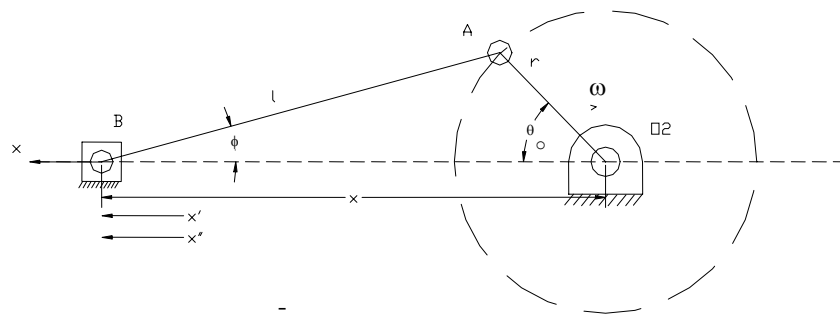


A AB O_rB (-)
θ



$$O_r \quad X$$

$$\theta \quad \theta \quad \ddot{X} \quad \dot{X} \quad x$$

$$r : O_r A$$

$$L = AB :$$

$$\lambda = r/L :$$

$$S = \dot{r} r :$$

$$\phi \quad : \quad \quad \quad : \quad (-)$$

$$X = L \cos \phi + r \cos \theta \quad (-)$$

$$L \sin \phi = \lambda \sin \theta$$

$$\sin \phi = \lambda \sin \theta$$

$$\cos \phi = \sqrt{L - \lambda^2 \sin^2 \theta} \quad (-)$$

$$: \quad (-) \quad (-)$$

$$X = L \left(1 - \lambda^2 \sin^2 \theta \right)^{1/2} + r \cos \theta \quad (-)$$

$$\begin{aligned} \frac{X}{r} &= \cos \theta + \frac{L}{\lambda} \left(1 - \lambda^2 \sin^2 \theta \right)^{1/2} \\ &= \cos \theta + \frac{L}{\lambda} \left(1 - \frac{\lambda^2}{r} \sin^2 \theta - \frac{\lambda^4}{\lambda} \sin^4 \theta - \frac{\lambda^6}{r^2} \sin^6 \theta - \dots \right) \end{aligned} \quad (-)$$

:

$$\sin \theta = \frac{e^{i\theta} - e^{-i\theta}}{2i} \quad \cos \theta = \frac{e^{i\theta} + e^{-i\theta}}{2}$$

:

$$\sin^r \theta = \frac{1}{r!} (e^{i\theta} - e^{-i\theta})^r = \frac{1}{r!} \left[(e^{ri\theta} - e^{-ri\theta}) - r(e^{ri\theta} - e^{-ri\theta}) + \frac{r^2}{2}(e^{ri\theta} - e^{-ri\theta})^2 + \dots \right]$$

$$= \frac{\cos^r \theta}{\lambda} - \frac{\cos^{r-1} \theta}{r} + \frac{r-1}{2\lambda} \cos^{r-2} \theta - \dots$$

:

$$\sin^r \theta = -\frac{1}{r-1} \cos^{r-1} \theta + \frac{r-2}{2} \cos^{r-2} \theta - \frac{r-3}{6} \cos^{r-3} \theta + \dots$$

: (-)

$$\frac{\dot{X}}{r} = \left(\frac{1}{\lambda} - \frac{\lambda}{\varphi} - \frac{r\lambda^r}{\varphi\varphi} - \frac{\Delta\lambda^\Delta}{r\Delta\varphi} - \dots \right) + \cos\theta + \cos\vartheta\theta \left(\frac{\lambda}{\varphi} + \frac{\lambda^r}{1\varphi} + \frac{1\Delta\lambda^\Delta}{\Delta1\vartheta} + \dots \right) \quad (-)$$

$$- \cos\vartheta\theta \left(\frac{\lambda^r}{\varphi\varphi} + \frac{r\lambda^\Delta}{r\Delta\varphi} + \dots \right) + \cos\vartheta\theta \left(\frac{\lambda^\Delta}{\Delta1\vartheta} + \dots \right) - \dots$$

:

$$\frac{\ddot{X}}{r} = \dot{\theta} \left[-\sin\theta - \vartheta\sin\vartheta\theta \left(\frac{\lambda}{\varphi} + \frac{\lambda^r}{1\varphi} + \frac{1\Delta\lambda^\Delta}{\Delta1\vartheta} + \dots \right) + \vartheta\sin\vartheta\theta \left(\frac{\lambda^r}{\varphi\varphi} + \frac{r\lambda^\Delta}{r\Delta\varphi} + \dots \right) - \vartheta\sin\vartheta\theta \left(\frac{\lambda^\Delta}{\Delta1\vartheta} + \dots \right) + \dots \right] \quad (-)$$

(-)

$$-\frac{\ddot{X}}{r} = \dot{\theta} \left(\cos\theta + A_\vartheta \cos\vartheta\theta - A_\varphi \cos\vartheta\theta + A_\varphi \cos\vartheta\theta - \dots \right) + \ddot{\theta} \left(\sin\theta + \frac{A_\vartheta}{\vartheta} \sin\vartheta\theta - \frac{A_\varphi}{\varphi} \sin\vartheta\theta + \frac{A_\varphi}{\varphi} \sin\vartheta\theta - \dots \right)$$

:

$\ddot{\theta}$:

$\dot{\theta}$:

$$A_\vartheta = \lambda + \frac{1\lambda^r}{\varphi} + \frac{1\Delta\lambda^\Delta}{1\vartheta\lambda} + \dots$$

$$A_\varphi = \frac{1\lambda^r}{\varphi} + \frac{r\lambda^\Delta}{1\varphi} + \dots$$

$$A_\varphi = \frac{r\lambda^\Delta}{r\lambda} + \dots$$

$$\ddot{\theta} \quad (-) \quad \ddot{\theta} = 0 \quad \dot{\theta} = \omega \quad \ddot{\theta} \approx 0 \quad (\omega)$$

$$-\frac{\ddot{x}}{r} = \omega^2 (\cos \theta + A_\gamma \cos \gamma \theta - A_\gamma \cos \gamma \theta + A_\gamma \cos \gamma \theta - \dots)$$

$$\lambda^2 \quad \lambda \ll 1 \quad (-)$$

$$\dot{x} = -\omega r \left(\sin \theta + \frac{\lambda}{\gamma} \sin \gamma \theta \right)$$

(-)

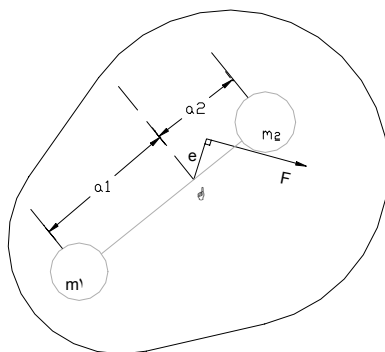
$$\ddot{x} = -\omega^2 r (\cos \theta + \lambda \cos \gamma \theta)$$

(-)

(-) (-)

"Dynamically- equivalent link"

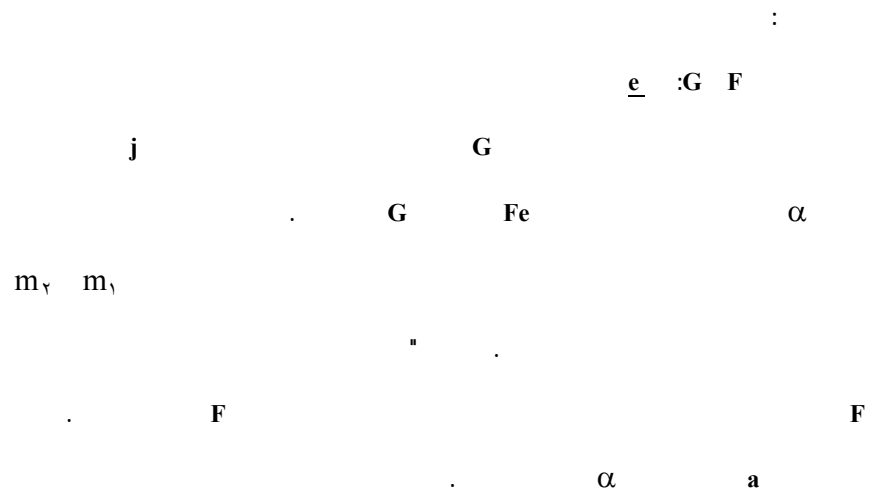
$$G \quad m \quad (-) \quad () F$$



(-)

$$a = \frac{F}{m} \quad (-)$$

$$\alpha = \frac{Fe}{J} \quad (-)$$



$$m_1 + m_2 = m \quad (-)$$

$$m_1 a_1 = m_2 a_2 \quad (-)$$

$$m_1 a_1^2 + m_2 a_2^2 = J \quad (-)$$

$$m_1 a_1 = m_2 a_2$$

$$a_1 = a_2$$

"Approximate Expression for Turning Moment "

$$(-) (-)$$

$$a_{\gamma} a_1$$

:

$$"m_{\gamma} = (\quad) "$$

$$"m_{\gamma} = (\quad) "$$

$$m_{\gamma} m_1$$

$$m_{\gamma}$$

$$m_1$$

$$(-) (-)$$

$$(-)$$

$$m_1 + m_{\gamma} = m_c$$

$$(-)$$

$$m_1 a_1 = m_{\gamma} a_{\gamma}$$

:

$m_c =$ Mass of Connecting rod

()

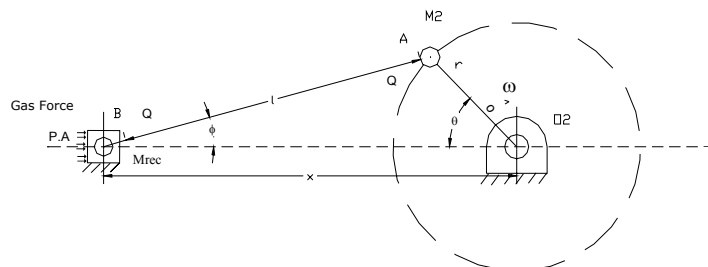
a_1

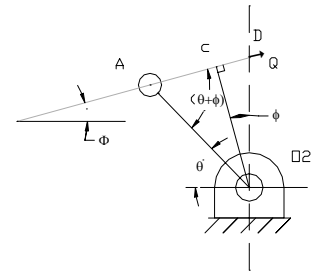
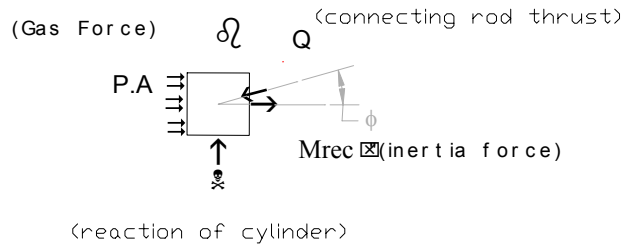
a_{γ}

$$(-)$$

$$(-)$$

$$: (-)$$





(-)

P θ $\frac{kg}{cm^2}$

A cm^2

W_{rec} ()

m, g

r, L

ϕ

Q kg

ω

: $\frac{W_{rec}}{g} \ddot{x} \quad \lambda = \frac{r}{L}$ (-)

$\ddot{x} = -\omega^2 r (\cos \theta + \lambda \cos^2 \theta)$ (-)

: $\Sigma F_x = \cdot$

$PA + \frac{W_{rec}}{g} \ddot{x} = Q \cos \phi$

$Q = \frac{PA + \frac{W_{rec}}{g} \cdot \omega^2 r (\cos \theta + \lambda \cos^2 \theta)}{\cos \phi}$

Q

$$M = Q \cdot O_{\gamma} C$$

$$: \quad - \quad . \quad O_{\gamma} \quad O_{\gamma} C$$

$$O_{\gamma} C = O_{\gamma} B \sin(\theta + \phi) = r \sin(\theta + \phi) \quad (-)$$

$$O_{\gamma} \quad - \quad m_{\gamma}$$

$$x \quad . \quad (-) \quad W_{rec}$$

$$: \quad (\quad)$$

$$Q = \frac{PA - m_{rec} \omega^{\gamma} r (\cos \theta + \lambda \cos^{\gamma} \theta)}{\cos \phi} \quad (- a)$$

$$M = \frac{PA + W_{rec} - \frac{W_{rec}}{g} \cdot \omega^{\gamma} r (\cos \theta + \lambda \cos^{\gamma} \theta)}{\cos \phi} r \sin(\theta + \phi) \quad (-)$$

$$O_{\gamma} D \quad . \quad (-)$$

$$O_{\gamma} D = \frac{O_{\gamma} C}{\cos \phi}$$

$$: \quad (-)$$

$$M = \left[PA - \frac{W_{rec}}{g} \cdot \omega^{\gamma} r (\cos \theta + \lambda \cos^{\gamma} \theta) \right] O_{\gamma} D$$

:

$$O_{\gamma} D = - \frac{\dot{x}}{\omega}$$

$$: \quad (-) \quad . (\quad)$$

(-)

$$M = \left[PA - \frac{W_{rec}}{g} \cdot \omega^{\gamma} r (\cos \theta + \lambda \cos^{\gamma} \theta) \right] r \left(\sin \theta + \frac{\lambda}{\gamma} \sin^{\gamma} \theta \right)$$

$$(-) (-) \quad \theta$$

$$\frac{\text{cm}}{\text{kg}} \cdot \frac{\text{cm}}{\text{cm}} / \frac{\text{cm}}{\text{cm}} = \frac{\text{cm}}{\text{kg}} \cdot \frac{\text{cm}}{\text{cm}} \cdot \frac{\text{cm}}{\text{cm}} = \frac{\text{cm}^3}{\text{kg} \cdot \text{cm}} = \frac{\text{cm}^2}{\text{kg}}$$

$$S = \gamma r = \varphi \cdot \text{cm}, L = \lambda \cdot \text{cm}$$

$$d = \gamma \cdot \Delta \text{cm}$$

$$r = \gamma \cdot \text{cm}, \lambda = \frac{r}{l} = \gamma \cdot \Delta$$

$$W_{\text{rec}} = \gamma \Delta \text{kg}, P = \varphi \cdot \gamma \Delta \frac{\text{kg}}{\text{cm}}$$

$$A = \pi \frac{d^2}{4} = \frac{\pi}{4} (\gamma \cdot \Delta)^2 = \gamma^2 \cdot \text{cm}^2$$

$$N = \gamma \Delta \cdot \text{r.p.m.}$$

$$\omega = \frac{\gamma \pi N}{\varphi \cdot \gamma} = \gamma \frac{\pi N}{\varphi} \frac{\text{rad}}{\text{sec}}$$

$$\frac{1}{\varphi}$$

$$x = L + r - \frac{s}{\varphi} = L + \frac{r}{\varphi} = \gamma \cdot \text{cm}$$

$$: (-) (-)$$

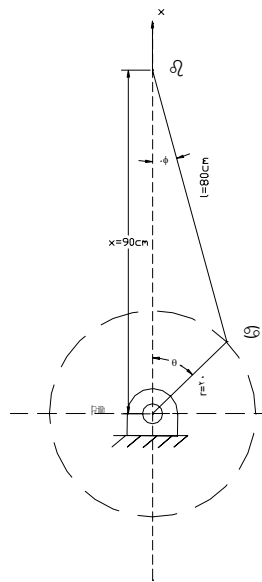
$$x = L \cos \phi + r \cos \theta = \gamma \cdot \text{cm} \tag{a}$$

(b)

$$\cos \phi = \left(1 - \lambda^2 \sin^2 \theta \right)^{1/2} = \left(1 - \gamma^2 \Delta^2 \sin^2 \theta \right)^{1/2}$$

$$(b) (a) \quad \phi \quad \theta$$

$$\theta = 22^\circ, \phi = 12^\circ$$



$$\cos\theta = 0.574, \cos\phi = -0.342$$

$$\sin(\theta + \phi) = 0.92, \cos\phi = 0.978$$

: (- b)

$$M = \frac{0.35 \times 730 + 135 - \frac{135}{9.81} \times 0.2(26.2)^2 (0.574 - 0.25 \times 0.342)}{0.978} \times 0.2 \times 0.92$$

$$= 9.8 \text{ kg-m}$$

(-) (-)

()

$$k) \quad J_c = m_c k^2$$

(

(-)

$$J_e = m_1 a_1^2 + m_2 a_2^2$$

: (-) (-)

$$m_1 = \frac{m_c a_2}{a_1 + a_2}$$

$$m_2 = \frac{m_c a_1}{a_1 + a_2}$$

: (-)

(-)

$$J_e = m_c a_1 a_2$$

:

$$J_c - J_e = m_c (k^2 - a_1 a_2)$$

(-)

: (-)

$$(J_c - J_e)\alpha = m_c (k^2 - a_1 a_2)\alpha$$

(-)

$$\alpha = \ddot{\phi} \quad \alpha$$

(-)

F_c

$$F_C(L \cos \phi) = m_c(k^r - a_r) \alpha$$

$$F_c = \frac{m_c(k^r - a_r) \alpha}{L \cos \phi} \quad (-)$$

$$O_r \quad (\quad) F_c$$

$$M_c = -F_c \cdot r \cos \theta$$

$$= -\frac{m_c(k^r - a_r) \alpha}{L \cos \phi} r \cos \theta \quad (-)$$

M_c

:

$$M_t = M + M_c$$

:

$$\alpha = \ddot{\phi}, (-)$$

$$\cos \phi = (1 - \lambda^r \sin^r \theta)^{\frac{1}{r}}$$

$$= 1 - \frac{\lambda^r}{r} \sin^r \theta - \frac{\lambda^r}{\lambda} \sin^r \theta - \frac{\lambda^r}{1^r} \sin^r \theta - \dots$$

$$\therefore \sin \phi = \lambda \sin \theta$$

$$\dot{\phi} = \omega \left(\lambda \cos \theta + \frac{\lambda^r}{r} \sin^r \theta \cos \theta + \frac{r \lambda^{\Delta}}{\lambda} \sin^r \theta \cos \theta - \dots \right) \quad (-)$$

$$\frac{\ddot{\phi}}{\lambda} = -\omega^r (C_1 \sin \theta - C_r \sin^r \theta \cos \theta + C_\Delta \sin^\Delta \theta - \dots)$$

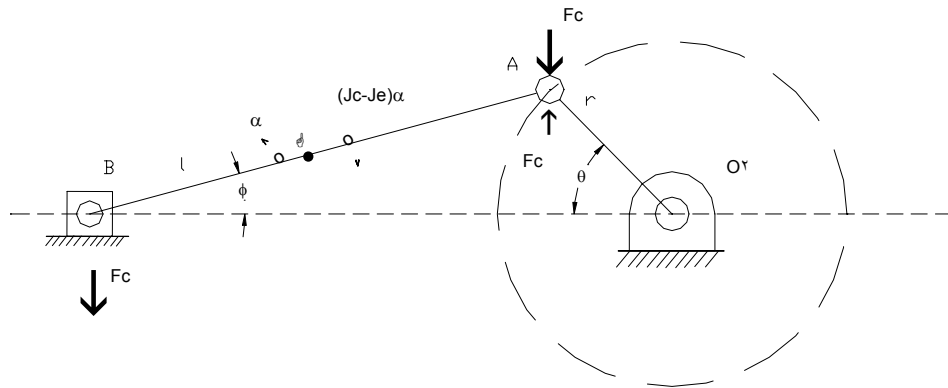
$$+ \dot{\omega} \left(C_1 \cos \theta - \frac{C_r}{r} \cos^r \theta + \frac{C_\Delta}{\Delta} \cos^\Delta \theta - \dots \right)$$

:

$$C_1 = 1 + \frac{1}{\lambda} \lambda^{\gamma} + \frac{\gamma}{\varphi \varphi} \lambda^{\varphi} + \dots$$

$$C_r = \frac{\gamma}{\lambda} \lambda^{\gamma} + \frac{\gamma \gamma}{\gamma \gamma \lambda} \lambda^{\varphi} + \dots$$

$$C_{\delta} = \frac{\gamma \delta}{\gamma \gamma \lambda} \lambda^{\varphi} + \dots$$



:

ω

λ^{γ}

$$\alpha = \ddot{\phi} = -\omega^{\gamma} \lambda \sin \theta \quad (-)$$

(-)

$$M_c = \frac{m_c (k^{\gamma} - a_1 a_{\gamma})}{L \cos \phi} \omega^{\gamma} \lambda r \sin \theta \cos \theta \quad (-)$$

(-) : - _____

kg

cm

(-)

kg

:

$$m_c = 12 \cdot \text{kg} \quad ; \quad a_x = 5 \cdot \text{cm} \quad ; \quad a_y = 3 \cdot \text{cm}$$

:

$$m_x = 45 \text{kg} \quad ; \quad W_{\text{rec}} = 9 + 45 = 135 \text{kg}$$

$$m_y = 45 \text{kg}$$

: (-)

$$k = 3 \cdot \text{cm}$$

$$\theta = 55^\circ \quad ; \quad \phi = 12^\circ$$

$$\cos \theta = 0.57 \quad ; \quad \cos \phi = 0.978$$

:(-)

$$\alpha = -\omega^2 \lambda \sin \theta$$

$$\alpha = -(26.2)^2 \times 0.25 \times 0.57 = -14.8 \frac{\text{rad}}{\text{sec}^2}$$

(-)

$$M_c = -1295 \times 0.2 \times 0.978 = -252 \text{ (n.m)}$$

$$(-) \quad) M = 7473 \text{ N.M} \quad ()$$

:

$$M_t = (7473 - 252) = 7221 \text{ N.M}$$

% %

"Turning Moment Diagram"

M (-) (-) θ M
 P θ
 θ

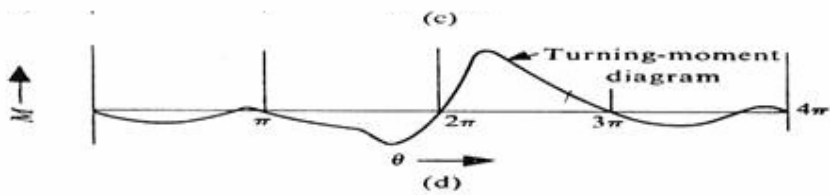
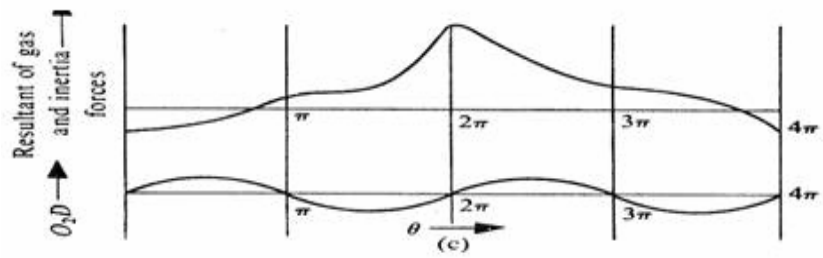
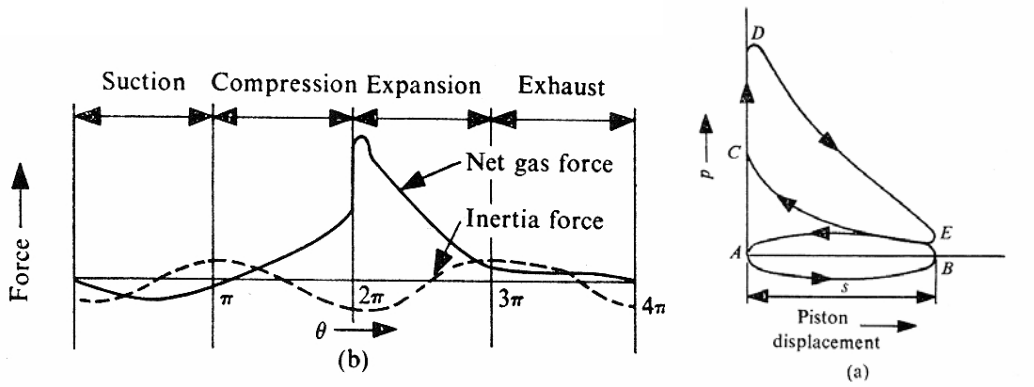


FIGURE 5.6

(-)

$$M = \left(\frac{P}{\theta} \sin \theta + \frac{PA}{\theta} \cos \theta \right) \times O_r D$$

$$M = \frac{P}{\theta} \sin \theta + \frac{PA}{\theta} \cos \theta \quad (- c)$$

$$M = \frac{P}{\theta} \sin \theta + \frac{PA}{\theta} \cos \theta \quad (- d)$$

" Fluctuation of Crankshaft Speed "

$$M = M_R + M \sin \theta$$

$$M = M_R + M \sin \theta \quad (-)$$

$$M = M_R + M \sin \theta \quad (-)$$

$$E = \int M d\theta$$

$$M_{av} = \frac{E}{\Theta} = \frac{1}{\Theta} \int M d\theta = \frac{1}{\Theta} \int M d\theta \quad (-)$$

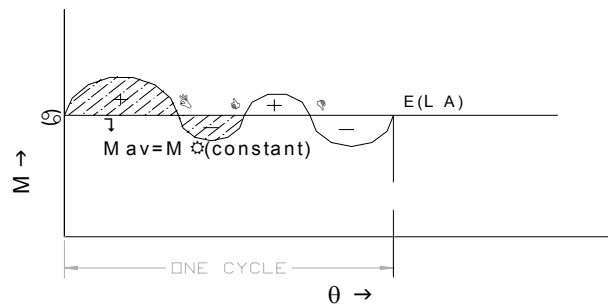


Figure 4.7

θ

$E \cdot M_R \theta$

θ

$$M_R = \frac{E}{\Theta} = M_{av}$$

$M_R < M_{av}$

()

$M_R > M_{av}$

()

(-)

$$M_R = M_{av}$$

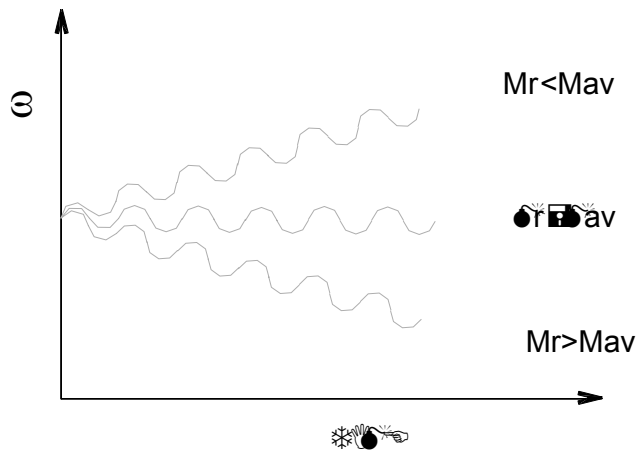


Figure 4, 5

$E(\equiv A) \quad D \quad C \quad B \quad A \quad (-) \quad M_R = M_{av}$

$M > M_R \quad B \quad A \quad M_R \quad M$

$M < M_R \quad C \quad B$

B

$$E_B = E_A + \int_{\theta_A}^{\theta_B} (M - M_R) d\theta = E_A +$$

B A

:

$$E_C = E_B + \int_{\theta_B}^{\theta_C} (M - M_R) d\theta = E_B -$$

C B

$(\Delta k_E)_{\max}$

$$(\Delta k_E)_{\max} = \int_{\theta_1}^{\theta_2} (M - M_R) d\theta$$

(-)

$\theta_2 \theta_1$

$$k_e = \frac{(\Delta k_E)_{\max}}{E}$$

(-)

(-) **E**

$$k_s = \frac{\omega_{\max} - \omega_{\min}}{\omega_{av}}$$

:

ω_{av}

$$\omega_{av} \approx \frac{\omega_{\max} - \omega_{\min}}{\gamma}$$

:() - -

(-)

(-)

$$(\Delta kE)_{\max} = \frac{1}{\gamma} J_f (\omega_{\max}^{\gamma} - \omega_{\min}^{\gamma}) = J_f \omega_{\text{av}}^{\gamma} k_s$$

$$k_s (J_f) \omega_{\text{av}} (\Delta kE)_{\max}$$

(-)

$$J_f \alpha = (M - M_R) \quad (-)$$

:

$$\alpha = \omega \frac{d\omega}{d\theta}$$

:

$$J_f \omega \frac{d\omega}{d\theta} = (M - M_R)$$

: $\theta_{\gamma} \theta_{\gamma}$

$$J_f \int_{\omega_{\min}}^{\omega_{\max}} \omega d\omega = \int_{\theta_{\gamma}}^{\theta_{\gamma}} (M - M_R) d\theta$$

(-)

$$\frac{1}{\gamma} J_f (\omega_{\max}^{\gamma} - \omega_{\min}^{\gamma}) = (\Delta kE)_{\max}$$

$$J_f \omega_{\text{av}}^{\gamma} k_s = (\Delta kE)_{\max}$$

$M > M_R$

$M < M_R$

(-)

: _____

$\gamma \text{cm} = 3.0^{\circ}$

$\gamma \text{cm} = \gamma \cdot \cdot \cdot N - m$

: A

... $\Delta_{\gamma} + 1, \gamma_{\gamma} - \cdot, \gamma \Delta_{\gamma} + 1, \gamma \Delta_{\gamma} - \cdot, \gamma \Delta_{\gamma} + \cdot, \gamma \Delta_{\gamma} - 1, \cdot \gamma$

%

$\wedge \cdot \cdot \cdot \text{r.pm.}$

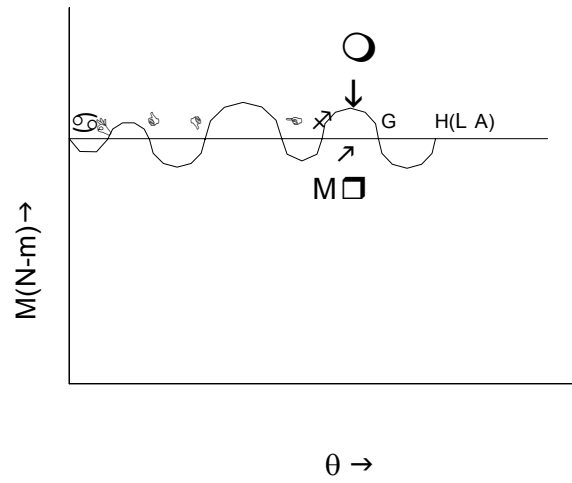


Figure 4.9

cm

$$y \cdot \frac{\pi}{\delta} = \frac{y \cdot \pi}{\delta} \text{ kg.m}$$

A E_A M_R H G F E D C B A

$$E_B = E_A - \delta$$

$$E_C = E_B + \gamma = E_A + \gamma$$

$$E_D = E_C - \delta = E_A + \gamma - \delta$$

$$E_E = E_D + \gamma = E_A + \gamma - \delta + \gamma$$

$$E_F = E_E - \delta = E_A + \gamma - \delta + \gamma - \delta$$

$$E_G = E_F + \gamma = E_A + \gamma - \delta + \gamma - \delta + \gamma$$

$$E_H = E_G - \delta = E_A + \gamma - \delta + \gamma - \delta + \gamma - \delta$$

()

E B

E. Thus,

$$(\Delta kE)_{\max} = E_E - E_B = (E_A + \gamma - \delta) - (E_A - \delta)$$

$$= \gamma \text{ cm} = \gamma \times \frac{\pi}{\delta} = \frac{\gamma \cdot \pi}{\delta} \text{ kg-m}$$

$$\omega_{av} = \lambda \cdot \frac{\gamma \pi}{\varphi} = 13.1^\circ / \text{sec}$$

$$k_s = 1.2$$

: (-)

$$J_f = \frac{(\Delta kE)_{\max}}{\omega_{av} k_s} = \frac{624}{(13.1)^\gamma \times 1.2} = 4.43 \text{ kg-m-sec}^\gamma$$

:

$$M = 150 + 200 \sin \gamma \theta - 100 \cos \gamma \theta \text{ kg-m}$$

:

θ

$$150 \cdot \text{r.p.m}$$

(i)

$\pm \%$

$$150$$

(ii)

$$\theta = 30$$

(iii)

$$150 \cdot \text{r.p.m}$$

)

(iv)

.(

:

: (-) .

$$\theta = \gamma \pi$$

(i)

$$M_{av} = \frac{1}{\gamma \pi} \int_{\gamma \pi}^{\gamma \pi} M d\theta = \frac{1}{\gamma \pi} \int_{\gamma \pi}^{\gamma \pi} (150 + 200 \sin \gamma \theta - 100 \cos \gamma \theta) d\theta = 150 \cdot \text{kg-m} = M_R$$

$$\frac{\varphi}{\delta}$$

$$150 \times \gamma \pi$$

:

$$1500 \times 2\pi \frac{150}{60} \text{ kg-m}$$

: ()

$$\frac{1500 \times 2\pi \times 150}{75 \times 60} = 314 \text{ hp}$$

(ii)

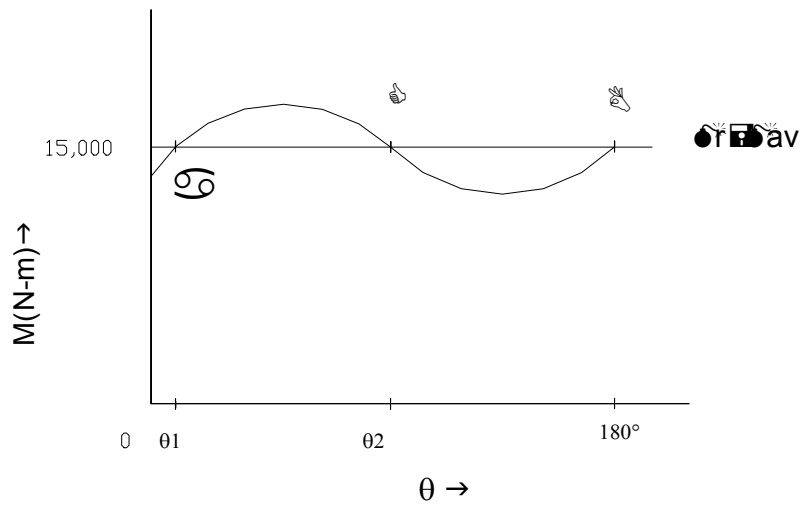


Figure 4.10

M_R M

$$200 \sin 2\theta - 180 \cos 2\theta = 0$$

$$\tan 2\theta = 0.9$$

$$2\theta_1 = 42^\circ, \quad 2\theta_2 = (180^\circ + 42^\circ)$$

$$\theta_1 = 21^\circ, \quad \theta_2 = 111^\circ$$

:

$$\theta_2 - \theta_1$$

(-)

$$(\Delta kE)_{\max} = \int_{\theta_1}^{\theta_2} (M - M_R) d\theta$$

$$= \int_{\theta_1}^{\theta_2} (\gamma \cdot \sin \gamma \theta - \lambda \cdot \cos \gamma \theta) d\theta$$

$$= [\gamma \cdot \sin \gamma \theta - \lambda \cdot \cos \gamma \theta]_{\theta_1}^{\theta_2} = \gamma \cdot \sin \gamma \theta - \lambda \cdot \cos \gamma \theta$$

$$\rightarrow k_s = \dots, \omega_{av} = \lambda \cdot \frac{\gamma \pi}{\dots} = \lambda \cdot \gamma \text{ rad/sec}$$

: (-)

$$J_f = \frac{\gamma \cdot \sin \gamma \theta - \lambda \cdot \cos \gamma \theta}{(\lambda \cdot \gamma)^2 \times \dots} = \lambda \cdot \gamma \text{ kg-m-sec}^2$$

$$(\Delta kE)_{\max} = M$$

$$M = \lambda \cdot \gamma \cdot \sin \gamma \theta - \lambda \cdot \cos \gamma \theta = \lambda \cdot \gamma \cdot \sin \gamma \theta - \lambda \cdot \cos \gamma \theta \quad \theta = \dots \quad \text{(iii)}$$

: (-)

$$\alpha = \frac{M - M_R}{J_f} = \frac{\lambda \cdot \gamma \cdot \sin \gamma \theta - \lambda \cdot \cos \gamma \theta}{\lambda \cdot \gamma} = \dots \frac{\text{rad}}{\text{sec}^2}$$

: (-)

(iv)

$$J_f \frac{d^2 \theta}{dt^2} = M - M_R$$

$$= \gamma \cdot \sin \gamma \theta - \lambda \cdot \cos \gamma \theta$$

(a)

$$\text{(a)} \quad \theta = \omega_{av} \cdot t$$

$$J_f \frac{d^2 \theta}{dt^2} = \gamma \cdot \sin \gamma (\omega_{av} \cdot t) - \lambda \cdot \cos \gamma (\omega_{av} \cdot t)$$

:

$$J_f \frac{d\theta}{dt} = -\frac{\lambda \cdot \cos \gamma (\omega_{av} \cdot t)}{\omega_{av}} - \frac{\gamma \cdot \sin \gamma (\omega_{av} \cdot t)}{\omega_{av}} + c_1$$

:

$$\omega = \frac{d\theta}{dt} = -\frac{1}{J_f \omega_{av}^{\gamma}} [\dot{\gamma} \cdot \cos \gamma(\omega_{av} \cdot t) + \dot{\gamma} \cdot \sin \gamma(\omega_{av} \cdot t)] + c_{\gamma}$$

:

$$c_{\gamma} = \frac{c_{\dot{\gamma}}}{J_f}$$

$$(c_{\dot{\gamma}} \quad)$$

:

$$\omega = \omega_{\min} \quad \gamma \theta = \gamma(\omega_{av} \cdot t) = \gamma \gamma^{\circ}$$

$$\omega = \omega_{\max} \quad \gamma \theta = \gamma(\omega_{av} \cdot t) = \gamma \gamma^{\circ}$$

:

(b)

$$\omega_{\min} + \omega_{\max} = \gamma c_{\gamma}$$

$$c_{\gamma} = \frac{\omega_{\min} + \omega_{\max}}{\gamma} = \omega_{av}$$

:

(b)

$$c_{\gamma} = \omega_{av}$$

$$\theta = (\omega_{av} \cdot t) = \frac{1}{J_f \omega_{av}^{\gamma}} [\dot{\gamma} \cdot \sin \gamma(\omega_{av} t) - \gamma \Delta \cos \gamma(\omega_{av} t)] + c_{\gamma}$$

:

$$\theta = \cdot$$

$$c_{\gamma}$$

$$c_{\gamma} = -\frac{\gamma \Delta}{J_f \omega_{av}^{\gamma}}$$

:

$$\theta - (\omega_{av} \cdot t) = \frac{1}{J_f \omega_{av}^{\gamma}} [\gamma \Delta \cos \gamma(\omega_{av} t) - \Delta \cdot \sin \gamma(\omega_{av} t)] - \frac{\gamma}{J_f}$$

:

$$[\theta - (\omega_{av} \cdot t)]_{\max} = \frac{1}{J_f \omega_{av}^{\gamma}} (\gamma \Delta^{\gamma} + \Delta \cdot \gamma^{\gamma}) - \frac{\gamma \Delta}{J_f \omega_{av}^{\gamma}} = \frac{\gamma}{J_f \omega_{av}^{\gamma}}$$

radian

$$= \cdot \cdot \cdot \gamma \gamma^{\circ}$$

leading

$$[\theta - (\omega_{av} \cdot t)]_{\min} = -\frac{1}{J_f \omega_{av}^2} (\varphi \Delta^2 + \Delta \cdot \varphi) - \frac{\varphi \Delta}{J_f \omega_{av}^2} = -\frac{112.3}{J_f \omega_{av}^2} \text{ radian}$$

$$= -0.238^\circ \text{ lagging}$$

--- 0.238°

"The Flywheel in a punching press"

$$\theta = \theta_1 \quad \theta = \theta_2$$

$$\theta = \varphi \pi (= \cdot) \quad \theta = \theta_1$$

$$\theta = \theta_1 \quad \theta = \cdot$$

$$\theta = \theta_1 \quad \theta = \theta_1$$

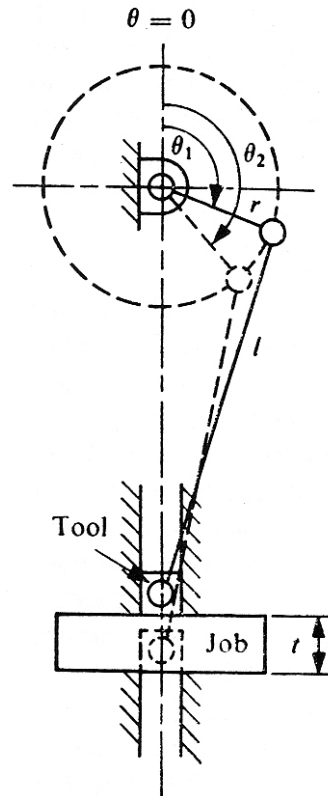


FIGURE 5.11

() E

:

$$E \frac{\theta_r - \theta_l}{\gamma \pi}$$

:

$$E \left(\gamma - \frac{\theta_r - \theta_l}{\gamma \pi} \right)$$

$$\omega_{\min} \quad \omega_{\max}$$

$$(\Delta kE)_{\max} = E \left(\gamma - \frac{\theta_r - \theta_l}{\gamma \pi} \right) = \frac{1}{\gamma} J_f (\omega_{\max}^{\gamma} - \omega_{\min}^{\gamma}) = J_f \omega_{av}^{\gamma} k_s$$

l r

$\theta_r \quad \theta_l$

$$\frac{\theta_r - \theta_l}{\gamma \pi} \approx \frac{t}{\gamma \Delta} = \frac{t}{\gamma T}$$

s

$\rho \cdot \text{kg-m}$

$r, \gamma \text{cm}$

$r, \Delta \text{cm}$

ρ

$\gamma, \gamma \text{cm}$

$$\gamma \gamma, \Delta \frac{\text{m}}{\text{sec}}$$

$$\gamma \gamma, \Delta \frac{\text{m}}{\text{sec}}$$

:

$$A_s = \pi dt$$

$$d = 3.8 \text{ cm}$$

$$t = 3.5 \text{ cm}$$

:

$$A_s = 3.8.5 \text{ cm}^2$$

$$E = 6.0 \times 3.8.5 = 2295 \text{ kg-m}$$

(-)

$$\frac{\theta_2 - \theta_1}{2\pi} = \frac{t}{T} = \frac{3.5}{20.4}$$

: (-)

$$(\Delta KE)_{\max} = E \left(1 - \frac{t}{T} \right) = \frac{1}{2} J_f (\omega_{\max}^2 - \omega_{\min}^2)$$

$$2295 \left(1 - \frac{3.5}{20.4} \right) = \frac{1}{2} W_f k (\omega_{\max}^2 - \omega_{\min}^2)$$

:

ω_f

k

$$V_{\max} = k\omega_{\max} = 27.5 \frac{\text{m}}{\text{sec}}$$

$$V_{\min} = k\omega_{\min} = 24.5 \frac{\text{m}}{\text{sec}}$$

:

$$2295 \times \frac{17.9}{20.4} = \frac{1}{2} W_f [(27.5)^2 - (24.5)^2]$$

$$= \frac{1}{2} W_f \times 158$$

$$W_f = \frac{2295 \times 34.4}{20.4 \times 158} = 244 \text{ kg}$$

$$6 \times 2295 \text{ kg-m}$$

:

$$= \frac{6 \times 2295}{25 \times 6} = 3.0 \text{ hp(metric)} = 2.295 \text{ (KW)}$$