The growth of Nanotechnology Applications in the World

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الخلاصة:

تقنية النانو هو العلم الذي يبحث في خلق المواد ذات الجزيئات الدقيقة. تطبيق تقنية النانو أصبح يغزو مختلف العلوم بما في ذلك الطب والكيمياء والطاقة وعلوم البيئة وتقنية المعلومات. في مجال الطب علوم الخلايا وزرع الأعضاء ليتصدر المجالات الطبية. وفي مجال تقنية ومعالجة المياه إلى جانب علم تصفية الهواء تم ابتكار منتجات حديثة متعددة الاستعمالات باستعمال تقنية النانو. وتم التركيز في هذه الورقة في مجال تصنيع مصفيات غبار الإسمنت المنبعث من المصانع. وتهتم الورقة بتصنيع الخيوط التركيبية باستعمال تقنية النانو المتمثلة في العزل الكهربائي لإنتاج الخيوط المدعومة والمتكونة من البولي بروبليين وألياف الكربون وذلك لتحسين جودة ومعدل أداء المصفيات والتي تعمل على جمع الغبار المنبعث من مصانع الإسمنت للحصول على بيئة نظيفة. وتم استعمال النماذج الرياضية لحساب قوة الشد لهذه الخيوط التركيبية والحصول على معامل كفاءة يصل إلى 20٪ أفضل من المصفيات التقليدية.

Abstract :

Nanotechnology is the science and creation of materials at a molecular level. Nanotechnology applications are used in medicine, chemistry, the environment, energy companies, and communication. Whether it is through nanotechnology education or nanotechnology application, this science continues to evolve and find more uses in everyday life.The use of nanotechnologies in medicine has provided many medical breakthroughs.Someof the medical nanotechnology applications are for diagnostics. These are used to assist in identifying DNA

and helping detect genetic sequences.Other uses of nanotechnology in medicine are in drug delivery and tissue engineering. Drug delivery can help in cancer treatments by administering drugs via implant versus the traditional injections. Tissue engineering is a new nanotechnology and involves repairing or artificially reproducing damaged tissues.Using molecular nanotechnology in chemistry and the environment has already resulted in positive benefits. Chemical catalysis is a process of reducing pollutants using a reagent or catalyst. This can be especially helpful if used in vehicle fuel cells or catalytic converters to reduce car emissions.Filtration is another field of nanotechnology applications that can help the environment. Extremely small holes in the filtration, known as nanofiltration, remove ions for wastewater treatment or air purification. [1] .

The main objective of the filter is the ability to hold dust filter so efficiency is a key factor in its choice, especially in the ability to hold a very small particle filter as well as the age factor and the environment on the other. There are many sources of dust including dust resulting frommanufacturing processes of cement that harmful to workers and the surrounding environment. Technology is the use of filters of effective techniques in the types of dust collectors, known especially after the use of nanotechnology in various fields and applications to achieve the advantages of saving energy and costs. This paper discusses the process of manufacturing nanofibers, and the performance of the filter in terms of efficiency and design specifications and variables. The primary function of filtration systems is to reduce the rate of emissions, both gaseous or solids where the greatest possible efficiency standards by adding materials such as carbon, glass, and Kevlar fibers to the polymer composed of composite materials that have superior structural characteristics of the most important high modulus and strength to weight ratios and mechanical properties. In this paper the use of reinforced materials using nanocarbon fiber is investigated where improvement of the efficiency of nanofilters by more than 20 % is achieved.

Keywords—Nano Technology, filter efficiency, nanofiber filter media, dust collectors, high modulus and strength.

I. INTRODUCTION :

The growth of using nanotechnology is expected to grow in the World at high rate as indicated in Fig (1). The opportunity of reaching mass market production is expected to reach the maximum level of production on 2020.

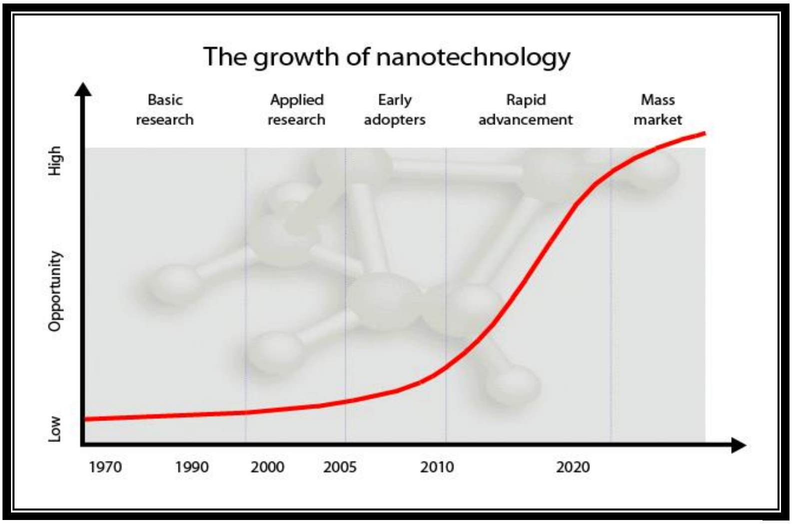

Fig 1 The growth of Nano Technology .

Cement industry is one of the most important industries in urban life to benefit from nanotechnology. Dust is one of the most important source of air pollution. Cement is made by blending different raw materials and exposure to high temperatures for configure the precise chemical proportions of lime, silica, alumina and iron in the final product, and known as (Cement Clinker). Dust produced carries with it a lot of risk to the environment and human.This dust has many flaws, especially on the atmosphere and the neighborhoods surrounding the plant, both in terms of its spread air or penetration by rain surface water due to the softness of this dust. The particles have a range in size from (20-100microns). Dust collectors are used in many processes to either recover valuable granular solid or powder from process streams or to remove granular solid pollutants from exhaust gases prior to venting to the atmosphere.

Dust collectors may be of single unit construction, or a collection of devices used to separate particulate matter from the process air streams from many industrial processes.

Fabric collectors use filtration to separate dust particulates from dusty gases. They are one of the most efficient and cost effective types of dust collectors available and can achieve a collection efficiency of more than 99% for very fine particulates. Nanotechnology is the engineering of functional systems at the molecular scale. This covers both current work and concepts that are more advanced. In its original sense, nanotechnology refers to the projected ability to construct items from the bottom up, using techniques and tools being developed today to make complete, high performance products.

II . MANUFACTURING OF NANO FIBERS BY ELECTOSPINNING

ZhenqMing, Huang and etc. [3] present a comprehensive review of research and developments of Nano fibers. The most important effective methods for the production of Nano fibers is Electrospinning rolled research on how to develop for the formation of fibers with diameters infinitesimal. Beginning in 1980, especially in the last ten years, there have been actual attempts to improve and develop the way electrospinning due to the high use of nanotechnology, and features flexibility mechanical properties on the other. The idea is to work the way to use of electrostatic force for polymers dissolved and pushed it between two poles carry opposite electric charges, and developed one of the electrodes in polymer dissolved and the other on the collector. Voltage difference here depends on the particular properties of the polymer viscosity and molecular weight. There are basically three elements to achieve the electrospinning process are: provide a source of high voltage, capillary tube with a pipette or needle diameter is small, metal screen to collect the formed constituents. Polymer melt is in some solvents and appropriate quantity before dealing with it in the electrospinning to be in the form of a liquid polymer solution is then entered in the pipeline. Electrospinning may emit some polymers smells, so it should be conducted operations inside the rooms with a good ventilation system. In addition, there are several criteria affect the process of transformation of the polymer to the nanofibers including properties of polymer solution such as viscosity, flexibility, conductivity and surface tension or the characteristics of the changes, including the hydraulic pressure in the capillary tubes or the distance between the tip and the surface of the complex, and the standards of the surrounding circumstances, including temperature, humidity and speed of air in the room. Production of fibers have very small diameters measured in nano is done to control the viscosity of the polymer solution for being the main factor. The diameter increases with increasing concentration of the polymer. High voltage also increases the diameter of the fiber that is highly elastic. This defect for electro spinning add to that the non-uniform diameters may be overcome by controlling the temperature. As well as the interface of this method are problems such as grains and pores of the fiber to be overcomed to control the polymer concentrations and temperatures and proportions of the solvent used.

Tadeusz, jaroszczyk and etc .[4]discussed the research which is still ongoing to develop this technology for nanofibers for use in Systems demobilization because it gives the dust cake a homogeneous distribution of dust to achieve high efficiency. Good quality nanofiber layering results in uniform dust cake distribution resulting in high efficiency. The basic understanding of the filtration mechanisms are not well known at the nanofiber scale. The classical fluid dynamics mathematical models used in the Continuum region of the filtration process do not apply to the slip flow that takes place around nanofibers. This region, described by large Knudsen numbers, requires a different approach such as the lattice-Boltzmann method. Table (1) describes the major parameters of engine air filtration. The ratio of nanofiber diameter to cellulose fiber diameter is approx. equal to 1:130. Fiber diameter is the main variable responsible for filter efficiency and pressure drop. The efficiency would increase even more drastically when nano fibers are utilized.Pressure drastically increases with decreasing fiber diameter in the classical region of filtration that can be described by the Navier- Stokes equation. Media with nanofibers provides significantly higher efficiency, especially in the initial stage of the filtration. Efficiency increases rapidly with decreasing fiber diameter. Pressure drop significantly increases with decreasing fiber diameter since it is a function of $1/d_f^2$, in this region, until the free molecule regime is reached where pressure drop is a function of $1/d_f^2$,the larger the Knudsen number, the lower the pressure drop. When dust deposits form on nanofibers, this benefit of low-pressure drop diminishes with increasing amounts of deposited dust. Moreover, nanofibers capture very fine particles. The pressure drop increases more rapidly for this compacted dust cake. Nanofibers are very good collectors of small particles, a very dense dust would be formed them resulting in drastic pressure drop increase. Therefore, a careful analysis of filter dust operational conditions is necessary before any decision concerning the filter media is made. There are several theoretical models that are useful in making this decision.Löffler [5] predicted the increase of pressure drop with time.

$$\Delta P_{dl} = \Delta P_m + \frac{\mu . \upsilon^2 \ . \ t. \ c . E_f}{(1 - \varepsilon_d). \ \rho_{d.} k_{DC}} \quad (1)$$

Where : ΔP_{dl} = pressure drop of dust- loaded filter element, ΔP_m = media pressure drop , E_f = filter efficiency , μ =air dynamic viscosity, ν =air velocity, t =filtration time, C=dust concentration, k_{DC} = dust cake permeability, Δd= dust density ,ε_d = porosity of the dust cake.Pressure drop, in this case, increases linearly with time and dust concentration and with the square of velocity. Because the air permeability decreases for dust cakes formed by fine dusts, pressure drop should increase for these dusts.

Table (1) MEDIA SPECIFICATIONSFORMINIING CABSTUDY

Filter	Basis Weight	Permeability	Thickness
Cellulose	67 lb/3000ft^2	58 ft /min at 0.5 in w.g.	0.013"
Cellulose+ Nanofibers	67 lb/3000ft^2	40 ft /min at 0.5 in w.g.	0.013"

III . THE USE OF FIBER IN INDUSTRIAL ENVIRONMENTS :

Kristine, Graham and etc.[6]discuss the theoretical filtration benefits of small fibers in air filtration applications, a process for making nanofibers, and real-world applications that demonstrate the practical usage of nanofiber based filter media. Filters containing three different media varieties were tested: a cellulose media, a cellulose/synthetic blended media, and a cellulose media with a nanofiber treatment. The nano fiber/cellulose composite media maintains a lower pressure drop as compared to the other two media varieties tested.

IV Improvement of Filters Dust Collection Systems :

Polymeric materials exhibit mechanical properties which come somewhere between viscous and elastic and hence they are termed viscoelastic. In addition when the applied stress is removed the materials have the ability to "recover" slowly over a period of time these effects can also be observed in metals but the difference is that in plastic they occur at room temperature whereas in metals they only occur at very high temperature. Fiber glass and Carbon fiber as material of improved mechanical properties are added to polypropylene to produce reinforced materials used in filter manufacture. This process will create a composite material that can tolerate high stresses and pressure for a long time before damaged and before stopping to work. It is proposed in this work to use nano carbon fiber with a concentration of 1 %. Carbon fibers, which are a new breed of high strength materials,are mainly used as reinforced in composite materials such as carbon fiber reinforced plastic.Carbon fiber offer the highest specific modulus and highest specific strength of all reinforcing fibers, the strength and modulus are outstanding compared to other materials, and compressive strength of carbon fibers is lower than of inorganic fibers but still higher than that of polymeric fibers. Compressive properties dictate the use of carbon composites in many structural applications. Recently a lot of research has been done on compressive properties and morphology of carbon fibers. Carbon fiber composites are ideally suited to applications where strength, stiffness,lower weight, and outstanding fatigue characteristics are critical requirements. Carbon fibers also have good electrical conductivity, thermal conductivity,and low linear coefficient of thermal expansion . The two main sectors of carbon fiber applications are high technology sector, which includes aerospace and nuclear engineering, and the general engineering and transportation sector, which includes engineering components such as bearings ,gears, cams ,etc,and automobile bodies . However, the requirements of two sectors are fundamentally different. The large scale use of carbon fibers in aircraft and aerospace is driven by maximum performance and fuel efficiency, while the cost factor and the production requirements are not critical. The use of carbon fibers in general engineering and surface transportation is dominated by cost constraints, high production rate requirements, and generally less critical performance needs.

V- Calculations and Results :

In More Complex Models to simulate creep curves of reinforced materials, it may be seen that the simple Kelvin model given an acceptable first approximation to creep and recovery behavior but does not account for relaxation .The Maxwell model can account for relaxation but was poor in relation to creep and recovery . It is clear therefore that some compromise may be achieved by combining the two models.It can be seen that although the exponential response predicted in these models are not a true representation of the complex viscoelastic response of polymeric materials, the overall picture is , for many purposes, an acceptable approximation to the actual behavior .As more and more elements are added to the model then simulation becomes complex model (Maxwell model with Kelvin model). In this work the combined model is used to simulate the stress strain time correlation to generate the tensile strength data needed in the design of dust filter collectors. Calculations are made for composite materials of concentration of 1%CF and 99%PP. In this case the stress – strain relation are given by equations:[7]

$$\varepsilon(t) = \frac{\sigma_o}{\xi_1} + \frac{\sigma_o t}{\eta_1} + \frac{\sigma_o}{\xi_1}.\left(1 - \exp(\frac{\xi_2}{\eta_1} t)\right) \qquad (2)$$

From this the strain rate may be obtained as :-

$$\acute{\varepsilon} = \frac{\sigma_o}{\eta_1} + \frac{\sigma_o}{\eta_2}.\exp(\frac{\xi_2}{\eta_2 t}) \qquad (3)$$

where :η_1,η_2, ξ_1, ξ_2 are the model constants .

The creep curve and isochronous graphs are plotted to find the model constants and applying mathematical model equations (2, 3).

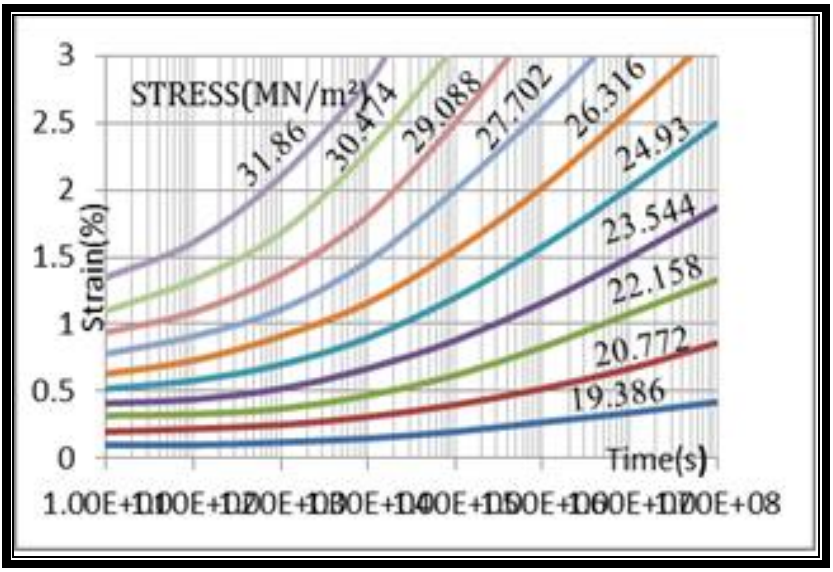

Fig (2) Creep curve for composite 1%CF and 99%PP

For composite material 1%CF and 99%Pp : The creep curve is plotted in Fig (2).

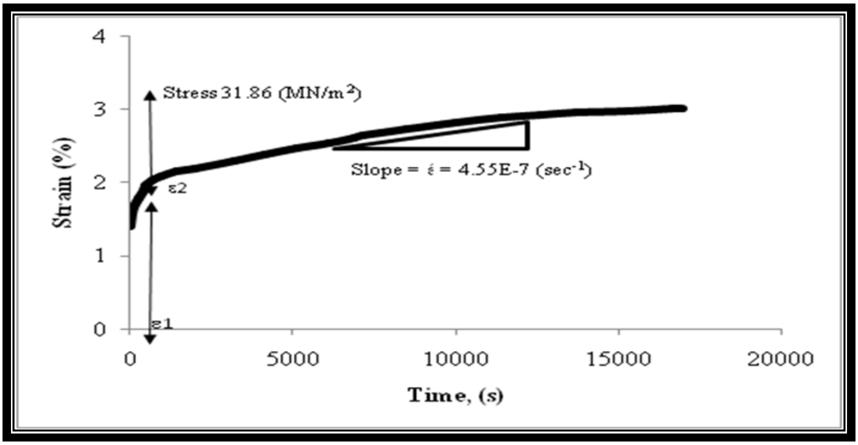

Fig (3) Calculation of modeling constants.

$\varepsilon 1=1.62\%$,$\varepsilon 2=0.88\%$,$\xi 1=1966.67(MN/m^2)$.($\eta 1=7.02exp(+07)$ $(MN.s/m^2)$,$\xi 2=3620(MN/m^2)$,$\eta 2=4.90exp(+08)$ $(MN.S/m^2)$. The stress four constant composite materials have been increased drastically to the levels reaching to the value of the stress more than 30MN/m^2,so the 1%CF and 99%PP. Composite material tensile strength produced in this work is satisfactory for producing filters needed in Cement industries.

VI . CONCLUSION

Nano technology have wide future applications in medicine and industries. Utilization of nano reinforced materials using nano carbon fibers are discussed in this paper to improve the performance of filters used to reduce dust in cement factories. Improvement of dust collection system of 20 % is achieved using electro spinning nano reinforced fibers.

REFERENCES :

1-Thomas, G. Using nanotechnology for more efficient dust collection, United Air Specialists Inc. copyright, CSC Publishing ,2011

2- Walter H. Duda-cement Data Book (BaurerlagGmb H. wiesbaden and Berlin(2007).

3- ZZheng-Ming Huanga.A review on polymer nanofibers by electrospinning and their applications in nanocomposites. AnnualTechnical Conference & Expo of the American Filtration & Separations Society, Galveston, Texas, USA.
4- TTadeuszJaroszczyk. Development of High Dust Capacity, High Efficiency Engine Air Filter WithNano Fibers. Keynote paper presented at the 34th International Congress on Powertrain and Transport Means KONES 2008, Stare Jabłonki, Poland, September 7-10, 2008, published on the internet: http://www.ilot.edu.pl/STRANG/kones2008
5- LOFFLER
6- Kristine G.PolymericNanofibers in Air Filtration Applications Fifteenth AnnualTechnical Conference & Expo of the American Filtration & Separations Society, Galveston, Texas, 2002
7- Crawford R.J Plastics engineering, Third Edition, Woolworth, 2007