Open Source Ventilator

Pakistan

Modeling of C-7 Open Lung Ventilator

Radial Arm De-pressor

March 27, 2020

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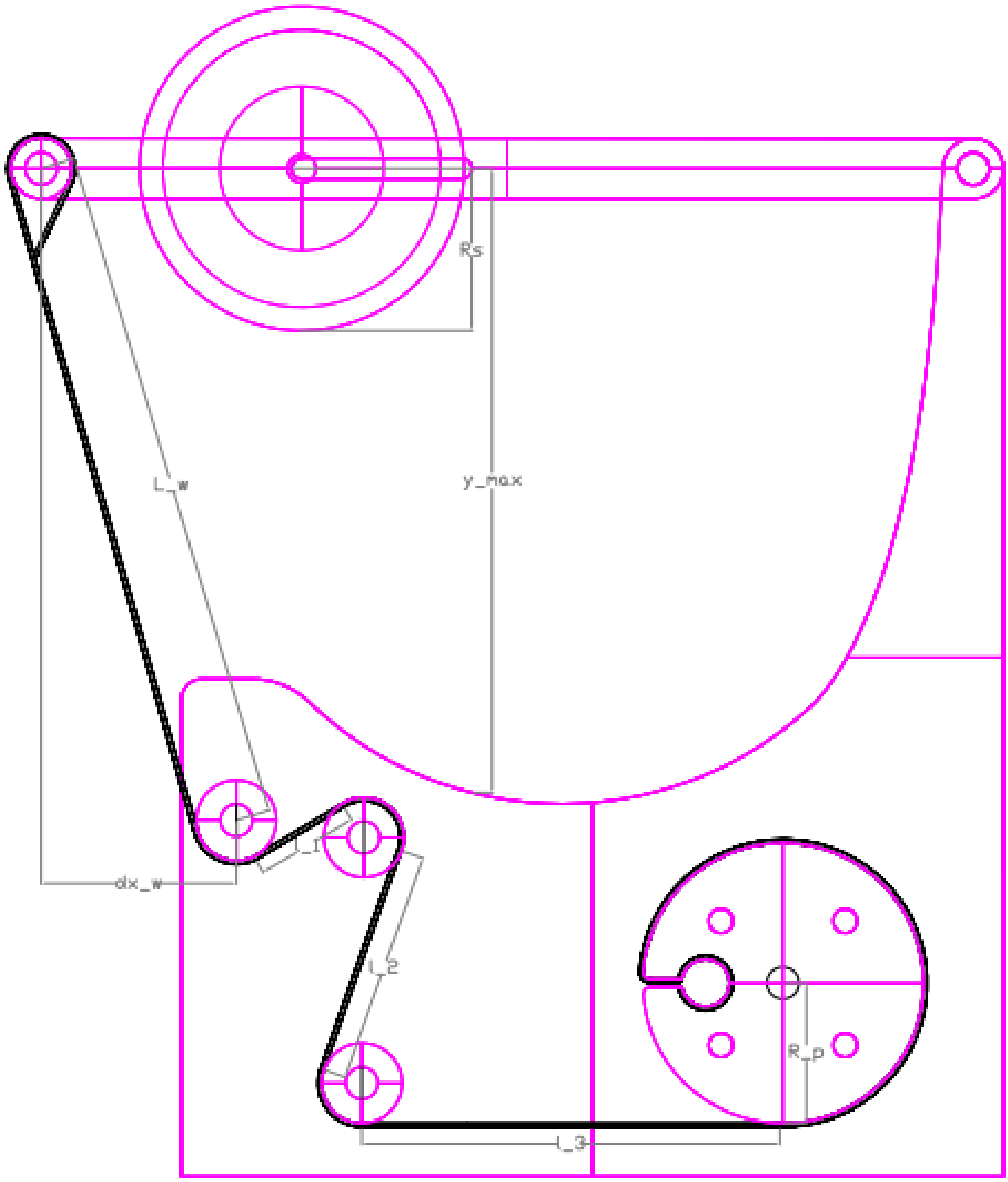
1. Kinematics Modeling



Assuming linearity and establishing cartesian kinematics, the geometry above provides the equation:

$$\theta° = \frac{180(y_{max} - R_S)}{\pi R_M * \cos{(\alpha_{web})}}$$

where,

$$\alpha_{web} = \sin^{-1}\left(\frac{dx_w}{L_w}\right) = 16.67°$$

$$R_S = Radius\ of\ Sticky\ Roller$$

$$R_M = Radius\ of\ Motor\ Roller$$

Since the sticky roller is free to roller, we can neglect large adhesion; hence, approximating using Hertz's equation, and assuming incompressibility for the given temperature and pressure withing BVM, the following equations can be used to estimate the belt velocity and hence the required angular velocity from the time derivation of equation (1), assuming steady state:

$$v_b = \frac{Q_{BVM}}{A_{cont}}$$

$$A_{cont} = 2a * w_S$$

where,

$$Q = Volume\ flow\ rate\ from\ BVM$$

$$w_S = width\ of\ sticky\ roller$$

$$A_{cont} = Contact\ area$$

$$a = \frac{4FR_S}{\pi E^*}$$

where,

$$F = m_s g = \rho_s * \forall_s * g$$

$$E^* = \frac{1 - v_S}{E_S} + \frac{1 - v_{BVM}}{E_{BVM}}$$

thus, the rotational velocity at motor is given by:

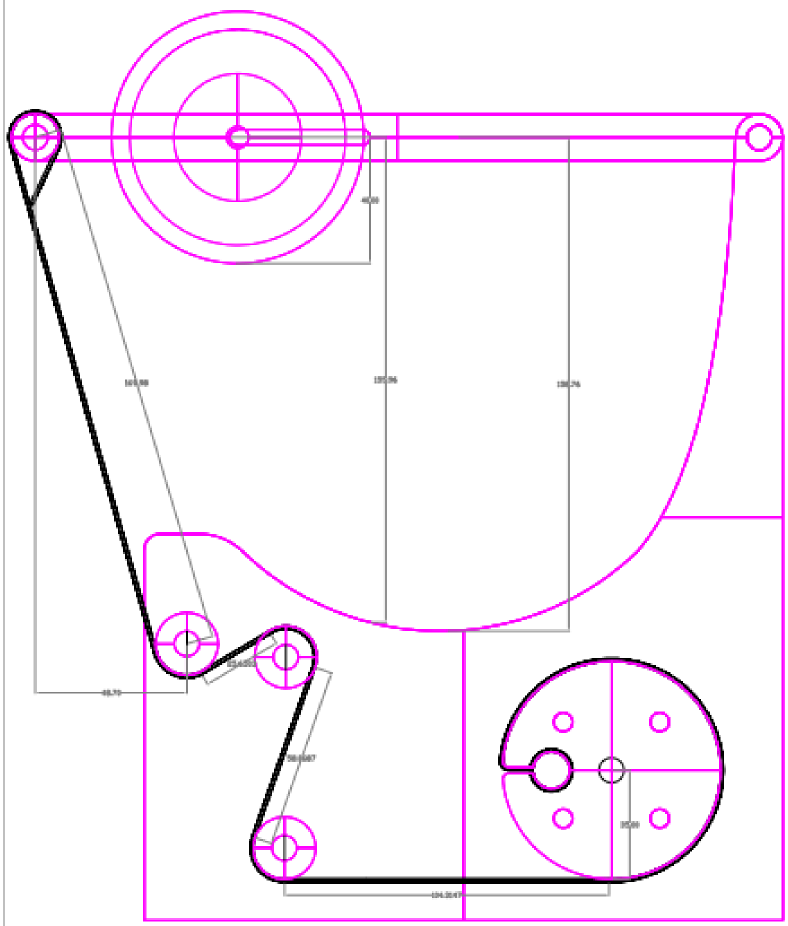
$$v_b = R_M \frac{d\theta}{dt}$$

$$\omega = \frac{v_b}{R_M}$$

where,

$$v_b = approx.\ belt\ velocity$$

1.1 Example case



Referring to the geometry and assuming linearity, it is possible to establish cartesian coordinates for the scenario shown (the starting position); for the maximum travel by the motor roller, the case is as follows (assuming mm units):

- Vertical max travel by sticky roller =~ 116
- since the relative length of lever and relative positions of rollers does not change, we assume the lever travels uniformly vertical, hence the angle of belt at webbing = 16.65 deg
- Thus the dL (length of belt being rolled) =~ 116/cos(16.65) = 121
- It is assumed that the belt remains taut the entire duration of travel. hence the length between the triple rollers and the pressure roller remains constant, thus, angular displacement by pressure roller = dL / radius of pressure roller = $\frac{121}{35}$ = 3.46 rad
- Turn by stepper in degrees = 3.46*180/pi() = 198.24 deg

Notes:

- The model only provides an approximation and since the fluid dynamics consists of non-linearity, it is best to create a prototype and measure the appropriate flow, pressure and volume that is being output for various cases. This should then be tabulated for the purpose of calibration and further testing.