Explosion

Pressure wave

→ Detonation → Impact ($\frac{dp}{dt}$ very high (10 atm)

dt " small (.1 ms)

Area small)

→ DDT (pipe) (due to $\Delta P \uparrow$)

→ Deflagration

Based on Mac number

$T\uparrow$ Mac no $\uparrow$

$P\uparrow$ $T\uparrow$

Deflagration → $\frac{dp}{dt}$ very low (1 atm)

high (few ms)

area high

→ Pipe

→ Confined vessel

→

Confined vessel → Gas/vapor, dust

dust (dp vs t) plot

fixed p but changing v.

→ Same as vap.

Gas/vapor

(On wall → dp meter) $P_{max} \approx 7.4$ bar / $\frac{dp}{dt}_{max}$ − 360 bar/s.

P vs t (Due to ignition effect deflagration)

% Conc vs $\frac{dp}{dt}$

for deflagration:-

$$\left(\frac{dp}{dt}\right)_{max} V^{1/3} = K_G$$

$K_G \rightarrow$ Gas; $V \rightarrow$ vessel volume

$$\left(\frac{dp}{dt}\right)_{max} V^{1/3} = K_{St} \rightarrow \text{dust}.$$

$K_G \uparrow$ & $K_{St} \uparrow$ when explosion robustness $\uparrow$.

Table 6.7 & 6.8 $\rightarrow P_m, K_G, K_{St}$ data

K_G & $K_{St} \rightarrow$ Dependencies
- composition of mixture,
- Mixing in vessel,
- Shape of reaction vessel,
- Energy of ignition source.

Dust explosion char

i) Particles below min size.
ii) · loading between limit.
iii) · " reasonably uniform.

Lower explosion limit $\rightarrow 20 g/m^3 - 60 g/m^3$.
upper " " $\rightarrow 2 kg/m^3 - 6 kg/m^3$.

Due to overpressure

$t_0 \rightarrow t_1 \rightarrow t_2 \rightarrow t_3 \rightarrow t_4$

$t_1 \rightarrow$ arrival time; $t_2 \rightarrow$ Shock duration; $t_3 \rightarrow$ Max under pressure; $t_4 \rightarrow$ reverse wind flow.

Idea of explosion damage = peak side on overpressure by PT.

Equivalent mass of TNT:-

$$z_e = \frac{r}{(m_{TNT})^{1/3}}$$

$r \rightarrow$ distance from ground-zero

$m_{TNT} \rightarrow$ Energy equil of TNT = 1120 cal/g.

If PT ⊥ wave → side on o.p.
PT ∥ wave → ~~peak side on~~
(reflected op = 2 × side on op)

For explosion on flat surface.

Refer 6-23 fig ($P_s \rightarrow z_e$).

$$P_s = \frac{P_o}{P_a}$$

$P_o \rightarrow$ peak side on op; $P_a \rightarrow$ ambient.

for air $\rightarrow P_s' = P_s \times 0.5$

$$\frac{P_o}{P_s} = \frac{1616\left[1+\left(\frac{ze}{4.5}\right)^2\right]}{\sqrt{1+\left(\frac{ze}{0.048}\right)^2} \cdot \sqrt{\left(1+\left(\frac{ze}{0.032}\right)^2\right) \cdot \left(1+\left(\frac{ze}{1.35}\right)^2\right)}}$$

$\uparrow$ at ground

TNT equivalency :-

$$m_{TNT} = \frac{\eta \, m \, \Delta H_c}{E_{TNT}}$$

$(1-10\%)$

chemical explosion :-

Calculate by Gibbs free energy due to change in moles due to reaction with air

Mechanical explosion :-

4 types

$E = \frac{E_{total}}{2}$

$E = \frac{(P_2 - P_1)V}{\gamma - 1}$ → for Near field

$E = \frac{P_2 V}{(\gamma - 1)}\left(1 - \left(\frac{P_1}{P_2}\right)^{\left(\frac{\gamma-1}{\gamma}\right)}\right)$ Greater distance

Isentropic

$E = R_g T \ln\left(\frac{P_2}{P_1}\right)$

$= P_2 V \ln\left(\frac{P_2}{P_1}\right)$ → isothermal

$E = P_2 V\left[\ln\left(\frac{P_2}{P_1}\right) - \left(1 - \frac{P_1}{P_2}\right)\right]$

Batch Thermo.

Predict max explosion.

then Mass of TNT then by Fig 6-26 find distance