ITM Elliptical Baffle blade, D1002753-v5

1/18/13

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

D1002753-v5 blades

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

Weight suspended

suspended bare baffle weight wt, lb $m_{wtlb} := 52.05 - 4 \cdot 1.26$ $m_{wtlb} = 47.01$

note: the magnets are estimated @ 0.1 lbs

fixed balance wt, lbs $m_f := 2 \cdot 1.26$

variable balance wt, lbs $m_v := 2 \cdot 1.26$

design weight is suspended bare baffle with fixed + variable balance weights, lbs $m_{bslb} := m_{wtlb} + m_f + m_v$

$m_{bslb} = 52.05$

note: add an additional variable wt, or remove original variable wt for vertical weight balance.

mass of total baffle, kg $m_{mp}(m_{bslb}) := \frac{m_{bslb}}{2.205}$ $m_{mp}(m_{bslb}) = 23.60544$

mass supported by each blade spring, kg $m_{bs}(m_{bslb}) := \frac{m_{mp}(m_{bslb})}{N}$ $m_{bs}(m_{bslb}) = 23.60544$

load on blade spring, N $P(m_{bslb}) := m_{bs}(m_{bslb}) \cdot 9.8$ $P(m_{bslb}) = 231.33333$

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

$$t_{in}(m_{bslb}) := \frac{t(m_{bslb})}{.0254} \qquad t_{in}(m_{bslb}) = 0.15769$$

incremental weight change
with δt in increase
in thickness, lbs

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

$$\delta t := 0.001$$

$$\delta m_{\delta tbslb}(\delta t) = 0.99654$$

maximum stress, Pa

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

$$S_{wms} = 4.81853 \times 10^{8}$$

maximum stress, psi

$$S_{wspsi} := S_{wms}\cdot 1.45\cdot 10^{-4} \qquad S_{wspsi} = 6.98686 \times 10^{4}$$

factor of safety

$$FS := \frac{S_{yieldms}}{S_{wms}} \qquad FS = 3.73558$$

constant factor, m

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

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

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

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

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

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

effective spring constant, N/m

$$k := \left(2\cdot\pi\cdot f_{0v}(\theta_m)\right)^2\cdot m_{mp}(m_{bslb})$$

$$k = 2.36571\times10^3$$

incremental force for 0.25 lb weight change, N

$$\delta F := \frac{0.25}{2.205}\cdot g$$

height change with 0.25 lb added weight, m

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

$$\delta h = 4.69673\times10^{-4}$$

Pendulum Frequency

length of pendulum, m

$$l_{fiw} := 47.1\cdot0.0254 \qquad l_{fiw} = 1.19634$$

pendulum frequency, Hz $f_{0p} := \dfrac{\sqrt{\dfrac{g}{l_{fiw}}}}{2\cdot\pi}$ $f_{0p} = 0.45552$

WIDTH OF BLADE SPRING

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

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

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

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

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

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 $\dfrac{C(\theta_m, m_{bslb})}{2\cdot .0254} = 2.704$ $R_{bsin} = 30.11811$

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

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

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

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

$$\tau_{wall} = 783.82382$$

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

$$S(\theta_m, m_{bslb}, x) = 4.81853 \times 10^8$$

Stress at position x, psi

$$S_{psi}(\theta_m, m_{bslb}, x) := S(\theta_m, m_{bslb}, x) \cdot \left(1.45 \cdot 10^{-4}\right)$$

$$S_{psi}(\theta_m, m_{bslb}, x) = 6.98686 \times 10^4$$

Design Stress at position x, psi

$$S_{wspsi} = 6.98686 \times 10^4$$

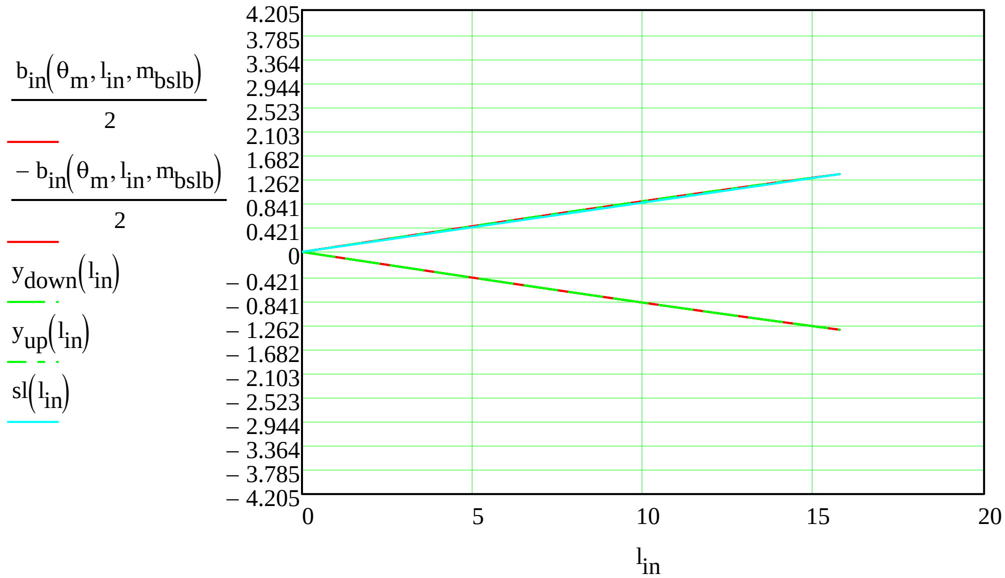
summary of design parameters

factor of safety

$$FS = 3.73558$$

weight of baffle + variable wt, lbs	$m_{bslb} = 52.05$
blade arc, deg	$\theta_{mdeg}(\theta_m) = 30$
blade length, in	$l_{bsin}(\theta_m) = 15.76981$
thickness, in	$t_{in}(m_{bslb}) = 0.15769$
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	$k = 2.36571 \times 10^3$
pendulum frequency, Hz	$f_{0p} = 0.45552$

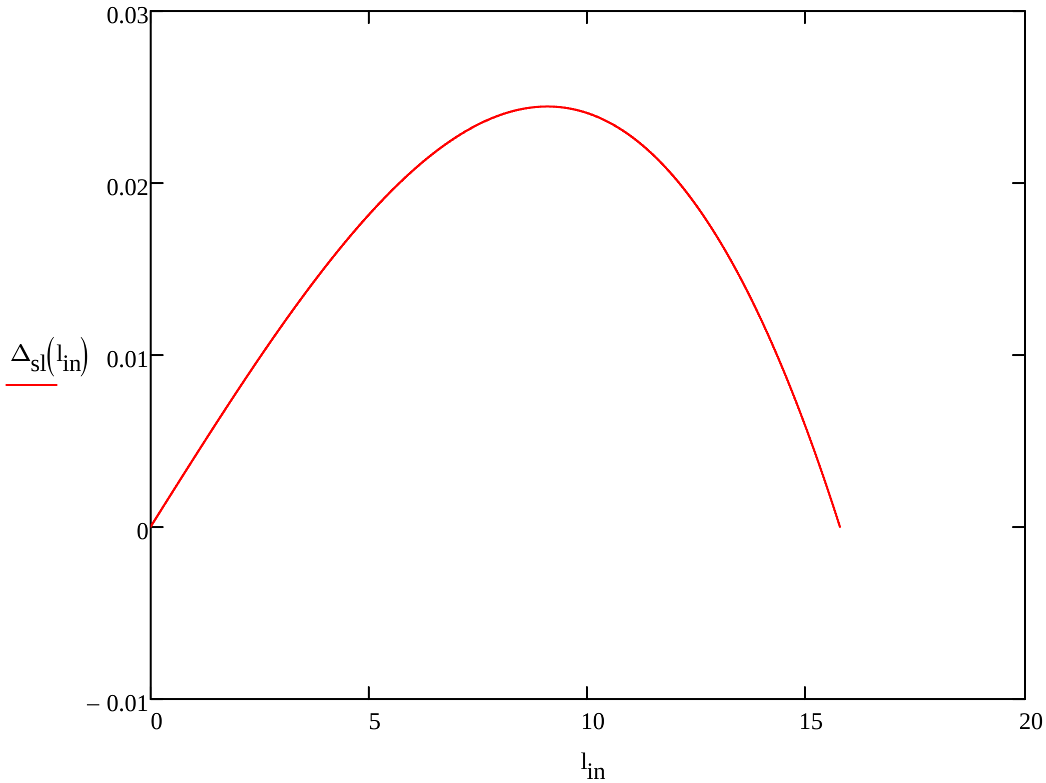
$l_{in} := 0, 0.001 .. l_{bsin}(\theta_m)$



$l_{in} := 1$

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

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



support of baffle with flexure wire

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

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

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

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

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

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

number of wires per spring $N_w := 1$

diameter of wire, m $d_w := \sqrt{\frac{4 \cdot m_{bs}(m_{bslb}) \cdot g}{\pi \cdot S_{ws} \cdot N_w}}$ $d_w = 2.25226 \times 10^{-3}$

diameter of wire, in $d_{win} := \frac{d_w}{0.0254}$ $d_{win} = 0.08867$

weight of baffle, lbs $m_{bslb} = 52.05$

mass of baffle, kg $m_{mp}(m_{bslb}) = 23.60544$

mass supported by each wire, kg $m_{bs}(m_{bslb}) := \frac{m_{mp}(m_{bslb})}{N}$ $m_{bs}(m_{bslb}) = 23.60544$