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COMPOSITE MATERIAL AND NANOMATERIALS ON STEALTH TECHNOLOGY

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Abstract— Stealth technology also known as Low Observability technology (LOT) is a technology which covers a range of techniques used with aircraft, ships and missiles, in order to make them less visible or partially invisible to radar and other detection methods. Different materials are used in this technology. So we analyze the effect of composite material on stealth technology, also the advantages and disadvantages of composite material on stealth technology. Nanotechnology is recognized as a very strong innovation driver and is therefore seen as a strategic technology for the world' s future economy. Composite-materials with their exceptional multifunctional properties may transform the functioning of aviation (Defense) industry dramatically.

Keywords— Nano-Technology, Stealth, Nano Material, Composite Material, Visual Stealth, Infrared Stealth

I. INTRODUCTION

The concept of stealth is not new: being able to operate without the knowledge of the enemy has always been a goal of military technology and techniques. However, as the potency of detection and interception technologies (radar, IRST, surface-to-air missiles etc.) has increased, so too has the extent to which the design and operation of military vehicles have been affected in response. A 'stealth' vehicle will generally have been designed from the outset to have reduced or controlled signature. It is possible to have varying degrees of stealth. The exact level and nature of stealth embodied in a particular design is determined by the prediction of likely threat capabilities and the balance of other considerations, including the raw unit cost of the system.

The current trend is limited to use some extent only in the fighter 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 with less visibility. It's extensive application, however, Instability of the particles and Difficulty in synthesis, isolation and application. Stealth technology is a sub-discipline of military counter measures which covers a range of techniques used with aircraft in order to make them less visible (ideally invisible) to radar, infrared and other detection methods. Stealth technology (often referred to as "LO", for "low observability") is not a single technology but is a combination of technologies that attempt to greatly reduce the distances at which a vehicle can be detected.

II. NANO-MATERIALS IN AIRFRAME STRUCTURE

Carbon Nano-tube (CNT) based Polymer Composites having 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.

Nano-clays reinforced Polymer Composites having Thermal and Flame Retardant properties.

Metal Nano-particles incorporated Composites: The extra ordinary electrostatic discharge and electromagnetic interference (EMI) shielding properties of these composites make them the probable futuristic solution for making the structure which is resistant to lightning strikes

NANO-COATINGS FOR AERO-ENGINE PARTS: SiC Nano-particles in SiC-particle-reinforced alumina Yittria stabilized Nano-zirconia can facilitate crack healing, resulting in improved high-temperature, and strength and creep resistance as compared to monolithic ceramics.

TiN Nano-crystallites embedded in amorphous Si3N4 are used for Wear-resistant coatings.
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 .
Nanotube and nanoparticles (Nano-graphite, Nano-Aluminium) containing polymer coating are used for electrostatic discharge, EMI shielding and low Friction applications of aircraft surfaces .

NANO-MATERIALS FOR AIRCRAFT ELECTRO-COMMUNICATION COMPONENTS: Magnetic Nano-particles (Iron oxide Nano-particles i.e. Fe2O3 & Fe3O4*)* incorporated polymer films and composites can be used in various Data Storage Media. Ceramic Nano-particles 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.

III. 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 nanometre dimensions are significantly different from those of atoms and bulks materials. This is mainly due to the nanometre size of the materials which render them:

- large fraction of surface atoms.
- High surface energy.
- spatial confinement.
- 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.

NOVEL PROPERTY

- Contain very small number of atoms (molecules).
- Electromagnetic forces are dominant.
- Wave particle duality. The electrons exhibit wave behaviour.
- Quantum confinement.

IV. STEALTH TECHNIQUES

Stealth Technology is used in the construction of mobile military systems such as aircrafts and ships to significantly reduce their detection by enemy, primarily by an enemy RADAR. The way most airplane identification works is by constantly bombarding airspace with a RADAR signal. Other methods focus on measuring acoustic (sound) disturbances, visual contact, and infrared (heat) signatures. Stealth technologies work by reducing or eliminating these tell-tale signals. Panels on planes are angled so that radar is scattered and no signal returns . Planes are also covered in a layer of absorbent materials that reduce any other signature the plane might leave. Shape also has a lot to do with the `invisibility' of stealth planes. Extreme aerodynamics keeps air turbulence to a minimum and cut down on flying noise. Special low-noise engines are contained inside the body of the plane. Hot fumes are then capable of being mixed with cool air before leaving the plane. This fools heat sensors on the ground. This also keeps heat seeking missiles from getting any sort of a lock on their targets.

An aircraft cannot be made truly invisible. For example, no matter how cool the exhaust vents of an aircraft are kept, the same amount of heat is always liberated by burning a given amount of fuel, and this heat must be left behind the aircraft as a trail of warm air. Infrared-detecting devices might be devised that could image this heat trail as it formed, tracking a stealth aircraft. No single

receiver may record a strong or steady echo from any single transmitter, but the network as a whole might collect enough information to track a stealth target. Anti-Stealth/ counter stealth can be achieved.

V. STEALTH MATERIAL

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

Carbon Nano-tube (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

Nano-clays reinforced Polymer Composites:

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

Metal Nano-particles 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.

Many modern military aircraft incorporate some type of surface treatment that provides radar cross section reduction to thereby transform these aircraft into "low observable" or "stealth" airplanes. Generally, these treatments employ materials that absorb or conduct incident radar energy, and typically include adhesive bonding or spray-paint-like processes for material adherence. Electromagnetic radiation absorbent/shielding materials and structures are well known.

Such electromagnetic radiation absorbent/shielding materials and structures are commonly used in electromagnetic capability/electromagnetic interference (EMC/EMI) test cells to eliminate reflection and interference during testing. Electromagnetic radiation absorbent materials and structures are also utilized in electromagnetic anechoic chambers for testing high frequency radar, in antennas, and in Low Observable (LO) structures.

Radar Absorbing Material (RAM) reduces the radar cross section making the object appear smaller. These materials are both very heavy and very costly, two key limitations to their adoption for many applications. The Materials which is come under RAM is as follows:

- Iron-Ball point
- Foam Absorber
- Jaumann Absorber

VI .BENEFITS OF STEALTH TECHNOLOGY

A smaller number of stealth aircraft may replace fleet of conventional attacks jets with the same or increased combat efficiency. Possibly resulting in longer term savings in the military budget. A Stealth aircraft strike capability may deter potential enemies from taking action and keep them in constant fear of strikes, since they can never know if the attack planes are already underway. The production of a stealth combat aircraft design may force an opponent to pursue the same aim, possibly resulting in significant weakening of the economically inferior party. Stationing stealth aircraft in a friendly country is a powerful diplomatic gesture as stealth planes incorporate high technology and military secrets.

The goal of stealth technology is to make an airplane invisible to radar. There are two different ways to create invisibility. The airplane can be shaped so that any radar signals it reflects are reflected away from the radar equipment. The airplane can be covered in materials that absorb radar signals. Most conventional aircraft have a rounded shape. This shape makes them aerodynamic, but it also creates a very efficient radar reflector. The round shape means that no matter where the radar signal hits the plane, some of the signal gets reflected back: A stealth aircraft, on the other

hand, is made up of completely flat surfaces and very sharp edges. When a radar signal hits a stealth plane, the signal reflects away at an angle, like this. In addition, surfaces on a stealth aircraft can be treated so they absorb radar energy as well. The overall result is that a stealth aircraft can have the radar signature of a small bird rather than an airplane. The only exception is when the plane banks -- there will often be a moment when one of the panels of the plane will perfectly reflect a burst of radar energy back to the antenna.

VII. LIMITATIONS OF STEALTH TECHNOLOGY

Stealth technology has its own disadvantages like other technologies. Stealth aircraft cannot fly as fast or is not manoeuvrable like conventional aircraft. The F-22 and the aircraft of its category proved this wrong up to an extent. Though the F-22 may be fast or manoeuvrable or fast, it can't go beyond Mach 2 and cannot make turns like the Su-37. Instability of the particles - Retaining the active metal Nano-particles 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 meta-stable 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.

VIII. CONCLUSION

The above details shows that the potential of Nano-materials with Stealth Technology in Aviation (Defence) Sector. Using Nano-technology with Stealth Technology in aviation gives the Low Observability with Light Weight, High Strength, High Toughness, Corrosion Resistance, Easy Reparability & Reusability, Less Maintenance & Durability with increase in carrying Pay load hence it becomes cheaper, safer and used for protecting to be the target than the conventional. However, as electronic sensors have replaced the eyes of pilots as the primary means of tracking other aircraft, more intricate means of defence were needed. This paper also concluded that potential of Nano-materials with Stealth Technology in Aviation (Defence) Sector. Using Nano-technology with Stealth Technology in aviation gives the Low Observability with Light Weight, High Strength, High Toughness, Corrosion Resistance, Less Maintenance & Durability with increase in carrying Pay load hence it becomes cheaper, safer and used for protecting to be the target than the conventional. These technology has some drawback also but due to above reason it can be ignored.

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