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NANOCRAFT- An Aircraft with Nanotechnology

Indradeep Kumar
Aeronautical Engineering 3rd year
MATS School of Engineering and IT, MATS University, Raipur

Abstract- The success of the Aviation Industry depends on various factors ranging from reduction of weight, availability of materials with multifunctional properties, eco-friendly fuels, less fuel consumption, faster and highly responsive communication systems, less or no repairs, extended and safe life, reduced time frame of development cycle from concept to implementation and many more. Nanotechnology is recognized as a very strong innovation driver and is therefore seen as a strategic technology for the world's future economy. Nano-materials with their exceptional multifunctional properties may transform the functioning of aviation industry dramatically. This paper shows the 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.

Keywords- Nano-craft, Nano-particle, Nano-tube, Nano-phase, Nano-scale, Thermo-phoretic, Chemical Vapor Deposition (CVD), Particulate film, Crystallinity, Nano-clay, Nano-fibers

I. INTRODUCTION

The aerospace industry is one of the most important heavy industries in the world. Countless companies rely on the ability to ship products and people around the world with the speed that can only be achieved by airOn acquiring the best performance of Aircraft, it is necessary to find a design of Aircraft so that the efficiency can be increased. Therefore, some different methods have been proposed to increase the efficiency. These include Nano-materials. Nano materials are cornerstones of Nano science and nanotechnology. Nanostructure Science and technology is a broad and interdisciplinary area of research and development activity that has been growing explosively worldwide in the past few years. It has the Potential for revolutionizing the ways in which materials and products are created and the range and nature of functionalities that can be accessed. It is already having a significant commercial impact.

Nano-scale: generally refers to the size scale of

1 nanometer (nm) = 10^{-9} m. It refers to the matter whose length scale, in any dimension, is approximately 1 to 100 nanometers.

The current trend is limited to use some extent only in the Aircraft but this paper is depicting where and which type of Nano-materials can be used in almost entire Aircrafts including navigation system. The Nanotechnology is a critical enabling technology for modern aviation and large-scale power generation. It's extensive application, however, Instability of the particles and Difficulty in synthesis, isolation and application

A. How Nano materials are formed?

Nano-materials can be created with various Modulation dimensionalities as: zero (atomic clusters, filaments and cluster assemblies), one (multilayers), two (ultrafine-grained over layers or buried layers), and three (Nano-phase materials consisting of equi-axed nanometer sized grains).

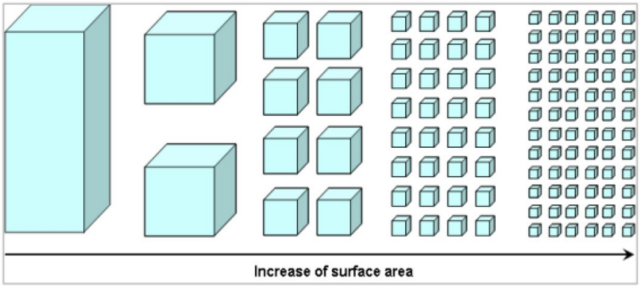


Fig: The total volume remains the same; the collective surface area is greatly increased.

For an aircraft generally Nano-materials are formed by **Gas Phase synthesis process** as follows:

1) In homogeneous Chemical Vapor Deposition (CVD), particles form in the gas phase and diffuse towards a cold surface due to Thermo-phoretic forces, and can either be scrapped of from the cold surface to give Nano-powders, or deposited onto a

substrate to yield what is called ***'particulate films'***.

2) In heterogeneous CVD, the solid is formed on the substrate surface, which catalyzes the reaction and a dense film is formed.

In order to form Nano-materials several modified CVD methods have been developed. Gas phase processes have inherent advantages, some of which are noted here:

a) An excellent control of size, shape, crystallinity and chemical composition
b) Highly pure materials can be obtained
c) Multicomponent systems are relatively easy to form and Easy control of the reaction mechanisms.

B. Properties of Nano-materials

Nano-materials have the structural features in between of those of atoms and the bulk materials. While most micro-structured materials have similar properties to the corresponding bulk materials, the properties of materials with nanometer dimensions are significantly different from those of atoms and bulks materials. This is mainly due to the nanometer size of the materials which render them:

1) large fraction of surface atoms;
2) high surface energy;
3) spatial confinement;
4) Reduced imperfections, which do not exist in the corresponding bulk materials.

Due to their small dimensions, Nano-materials have extremely large surface area to volume ratio, which makes a large to be the surface or interfacial atoms, resulting in more "surface" dependent material properties. Especially when the sizes of Nano-materials are comparable to length, the entire material will be affected by the surface properties of Nano-materials.

C. Novel Property

Small size effect (Quantum size effect)

1) Contain very small number of atoms (molecules)
2) Electromagnetic forces are dominant.
3) Wave particle duality. The electrons exhibit wave behavior.
4) Quantum confinement.
5) Discrete energy levels

D. Why nanomaterials?

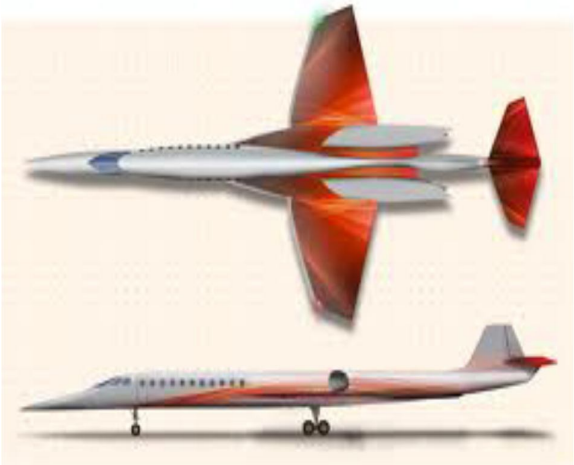
Nano-materials can be metals, ceramics, polymeric materials, or composite materials so it can be used anywhere in the Aircraft depending on the necessity.

Fig. The Aerospace industry is under pressure to improve its environmental footprint, primarily by making Aircraft more efficient. Image credit Bureau of Labor Statics.

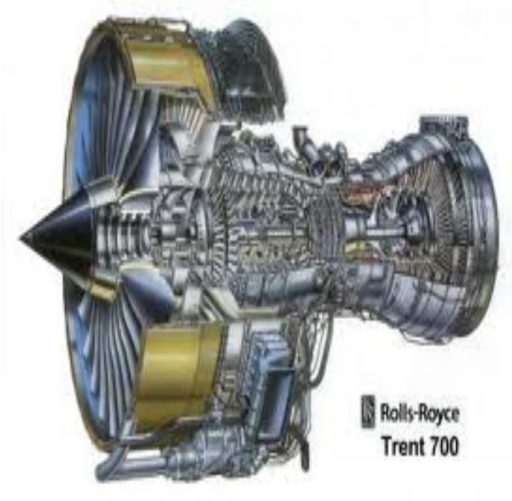
E. Nano-materials for different Sectors of Aviation Industry

Nano-materials can be primarily used in three areas of Aviation Industry. These are:

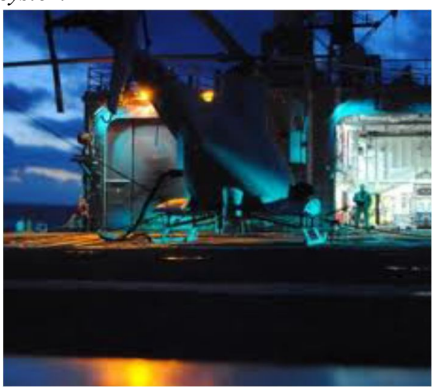
1) Airframe Structure



2) Aero-Engine Parts



3) Aircraft Electro-Communication System



4) Nano-materials in Airframe Structure

F. Properties of Materials required for Airframe Structure

The design requirements of the materials to be used in Airframe Structure are:

1) Light Weight
2) High Strength
3) High Toughness
4) Corrosion Resistance
5) Easy Reparability & Reusability
6) Less Maintenance & Durability

G. Nano-materials which can fulfill the requirements

The modern aviation design requirements like faster, miniature, highly maneuverable, self-healing, intelligence guided, smart, eco-friendly, light weight and stealth systems warrant for materials with extraordinary mechanical and multifunctional properties.

H. Carbon Nanotube (CNT) based Polymer Composites

Properties of CNT based polymer composites are their wide range of Young's Modulus, High Specific Strength, Crash Resistance and Thermal Performance and these properties can provide conventional composites and light weight metals. Some CNT based composites which can be used for Airframe structure are: CNT/Epoxy, CNT/Polyimide, and CNT/PP

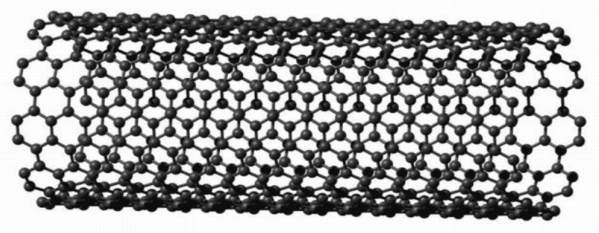


Fig: Nanotube

I. Nano-clays reinforced Polymer Composites

Properties of these composites are: Barrier Properties, Thermal and Flame Retardant.

J. Metal Nanoparticles incorporated Composites

The extra ordinary electrostatic discharge and electro-magnetic interference (EMI) shielding properties of these composites make them the probable futuristic solution for making the structure which is resistant to lightning strikes.

II. NANO-COATINGS FOR AERO-ENGINE PARTS

The coatings are generally used for protecting the structures and surfaces of the aircraft from harsh environments. The stringent requirements like resistance to extreme temperatures, extreme climates, corrosion, abrasion and wear of engine parts have

sparked an increased demand for more reliable high performance coatings. Some Nano-materials Coatings with improved high-temperature properties may allow higher engine-operating temperatures and therefore improved performance in the future. is towards Nano-coatings to enhance the durability of metals. In particular, magnesium alloys, which are far lighter than steel or aluminium, are prone to corrosion, due to the high chemical reactivity of magnesium. Coatings can help prevent corrosion, but the type,typically used contain chromium complexes which are a highly toxic pollutant. Materials used for these novel anti-corrosion Nano-coatings include silicon and boron oxides, and cobalt-phosphorous Nano-crystals. Nano-coatings are also now being used on turbine blades and other mechanical components which have to withstand high temperatures and friction wear. Tribological coatings can drastically lower the friction coefficient and improve resistance to wear - this greatly improves the efficiency of the engines.

A. Many Nano-structured and Nano-scale coating materials have been suggested as possible friction modifying agents, such as carbides, nitrides, metals, and various ceramics few are as follows:

1) *SiC Nano-particles in SiC-particle-reinforced alumina*

2) *Yittria stabilized Nano-zirconia*

B. These can facilitate crack healing, resulting in improved high-temperature, and strength and creep resistance as compared to monolithic ceramics.

1) TiN Nano-crystallites embedded in amorphous Si_3N_4 are used for Wear-resistant coatings.

2) The Nano-composite coatings made of crystalline Carbide, Diamond like Carbide and metal di-Chalcogenide, **TiN** are used for low friction and wear resistant applications of aircraft.

3) Nanotube and nanoparticles (Nano-graphite, Nano-Aluminium) containing polymer coating are used for electrostatic discharge, EMI shielding and low Friction applications of aircraft surfaces.

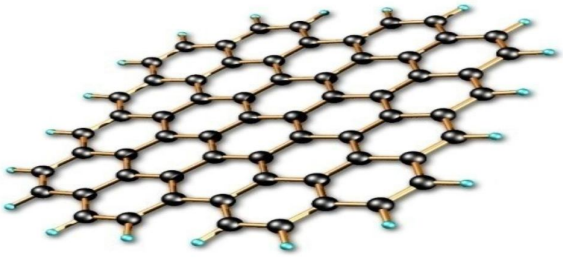


Fig: film Grapheme

III. NANO-MATERIALS FOR AIRCRAFT ELECTRO

A. Communication Components

CNTs have unique set of properties, including ballistic electron transport and a huge current carrying capacity, which make them of great interest for future Nano-electronics.

Magnetic Nanoparticles (Iron oxide Nanoparticles i.e. Fe_2O_3 & Fe_3O_4*)* incorporated polymer films and composites can be used in various Data Storage Media.

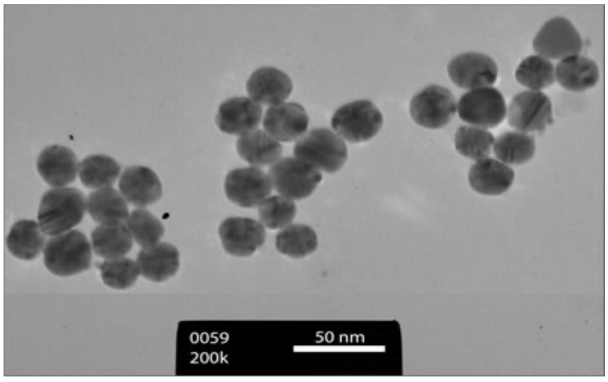


Fig: Nanoparticle

Ceramic Nanoparticles like Barium Titanate, Barium Strontium Titanate are used for making Super Capacitors.
MEMS (Micro Electro Mechanical Systems) and NEMS (Nano Electro Mechanical Systems) offer the possibility of developing a standard fuel management unit which controls the fuel control in aero-engines.

B. Some More Applications

Nanoparticles like Nano-graphite, Nano-silica are extensively used in rubber compounds to prepare Gaskets and Sealants which may find applications in aero-engines.
Nano-chromium based corrosion inhibitors are being developed for protection of Aluminium metals or aero structures. Nano-powder of Copper, Aluminium, Iron are being used in the preparation of making conductive plastics which will be used in various components of aircraft where electrostatic discharge of EMI shielding applications are required. Many Nano-fibers and textiles are being used in parachutes and aircraft arresters.

C. Disadvantages of Nano-materials

(i) Instability of the particles - Retaining the active metal nanoparticles is highly challenging, as the kinetics associated with Nano-materials is rapid. In order to retain
Nano-size of particles, they are encapsulated in some other matrix. Nano-materials are Thermodynamically metastable and lie in the region of high-energy local-minima. Hence
They are prone to attack and undergo transformation. These include poor corrosion Resistance, high solubility, and phase change of Nano materials. This leads to deterioration in properties and retaining the structure becomes challenging.
(ii) Fine metal particles act as strong explosives owing to their high surface area coming in direct contact with oxygen. Their exothermic combustion can easily cause explosion.
(iii) Impurity - Because nanoparticles are highly reactive, they inherently interact with impurities as well.
(iv) Biologically harmful – Nano-materials are usually considered harmful as they become transparent to the cell-dermis. Toxicity of Nano-materials also appears predominant owing to their high surface area and enhanced surface activity. Nano-materials have shown to cause irritation, and have indicated to be carcinogenic. If inhaled, their low mass entraps them inside lungs, and in no way they can be expelled out of body. Their interaction with liver/blood could also prove to be harmful (though this aspect is still being debated on).
(V) Difficulty in synthesis, isolation and application - It is extremely hard to retain the size of nanoparticles once they are synthesized in a solution. Hence, the Nano-materials have to be encapsulated in a bigger and stable molecule/material. Hence free
(vi) Recycling and disposal - There are no hard-and-fast safe disposal policies evolved for Nano-materials. Issues of their toxicity are still under question, and results of exposure experiments are not available. Hence the uncertainty associated with effects of Nano materials is yet to be assessed in order to develop their disposal policies.

IV. CONCLUSION

The above details shows that the potential of Nano materials in Aviation Sector. Using nanotechnology in aviation gives the Light Weight, High Strength, High Toughness, Corrosion Resistance, Easy Reparability & Reusability, Less Maintenance & Durability hence it becomes cheaper, safer and used for protecting the structures and surfaces of the aircraft from harsh environments than the conventional. This technology has some drawback also but due to above reason it can be ignored.

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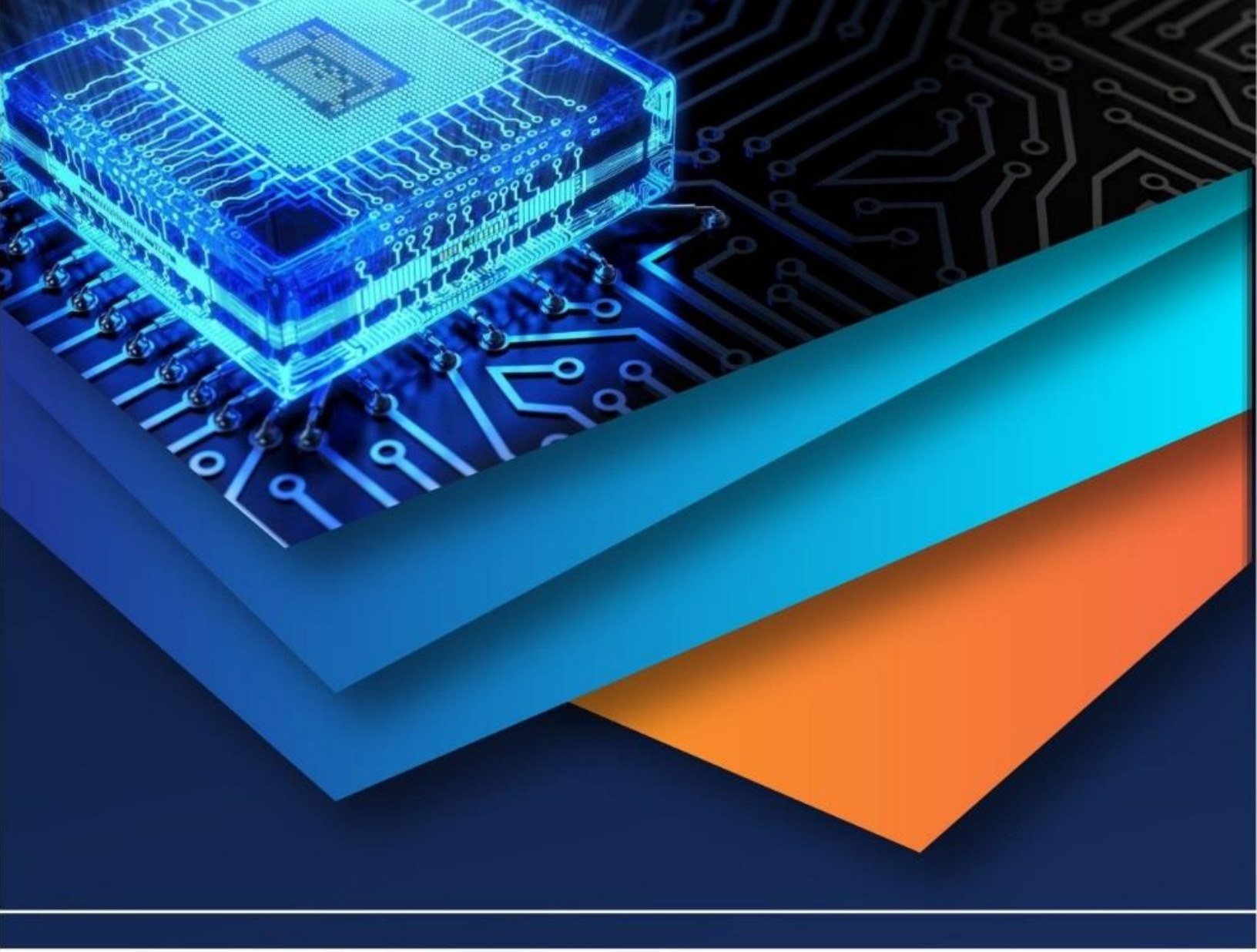

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