Arm Cavity Baffle blade D1002608-V4 revised 8/13/12

3/4/13

acceleration of gravity, m/s^2 $g := 9.8$

Revised DESIGN TO HOLD 170.5 **LBS**

Arm Cavity baffle blade spring D1002608-v4

corrected E factor, based on data from D1002608-v3 sn 001 $\rho := 0.9896$

reduced modulus of elasticity, Pa $E := 186 \cdot 10^{9} \cdot \rho$ $E = 1.84066 \times 10^{11}$

modulus of elasticity, psi $E_{psi} := \frac{E}{6895}$ $E_{psi} = 2.66955 \times 10^{7}$

yield stress of C-250 steel, Pa $S_{yieldms} := 1800 \cdot 10^{6}$

yield stress of C-250 steel, psi $S_{yieldmspsi} := S_{yieldms} \cdot \left(1.45 \cdot 10^{-4}\right)$

$S_{yieldmspsi} = 2.61 \times 10^{5}$

Blade Parameters

number of springs $N := 1$

arc of blade spring, rad $\theta_m := \frac{\pi}{6}$

blade arc angle, deg $\theta_{mdeg}(\theta_m) := \theta_m \cdot \frac{180}{\pi}$ $\theta_{mdeg}(\theta_m) = 30$

radius of blade spring, m $R_{bs} := 0.765$

radius of blade spring, in $R_{bsin} := \frac{R_{bs}}{.0254}$ $R_{bsin} = 30.11811$

horizontal distance of suspension point from blade spring mount, in $x_{bsin}(\theta_m) := R_{bsin} \cdot \sin(\theta_m)$ $x_{bsin}(\theta_m) = 15.05906$

horizontal distance of suspension point from blade spring mount, m $x_{bs}(\theta_m) := x_{bsin}(\theta_m) \cdot .0254$ $x_{bs}(\theta_m) = 0.3825$

length of blade spring, m $l_{bs}(\theta_m) := R_{bs} \cdot \theta_m$

length of blade spring, in $l_{bsin}(\theta_m) := \frac{l_{bs}(\theta_m)}{.0254}$ $l_{bsin}(\theta_m) = 15.76981$

design weight, lb $m_{bslb} := 170.5$

design width, in $b_{in} := 2.704$

Weight suspended

weight of baffle with fixed balance weights, lbs $m_o := 122.6 + 39.9$ $m_o = 162.5$

balance wt, lbs $m_V := 170.5 - 162.5$ $m_V = 8$

weight of total suspended baffle with variable balance weights, lbs $m_{bslb} := m_o + m_V$ $m_{bslb} = 170.5$

mass of total baffle, kg $m_{mb}(m_{bslb}) := \frac{m_{bslb}}{2.205}$ $m_{mb}(m_{bslb}) = 77.32426$

mass supported by each blade spring, kg $m_{bs}(m_{bslb}) := \frac{m_{mb}(m_{bslb})}{N}$ $m_{bs}(m_{bslb}) = 77.32426$

load on blade spring, N $P(m_{bslb}) := m_{bs}(m_{bslb}) \cdot 9.8$ $P(m_{bslb}) = 757.77778$

Calculate thickness

$$t(m_{bslb}) := \left(\frac{12 \cdot P(m_{bslb}) \cdot R_{bs}^{\ 2}}{0.0254 \cdot E \cdot b_{in}} \cdot \sin\left(\frac{l_{bsin}(\theta_m)}{R_{bsin}} \right) \right)^{\frac{1}{3}}$$

thickness of blade spring, in

$$t_{in}(m_{bslb}) := \frac{t(m_{bslb})}{.0254} \qquad t_{in}(m_{bslb}) = 0.23419$$

incremental weight change with δt in increase in thickness, lbs

$$\delta m_{\delta tbslb}(\delta t) := m_{bslb} \cdot \left[\left(\frac{t_{in}(m_{bslb}) + \delta t}{t_{in}(m_{bslb})} \right)^3 - 1 \right]$$

$$\delta t := 0.001$$

$$\delta m_{\delta tbslb}(\delta t) = 2.19347$$

maximum stress, Pa

$$S_{wms} := \frac{E \cdot t(m_{bslb})}{2 \cdot R_{bs}}$$

$$S_{wms} = 7.1562 \times 10^{8}$$

maximum stress, psi

$$S_{wspsi} := S_{wms} \cdot 1.45 \cdot 10^{-4} \qquad S_{wspsi} = 1.03765 \times 10^{5}$$

factor of safety

$$FS := \frac{S_{yieldms}}{S_{wms}} \qquad FS = 2.5153$$

constant factor, m

$$C(\theta_m, m_{bslb}) := \frac{6 \cdot P(m_{bslb}) \cdot R_{bs}}{S_{wms} \cdot t(m_{bslb})^2}$$

$$C(\theta_m, m_{bslb}) = 0.13736$$

$$\frac{C(\theta_m, m_{bslb}) \cdot \sin\left(\frac{l_{bsin}(\theta_m)}{R_{bsin}} \right)}{0.0254} = 2.704$$

Vertical Bounce Frequency

vertical height of suspension from blade spring mount, m

$$y_{bs}(\theta_m) := R_{bs} \cdot (1 - \cos(\theta_m))$$

$$y_{bs}(\theta_m) = 0.10249$$

vertical height of suspension from blade spring mount, in

$$y_{bsin}(\theta_m) := \frac{y_{bs}(\theta_m)}{0.0254}$$

$$y_{bsin}(\theta_m) = 4.03506$$

unloaded height of blade spring, m

$$y_{max} := l_{bs}(\theta_m)\cdot\sin(\theta_m)$$

vertical distance blade moves, m

$$\Delta_y(\theta_m) := y_{max} - y_{bs}(\theta_m) \qquad \Delta_y(\theta_m) = 0.09779$$

vertical distance blade moves, in

$$\Delta_{yin}(\theta_m) := \frac{\Delta_y(\theta_m)}{0.0254} \qquad \Delta_{yin}(\theta_m) = 3.84984$$

vertical resonant frequency based on blade depression, Hz

$$f_{0v}(\theta_m) := \frac{\sqrt{\dfrac{g}{\Delta_y(\theta_m)}}}{2\cdot\pi} \qquad f_{0v}(\theta_m) = 1.59329$$

effective spring constant, N/m

$$k := \frac{m_{mb}(m_{bslb})\cdot g}{\Delta_y(\theta_m)}$$

$$k = 7.74935 \times 10^{3}$$

ACB target, lbs

$$m_{tarlb} := 1.2$$

ACB target ctrwt, lbs

$$m_{ctrlb} := 0.25$$

total ACB target + ctrwt, lbs

$$m_{tartlb} := m_{tarlb} + m_{ctrlb}$$

$$m_{tartlb} = 1.45$$

ACB target + ctrwt, kg

$$m_{tartkg} := \frac{m_{tartlb}}{2.205} \qquad m_{tartkg} = 0.6576$$

ACB, lbs

$$m_{bslb} = 170.5$$

height change due to ACB target-ctrwt, m

$$\Delta h := m_{tartkg}\cdot\frac{g}{k}$$

$$\Delta h = 8.31611 \times 10^{-4}$$

horiz. distance from ACB SUS to target m $x_{acbtar} := 0.2$

horiz. distance from ACB SUS to ctrwt m $x_{acbctr} := 0.4$

vertical height of target from SUS point, m $h_{tar} := 52.659 \cdot 0.0254$

vertical height of ACB CG from SUS point, m $h_{acb} := 40.474 \cdot 0.0254$

vertical height of ctr weight from SUS point, m $h_{ctr} := 31.85 \cdot 0.0254$ $m_{bslb} = 170.5$

tilt angle of unbalanced ACB with target, rad

$$\theta := \frac{x_{acbtar} \cdot m_{tarlb} - x_{acbctr} \cdot m_{ctrlb}}{h_{acb} \cdot m_{bslb} + h_{tar} \cdot m_{tarlb} + h_{ctr} \cdot m_{ctrlb}}$$

$$\theta = 7.90567 \times 10^{-4}$$

horizontal displacement of ACB, m $x_{ACB} := h_{acb} \cdot \theta$

$$x_{ACB} = 8.12734 \times 10^{-4}$$

height change due to ACB target-ctrwt, m $\Delta h := m_{tartkg} \cdot \frac{g}{k}$

$$\Delta h = 8.31611 \times 10^{-4}$$

height change with added weight, m $\Delta h_{bal} := 0.031 \cdot 0.0254$ $\Delta h_{bal} := 0.0417 \cdot ($

balance weight increment to cause
0.031 in deflection, lb

$$\Delta m_{ballb} := \frac{\Delta h_{bal} \cdot k \cdot 2.025}{g}$$

$$\Delta m_{ballb} = 1.69603$$

incremental force for
1.26 lb weight change, N

$$\delta F := \frac{1.26}{2.205} \cdot g$$

height change per lb of added weight, m

$$\delta h := \frac{\delta F}{k}$$

$\delta h = 7.22641 \times 10^{-4}$

$\delta h_{in} := \frac{\delta h}{0.0254}$

Pendulum Frequency

length of pendulum, m $l_{fiw} := 40 \cdot 0.0254$ $l_{fiw} = 1.016$

pendulum frequency, Hz $f_{0p} := \frac{\sqrt{\frac{g}{l_{fiw}}}}{2 \cdot \pi}$ $f_{0p} = 0.4943$

WIDTH OF BLADE SPRING

blade width at lin from tip, in $b_{in}(\theta_m, l_{in}, m_{bslb}) := \frac{C(\theta_m, m_{bslb})}{.0254} \cdot \sin\left(\frac{l_{in}}{R_{bsin}}\right)$

blade width at 1/4 from tip, in $b_{in}\left(\theta_m, \frac{l_{bsin}(\theta_m)}{4}, m_{bslb}\right) = 0.70589$

$\frac{l_{bsin}(\theta_m)}{4} = 3.94245$

blade width at 1/2 from tip, in $b_{in}\left(\theta_m, \frac{l_{bsin}(\theta_m)}{2}, m_{bslb}\right) = 1.39969$

$\frac{l_{bsin}(\theta_m)}{2} = 7.8849$

blade width at 3/4 from tip, in $b_{in}(\theta_m, l_{bsin}(\theta_m) \cdot 0.75, m_{bslb}) = 2.06955$

$l_{bsin}(\theta_m) \cdot 0.75 = 11.82735$

max width of blade spring, in

$$b_{in}(\theta_m, l_{bsin}(\theta_m), m_{bslb}) = 2.704$$

$$b_{inm}(\theta_m, m_{bslb}) := b_{in}(\theta_m, l_{bsin}(\theta_m), m_{bslb})$$

$$l_{bsin}(\theta_m) = 15.76981$$

Solid Works equation

$$x := 0$$

blade width amplitude, in

$$\frac{C(\theta_m, m_{bslb})\cdot\sin\left(\frac{l_{bsin}(\theta_m)}{R_{bsin}}\right)}{0.0254} = 2.704$$

$$y_{down}(x) := -2.70398\cdot\sin\left(\frac{x}{30.11811}\right)$$

$$y_{up}(x) := 2.70398\cdot\sin\left(\frac{x}{30.11811}\right)$$

straight line eqtn

$$sl(l_{in}) := \frac{C(\theta_m, m_{bslb})\cdot\sin\left(\frac{l_{bsin}(\theta_m)}{R_{bsin}}\right)}{2\cdot 0.0254}\cdot\frac{l_{in}}{l_{bsin}(\theta_m)}$$

Stress at any Cross Section

maximum torque at mount, in-lb

$$\tau_{wall} := x_{bsin}(\theta_m)\cdot m_{bslb}$$

$$\tau_{wall} = 2.56757 \times 10^3$$

stress at x, Pa

$$S(\theta_m, m_{bslb}, x) := \frac{6\cdot P(m_{bslb})\cdot R_{bs}\cdot\sin\left(\frac{x}{R_{bsin}}\right)}{.0254\cdot b_{in}(\theta_m, x, m_{bslb})\cdot t(m_{bslb})^2}$$

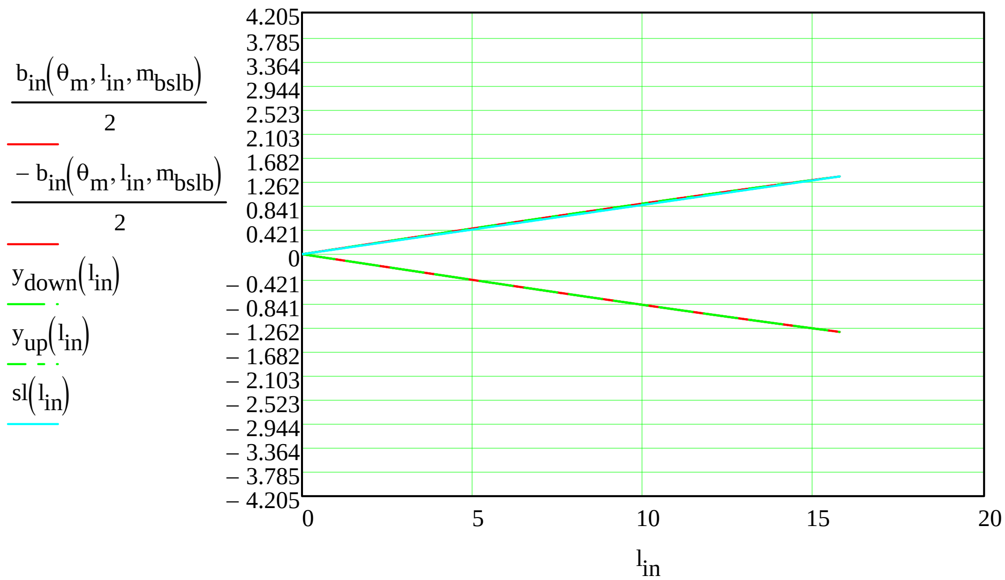
$$x := \frac{l_{bsin}(\theta_m)}{2} \qquad x := 0.1$$

Stress at position x, Pa	$S(\theta_m, m_{bslb}, x) = 7.1562 \times 10^{8}$
Stress at position x, psi	$S_{psi}(\theta_m, m_{bslb}, x) := S(\theta_m, m_{bslb}, x) \cdot (1.45 \cdot 10^{-4})$
	$S_{psi}(\theta_m, m_{bslb}, x) = 1.03765 \times 10^{5}$
Design Stress at position x, psi	$S_{wspsi} = 1.03765 \times 10^{5}$

summary of design parameters

factor of safety	$FS = 2.5153$
weight of baffle plus balance wt, lbs	$m_{bslb} = 170.5$
blade arc, deg	$\theta_{mdeg}(\theta_m) = 30$
blade length, in	$l_{bsin}(\theta_m) = 15.76981$
thickness, in	$t_{in}(m_{bslb}) = 0.23419$
maximum width, in	$b_{inm}(\theta_m, m_{bslb}) = 2.704$
radius of blade spring, in	$R_{bsin} = 30.11811$
horizontal distance of suspension point from blade spring mount, in	$x_{bsin}(\theta_m) = 15.05906$
vertical height of suspension from blade spring mount, in	$y_{bsin}(\theta_m) = 4.03506$
vertical bounce frequency, Hz	$f_{0v}(\theta_m) = 1.59329$
effective spring constant, N/m	$k = 7.74935 \times 10^{3}$
pendulum frequency, Hz	$f_{0p} = 0.4943$

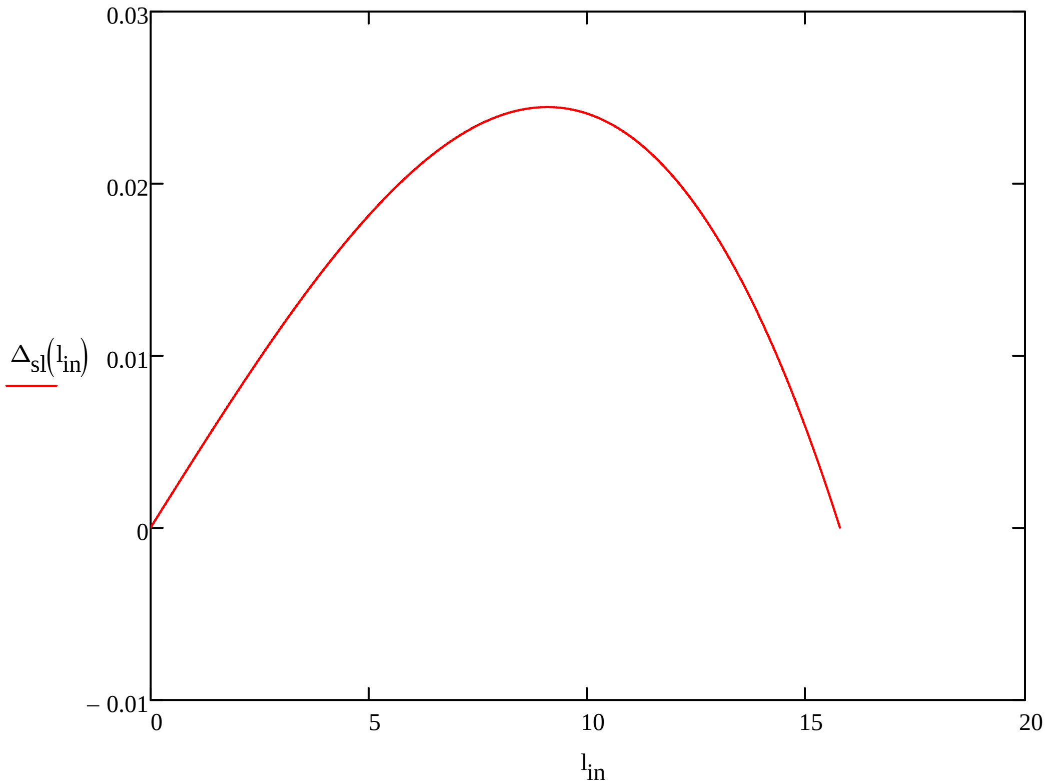
$l_{in} := 0, 0.001 .. l_{bsin}(\theta_m)$



$l_{in} := 1$

$l_{in} := 0, 0.001 .. l_{bsin}(\theta_m)$

difference from straight line $\Delta_{sl}(l_{in}) := y_{up}(l_{in}) - sl(l_{in})$



support of baffle with flexure rod

yield stress of C-250 steel, Pa $\quad S_{yieldms} := 1800 \cdot 10^{6}$

yield stress of C-250 steel, psi $\quad S_{yieldmspsi} := S_{yieldms} \cdot \left(1.45 \cdot 10^{-4}\right)$

$$S_{yieldmspsi} = 2.61 \times 10^{5}$$

factor of safety $\quad FS_{wire} := 31$

working stress of flexure wire, psi $\quad S_{wpsi} := \frac{S_{yieldmspsi}}{FS_{wire}} \quad S_{wpsi} = 8.41935 \times 10^{3}$

working stress of flexure wire, Pa $\quad S_{ws} := \frac{S_{wpsi}}{1.45 \cdot 10^{-4}} \quad S_{ws} = 5.80645 \times 10^{7}$

number of wires per spring $N_w := 1$

diameter of wire, m $d_w := \sqrt{\frac{4 \cdot m_{bs}(m_{bslb}) \cdot g}{\pi \cdot S_{ws} \cdot N_w}}$ $d_w = 4.07634 \times 10^{-3}$

diameter of wire, in $d_{win} := \frac{d_w}{0.0254}$ $d_{win} = 0.16049$

weight of baffle, lbs $m_{bslb} = 170.5$

mass of baffle, kg $m_{mb}(m_{bslb}) = 77.32426$

mass supported by each wire, kg $m_{bs}(m_{bslb}) := \frac{m_{mb}(m_{bslb})}{N}$ $m_{bs}(m_{bslb}) = 77.32426$

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