Appendix 4:

Structural Analysis

Structural Analysis: Part 1. : Mounting to a Cylindrical Satellite

S1.1

Given

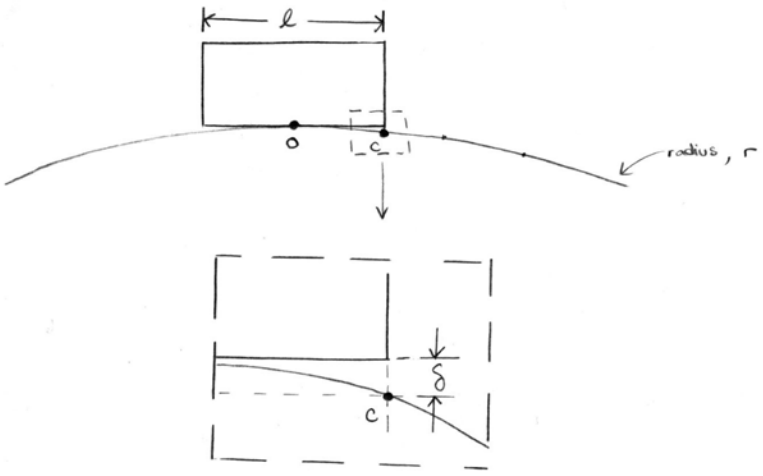
Able to attach to flat plates and surfaces with a radius of 18in or larger.

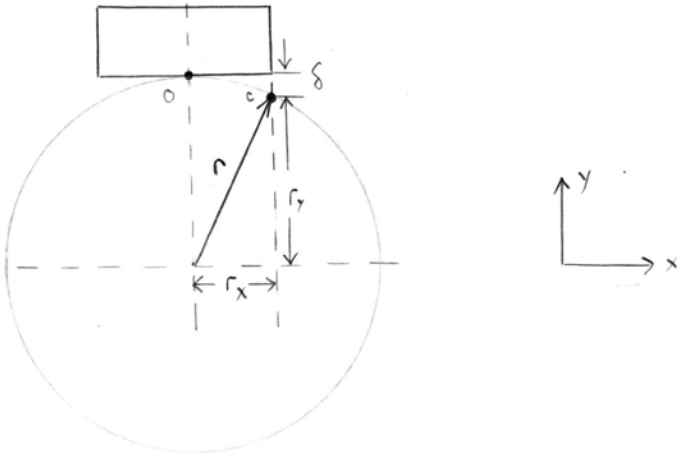
Geometry of the enclosure, $\ell = w = 2.875$ in

Find

Show that the enclosure is able to attach to a surface of $r = 18$ in

Diagram





$O = (0, r)$

$C = (r_x, r_y) = (\ell/2, r - \delta)$

Structural Analysis: Part 1.: Mounting to a Cylindrial Satellite

Analysis

$$r^2 = r_x^2 + r_y^2 = \left(\frac{\ell}{2}\right)^2 + (r-\delta)^2 = \frac{\ell^2}{4} + r^2 - 2r\delta + \delta^2$$

$$\delta^2 - 2r\delta + \frac{\ell^2}{4} = 0$$

$$\delta = \frac{-(-2r) \pm \sqrt{(-2r)^2 - 4(\ell^2/4)}}{2} = r \pm \sqrt{r^2 - \ell^2/4}$$

$$\delta = (18\text{in}) \pm \sqrt{(18\text{in})^2 - (2.875\text{in})^2/4} = .05749\text{ in},\ 35.9425\text{in}$$

↑ reject

Solution

$$\boxed{\delta(r) = r - \sqrt{r^2 - \ell^2/4}}$$

r (in)	δ (in)
18	.05749in
20	.05173in
25	.04136in
30	.03446 in

$$\boxed{\delta_{Max} = .05749\text{in}}$$

$\delta_{Max} = .05749\text{in} < 1/16\text{in}$. Add an additional amount of adhesive to account for δ on cylinders with radius r.

Structural Analysis: Part 2: Total Mass

Given

The total mass is given by m_t

The connector mass is given by $m_{c,t}$

The DB9 connector mass, $m_{c,1}$, is 0.02 lb } Right Angle connectors

The MicroD 9S connector mass, $m_{c,2}$, is 3.9g

The MicroD 15S connector mass, $m_{c,3}$, is 4.7g

The density of the 300 Series Stainless Steel, ρ_s, is .2908 lb/in^3

Geometry of the Screw

Mass of the enclosure from the part models, $m_{e,t}$

Mass of the PCB, m_p is 0.02 lb

Find

Total mass, $m_t < .3$ lb

Assumptions

(1) The given masses of the connectors are correct

(2) The given density of the screw is correct

(3) Neglect the mass of the cables

Analysis

$$m_t = m_{e,t} + m_{s,t} + m_{c,t} + m_p$$

where $m_{e,t}$ is the total mass of the enclosure

$m_{s,t}$ is the total mass of the screws

$m_{c,t}$ is the total mass of the connectors

m_p is the mass of the PCB

$$m_{c,t} = m_{c,1} + m_{c,2} + m_{c,3}$$

$$m_{s,t} = 16 \cdot m_s$$

$$m_s = \rho_s \forall_s$$

$$\forall_s = \pi r^2 h + \pi R^2 H = \frac{\pi}{4}\left(d^2 h + D^2 H\right)$$

Structural Analysis: Part 2: Total Mass

S 2.2

$d = .06in$, $h = .25in$, $D = .116in$, $H = .044in$

$$\forall_s = \frac{\pi}{4}\left[(.06in)^2(.25in) + (.116in)^2(.044in)\right] = .0017186\,43\ in^3$$

$$m_s = \rho_s \forall_s = (.2908\ lb/in^3)(.0011718 6in^3) = 3.4 \times 10^{-4}\ lb$$

$$m_{t,s} = 16 \cdot m_s = 16\,(3.4 \times 10^{-4} lb) = .0054524503\ lb$$

$m_{t,s} = .0054524503\ lb$

$$m_{c,1} + m_{c,2} = 3.9g + 4.7g = 8.6g = .018959754547 9\ lb$$

$$m_{c,t} = m_{c,1} + m_{c,2} + m_{c,3} = .018916 + 0.02\,lb = .0389597545479\ lb$$

$m_{c,t} = .0389597545479\ lb$

$m_p = 0.02\ lb$

From the assembly model the mass of the enclosure is

$$m_{e,t} = m_t + m_b + m_{s,a} + m_{s,b}$$

From Pro/Engineer: $m_t = 5.0291459 \times 10^{-2}\ lb$

$m_b = 1.0126249 \times 10^{-1}\ lb$

$m_{s,a} = 1.4428541 \times 10^{-2}\ lb$

$m_{s,b} = 1.3799165 \times 10^{-2}\ lb$

$m_{e,t} = 0.17978165 5\ lb$

$$m_t = m_{t,s} + m_{c,t} + m_p + m_{e,t}$$

$m_t = 0.2441938598\ lb$

Solution

$m_t = 0.24419\ lb < 0.3\ lb$

Structural Analysis : Part 3: Enclosure Size

Given

Geometry of the enclosure, $\ell = w = 2.875in$, $h = 1.0625in$

Geometry of the PCB, $\ell = 2.61in$, $w = 2.25"$, $h = .0625in$

Connector height, $h = 0.5in$

Find

Dimensions of the enclosure (outer dimensions) versus the PCB (w/ connectors)

Analysis

The enclosure outer dimensions are $\ell = w = 2.875in$, $h = 1.0625in$

The PCB outer dimensions are $\ell = 2.61in$, $w = 2.25$, $h = .5625in$

The difference is $\ell_d = 0.265in$, $w_d = 0.625in$, $h_d = 0.5in$

The percent difference is $\ell_p = 10.15\%$, $w_p = 27.78\%$, $h_p = 88.88\%$

The mounting of the PCB accounts for a height of $h_m = 0.25in$

The connections of the sides accounts for $w_s = 0.5in$

The new difference is $\ell_{d'} = 0.26in$, $w_{d'} = .125in$, $h_{d'} = .3125in$

Solution

The difference in the dimensions is $\ell_{d'} = 0.26in$

$w_{d'} = .125in$

$h_{d'} = .3125in$