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Investigation of Various Baffle Design Effects on Center of Gravity Deviation in a Training Aircraft Wing Fuel Tank using CFD and 1D Simulations

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Abstract

In aircraft fuel tanks, there are baffle components in order to damp sloshing effects and prevent center of gravity (CoG) traveling from its initial location [1]. These baffles have significant role to damp force, moments and CoG deviation acting on aircraft body. Damping efficiency is important to improve stability performance of aircraft and to control its flight mechanics. Thus, decision on baffle design is directly related to their damping performance [2]. Ribbed baffles have cutout holes on its surface as design details [3]. These cutout holes directly affect CoG deviation amount and retreat duration of deviated CoG in the tank. In this study, various cutout designs and aircraft wing tank geometries were modeled with Siemens NX CAD modeling program. These various designs were used in 1D and transient CFD sloshing analyses, then effects of different designs were investigated. 1D analyses were constructed using Siemens Amesim program and they were managed in order to get initial conditions for further CFD analyses. Various cutout holes have been suggested with different diameters and allocations on the baffle. In 1D modeling, these cutout designs were implemented into the model with its diameter and location data based on global coordinate system of the aircraft. As an input, bank-to-bank maneuver acceleration was applied on aircraft body. After acceleration was finished, simulations were conducted until steady conditions were met in order to get retreat duration. Different CoG deviation results and retreat durations were obtained after 1D simulations. The aim of the 1D analyses was to achieve minimum deviation amount and minimum retreat duration, that will be assumed to be the most desirable case among all and later will be constructed with Siemens StarCCM+ program in order to obtain 3D analysis. In CFD analysis, fluctuations were also considered in CoG deviation behavior which cannot be calculated with 1D analyses [4]. For the optimum case, unsteady CFD analysis will be managed as multi-phase sloshing flow of jet fuel (JP8) and air using Volume of Fluid (VOF) method. Much detailed CoG deviation and retreat duration data and sloshing effects of free surface fluctuations and 3D turbulent eddies will be then observable from CFD simulations. As a result, optimum performance efficiency of baffles was considered as lower CoG deviation distance and shorter retreat duration.

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