ESP Example

Given:

- Airflow = Q = 2000 m^3/min
- Average particle charge = q = 10 electron charges
- Electric field = 50,000 V/m
- Particle diameter = d_p = 1 μm
- Each plate dimension = 6m x 3m

Question:
How many plates are needed to achieve a design efficiency of 99%?

ESP Solution

1. Determine Cunningham slip factor @ d_p 1.0 μm

Table 1. Cunningham Slip Correction Factors for Air (298°K, 1.0 atm)			
d_{pa}(μm)	C_c	d_{pa}(μm)	C_c
0.001	221.6	0.1	2.911
0.002	111.1	0.2	1.890
0.003	74.25	0.3	1.574
0.004	55.83	0.4	1.424
0.005	44.78	0.5	1.337
0.006	37.41	0.6	1.280
0.007	32.15	0.7	1.240
0.008	28.20	0.8	1.210
0.009	25.14	0.9	1.186
0.01	22.68	1.0	1.168

2. Calculate electric charge on each particle

   $q = 10e = 10\ (1.6 \times 10^{-19}\ C) = 1.6 \times 10^{-18}\ C$

ESP Solution

3. Calculate drift speed:

$$V_e = \frac{qEC_c}{3\pi\mu d_p} = \frac{(1.6\times10^{-18}\text{C})(5\times10^{4}\text{ V/m})(1.166)}{(3\pi)(1.81\times10^{-5}\text{kg/m.s})(10^{-6}\text{m})} = 5.47\times10^{-4}\text{ m/s}$$

4. For an efficiency of 99%:

$$\exp\left(-\frac{AV_e}{Q}\right) = 1 - 0.99 = 0.01 \quad \Rightarrow \quad \frac{AV_e}{Q} = 4.61$$

ESP Solution

5. Calculate total collecting area:

$$A = \frac{(4.61)(33.33\,\mathrm{m}^3/\mathrm{s})}{(5.47\times10^{-4}\,\mathrm{m}/\mathrm{s})} = 280{,}632\,\mathrm{m}^2$$

Note Q of 2000 m^3/min converted to m^3/sec

6. Calculate number of plates:

Each plate has a collecting area of 6m x 3m = 18 m^2 x 2 sides = 36 m^2

n = number of plates = 280,632 m^2 / 36 m^2 = **7,795 plates**