

POLYTETRAFLUROETHYLENE FOR REPLACING BOROSILICATE AIRFILTERS**K.V.Poornachandran**

Dhanalakshmi Srinivasan College of Engineering, Coimbatore, Tamil Nadu, INDIA

Amrit Anand Dosar

Babu Banarasi Das University, Lucknow (U.P.) India

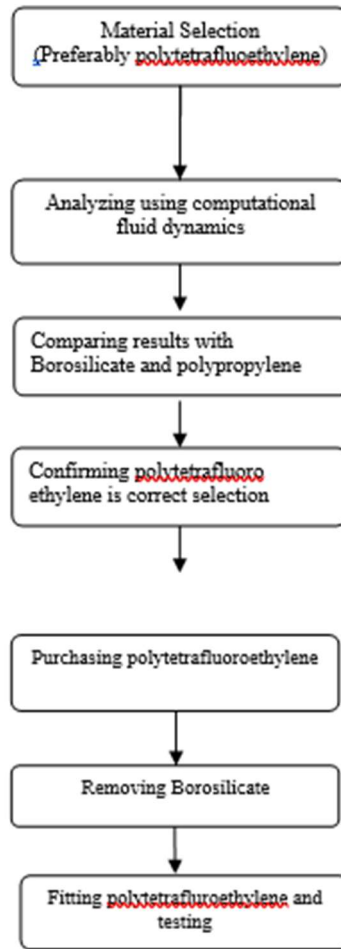
ABSTRACT

Environmentally degradable plastic material Polytetrafluoroethylene is not used as material in air filters. In this paper attempt is made to use Environmentally degradable plastic material polytetrafluoroethylene as air filter. This is an innovative paper which replaces borosilicate sand like material used in air filter with plastic material polytetrafluoroethylene (PTFE). For this two plastic materials polypropylene and polytetrafluorethylene materials airflow flow properties are analyzed using Computational Fluid Dynamics (CFD) and compared with air flow properties of borosilicate. From the results polylytetrafluoroethylene found to be perfectly alright. It can be efficiently used as air filter.

KEYWORDS: End Milling, White layer, LN2 cooling, Cutting temperature

1. INTRODUCTION

Borosilicate are usually used in the air filters. The Purpose of the Borosilicate used in air filter critical for the effective working of the air filters. Though the conventional Borosilicate used in air filters serves the purpose effectively, It is very costly. In order to overcome with this problem we have come upon with the concept of Plastic Air filters. The purpose of the plastic air filter is to replace the conventional Borosilicate in the Air filter at all effective means. The cost comparison is as shown below. Cost of production of Borosilicate is Rs 340Rs/Piece. Cost of production of plastic Air filter is Rs 6/piece. Net saving is Rs 336/piece. Hence the Net saving for the month is Rs 1 lacs. Process of selection of PTFE.



BOROSILICATE AIRFILTERS

Properties of Borosilicate

MECHANICAL PROPERTIES	VALUES
Young's Modulus	0.00006 Gpa
Molecular Formula	(C ₃ H ₆) _n
Density	2.23 g/cm ³
Operating temperature C	-230 C – 490 C
Porosity	0.6

Properties of Polypropylene

MECHANICAL PROPERTIES	VALUES
Young's Modulus	1.5 – 2 Gpa
Molecular Formula	(C ₃ H ₆) _n
Density	0.949g/cm ³
Operating temperature C	-73 C – 204 C
Porosity	0.8

Properties of Polyterafluoroethylene

MECHANICAL PROPERTIES	VALUES
Young's Modulus	1.5 – 2 Gpa
Molecular Formula	(C ₂ F ₄) _n
Density	2.16 g/cm ³
Operating temperature C	260 C
porosity	0.5

OBJECTIVE OF THIS PROJECT

For better understanding of the operation and design of the plastic air filters computer software based on Computational flow dynamics can be used. The objective of this project is to analyze the transient dynamic behavior of plastic air filter using CFD software and comparing the experimental and theoretical results. The investigation is aimed to study:

- 1.The numerical solutions for transient dynamic behavior of plastic air filter using CFD in ANSYS.
- 2.The numerical solutions for transient dynamic behavior of Borosilicate using ANSYS.
- 3.Comparing the observations of plastics air filter and Borosilicate.
- 4.Production and Implementation of the Plastic air filters.

PROBLEM IDENTIFICATION

PROBLEM DESCRIPTION

1. Air filter industries are now using Borosilicate air filters sand like material as air filters . Cost of Borosilicate is Rs 340/piece and also it is imported . In order to reduce the cost and to make the material locally polyterafluoroethylene is used air filter.
2. Due to increasing technical and environmental requirements, the operational conditions are becoming more severe. Plastic air filter have to operate at higher pressure and higher speeds, so sufficient air pressure in air filter interface is vital if excessive wear, friction are to be avoided and a long air filter life is to be ensured. In plastic air filter face deformation caused mainly by tensile and compressive load. A good understanding of the wear mechanism involved will help determine the air filter deterioration

ANALYSIS OF AIRFILTERS USING COMPUTATIONAL FLOW DYNAMICS IN ANSYS

1. Modeling of Filter:

The filter is modeled using solidworks software. The filter internal diameter is 24 mm & outside diameter is of 40 mm. The length of the filter is of about 50 mm. By using these dimensions the filter is modeled as shown in figure-1. The model is saved as IGS format for doing analysis.

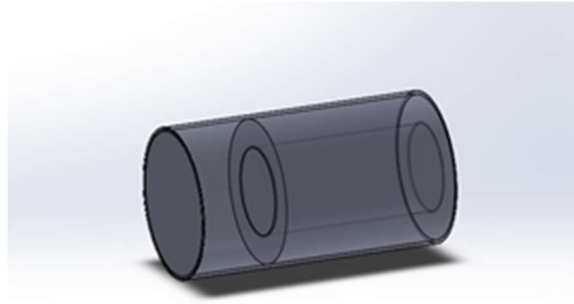


Fig.1 Filter Model

There exist several CAD data exchange formats which are used to exchange data between different CAD packages. Most of these formats are also supported in a grid generator package. A non-exhaustive list is given below:

- IGES
- ACIS
- STEP
- Para solid
- STL

When CAD geometry is imported into a grid generator package an inconsistent geometry can be the result. This can be due to e.g. tolerance differences between the CAD package and the grid generator package. This imported geometry can then not be meshed or not be meshed adequately.

Sometimes direct input from a specific CAD package into the grid generator package is also supported, e.g. CATIA, Pro/Engineer, Euclid, EDS/ Unigraphics, CADD5, I-DEAS.

2. Analysis of Filter:

Computational Fluid Dynamics (CFD) is becoming a critical part of the design process for more and more companies. CFD makes it possible to evaluate velocity, pressure, temperature, and species concentration of fluid flow throughout a solution domain, allowing the design to be optimized prior to the prototype phase. The basic principle of the CFD modeling method is that the simulated flow region is divided into small cells within each of which the flow either kept under constant conditions or varies smoothly. Differential equations of momentum, energy, and mass balance are discretized and represented in terms of the variables at the center of or at any predetermined position within the cells.

Here the model is analyzed using the ANSYS-14 (Fluent) software. The model is imported into the software by using the import geometry option, where we have saved the modeled files as an IGS format.

2.1 Need for CFD:

Applying the fundamental laws of mechanics to a fluid gives the governing equations for a fluid. The conservation of mass equation is

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{V}) = 0$$

And the conservation of momentum equation is

$$\rho \frac{\partial \vec{V}}{\partial t} + \rho(\vec{V} \cdot \nabla) \vec{V} = -\nabla p + \rho \vec{g} + \nabla \cdot \tau_{ij}$$

These equations along with the conservation of energy equation form a set of coupled, non linear partial differential equations. It is not possible to solve these equations analytically for most engineering problems.

However, it is possible to obtain approximate computer based solutions to the governing equations for a variety of engineering problems. This is the subject matter of Computational Fluid Dynamics.

2.2 Grid Generation:

Once a valid geometry is obtained, the grid generation process can start. Normally the grid is constructed from lower topologies to higher topologies, i.e. first the edges are meshed, then the faces and finally the volumes.

In boundary layers and shear layers the behavior of the flow is dominated by diffusion mechanisms (laminar or turbulent diffusion).

The mesh of a filter model is shown in the figure-2. The object is meshed using a default conditions applicable in the ANSYS software. The mesh generated in here is a coarse mesh.

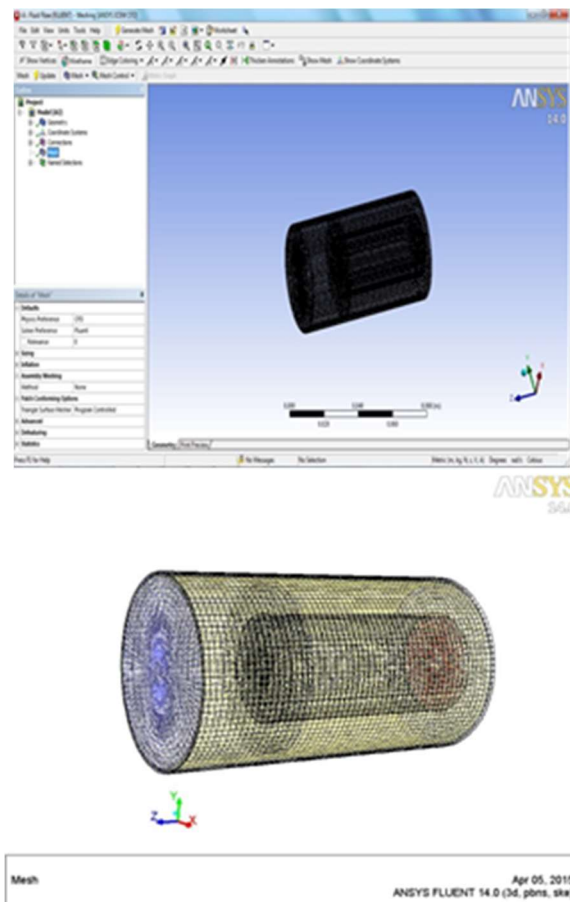


Figure-2 Meshed Model

The sections are named in here. The sections were named in here because by using the naming as a reference we will define the boundary conditions to the filter in the fluent software. The mesh statistics is as stated below.

6784 mixed cells, zone 4, binary.
16665 mixed cells, zone 7, binary.
1620 mixed wall faces, zone 14, binary.
6480 mixed interior faces, zone 6, binary.
2044 mixed wall faces, zone 1, binary.
13389 mixed interior faces, zone 2, binary.
46457 quadrilateral interior faces, zone 3, binary.
3830 mixed wall faces, zone 8, binary.
1239 mixed pressure-inlet faces, zone 9, binary.
469 mixed pressure-outlet faces, zone 10, binary.
5076 quadrilateral wall faces, zone 11, binary.
4860 quadrilateral interface faces, zone 12, binary.
3240 quadrilateral interface faces, zone 13, binary.
1620 interface face parents, binary.
6480 interface face parents, binary.
1620 interface metric data, zone 14, binary.
6480 interface metric data, zone 6, binary.
33962 nodes, binary.
33962 node flags, binary.

2.3 Fluent Analysis of Filter:

The model is analyzed by using the solver type as Pressure Based Navier Stokes equation. Then the flow model is considered as K-Epsilon model since there will be both laminar and turbulent flow in the filter. The K-Epsilon represents the flow influences both the Kinetic energy and dissipation rate. After defining the flow the material has to be selected.

The material selected over in here is to be air, since the air will be flowing inside the filter. Then the cell zone conditions have to be defined to select the porosity for the filter. Each material will have a separate porosity. Those values are given as a cell zone condition for the filter model. For the other material cell zone condition is set as default. Then the boundary condition for the model is given. The boundary condition defined as shown in below:

Filter – Porosity (Boro silicon = 0.6, PP = 0.8, PTFE = 0.5)

Inlet - Pressure Inlet = 4 Bar

Outlet – Pressure Outlet

Filter – Wall

Interior Surface – Interior

After defining these values as a boundary condition we have to define the reference zone in which the flow will be given as a reference zone. The inlet is selected as a reference zone. In the solution monitor we have to monitor the mass flow rate of air in the inlet and outlet. After defining the solution monitor the solution is initialized to proceed for the iteration. After the iteration process the results for the filter by applying different material is obtained and those results were obtained by using the contour diagrams and plots taken from it. The results obtained for those materials are tabulated in below. The Table-1 show the pressure created over the model and the Table-2 shows the velocity

created over the model. Then the Table-3 is the mass flow rate in the inlet and outlet condition.

RESULT ANALYSIS

Table-1 Pressure variation over the model

Filter Type	Pressure Minimum (Pa)	Pressure Maximum (Pa)
Boro Silicate	4×10^5	1.58×10^5
PP	4×10^5	1.58×10^5
PTFE	4×10^5	1.58×10^5

Table-2 Velocity variation over the model

Filter Type	Velocity Minimum (m/s)	Velocity Maximum (m/s)
Boro Silicate	0.38	1
PP	0.38	0.8
PTFE	0.35	0.78

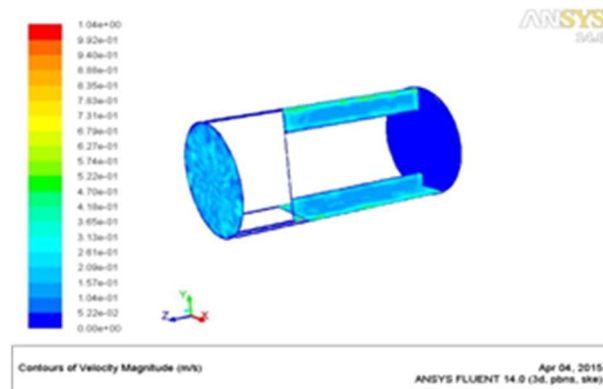
Table-3 Mass flow rate over the model

Filter Type	Mass Flow Rate Inlet (Kg/S)	Mass Flow Rate Outlet (Kg/S)
Boro Silicate	8.201×10^{-7}	4.8166×10^{-9}
PP	7.926×10^{-7}	4.3326×10^{-9}
PTFE	8.69×10^{-7}	4.82×10^{-9}

..

From these plots we can compute the value of the turbulence and velocity of the filter along the length of the filter at any point.

The contours for the filter is shown in the below figures. The velocity contour for the borosilicate is shown in the figure-3



.Fig-3 Velocity for Borosilicate

The velocity maximum and minimum were calculated from these contours only. The turbulence for borosilicate is shown in the figure-4.

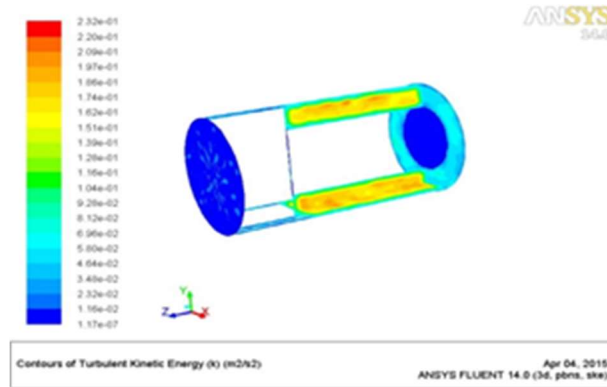


Fig-4 Turbulence for Borosilicate

The velocity contour for the polypropylene is shown in the figure-5

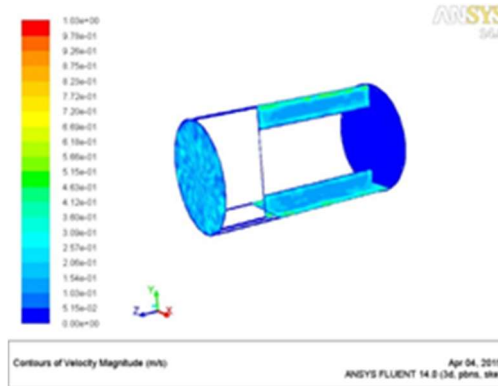


Fig-5 Velocity for Polypropylene

The turbulence for polypropylene is shown in the figure-6.

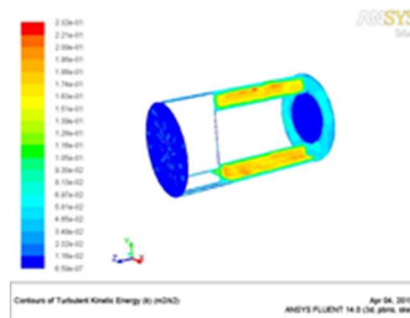


Fig-6 Turbulence for Polypropylene

The velocity contour for the poly tetra fluoro ethylene is shown in the figure-7

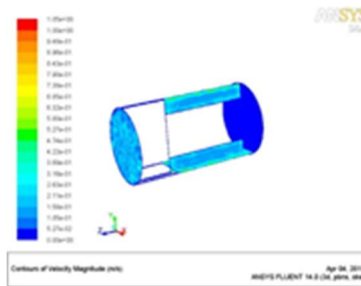


Fig-7 Velocity for Poly Tetra Fluoro Ethylene

The turbulence for poly tetra fluoro ethylene is shown in the figure-8.

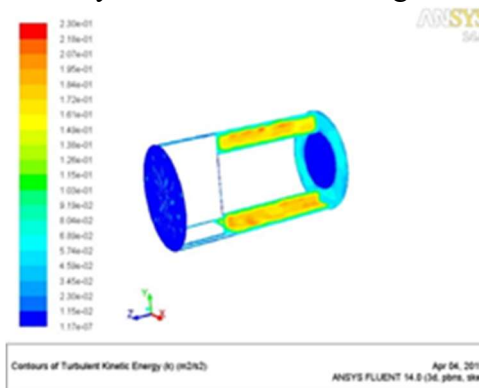


Fig-8 Turbulence for Poly Tetra Fluoro Ethylene

The plot for these models is also shown in here. For all the plots the x-axis is considered for the length of the filter model.

The velocity plot for the borosilicate is shown in the figure-9 and the turbulence plot for the borosilicate is shown in the figure-10.

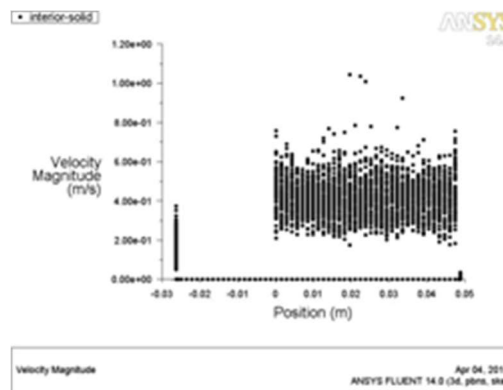


Fig-9 Velocity for Borosilicate

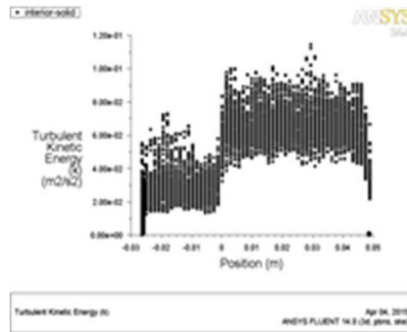


Fig-10 Turbulence for Borosilicate

The velocity plot for the polypropylene is shown in the figure-11 and the turbulence plot for the polypropylene is shown in the figure-12

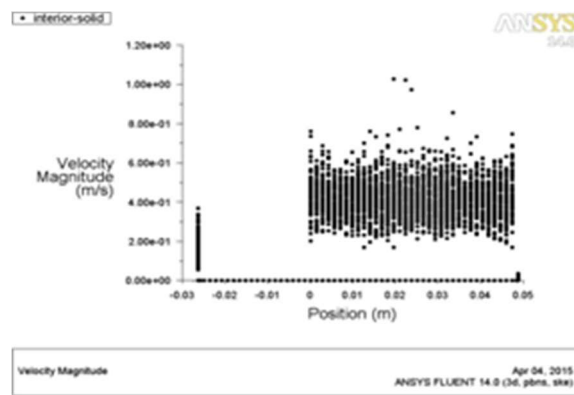


Fig-11 Velocity for Polypropylene

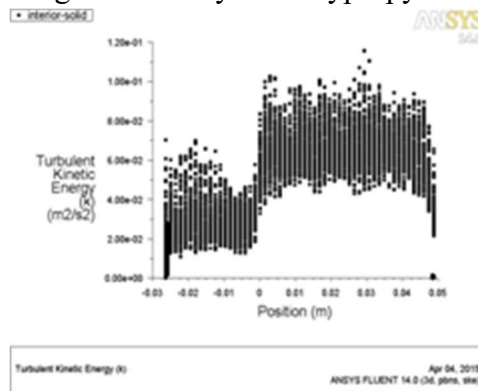


Fig-12 Turbulence for Polypropylene

The velocity plot for the poly tetra fluoro ethylene is shown in the figure-13 and the turbulence plot for the poly tetra fluoro ethylene is shown in the figure-14.

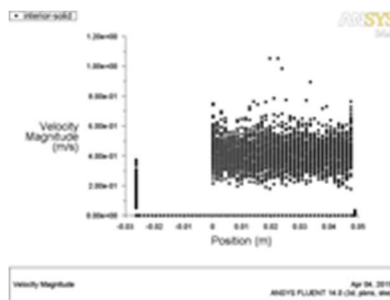


Fig-13 Velocity for Poly Tetra Fluoro Ethylene

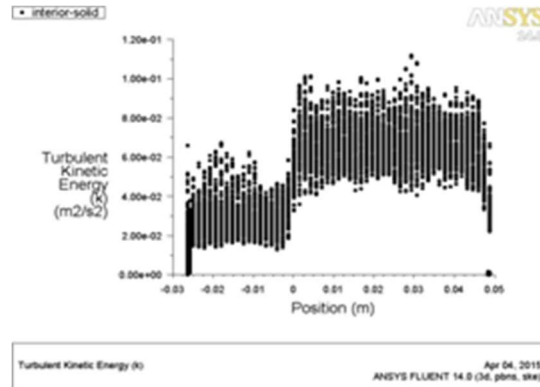


Fig-14 Turbulence for Poly Tetra Fluoro Ethylene

CONCLUSION

From the above two plastic materials polypropylene and polytetrafluorethylene materials airflow flow properties are analyzed using Computational Fluid Dynamics (CFD) and compared with air flow properties of borosilicate. From the results polytetrafluoroethylene found to be perfectly alright. It can be efficiently used as air filter. From the table it is clear that Plastic Airfilter Polytetra Fluoroethylene (PTFE) has got High mass flow rate initially and high pressure development initially. So polytetrafluoroethylene can be easily replaced for Borosilicate.

REFERENCES

1. Thomas.O.larsen , Tom . L. Anderson , Bent thorning , Marlin .E.Vigild on the effect of “The effect of particle addition and fibrous reinforcement on epoxy matrix composites for severe sliding conditions”, Science direct , Wear 284 (2008) , pp 837-868 .
2. B.Suresha,,Kishore,P.Sampathkumar on “Investigation of the influence of graphite filler on dry sliding wear and abrasive wear behavior of carbon fabric reinforced epoxy composites , Science Direct , Wear 267 (2009) , p.p 1405-1414
3. Michael J.Mcclure,Patrica S. Wolf , David G.Simpson , Scott A.sell , Gary L.Bowl , On the “ The use of air-flow impedance to control fiber deposition patterns during electro spinning “. Science Direct , Biomaterials 33 (2012) p.p 771-779
4. E.Stodolak , T.Gumula,R.Leszczynsi,J.Wieczorek , S.Blazewics on “Composite material used as a membrane for ophthalmology applications “. Elsewere , Composite science and Technology (2010) p.p 1915-1919
5. J.S.Ridgway , J.B.Hull, C.R.Gentle on “development of a novel binder system for manufacture of ceramic heart valve prosthesis”.Journal of material processing technology ,109 (2001) p.p 161-167
6. J.S.Ridgway,J.B.Hull , C.R.Gentle on “prime approach for the moulding of conduit ceramic parts” .Journal of material processing technology 133(2008) p.p 181-188
8. Daniel Hoffmann , Joe o’ Brien , Das Brennan , Michael Loughman on “optically encoded silicon micro beads :Detection and characterization in micro fluidic systems”. Science Direct. Sensors and Actuators B122 (2007) p.p 653-658.
9. T.Shankarlal , A. Mani on “Experimental investigation for ejector refrigeration system with

ammonia “ Science Direct , Renewable energy 32 (2007) p,p 1403 – 1413

10. E.L.Lawrance , I.G.Turner on “Material for Urinary Catheters : a review of their history and development I U.K “. Science direct , Medical Engineering and physics 27 (2005) , p.p 443-453

11.Ahmed Keshtkar on “Design and construction of sized pencil probe to measure bio-impedance “.Science Direct, Medical Engineering and physics 29(2007) p.p 1043-1048