International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor (2018): 7.426

Polytetra Fluoro Ethylene (PTFE) Nanofiber Coated Glass Fabric Using Electrospinning Method

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Abstract: ***Polytetrafluoroethylene (PTFE) membrane coated glass fabric is available as robust filter media for high temperature dust filtration. Since it is a membrane coated media, only pores left out contributes to the filtration. PTFE membrane can withstand temperatures up to 500 °F (260 °C). The process of creation of PTFE based nanofiber nanoweb using free-surface electrospinning technology on twill weave glass fabric as well as its stabilization by heat treatment has been developed with an objective of providing an effective high temperature resistant fine dust filter media which can be used with less energy consumption during operation because of high porosity. The developed nanofiber coated glass fabric retains air permeability to the extent of 50-70% and remains stable at 260 °C. The prototype of dust collector bags were fabricated and subjected to filtration, mechanical and industrial trial. Filtration efficiency study clearly shows the improvement in filtration efficiency by 90% with respect to neat fabric and 30% more as compared to marketed product. The mechanical study reveals that the coated media has better strength as compared to non-coated or bare glass fabrics. The industrial study shows that the commercial product has filtration efficiency about 65-70% while the PTFE nanocoated media has efficiency of 85.3 %.***

Keywords: Nanofibers, Free surface Electrospinning, stabilization, filtration

1. Introduction

Poly (tetra fluoro ethylene) (PTFE) is a fluoro-plastic that offers exceptional resistance to high temperatures and corrosive environments, yet is inert, nontoxic, and is used in a various application in general Industry, semiconductor, consumer, and medical field. PTFE is difficult to process, due to its low solubility and high melting temperature, by conventional molten polymer techniques but can be extruded as a paste and then drawn into various forms to produce fiber, ribbon, expanded membrane, or tubes. An alternative means for processing PTFE is to provide a dispersion of PTFE that can be used to form coatings or alternatively, combined with fiber forming polymers and electro statically spun ("electrospun" or "espun") to produce nonwoven fabrics, coverings, bats, or composites composed of Nanofiber.

PTFE membrane coated filter media (Base: Glass fabric) are used as filter media for high-temperature gas filtration, for example in Cement industry. PTFE membrane can withstand temperatures up to 500°F (260°C).

Since it is a membrane coated /laminated media, only pores left out contributes to the filtration. PTFE Nanofiber coated filter media can filter the very fine particles, as well as energy efficient.

2. Materials and Methods

- Aqueous based fluorochemical dispersion with solid content 35%.
- DuPont PTFE dispersion of average 0.2-micron size particles with solid content ~60%.
- Silicon deformer.
- Acetic acid, LR, 99% pure.
- Phosphoric acid LR, 85%

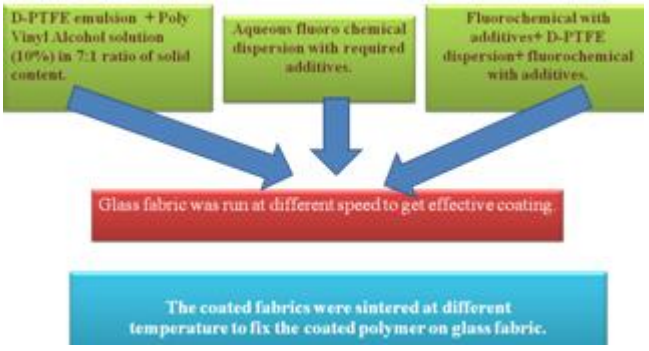
Additives like softeners, binders, crosslinking agent compatible with Fluorochemical dispersion.

- Polyvinyl alcohol solution (10%)
- Polyamide (Nylon-6) solution (12%)
- PEG-4000

3. Methodology

Two different forms of commercially available PTFE Emulsion systems have been used along with thickening polymers and additives as electro spinning media. Glass fabrics of different constructions (Plain as well as twill type) and different mass per unit area have been used as the substrates in the electrospinning process. ELMARCO make NanospiderTM NS 3A1000U Machine has been used for electro spinning process. The working width of the machine is 1 meter, and it is continuous production free-surface electrospinning machine. The PTFE Nanofiber coated fabrics have been heating treated for fixation/sintering process in a continuous two-stage hot air circulated heating machine at desired temperatures.

The coated glass fabrics have been evaluated with respect to coating stability and the comparative air permeability properties as well as fabric strength, tensile as well as tear strength.



4. Result and Discussion

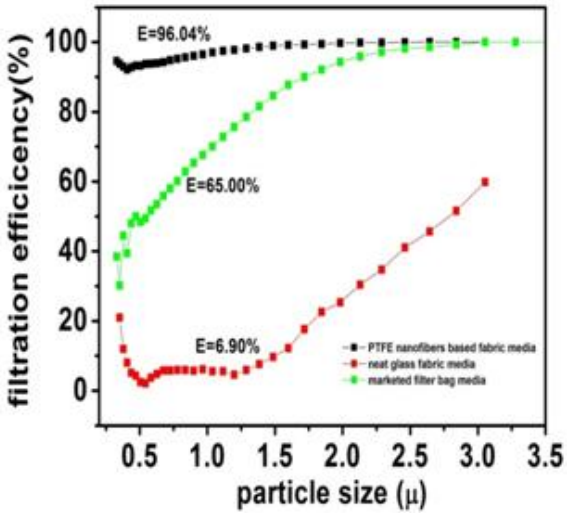
In the case of reactive PTFE emulsion system, the coating can become adherent and stable while heat curing at 150 – 200 0C. However, in the case of standard DuPont PTFE emulsion system, heat sintering at 330 – 350 0C is required. The fabric becomes gray to black and adherence of the coating is not proper. This problem using DuPont PTFE emulsion system could be overcome by Heat –cleaning of the glass fabric prior to its use as the substrate in the electro spinning process. About 40 % reduction of Air permeability has been achieved in certain cases.

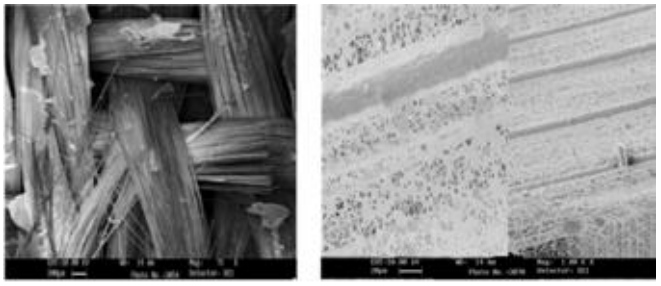
Test parameter	Unit	Test methods	Uncoated glass fabric	Coated glass fabric
Air Permeabi-lity	m3/m2/ min	Pressure 50pa TestArea 20cm2	20.78	12.32
Tensile strength Warp wise Weft wise	N/50mm	IS1969	1865.6 3494.8	2879.0 3817.0
Bursting strength	psi	ISO13938-1	>1000	>1000

Filtration efficiency

Filtration efficiency has been tested by using PALAS instrument. The fine dust of NaCl soot has been passed through nanofibers based glass fabric, marketed product, and neat/ uncoated glass fabric. Filtration efficiency study clearly shows the improvement in filtration efficiency by 90% with respect to neat fabric and 30% more as compared to marketed product. Summarized result in below table:

	Filtration efficiency	Pressure drop	Filter area	Total volume flow
Nanofibers coated fabric	96.04%	40 Pa	100^2 cm	90 L/min
Marketed product	65.00%	45 Pa	100^2 cm	90 L/min
Neat fabric	6.90%	27 Pa	100^2 cm	90 L/min





Uncoated Glass fabric Coated Glass fabric

Prototype development

We developed as per below dust collector filter bag prototype modular from PTFE Nanofiber coated glass fabric as per industry requirement snap band type design.

Industrial Testing/Trails

ATIRA has developed a glass filter with most advance technology for flue gas filtration in industry. The filer Air permeability test is 12.32 at 50 PA, tensile strength 2879 wrap wise ad 3817 weft wise, bursting strength more than 1000.The trial has been conducted in 4 Tons/Hr coal fired steam boiler in a one of the textile process house. The unit is using Indonesian coal having 4650 kcal/kg GCV of steam coal with 30 % moisture and ash 7.0 % in Fluidized bed combustion steam boiler.

The filter fabric is cut and installed after cyclone separator and before stack. The trials are taken more than 4 times at 30 minutes intervals during the running of boiler.

Condition at the time of trail has carried out in Industry:

1) Steam Boiler: 4 TPH(Fluidized Bed Combustion)
2) Coal:Indonesian-GCV 4650 Kcal/Kg, 30 % Moisture.
3) ID Fan Capacity : 10.0 HP 9800 CFM
4) FD Fan Capacity : 7.5 HP 7450 CFM
5) PA Fan Capacity : 1.5 HP, 350 CFM
6) O2 % Level : 4.4
7) Co2 % Level : 14.3
8) Avg.Flue gas Temp.at
9) Stack, Degree C : 156
10) Atmospheric Temp. Degree C : 33
11) Avg. mean pressure before filter, mm of Hg : 680
12) Avg. mean pressure after filter, mm of Hg : 667
13) Velocity, Mt/Sec : 4.82
14) Flow rate in LPM : 16.0
15) Actual Flow : 15.2 ,15.1 and 15.3

Filtration efficiency of PTFE Nanofibers based Glass fabric:

Sr. No.	Actual Flow ,LPM	Initial Thimble Weight, gms	Final Thimble Weight, gms	Suspended Particulate Matter, mg/Nm3	Avg. Flue Gas Temp. ^{0}C	Filtration Efficiency, %
Before Filter						
1	15.2	1.400	1.987	1288	151	
2	15.1	1.389	1.924	1182	172	
3	15.1	1.368	1.926	1231	158	
Avg.	15.1	1.386	1.946	1234	160	
After Filter						
1	15.2	1.398	1.496	216	148	85.3
2	15.1	1.405	1.489	185	154	
2	15.3	1.390	1.456	144	160	
Avg.	15.2	1.397	1.480	182	154	

5. Conclusions

All basic studies related to the selection of substrate, treatment of the substrate, compositions of two different classes of PTFE emulsion systems, electrospinning parameters, and the heat curing / sintering conditions have been completed.

Reduction of air permeability value clearly signifies that the open pores of the base fabric have been covered by the PTFE fiber network.

Filtration efficiency of nanofibers based fabric excellent as compare to the marketed product and neat/uncoated fabric. Generally in conventional bag filters the efficiency varies from 68 to 72 %.

This Nano filtration filter fabrics efficiency are 85.3 % which very good as compare to conventional filter fabric in the market

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