Que 1

Specific grinding energy is 35 W-s/mm3 in Homework
but here que solved by taking it as 25 W-s/mm3

Given

$u = 25 \ W\text{-}s/mm^3$

$RPM = 3000$

$D = 120 \ mm$

$b = 20 \ mm$

$C = 5 \ grains/mm^2$

$P = 2 KW$

$V = 1.5 \ m/min \qquad r = 10 \qquad K_2 = 0.2k \ mm/N$

$$P = u \cdot v \cdot d \cdot b$$

$$2000 \ W = 25 \ \frac{W\text{-}s}{mm^3} \times \frac{1.5 \times 10^3 \ mm}{60 \ s} \times d \times 20 mm$$

$$d = \frac{2000 \times 60}{25 \times 1.5 \times 10^3 \times 20} = \underline{0.16 \ mm}$$

Grinding force × Peripheral velocity = Power

$$\Rightarrow F_g \left(\frac{\pi D N}{60} \right) = \text{Power}$$

$$F_g (N) \times \frac{\pi \times 120 \times 10^{-3} \times 3000}{60} = 2000 \ W$$

$$F_g = \frac{\cancel{2000} \times \cancel{60}}{\pi \times \cancel{120} \times 10^{-3} \times 3\cancel{000}} = \frac{1000}{3\pi} = \underline{106.10 \ N}$$

$$F/\text{grain} = u \times \frac{1}{2} \omega \times t$$

$$= u \times \frac{1}{2} r t^2$$

$$t = \sqrt{\frac{4v}{V.c.r.}\sqrt{\frac{d}{D}}}$$

$$= \sqrt{\frac{4 \times 1.5 \times 10^3 / \cancel{60}\ mm/\cancel{s}}{\left(\frac{\pi D N}{\cancel{60}}\right) \times \cancel{mm/s} \, \frac{5}{mm^2} \times 10}\sqrt{\frac{0.16\ \cancel{mm}}{120\ \cancel{mm}}}}$$

$$t = \sqrt{\frac{4 \times 1.5 \times 10^3}{\pi \times 120 \times 3000 \times 5 \times 10}\sqrt{\frac{0.16}{120}}}\ , mm$$

$$t = 1.97 \times 10^{-3}\ mm$$

$$F/\text{grain} = \frac{25\ W\text{-}s}{mm^3} \times \frac{1}{2} \times 10 \times (1.97 \times 10^{-3})^2\ mm^2$$

$$= \frac{25 \times 1000\ N.mm}{mm3} \times 0.5 \times 10 \times (1.97 \times 10^{-3})^2 \times mm^2$$

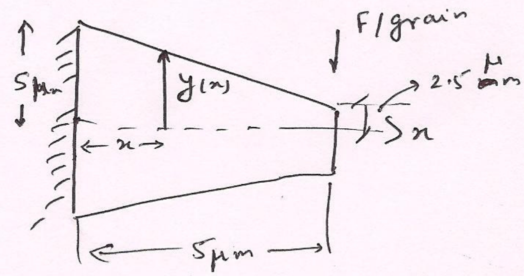
$$= 0.4851\ N$$

$$K_1 = 49.25 \times 10^3 \frac{\cancel{Ws}}{\cancel{m^2}} \frac{N}{m}$$

$$\delta T = K_2 . K_1 . 1/t . d = 0.2 \frac{K.mm}{N} \times 49.25 \times \frac{1}{1.97 \times 10^{-3}\ mm} \times 0.16\ mm$$

$$= 0.2 \times 49.25 \times 0.16 \times 1/1.97 \times 10^3 = 800 K$$

$y(0) = 5\,mm$



$$\frac{y(x) - 5}{x - 0} = \frac{2.5 - 5}{5 - 0}$$

$$y(x) - 5 = \frac{-2.5}{5} \cdot x$$

$$y(x) - 5 = -\frac{x}{2}$$

$$y(x) = 5 - \frac{x}{2}$$

$$\sigma(x) = \frac{M\, y(x)}{I(x)}$$

$$= \frac{F.(5-x)\, y(x)}{\frac{\pi\, y(x)^4}{4}}$$

$$= \frac{4F\,(5-x)\,\cancel{(5-x/2)}}{\pi\,\cancel{\left(5-\frac{x}{2}\right)^4}\left(5-\frac{x}{2}\right)^3}$$

$$\sigma(x) = \frac{4F\,(5-x)}{\pi\,(5-x/2)^3}$$

$$\frac{d\sigma(x)}{dx} = \frac{d}{dx}\left[\frac{4F}{\pi}\,\frac{(5-x)}{(5-x/2)^3}\right]$$

$$\frac{d}{dx}\left[\frac{4F}{\pi}\frac{(5-x)}{(5-x/2)^3}\right] = 0$$

$$\Rightarrow \quad x = 5/2$$

$$\sigma(x) = \frac{4F}{\pi}\cdot\left[(5-5/2)\Big/\left(5-\frac{5}{4}\right)^3\right]\mu m^2$$

$$= \frac{4F}{\pi}\times\frac{2.5}{52.743}\times\frac{1}{(10^{-6})^2}$$

$$= \frac{4\times 0.4851}{\pi}\times\frac{2.5}{52.743}\times 10^{12}\ \frac{N}{m^2}$$

$$\sigma(x) = 29.2\ GPa$$

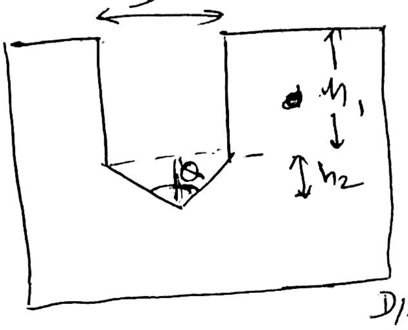
Note: Brittle materials donot fail in shear they always fail in tension. Failure in shear is not applicable even though they may show failure in shear as well.

From Matweb, Sintered-SiC has compressive strength 4.6 GPa. Therefore the grain will fail from the center.

Q.2

F = feed rate (mm/min) = $N \times f$

Spindle speed (N); f in mm/rev

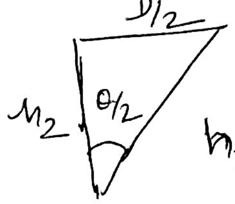


feed = f

Distance travelled

$d = h_1 + h_2$

h_1: depth of hole; h_2: Depth due to conical region



$$h_2 = \frac{D}{2\tan\theta/2}$$

Taylors eqn $\Rightarrow VT^n = C$

T = Time Total to make holes = Time taken for one hole

= no. of holes × Time taken for one hole

$$= n_0 \times \frac{d}{F}$$

$$V = \pi D N$$

$$VT^n = C$$

put V_1, T_1 & V_2, T_2 using two set of experiments data & calculate n & C

Que -5

Three distinct possibilities exist for the values of ζ [32, 33]:

1. ζ>1 yields real roots and an over-damped system (Fig. 3.75a

$$x_{trans}(t) = \left(c_1 e^{\omega_d t} + c_2 e^{-\omega_d t}\right) e^{-\zeta\omega_n t}$$

where c_1 and c_2 are unknown coefficients to be determi
boundary conditions and where ω_d is the frequency of the
vibration given by

$$\omega_d = \sqrt{1-\zeta^2}\,\omega_n$$

2. ζ=1 yields two identical roots and a critically damped
3.75b):

$$x_{trans}(t) = \left(c_1 + c_2 t\right) e^{-\omega_n t}$$

3. ζ<1 yields imaginary roots and an under-damped system (F

$$x_{trans}(t) = A e^{-\zeta\omega_n t} \cos\left(\omega_d t - \psi\right)$$

where ψ is the phase angle.

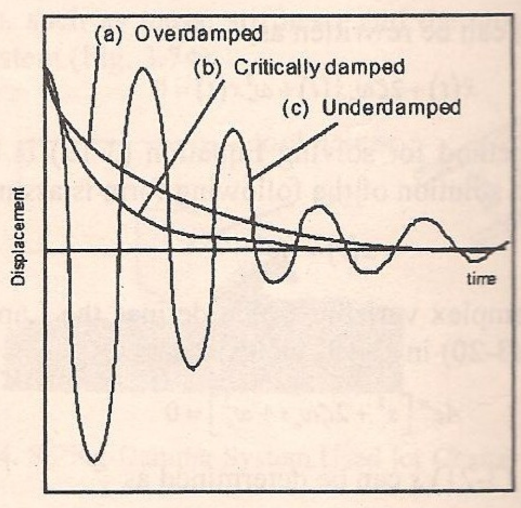


Fig. 3.75. Transient Response of (a) Overdamped, (b) Critically Da
Underdamped Single Mass Vibrator.

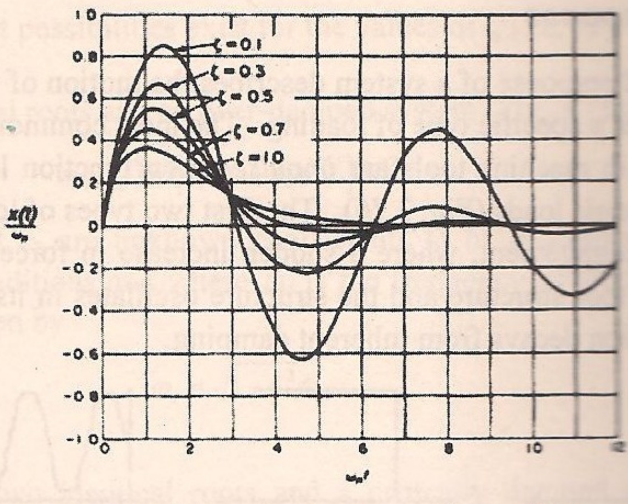


Fig. 3.77. Unit Impulse Response Curves [32]

The unit step response (Fig. 3.78) of the single mass vibrator is

For $\zeta<1$,

$$x(t)=1-\frac{e^{-\zeta\omega_n t}}{\sqrt{1-\zeta^2}}\sin\left[\omega_d t+\tan^{-1}\left(\frac{\sqrt{1-\zeta^2}}{\zeta}\right)\right]\quad (t\geq 0)$$

For $\zeta=1$,

$$x(t)=1-e^{-\omega_n t}\left(1+\omega_n t\right)\quad (t\geq 0)$$

For $\zeta>1$,

$$x(t)=1+\frac{\omega_n}{2\sqrt{\zeta^2-1}}\left(\frac{e^{s_1 t}}{s_1}-\frac{e^{s_2 t}}{s_2}\right)\quad (t\geq 0)$$

where $s_1=\left(\zeta+\sqrt{\zeta^2-1}\right)\omega_n$ and $s_2=\left(\zeta-\sqrt{\zeta^2-1}\right)\omega_n$.

In designing machine tools, tool vibration should be minimiz as a force impulse or step has been encountered. However, t damping ($\zeta=1$) conditions should not be exceeded since critica will minimize the detrimental effects of vibration and chatter, wi ing the system to equilibrium conditions without overshoot or os

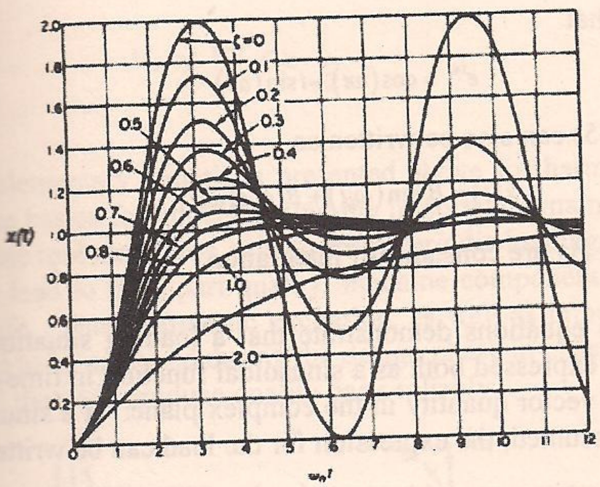


Fig. 3.78. Unit Step Response Curves [32]

l rotation and the reciprocation of other masses during the ma-
rocess may result in dynamic instabilities due to the periodic na-
e excitation. This type of load will cause unacceptable structural
when the forcing frequency coincides with one of the natural fre-
of the structure. This phenomenon is known as *resonance*. Dur-
esigning of a machine tool, it is critical to consider the dynamic
of the machine due to harmonic loading.

er to better introduce the resonance notion, the response of a
system owing to periodic excitations, is analyzed mathematically
dering the response of a single mass vibrator. The equation of
or such a system is given by:

$$\ddot{x}(t)+\omega_n^2 x(t)=0 \tag{3-33}$$

ucing the general solution for the response Equation (3-20) into
(3-33), the following characteristic equation is obtained,

$$s^2+\omega_n^2=0 \tag{3-34}$$

ields two complex roots $\lambda_{1,2} = \pm\, i\omega_n$. This gives the following solu-

$$x(t)=A_1e^{i\omega_n t}+A_2e^{-i\omega_n t} \tag{3-35}$$

A_1 and A_2 are the constants of integration. For $x(t)$ to be real, A_1
the complex conjugate of A_2. This consideration allows the solu-
Equation (3-35) to be expressed alternatively as a sinusoidal func-