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A Review on Nano-Casing Of Jet Engine And Diesel Engine Using Single-Walled Carbon Nanotubes

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Abstract

In the modern age, nanotechnology is found to be beneficial in different spheres as in few industries. The aviation industry is one of them. As the properties of materials vary a lot in nanomaterials compared to the bulk material, the development of any field relies on the fact that these materials are much advantageous than bulk metals. Now a day's Single-Walled Carbon nanotubes (SWCNTs) having greatest attention on the earth. This paper presents the review of the reduction in weight by the replacement of conventional engine casing material which results in the trimming of fuel consumption as well as enhances the strength of the engine.

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Keywords: Nanostructures; Nanoscience; Nanotechnology; Nanomaterials; Carbon-Nanotubes.

1. Introduction

For worldwide transportation of people in the shortest time and least hazard, the only means is the airplane. For business purpose too, a lot of companies are extremely dependent on the performance of the airplane. So the proper designing of the airplane is required to achieve maximum efficiency and performance. The efficiency can be increased by exploiting the excellent properties of the nanomaterials. Nanomaterials are cornerstones of

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Nomenclature

Å	- Angstrom (1exp.-10)
TPa	- Tera Pascal (unit)
GPa	- Giga Pascal (unit)
sccm	- standard cubic centimetres per minute (unit)
oC	- Degree Celsius
nm	- nano meter (unit)
W/mk	- Watts per meter Kelvin
Scm-1	- Siemens per centimetre
1-D	- One Dimensional
2-D	- Two Dimensional
TA	- Thermal Analysis
cm	- centimetre
HCl	- Hydro Choleric Acid
FCM	- FexCyMg1-(x+y)
FVM	- FexVyMg1-(x+y)
NCM	- NixCyMg1-(x+y)
XRD	- X-Ray powder Diffraction
FESEM	- Field Emission Scanning Electron Microscope
EDAX	- Energy Dispersive X-ray Analysis
HRTEM	- High-Resolution Transmission Electron Microscopy

Nanotechnology and Nanoscience. In recent years there is a tremendous research are progressing in the field of aviation. Nanoscience has the potential to revolutionaries the aerospace industry as it has offered lots of new materials with diversified functionalities. Many astonishing characteristics of the nanomaterials have made it possible to commercialize many products which have changed the old concepts significantly. Basically, nanoparticles are those which have at least one dimension with 100 nm where 1 nanometre (nm)= 10^{-9} m and of different shape nanofiller as shown in figure 1.

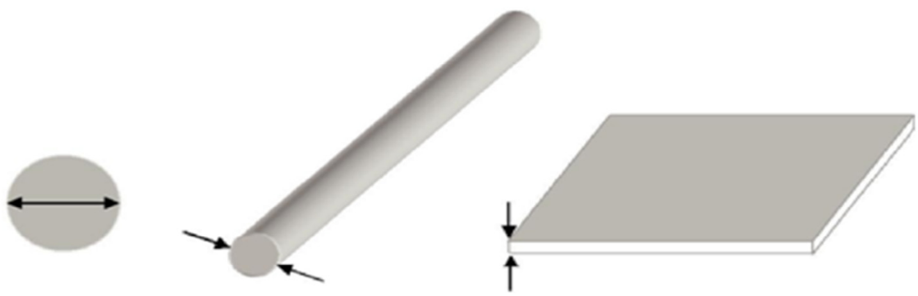

Fig. 1. various nanofillers of nanoscale dimensions.

1.1. Simple Definition Of Nanotechnology

Nanotechnology is the name of the application technology where nanoscience is applied in practical devices. Nanotechnology starts from atoms and molecules and their integration and manipulation to form a device. Tailoring of the properties of the materials in the nano range is possible now with nanotechnology, especially for commercial and industrial applications. As material properties can be tailored in nanoscience and the devices made from materials, hence it can be said that the whole aviation industry depends on nanotechnology.
Two types of nanomaterials can be defined:

1. Non-intentionally-made nanomaterials: This type of nanomaterials are produced during volcanic eruptions, proteins, viruses, etc. or that produced due to unintentional human activity such as diesel combustion.
2. Intentionally-made' nanomaterials: Deliberately produced nanomaterials that are produced through a definite fabrication process or the nanomaterials that are produced through some biological activity

Some good examples are:

- Our nails increase in length of 1 nm in 1 second.
- Tip of a pin is about 1,000,000 nm in diameter.
- The diameter of our hair is 80,000 nm.

1.2. Why Nanomaterials?

Anywhere within the airplane nanomaterials may be used. Nanomaterials in different forms like Nanoceramics, nanocomposites or polymeric nanoparticels Nanomaterials can be used as required in the airplane system.

1.3. Properties Of Nano-Materials

The structure of nanomaterials is in between the bulk materials and those of atoms. The properties of microstructured materials mostly resemble with that of the bulk materials. But nanostructured materials have properties that are significantly different from bulk materials[14]. Such difference of properties of the nanomaterials are due to the facts:

- The nano-sized materials have a large number of surface atoms.
- Their surface energy is very high.
- The occurrence of spatial confinement Reduced or no imperfection in the nanomaterial.

Here introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 10 pt. Here follows further instructions for authors.

2. Literature Survey

Because of the various useful utilization of SWCNTs in several fields of science, the spectrum of literature published previously related to SWCNTs has been reviewed by me. SWCNTs having many properties in terms of their structure of the atom as well as arrangement, processing method, mechanics, characterization and physical and chemical characteristics in many journals and review papers. This paper has a short overview is mentioned related to properties of SWCNTs and their application in Casing of Jet engine and or Diesel Engine. Following are some literature reviews:

Andrea Szabo et al. [4] reviewed the characteristics of MWCNT. The characterization of MWCNT was effectively done using Raman spectroscopy optical characterization. In Raman spectroscopy, the information regarding the defects, the alignment of tubes and the purity can be estimated to differentiate MWCNT from another type of Carbon allotropes.

A. L. Palaniappan et al. [14] focused on the recent progress in the field of CNT research in connection to surface modification, control synthesis, functionalization, and sensor development [4]. He reported that the surface area enlargement and the control of morphology are the key features which influence the performance of the device.

Elisabetta Comini et al. [11] reported that 1-D metal oxides nanowires are optimistic materials in the formation of nanodevices. Tin, Zinc, and Indium oxides formed in single crystalline nanowires by the condensation from vapour phase are reported.

L. Valentini et al. [4] developed CNT based film by using plasma-enhanced CVD capable of detecting low-concentration of oxidizing gas. The electrical properties of the sensor film were tuned using heat treatments and a transformation from semiconductor to metallic behavior took place at high temperature.

R. Cheung et al. [15] prepared Carbon nanotubes uniform using CVD technique. A high yield of CNT was developed on a Si substrate using Ni as a catalyst. The diameter of the Carbon nanotubes was dependent on the annealing temperature, hence the diameter could be controlled based on the annealing temperature before growth.

3. Classification

Carbon nanotubes are generally of two types, which are of single-walled and multi-walled, which constitute one layer or one sheet of graphene, shaped in the cylindrical tube is termed as the Single-Walled Carbon Nanotubes (SWCNTs). In Multi-Walled Carbon Nanotubes (MWSNTs)[1], a position perpendicular to the axis of the tube gives a family of tubes having the same centre. The conductivity of SWCNTs is depended on the direction in which graphene sheet is rolled and the tube shape, which is set by the two integers, namely 'n', 'm'. Depending upon the integer values of 'n' and 'm', the nanotubes is observed as they have the structure of:

1. Armchair (n=m) (fig. 2)
2. Zigzag (m=0) (fig. 3)
3. Chiral (for all other values of 'n' & 'm') (fig. 4)

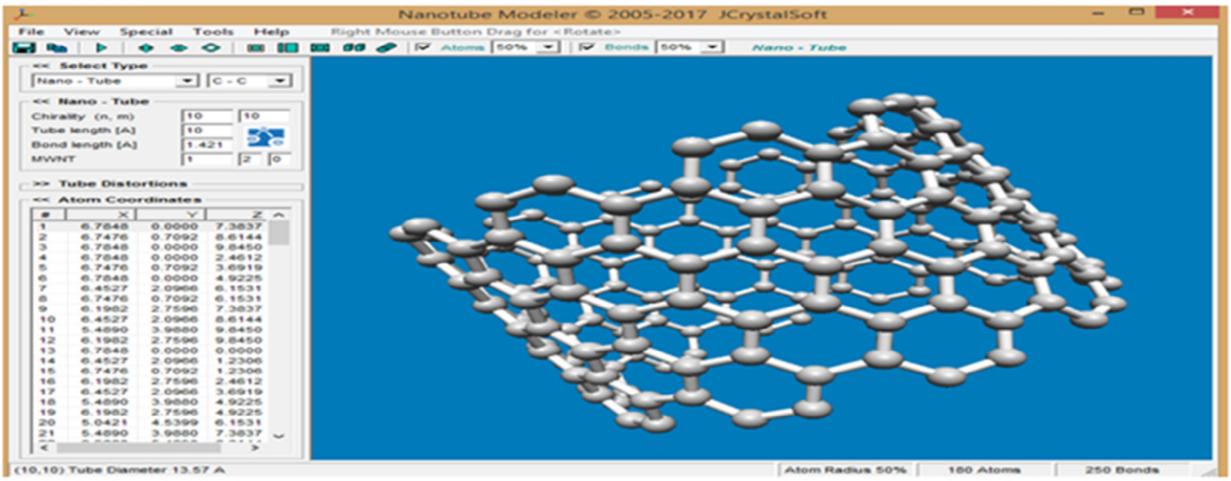

Fig. 2. Armchair SWCNT

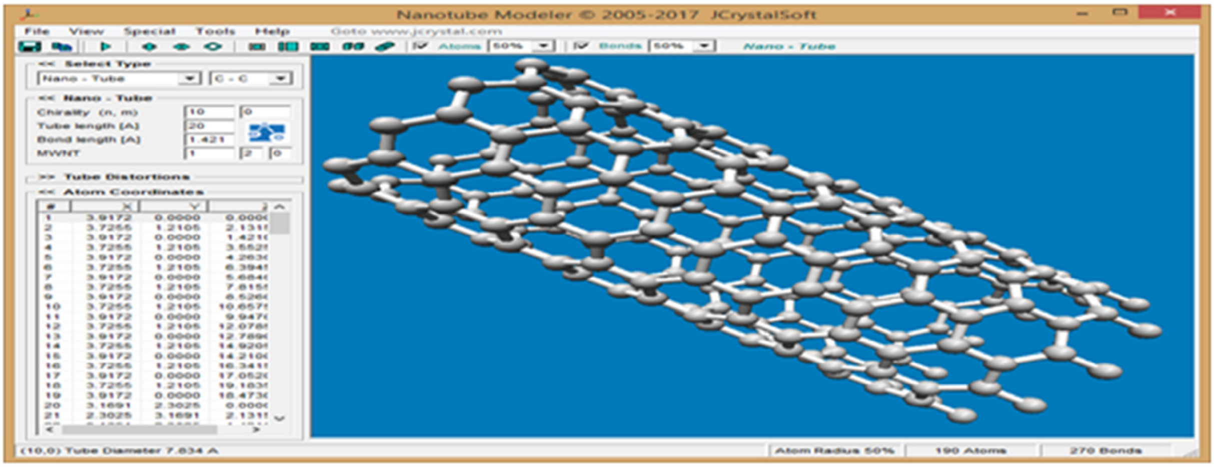

Fig. 3. Zigzag SWCNT

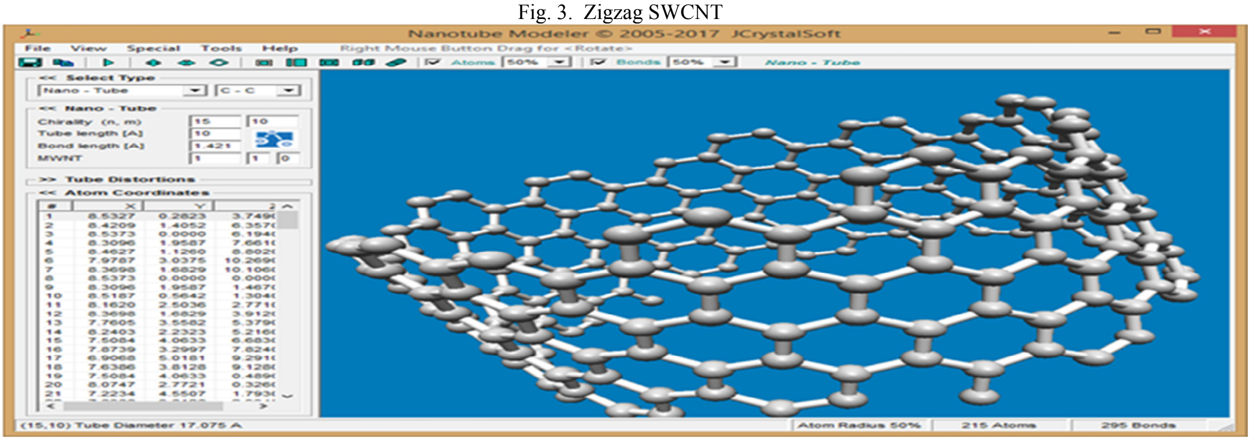

Fig. 4. Chiral SWCNT

4. Manufacturing

Products featuring SWCNTs recently have many implementations either dispersed in the form of powder [1] or accumulates as a very thin film. However, for the trading purpose of the product of SWCNTs, are still very crucial so their execution accomplished in combination with the conventional fabricating procedures [14]. None the less, because of the variety of research performed on SWCNT, advancements in their fabricating are continuously increasing.

Wang et al. [16]. Described CNTs composite having unrivalled multi-functionalities, like very high strength (up to 3.8GPa), higher electrical conductivity (s)= 1230Scm^{-1}, Young's modulus (E) = 293Gpa, and Thermal Conductivity (k) = 41$Wm^{-1}K^{-1}$. These values were found along the length, very good alignment, high volume fraction, in coexistence with less waviness of the Carbon nanotubes and a novel procedure are feasible for trade production.

4.1. Experimental Procedure

4.1.1. Materials

The chemicals which were used in the synthesis of catalyst are ferric nitrate hexahydrate, magnesium nitrate hexahydrate, Nickel nitrate hexahydrate, cobalt nitrate hexahydrate, chromium nitrate hexahydrate, oxalic acid, and Citric acid [2],[5] as the combustive fuel. The gases which is used in the synthesizing of SWCNTs are Acetylene

(99.9%) as a carbon source, nitrogen (99%) as a carrier gas and hydrogen (99%)[9] as a reducing agent. Commercial grade acid HCl was used for the purification of SWCNTs. Double distilled water used as the solvent in which acetylene. All chemicals are of Analytical grade and which can be used without filtrations.

5. Combustive Catalyst Synthesis

5.1. FNM Catalyst Synthesis

For preparing the combustive catalyst, the solution combustion synthesis method was used to prepare $Fe_xNi_yMg_{1-(x+y)}O$ (FNM) catalyst [8]. The used metal nitrates are Ferrous Nitrate [$Fe(NO_3)_2$], Nickel Nitrate [$Ni(NO_3)_2$] and magnesium Nitrate [$Mg(NO_3)_2$] [6] were taken as stoichiometric form $FexNiyMg_{1-(x+y)}O$ (FNM). Different- different molar composition of stoichiometric forms like Fe0.20Ni0.14Mg0.66O (FNM-a), Fe0.25Ni0.09Mg0.66O (FNM-b) and Fe0.30Ni0.04Mg0.66O (FNM-c) was formed by the keeping magnesium nitrate molar ratio constant.

6. Synthesis And Purification Of SWCNTs

6.1. Illustration Of CVD Apparatus

The SWCNTs was synthesized by using the combustion catalyst by Chemical Vapour Deposition (CVD) method [4]. The apparatus having a horizontal tube which consists of heating filament accompanied by a program controller, which controls the desired reaction temperature. The tube is also attached to the mass flow meter and different-different gas source which is attached to the valves. An illustrative block diagram for CVD test apparatus for SWCNTs production is shown in figure 5. The horizontal tube which is made up of alumina, having an input and output hole for the gases. The filament which is all around the tube for maintaining temperature over the tube [17]. The temperature was maintained by a programmable controller placed in the middle of the tube. An electric digital mass flow meter is attached in the gas cylinder to regulate the flow rate depending upon the requirement of various gases like nitrogen, hydrogen, and acetylene.

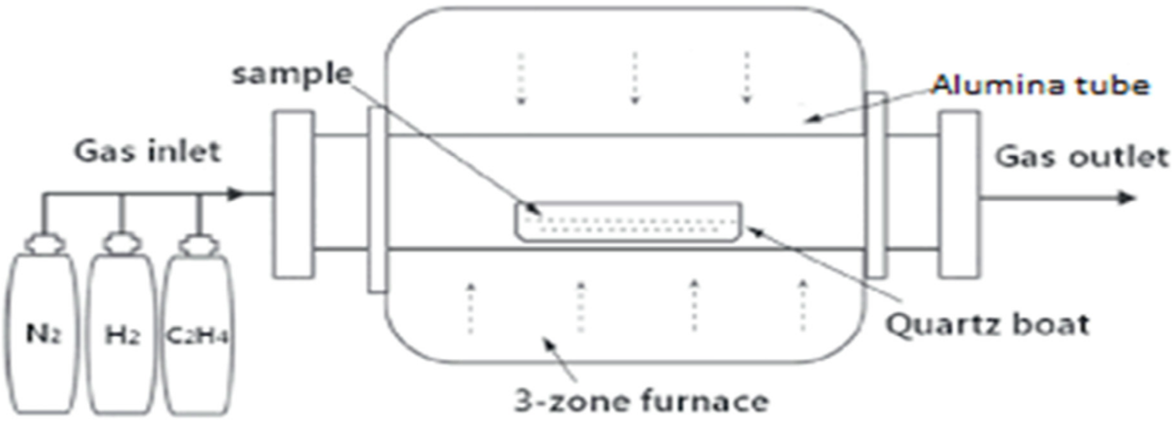

Fig. 5. CVD apparatus

6.2. Synthesis Of SWCNTS

The Chemical Vapour Deposition procedure was processed at the atmospheric pressure in the horizontal tube, the catalytic reaction SWCNTs was processed out along with different-different Catalyst like FNM, FCM, FVM, and NCM. Approximately 100 mg of combustive catalyst was put on a quartz and kept at the central part of the tube. The catalyst was heated under the Nitrogen atmosphere with the flow rate of 100sccm for removing the moisture. Then it is followed by the Hydrogen flow of 100sccm to decrease the catalytic surface unless-until the temperature

inside the tube reaches to 650°C. Further reaction processed out by varying the (10-100sccm) at the different-different temperature ranging from 650-850°C for 10 minutes. After the reaction furnace to be cooled to room temperature in the Nitrogen atmosphere.
The Mass of Carbon accumulated by acetylene decomposition when the catalyst is used calculated by below equation.
Normally the weight percentage of the Carbon accumulated was estimated along with the catalyst.

Carbon deposition $\% = (\frac{\mathrm{mtot} - \mathrm{mcat}}{mcat}) \times 100$ ……...……………… 6.1

Where m_{cat} is the mass of catalyst before starts and m_{tot} is total mass of the acetylene after the reaction.

6.3. Purification Of SWCNTS

Carbon which is synthesized is then purified by treating with acid for removing the metallic particles which are there in the catalyst. Purification carried out by stimulating the carbon which is synthesized along with the conc. aqueous solution of HCl (by weight 35-36%) [12] at the ambient temperature around 40-45 minutes. After that solution drenched and washed by distilled water unless-until product get stable and then purified SWCNTs was dried out at 80°C for 5-6 hours.

6.4. Characterization

Characterization Methods:

The synthesized catalyst and SWCNTs are characterized by the many physical and chemical processes like XRD, FTIR, FESEM, EDAX, HRTEM. TGA and Raman spectroscopy to get the structure, surface area and morphology of the SWCNTs. Fourier-Transform Infrared Spectroscopy (FTIR), recorded using was Varian 670FTIR spectrometer of the range of 4000-400cm^{-1} [12]. Scanning Electron Microscopy (SEM) image was acquired by using a Carl Zeiss Auriga SEM-FEB field emission scanning electron microscope. All the SEM samples were sputter coated with a very thin layer of gold to avoid charge accumulation on it. Thermo-gravimetric Analysis (TGA) performed [10] on TA instrument Q500 Thermo-gravimetric Analyzer (TGA) at the heating rate of 10°C/minute in the Nitrogen atmosphere [13].

7. Application

Next generation casing of Jet engine and Diesel Engine will have severe demands regarding light-weight, visual as well as thermal signature, enhanced strength. and manoeuvrability. These requirements provoke a necessity for the advanced material and system which can be consolidated in different technologies.
In particular, these segments examine the reduction in weight by the replacement of conventional engine casing material which results in the trimming of fuel consumption as well as enhances the strength of the engine.

8. Conclusions

SWCNTs study has been reviewed and found out the potential application of SWCNTs for the commercial purpose of Diesel engine and Jet engine Casing.

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