粘滞系数　　数据处理

张博厚 PB22071354

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1 实验内容

三种小球共同匀速下降区的长度为:

$$l = \frac{1}{3}(18.62 + 18.60 + 18.65)cm = 18.62cm$$

圆筒直径的平均值为:

$$R = \frac{1}{3}(8.154 + 8.050 + 8.020)cm = 8.075cm$$

圆筒高度的平均值为:

$$h = \frac{1}{3}(41.52 + 41.48 + 41.42)cm = 41.47cm$$

蓖麻油的密度为:

$$\rho_0 = \frac{1}{3}(0.9550 + 0.9551 + 0.9551) \times 10^3 kg/m^3 = 0.9551 \times 10^3 kg/m^3$$

蓖麻油的温度为:

$$T = \frac{1}{3}(25.56 + 25.50 + 25.11)^\circ C = 25.39^\circ C$$

1.1 利用大球计算粘滞系数

大球的直径平均值为:

$$d = \frac{1}{6}(0.3487 + 0.3490 + 0.3489 + 0.3490 + 0.3490 + 0.3486)cm = 0.3489cm$$

大球质量平均值为:

$$m = \frac{1}{6}(0.1802 + 0.1801 + 0.1802 + 0.1796 + 0.1799 + 0.1797)g = 0.1800g$$

故其密度为:

$$\rho = \frac{m}{\frac{4}{3}\pi(\frac{d}{2})^3} = \frac{0.1800 \times 10^{-3}}{\frac{4}{3}\pi(\frac{0.3489 \times 10^{-2}}{2})^3} = 8.094 \times 10^3 kg/m^3$$

其通过匀速区的平均时间为:

$$t = \frac{1}{6}(3.09 + 3.05 + 3.13 + 3.07 + 2.99 + 3.11)s = 3.07s$$

故其平均速度为:

$$\overline{v} = \frac{0.1862m}{3.07s} = 0.0607m/s$$

可知粘滞系数为:

$$\eta_0 = \frac{1}{18} \frac{(8.094 - 0.9551) \times 10^3 \times 9.8 \times (0.3489 \times 10^{-2})^2}{0.0607 \times (1 + 2.4 \times \frac{0.3489}{2 \times 8.075})(1 + 3.3 \times \frac{0.3489}{2 \times 41.47})} = 0.7309 Pa \cdot s$$

1.2 利用中球计算粘滞系数

中球直径平均值为:

$$d = \frac{1}{6}(0.1989 + 0.1996 + 0.1991 + 0.1995 + 0.1989 + 0.1997)cm = 0.1993cm$$

中球质量平均值为:

$$m = \frac{1}{6}(0.0342 + 0.0342 + 0.0341 + 0.0340 + 0.0341 + 0.0341)g = 0.0341g$$

其密度为:

$$\rho = \frac{0.0341 \times 10^{-3}}{\frac{4}{3}\pi(\frac{0.1993 \times 10^{-2}}{2})^3} = 8.227 \times 10^3 kg/m^3$$

通过匀速区的平均时间为:

$$t = \frac{1}{6}(8.89 + 8.94 + 8.88 + 8.91 + 8.78 + 8.95) = 8.89s$$

故其平均速度为

$$\overline{v} = \frac{0.1862}{8.89} = 0.0209m/s$$

故粘滞系数为:

$$\eta_0 = \frac{1}{18} \frac{(8.227 - 0.9551) \times 10^3 \times 9.8 \times (0.1993 \times 10^{-2})^2}{0.0209 \times (1 + 2.4 \times \frac{0.1993}{2 \times 8.075})(1 + 3.3 \times \frac{0.1993}{2 \times 41.47})} = 0.7250 Pa \cdot s$$

1.3 利用小球计算粘滞系数

小球直径平均值为:

$$d = \frac{1}{6}(0.1478 + 0.1480 + 0.1480 + 0.1479 + 0.1472 + 0.1472) = 0.1477cm$$

质量平均值为:

$$m = \frac{1}{6}(0.0142 + 0.0144 + 0.0141 + 0.0142 + 0.0139 + 0.0140) = 0.0141g$$

则其密度为:

$$\rho = \frac{0.0141 \times 10^{-3}}{\frac{4}{3}\pi(\frac{0.1477\times10^{-2}}{2})^3} = 8.358 \times 10^3 kg/m^3$$

小球通过匀速区的平均时间为:

$$t = \frac{1}{6}(15.83 + 15.82 + 16.20 + 16.12 + 15.91 + 16.15) = 16.01s$$

平均速度为

$$v = \frac{0.1862}{16.01} = 0.0116m/s$$

粘滞系数:

$$\eta_0 = \frac{1}{18}\frac{(8.358 - 0.9551) \times 10^3 \times 9.8 \times (0.1477 \times 10^{-2})^2}{0.0116 \times (1 + 2.4 \times \frac{0.1477}{2\times8.075})(1 + 3.3 \times \frac{0.1477}{2\times41.47})} = 0.7374Pa \cdot s$$

2   参数修正

大球的雷诺数为:

$$R_{e1} = \frac{2rv\rho_0}{\eta_0} = \frac{0.3489 \times 10^{-2} \times 0.0607 \times 0.9551 \times 10^3}{0.7309} = 0.28$$

因此应做修正:

$$\eta_1 = \eta_0 - \frac{3}{16}dv\rho_0 = 0.7309 - \frac{3}{16}0.3489\times10^{-2}\times0.0607\times0.9551\times10^3 = 0.6930Pa\cdot s$$

中球的雷诺数为:

$$R_{e2} = \frac{0.1993 \times 10^{-2} \times 0.0209 \times 0.9551 \times 10^3}{0.7250} = 0.055 < 0.1$$

故结果不需修正
小球的雷诺数为:

$$R_{e3} = \frac{0.1477 \times 10^{-2} \times 0.0116 \times 0.9551 \times 10^3}{0.7374} = 0.022 < 0.1$$

故结果不需修正