From the definition of pressure, we derived the suction force F.

$P = \frac{F}{A}$ ⟶ $F = P * A$

Where,

F : is the suction force or lifting capacity

P: is the Pressure

A: is the contact area (size of suction cup)

For a vertical suction cup with a vertical direction force, the suction force becomes the following:

$$F = \left(\left(\frac{m}{\mu}\right) * \left((\mathrm{g} + \mathrm{a}) * S\right)\right)$$

With,

m = mass = h * l * w * ρ = height * length * width *density

a = acceleration of the system = $\frac{V}{t}$

μ = viscosity = (0.1 – 0.3)

S = factor of safety (2.0 – up) suggested value for a smooth/closely compacted workpiece surfaces, and for vertically applied loads.

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With,

m = mass = height * length * width *density = h * l * w * ρ = 0.0118 * 1.5354 * 0.4291 * 0.0390 =
m = 0.00013773 kg = 0.13773 * 10^{-3} Kg = 0.138 g = 0.0003 lbs.

a = acceleration of the system = $\frac{V}{t}$

$\mu =$ viscosity = (0.1 – 0.3)

g = 9.81 m/s^2 = 386.22 in/s^2

S = 2, (suggested factor of safety value is 2.0 – up for oiled workpieces and vertical suction gripper position).

We need to find the velocity to compute the acceleration of the system.

Using the Bernoulli's equation, also called Energy equation, we found that the atmospheric pressure should be higher than the head pressure for lifting to occur.

$$\underbrace{P_1}_{\text{Pressure energy}} + \underbrace{(\rho * g * h_1)}_{\text{Potential energy}} + \underbrace{\frac{1}{2}(\rho * V_1^2)}_{\text{Kinetic energy}} = \text{Constant}$$

$$P_1 + (\rho * g * h_1) + \frac{1}{2}(\rho * V_1^2) = P_2 + (\rho * g * h_2) + \frac{1}{2}(\rho * V_2^2)$$

The above equation reduces to the following:

$$P_1 = (\rho * g * h_2) \longrightarrow P_1 = P_{atm} > P_2 = P_h$$

Equalizing the energy equation of the two different points, (point1 being the flower & point2 being the backpack style machine), we will solve for the velocity.

$$P_1 + (\rho * g * h_1) + \frac{1}{2}(\rho * V_1^2) = P_2 + (\rho * g * h_2) + \frac{1}{2}(\rho * V_2^2)$$

$P_1 = 0$, $h_1 = 0$, $V_1 = 0$

$$P_1 = (\rho * g * h_2) + \frac{1}{2}(\rho * V_2^2)$$

$$V = \sqrt{\frac{2*[P1 - (\rho * g * h2)]}{\rho}} = \sqrt{\frac{2*[101325 - (1080 * 9.81 * 0.15)]}{1080}} = 0.97 \text{ m/s} = 38.189 \text{ in/s}$$

$$V = 0.97\ m/s = 38.189 \text{ in/s}$$

Now that we have the velocity, let's find the acceleration, then the suction force.

$a = \frac{V}{t} = \frac{0.97}{0.5} = 1.94 \text{ m/s}^2$ $\qquad$ $a = 1.94 \text{ m/s}^2 = 76.38 \text{ in/s}^2$

$$F = \left(\left(\frac{m}{\mu}\right) * \left((g + a) * S\right)\right) = \left(\left(\frac{0.138}{0.3}\right) * \left((9.81 + 1.94) * 2\right)\right) = 10.81 \approx 11 \text{ N} = 2.47 \text{ lbf}$$

Thus, the suction force yields the following:

$$F = 11\text{N} = 2.47 \text{ lbf}$$

Checking the pressure yields the following:

$$P = \frac{F}{A}$$

$A = 2 * \{(w * l) + (h * l) + (h * w)\} = 2 * \{(0.1105 * 0.0305) + (0.00009 * 0.0305) + (0.00009 * 0.1150)\}$

$A = 0.0068 \text{ m}^2 = 10.54 \text{ in}^2$

$$P = \frac{11}{0.0068} = 1617.65 \text{ N/m}^2 = 0.2346 \text{ psi}$$

$$P = P_2 = P_h = 1617.65 \approx 1618 \text{ N/m}^2 = 0.2346 \text{ psi}$$

Which confirms our previous assumption of:

$P_1 = P_{atm} > P_2 = P_h$ $\qquad$ $101325 \text{ N/m}^2 > 1618 \text{ N/m}^2$

Hence, suction will occur as predicted.