition. The stall of a helicopter in hover occurs when the pitch angle is too small to generate the thrust required to support its weight, or when the critical angle of attack that gives maximum lift is reached or exceeded. In order to find the minimum pitch angle, a 3D CFD simulation was done in this work using ANSYS FLUENT as the CFD solver. We started with a small value of the pitch angle θ, and we kept increasing its value until we found the thrust coefficient required to fly in a hover state and support the weight of the helicopter. For the CFD analysis, the Multiple Reference Frame (MRF) method with k-ε turbulent model was used to study the 3D flow around the rotor for θmin. On the other hand, a 2D simulation of the airfoil NACA 0012 was executed with a velocity inlet Vin=ΩR/2 to visualize the flow at the location span R/2 of the disk rotor using the Spallart-Allmaras turbulent model. Finding the critical angle of attack at this position will give us the ability to predict the stall in hover flight. The results obtained will be exposed later in the article. This study was so useful to analyze the limitations of the helicopter's main rotor and thus to predict accidents that can lead to a lot of damages.

Keywords : aerodynamic, CFD, helicopter, stall, blades, main rotor, minimum pitch angle, maximum pitch angle
Conference Title : ICAAAE 2024 : International Conference on Aeronautical and Aerospace Engineering
Conference Location : Warsaw, Poland
Conference Dates : August 08-09, 2024