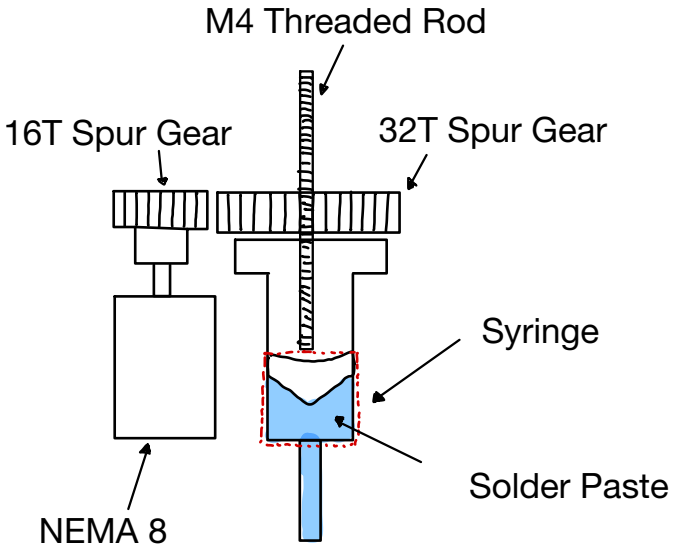
Minimum Torque Calculation

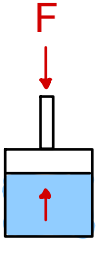


(i)

Free Body Diagram:

$d_{syringe} = 13.5\ mm = 0.0135\ m$

Static:



$A = \frac{\pi}{4} d^2$

$= \frac{\pi}{4} (0.0135)^2$

$A = 1.43 \times 10^{-4}\ m^2$

$P = \frac{8 \eta L Q}{\pi r^4}$

η dynamic viscosity — $\eta = 765\ Pa\,s$

L Length — $L = 0.0123\ m$ (Based on the length needle tip)

Q Volume flowrate — $Q = 1\ \mu L = 1 \times 10^{-9}\ m^3/s$

r radius of syringe — $r = \frac{0.0135}{2}\ m$

$R_{solder\ paste} = P \times A$

$\Sigma F_{y\downarrow +} = 0$

$F - R_{solder\ paste} = 0$

$F = R_{solder\ paste}$

$F = P_{solder\ paste} A_{solder\ paste}$

$F = 115.4 \times 1.43 \times 10^{-4}$

$F = 0.0165\ N$

$P = \frac{8 \times 765 \times 0.0123 \times 1 \times 10^{-8}}{\pi (0.00675)^4}$

$P = 115.4\ Pa$

$$\text{Torque} = \frac{F \cdot \text{pitch}}{2\pi} \qquad \text{pitch} = 0.7\ \text{mm} = 0.0007\ \text{m}$$

$$\text{Torque} = \frac{0.0165 \times 0.0007}{2\pi}$$

$$\text{Torque} = 1.84 \times 10^{-6}\ \text{Nm}$$

Gear ratio (2:1)

$$T_{min\_motor} = \frac{1.84 \times 10^{-6}}{2}$$

$$T_{min\_motor} = 9.2 \times 10^{-7}\ \text{Nm}$$