International Journal of Advanced Science and Technology
Vol. 29, No. 7s, (2020), pp. 4889 - 4894

Implementation of NANO Particles in Aircraft and CFD Simulation on Aircraft in Cruising

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Abstract

Recently, Nanotechnology has been used in various fields. This paper deals with the implementation of produced nano materials in aviation industry to contribute to the structural toughness of the aircraft and also calculating and finding out the drag and lift coefficient using CFD simulation. This paper presents an idea on modern aviation design and also provides a detailed analysis on streamline requirements and aerodynamic structure.

Keywords: *Nanotechnology, aviation industry, CFD, Nano-particles, Nano-scale.*

I. INTRODUCTION

Aviation industry is one of the fastest growing and a reliable industry in the transportation world. This means, a lot of aircrafts are manufactured and retired every year. The maximum lifetime of an aircraft until retirement is about 30-35 years. Some airlines have a young fleet policy of 10 years. This is due to the aging structure of the aircraft .This means millions of dollars' worth aircraft is to be bought every 10 years approximately and money has to be invested for structural maintenance. To hurdle this obstruction of structural deterioration, Nano materials can be used. It's not surprising that nanotechnology can be used in a heavy industry such as this. The significant interest in nanotechnology for the aerospace industry is justified by the potential of nanomaterials and nanoengineering to help the industry achieve this goal. Nano materials can contribute to higher properties compared to their counterparts with microscale or larger grain structure. Nano materials have also properties like yield strength, tensile strength and corrosion resistance, coupled with low density which helps keep the total weight of the aircraft down. The objective of the simulation is to set up a 3D mesh for an Aircraft flow simulation with a resolved boundary layer of Y+ < 1, and to study the Residuals. The kOmegaSST turbulence model was adopted.

The STL file downloaded online is a scaled Airbus A350-900 model. The simulation was done in an open source software called Open Foam and some third party soft wares linked to it. For the material strength and UV effect with the nano product, UV-vis was taken. UV-vis spectroscopy is based on the principle of electronic transition in atoms or molecules upon absorbing suitable energy from an incident light that allows electrons to excite from a lower energy level to higher excited energy level. That is, UV is used to understand the absorption ability of the material

I. LITERATURE SURVEY

K. Sruthi et al (2017) concludes that the difference between the values of deformation, equivalent stress, max principle stress, stress intensity and shear stress with Al alloy and Aluminium + Silicon Carbide are minimal. The results obtained are optimum, as the difference between the two result values are minimal. We can use aluminium + Silicon carbide instead of using aluminium alloy in order to give the more strength to the structure. The effect of pressure during take-off condition is more for Aluminium and less for Al + SiC which is strongest and light weight, and also reduces the weight of the wing. It can be conclude that at the above assumed loading conditions and constraints flight wing structure will not fail due to material properties. The author concludes that aluminium+ silicon carbide can be replaced with aluminium alloy.

Xiangyu Gu et al (2018) presented an automated CFD-based analysis process. The robustness of the implemented process relies on knowledge-based layer implemented into the automated pre-processing step of the geometrical components, allows taking advantage of high fidelity simulations, also for large explorations of the design space. The well-known aircraft configuration DLR-F6 is chosen to verify the automated analysis process. The CFD analysis process is integrated into the DLR multi-fidelity aircraft design environment, which relies on the DLR open source distributed framework RCE, and the DLR central data model CPACS.
The overall aircraft design synthesis is performed for a conventional passenger transportation aircraft configuration, by making use of variable fidelity methods for the aerodynamic analysis. The results discuss the impact of employing CFD-based analysis into overall aircraft design applications.

Indradeep Kumar (2015) presented modern aviation design requirements like faster, miniature, highly maneuverable, self-healing, intelligence guided, smart, eco-friendly, light weight warrant for materials with extraordinary mechanical and multifunctional properties.

Pamela Alex et al (2011) demonstrated the production of nano crystals of cobalt in bulk quantities in aqueous medium using hydrazine as the reducing agent. Preparation of Co nano powders of 30 - 70 nm of 99.99% purity was accomplished from 0.25 - 2 M CoSO4 solutions in batch scale of 0.1 to 1 kg. The results of characterization studies using XRD, SEM, TEM indicate the formation of finer particles with increase in concentration of cobalt ions in solution and dominance of fcc cobalt in room temperature reduction. VSM results revealed a higher saturation magnetization of the nano cobalt at 100 K to be comparable to that of the bulk metal.

Hassan Naseem Khan et al (2013) implemented a CAD modeling of the complete wing of a fighter aircraft using CATIA analysis. The model was also analyzed in ANSYS software for comparison of results. The results from both the software were also compared with actual experimental static testing results with an error of 5%. With same computing time the results were reasonably close in both the software. For complex geometries, fuselage attachment of the main Stress contour of the wing: Enlarged image of maximum stress concentration area modeling of the complete wing of a fighter aircraft was done in CATIA® along with FEM analysis. The model was also analyzed in ANSYS® of results. The results from both the software were also compared with actual experimental static testing results with an error of. With same computing time the results were reasonably close in both the software. For complex geometries, a small deviation of results was observed due to the simplifications done for the ANSYS model.

Manikantissar et al (2017) presents an evaluation on ways through which Computational Fluid Dynamics (CFD) package may be incorporated into a conceptual design method is performed. The repeatability of the CFD solution as well as the accuracy of the calculated aerodynamic coefficients and pressure distributions was also evaluated on two different wing-body models. The overall run times of three different mesh densities was also evaluated to investigate if the mesh density could be reduced enough so that the computational stage of the CFD cycle may become affordable to use in the

conceptual design stage. A farfield method was derived and used in this analysis to calculate the lift and drag coefficients

II. EXPERIMENTATION

CFD SIMULATION

Selecting the model: The model chosen was the state of the art airbus A350. The Airbus A350 XWB is a long range, twin engine, wide body aircraft developed by Europe's aircraft manufacturer Airbus. The A350 is the first Airbus aircraft with both fuselage and wing structures made mostly of carbon fiber reinforced polymer. The aircraft structure was done using SOLIDWORKS® and was acquired from an open source. Fig 1 represents the designed aircraft structure with a scale of 1:1000. The figure is scaled into a small figure to make ease the simulation and its runtime. However this didn't affect the result as it was relative to the size.

Fig 1. Designed aircraft model.

Creating the mesh: The cell size in the blockMesh is 0.05, owing to the fact that a scaled A350 XWB model was selected, otherwise a cell size of 0.5 can be executed for an un-scaled model. Regardless, any of the following cell size can be applied (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0). Four boundary layers were generated with an expansion ratio of 1.2, adding to the total cell count of over 3 million cells. A steady-state solver was employed. Fig 2 shows the streamline and turbulent airflow around the aircraft and the possible drag contributing area of the aircraft.

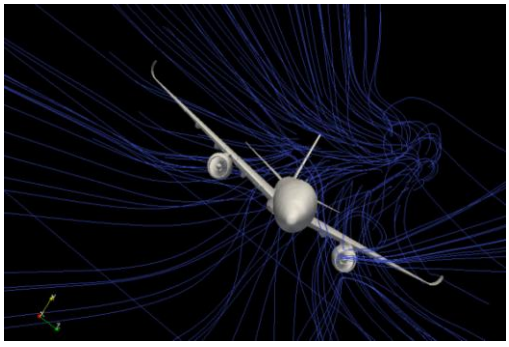


Fig 2. Streamline and turbulent airflow around the aircraft.

Nano Particles and coating

Elements used

A mixture of Al, Co doped in ZnO with urea used as fuel for synthesis. (. 9.1g of zinc oxide, 0.38g of Cobalt, 0.09g of aluminum)

Synthesis of the particles: The process used is solution combustion synthesis which is an effective method for the synthesis of nanoscale materials and has been used in the production of powdered form of the element for verity of advance application which in this case is to make the element suitable or compatible for the process of characterization

Characterization: The most prominent characterization done was the UV-vis. Now after the synthesis process, the various types of characterization was done and studied. The UV characterization was done in nanotechnology department, SRM institute of science and technology, Kattankulathur, Chennai. UV-vis is a technique that measures the absorbance of a solution across the ultraviolet and visible regions of the light spectrum, hence the name is UV- vis. We used the Agilent 8453 spectrophotometer and the chemstation software. The spectrophotometer has two lamps, deuterium lamp which generates light in the UV region which is between 190 and 400 nm and a tungsten lamp which generates light in the visible and near IR- region of 400 and 1100 nm in wavelength. Switch ON the instrument and let it warm for 45 minutes to make sure that the lamps are nice and hot and the measurement is of a good quality. We used different types of cuvettes, some of them are like quartz one and has a frosted side and the others are plastic types that is regularly used and are disposable. Blank the cuvette and add a ml of water and wait till we get a black which is nice and flat and put the cuvette in the sample holder

Coating

The coating of the nano particle was applied on a 1:500 model boeing 777 just for representation. The process followed Surface preparation: Before applying the product the surface was cleaned, dried, with no oil residues. There were no fingerprints left on the surface, as well as any residues of other detergents.

Impregnation: The nano product was applied by polishing it on the surface with a microfiber cloth as shown in fig 3. The nano product was applied with circular movements on the clean surface. After applying the nano product the surface is left for at least 30 minutes to dry completely. At higher air humidity this process may take up to a couple of hours.

Fig 3. Model of Aircraft coated with nano product.

After that, the surface is polished with the same microfiber cloth. The final effect is achieved in 24-26 hours. At temperatures higher than +25°C the nano product should be applied on smaller sections since it dries faster. Applying the product at temperatures lower than +5°C is not recommended. In my case the process was done in a moderate of 20 to 22°C in a temperature controlled laboratory.

III. RESULTS

CFD simulation

The CFD analysis showed the Cl value of the aircraft and also stressed the change in altitude with and without the angle of attack of the aircraft.

When the aircraft, in cruising altitude pitch the nose with a slight angle of attack, let's say around 10-15 degrees, the aircraft shows an approximate maintain of altitude i.e the aircraft does not loose altitude at all nor gain a steady altitude. Depending on the speed and a certain angle of attack, an aircraft can be made to gain or sustain a certain altitude as shown in fig.4.

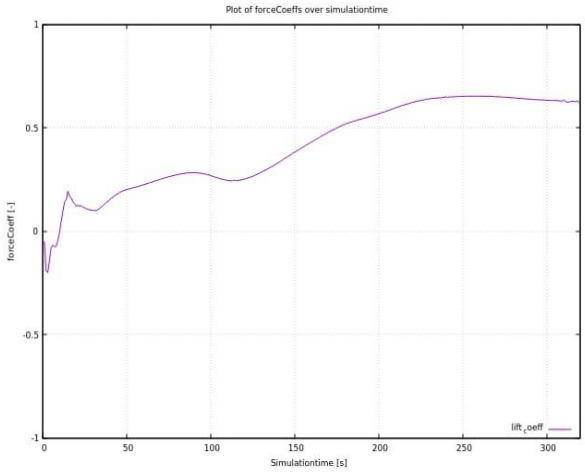


Fig 4. The simulation graph of aircraft at cruise altitude.

Now when there is no angle of attack, or when the nose of the aircraft is not tilted and flies with an exact 0 degree angle, the aircraft tend to start decreasing its altitude as shown in figure 5.

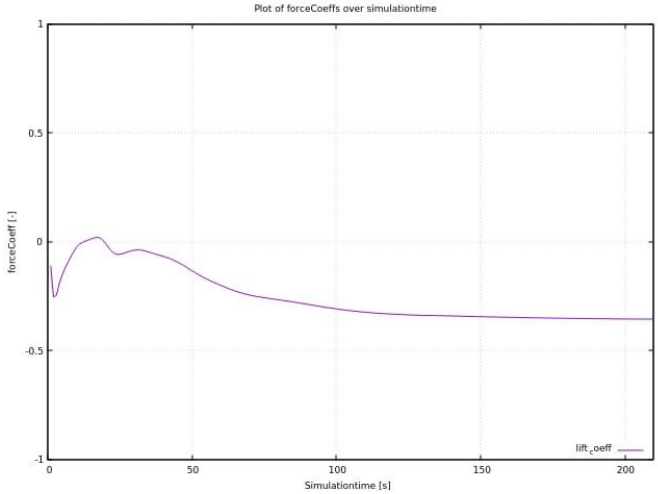
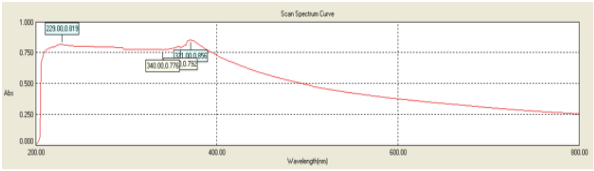


Fig 5. Simulation graph coefficient of lift with respect to no angle of attack of aircraft at cruise altitude.

UV-vis

On performing the characterization the results obtained are shown in fig 6.



No.	P/V	Wavelength(nm)	Abs	Comment
1	Peak	371.00	0.856	
2	Peak	229.00	0.819	
1	Valley	360.00	0.792	
2	Valley	340.00	0.776	

Fig 6. Graph with plot points of peak / vally.

The outcome graph demonstrates the UV absorption rate with respect to wavelength. Here , the peak value gives the maximum absorption coefficient value of 0.286 at 372 nm wavelength value .This gives an advantage over other element combinations such as the carbon fiber – polymer or aluminum 7075 (aircraft metal) which gives higher absorption rate on higher wavelength. This can be compared with in UV-Visible spectroscopy of CCR extract before and after 3 hours immersion of aluminum alloy by Ambrish Singh.

IV. CONCLUSION

In this paper a combination of Co, Al doped ZnO which has a better result in UV- vis spectrography than the aluminum 7075 (used in today's aircraft) is implemented. The nanoparticles when coated on the aircraft can result in lesser effect of the UV rays on the aircraft hence contributing to more lifetime of the aircraft. The result was obtained with a careful balance of ratios between Al and Co with uria used as an agent. The nano coating of this element on the bulk structure could prove a longer lifetime of the airframe and the metal alloy used in manufacturing of aircraft also Depending on the speed and a certain angle of attack, an aircraft can be made to gain or sustain a certain altitude.

Conflict of Interest: The authors declare no conflict of interest.

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