DEVELOPMENT OF DISTRIBUTION FUNCTIONS FOR MODELING OF POLYMER FLOW THROUGH POROUS FILTER MEDIA

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Introduction

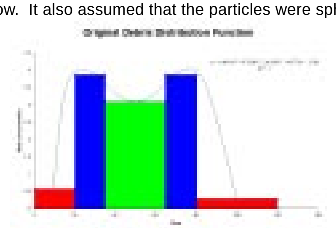
A CAEFF computer program that simulates polymer flow through a porous filter medium was developed for DuPont. The accuracy of the model could be improved by updating the distribution functions and verifying the model's assumptions with experimental data.

Objectives

- Improve computer model's ability to predict debris distribution
- Develop copper and crosslinked Nylon 6,6 particle size distribution functions
- Develop a shape factor distribution function

Distribution Function Assumptions

- Initially, the filtration model assumed a coarse particle size, resulting in the distribution function shown below. It also assumed that the particles were spherical.



- The revised distribution function assumes that smaller spherical particles are predominant in the melt flow because physical phenomena occurring within a process tend to break particles into many smaller pieces.

Particle Analysis

Copper

Object Number	Area (mm^2)	Diameter max (mm)	Diameter min (mm)	Diameter ave (mm)	Perimeter (mm)	Length (mm)	Width (mm)
17	0.00125	0.05304	0.03150	0.03913	0.13820	0.05387	0.03647
22	0.00157	0.05486	0.03453	0.04461	0.15303	0.05568	0.04232
29	0.00180	0.05884	0.03674	0.04664	0.17388	0.05987	0.04860
40	0.00303	0.08381	0.04036	0.05960	0.23404	0.09142	0.04522
42	0.00145	0.04725	0.03874	0.04194	0.14146	0.04387	0.04287
44	0.00103	0.04199	0.02805	0.03536	0.12122	0.03890	0.03094
46	0.00261	0.07861	0.03003	0.05668	0.21805	0.08117	0.04639
54	0.00095	0.04107	0.02791	0.03312	0.12984	0.04689	0.03165
56	0.00105	0.04384	0.02996	0.03456	0.14780	0.05102	0.03827
63	0.00062	0.03076	0.02361	0.02707	0.08944	0.03178	0.02735
64	0.00133	0.05489	0.03029	0.04056	0.15516	0.05493	0.04202
65	0.00082	0.03570	0.02496	0.03200	0.10569	0.03967	0.03049
66	0.00558	0.13418	0.05099	0.07816	0.33138	0.13436	0.05993
75	0.00178	0.05829	0.03068	0.04595	0.16608	0.05685	0.03890
77	0.00035	0.02590	0.01268	0.02102	0.07766	0.02590	0.02053
79	0.00078	0.04609	0.02299	0.03116	0.11931	0.04609	0.02719
81	0.00304	0.07625	0.04442	0.05999	0.22563	0.07274	0.05678
83	0.00162	0.05393	0.03400	0.04357	0.16129	0.05378	0.04084
85	0.00061	0.04227	0.01690	0.02727	0.10165	0.04343	0.01853

Generated data from ImagePro® software of sample A1 Chatt-A-1400

Nylon

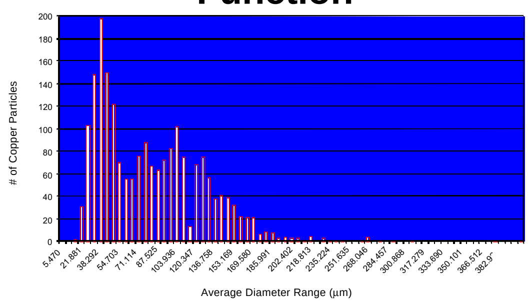
Object Number	Area (μm^2)	Diameter max (μm)	Diameter min (μm)	Diameter ave (μm)	Perimeter (μm)	Length (μm)	Width (μm)
914	75044.9	389.4213	242.8571	302.7171	1093.758	391.2513	264.7294
1499	73795.91	381.9606	248.0948	302.0327	1132.374	365.0217	301.777
1525	36000	232.5546	183.0579	207.7227	750.4526	228.2319	227.5154

Generated data from ImagePro® software of filter bed sample

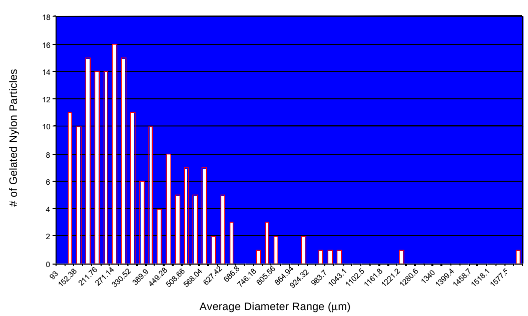
Particle Size Distribution Function Development

- Generated a table of particles' average diameters in μm
- Sorted the average diameters in ascending order
- Determined the maximum and minimum average particle diameters
- Subtracted the minimum from the maximum particle diameter and divided that value by the number of desired ranges, 70 for copper and 50 for nylon, to obtain the range width
  (max-min) / # of ranges = range width
- Counted the number of particles in each range, then plotted the number of particles in each range versus an average particle diameter range in the form of a bar graph

Copper Particle Size Distribution Function



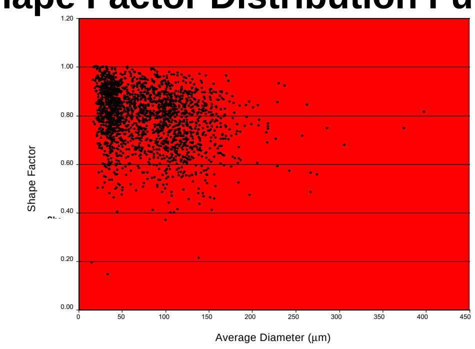
Nylon 6,6 Particle Size Distribution Function



Shape Factor Distribution Function Development

- Calculated the shape factor for each particle
  $\Psi = 4\pi S/P^2$
  where S = cross-sectional area
  P = perimeter
- $\Psi \approx 1$ for sphere-like particles while $\Psi \rightarrow 0$ for thin, cylindrical rod-like particles.
- Graphed shape factor versus average particle diameter in the form of an x-y scatter plot.

Shape Factor Distribution Function



Conclusions

- Copper and gelated nylon 6,6 particle size distribution functions and a shape factor distribution function were successfully developed with data obtained from analysis of mesh screen and filter beds from DuPont.
- With the updated particle size distribution function, the model can provide a more accurate prediction of the pressure distribution and velocity field in a filter medium.
- The shape factor distribution function supports the computer model's assumption of spherical debris particles. The model was verified by the experimental data.
- DuPont can use the improved filtration model to prolong the life of spin packs and increase the cost efficiency of filters.

Acknowledgements: Bijan Seyfzadeh and David Zumbrunnen (Clemson University); Roger Ross, Tina Kravetz, John Buzinkai, and Andy Ragone (DuPont). This work was supported primarily by the ERC Program of the National Science Foundation under Award # EEC 9731680.

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