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MIDSEM

ME 688

1) Workpiece strength = σ_W

Concentration = c.

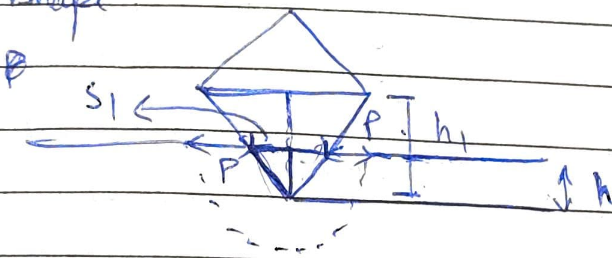
Semi angle = $\beta = 45^\circ$.

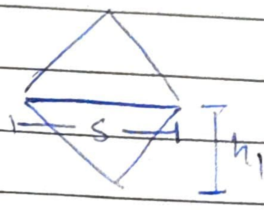
Length of abrasives edges = s.

height = h_1 = s^2 Volume = $\frac{s^2 h_1}{3}$.

Density of abrasives = ρ_p.

Assumption :- Brittle fracture and hemispherical shape





$$\frac{s_1}{s} = \frac{h}{h_1}$$

$$s_1 = \frac{h s}{h_1}$$

$$d = sh/h_1 + 2p$$

$$= s h/h_1 + 0.1 \times 2 h \times 9.$$

$$= \frac{s h}{h_1} + 0.2 h \times 9 = h\left[\frac{s}{h_1} + \overset{1.8}{\cancel{0.2\times 9}}\right].$$

a) Concentration $= c$.

~~Kla of~~ Considering abrasive monolayer $= C \cdot V_p$

Volume of abrasive monolayer $= c \cdot V_p$.

$$V_p = m^2 \times 2h_1 = 2h_1 m^2.$$

Volume of monolayer $= c\,2h_1 m^2$.

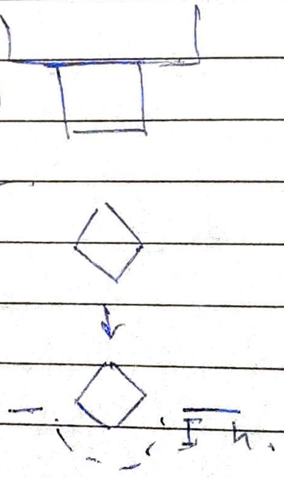
$$N = \frac{\text{Volume of monolayer}}{\text{Volume of one abrasive}}$$

$$= \frac{\cancel{2}\cancel{h_1} m^2 c}{\frac{\cancel{2} s^2 \cancel{h_1}}{3}}$$

$$N = \frac{3m^2 c}{s^2}.$$

b) $Y = a\sin(2\pi F t)$

$$\frac{dy}{dt} = 2\pi a f \cos 2\pi F t$$



$$V_{max} = 2\pi a F$$

$$KE = \frac{1}{2} m (2\pi a F)^2$$

$$m = \rho V = \frac{\rho_p \times 2 s^2 h_1}{3}.$$

$$KE = \frac{1}{2} \frac{2 s^2 h_1}{3} (2\pi a F)^2.$$

Work done = $\frac{1}{2} f h = kE$

$$\cancel{\frac{1}{2}} f h = \cancel{\frac{1}{2}} \times \frac{2s^2 h_1}{3} (2\pi a F)^2$$

$$f h = \frac{2s^2 h_1 (2\pi a F)^2}{3}$$

$$h = \frac{2s^2 h_1 (2\pi a F)^2}{3 f}$$

$$f = \sigma_w \frac{\pi d^2}{4}$$

$$f = \sigma_w \frac{\pi}{4} h^2 \left[\frac{s}{h_1} + 1.8 \right]^2$$

$$h = \frac{8 s^2 h_1 (2\pi a F)^2}{3 \sigma_w \pi h^2 \left[\frac{s}{h_1} + 1.8 \right]^2}$$

$$h^3 = \frac{8 s^2 h_1 (2\pi a F)^2}{3 \sigma_w \pi \left(\frac{s}{h_1} + 1.8 \right)^2}$$

$$h = 2 \sqrt[3]{\frac{s^2 h_1 4\pi^2 a^2 F^2}{3\sigma_w \pi \left(\frac{s}{h_1} + 1.8 \right)^2}}$$

$$\frac{h_1}{s} = \sin 45^\circ$$

$$\frac{h_1}{s} = \frac{1}{\sqrt{2}}$$

$$h_1 = s/\sqrt{2}$$

$$h = 2 \sqrt[3]{\frac{s^2 s \times 4\pi a^2 F^2}{\sqrt{2} \times 3\sigma_w (\sqrt{2} + 1.8)^2}}$$

$$h = 2s \left(\frac{4\pi a^2 F^2}{3\sqrt{2} \sigma_w (\sqrt{2} + 1.8)^2} \right)^{1/3}$$

$MRR = \eta N V_p F$

$MRR \,\alpha\, N V_p F$

$$MRR = \eta N V_p F = \eta \frac{3m^2 c}{s_1^2} \times \frac{\pi d^2}{4} F$$

$$= \eta \frac{3m^2 c}{s_1^2} \times \pi \frac{h^2}{4} \left[\sqrt{2} + 1.8\right]^2 F.$$

h is already derived.

c) $f = \frac{F_m a}{h_n}$

$F_{one} = F/N$

$$\sigma_w = \frac{F_{one}}{A}$$

$A = \pi d_w^2/4$

$$\sigma_w = \frac{F}{N \pi h_w^2 \left[\frac{s}{h_{\sigma 1}} + 1.8\right]}$$

$$\sigma_t = \frac{F}{N \pi h_t^2 \left(\frac{s}{h_{\sigma 1}} + 1.8\right)}$$

$$\frac{\sigma_w}{\sigma_t} = \frac{h_T^2}{h_w^2} \qquad \frac{h_T}{h_w} = \sqrt{\frac{\sigma_w}{\sigma_t}}$$

$$h_n = h_w + h_T$$

$$\frac{\sigma_w}{\cancel{\sigma}} = \frac{\cancel{f} f_m a}{N \pi h_n h_w^2 \left[\frac{S}{h_1} + 1.8\right]}$$

$$\sigma_w = \frac{f_m a}{N \pi (h_w + h_T) h_w^2 \left[\frac{S}{h_1} + 1.8\right]}$$

$$h_w^3 = \frac{f_m a}{N \pi \left(1 + \frac{h_T}{h_w}\right) \sigma_w \left[\frac{S}{h_1} + 1.8\right]}$$

$$h_w^3 = \frac{\cancel{f_m a}\ f_m a}{N \pi \left(1 + \sqrt{\frac{\sigma_w}{\sigma_t}}\right) \sigma_w \left[1.8 + \frac{S}{h_1}\right]}$$

$$h_w = \left(\frac{f_m a}{N \pi \left(1 + \sqrt{\frac{\sigma_w}{\sigma_t}}\right) \sigma_w \left(1.8 + \frac{S}{h_1}\right)}\right)^{1/3}$$

$$MRR = \eta N V_p F$$

$$= \eta \frac{3 m^2 e}{S_1^2} \times \frac{\pi h_w^2}{4} \left(\sqrt{2} + 1.8\right)^2 F$$

2) $u = 4.1\ J/mm^3$

$P_h = 60\ bar = 60 \times 10^5\ Pa\ \ 6\ N/mm^2$

$\frac{A\ piston}{A\ plunger} = 50$

$d_o = 500\ \mu m$

$\eta = 0.9$

$P_h A_h = P_I A_I$

$P_h \frac{A_H}{A_I} = P_I$

$6 \times 50 = P_I = 300\ N/mm^2$

By applying Bernoulli's equation

$P_w + \cancel{\frac{1}{2}\rho v_w^2} + \cancel{\rho g h_1} = \cancel{\rho g h_2} + \frac{1}{2}\rho_w v_{wj}^2 + \cancel{P_{at}}$

$P_w >> P_{at}$

$v_w << V_{wj}$

$h_1 \approx h_2$

$P_w = \frac{1}{2}\rho_w V_{wj}^2$

$\sqrt{\frac{2P_w}{\rho_w}} = V_{wj} = \sqrt{\frac{2 \times 300}{1000}} = 774.6\ m/s$

$\dot{Q}_w = \rho_w A_w v$

By conservation of momentum. $V_{awj} >> V_{ab}$

$$\dot{m}_w V_{wj} + \cancel{\dot{m}_{ab} V_{ab}} = \dot{m}_{ab} V_{awj}' + \dot{m}_w V_{awj}'$$

$$\dot{m}_w V_{wj} = (\dot{m}_{ab} + \dot{m}_w) V_{awj}'$$

$$\frac{\dot{m}_w V_{wj}}{\dot{m}_{ab} + \dot{m}_w} = V_{awj}$$

But there is 10% loss in momentum.

$$\frac{0.9 \times \dot{m}_w V_{wj}}{\dot{m}_{ab} + \dot{m}_w} = V_{awj}'$$

Power ~~KE of abrasive~~

$$= \frac{1}{2} \dot{m}_{ab} V^2$$

$$= \frac{1}{2} \dot{m}_{ab} \times \left(\frac{0.9 \times \dot{m}_w V_{wj}'}{\dot{m}_{ab} + \dot{m}_w} \right)^2$$

$$\dot{m}_w = \rho_w \dot{Q}_w = \rho_w \frac{\pi d_o^2}{4} V_{wj}$$

$$= \frac{1}{2} \dot{m}_{ab} \times \left(\frac{0.9 \rho_w \pi d_o^2 V_{wj}^2}{4\left(\dot{m}_{ab} + \frac{\rho_w \pi d_o^2 V_{wj}'}{4}\right)} \right)^2$$

$$MRR = \frac{1}{U} Power = \frac{1}{2U} \dot{m}_{ab} \left(\frac{0.9 \dot{m}_w V_{wj}'}{\dot{m}_{ab} + \dot{m}_{wj}} \right)^2$$

$$\frac{d\,MRR}{d\dot{m}_{ab}} = \frac{1}{2u}\left(\frac{(0.9\dot{m}_w V_{wj})^2}{(\dot{m}_{ab}+\dot{m}_{wj})^2} - \frac{2(0.9\dot{m}_w V_{wj})^2}{(\dot{m}_{ab}+\dot{m}_{wj})^3}\right)$$

$$\cancel{0}\ \cancel{\frac{1}{2u}}\ \frac{(0.9\dot{m}_w V_{wj})^2}{(\dot{m}_{ab}+\dot{m}_{wj})^{2}} = \frac{2(0.9\dot{m}_w V_{wj})^2}{(\dot{m}_{ab}+\dot{m}_{wj})^{3}}\,\dot{m}_{ab}$$

$$2\dot{m}_{ab} = \dot{m}_{ab} + \dot{m}_{wj}$$

$$\dot{m}_{ab} = \dot{m}_{wj}$$

$$= \rho_w \frac{\pi d_0^2}{4} V_{wj}$$

$$= 1000 \times \pi \times \frac{(500\times10^{-6})^2}{4} \times 774.6$$

$$\dot{m}_{ab} = 0.152 \text{ kg/s}$$

MRR @ 90% max $\dot{m}_{ab} = 0.9\,\dot{m}_{wj}$

$$\frac{1}{2u}\,\frac{0.9\dot{m}_{wj}}{\cancel{\dot{m}_{ab}}}\left(\frac{0.9\,\dot{m}_w V_{wj}}{0.9\dot{m}_w + \dot{m}_w}\right)^2 = \frac{1}{2u}\,0.9\dot{m}_{wj}\,\frac{0.9^2}{1.9^2}$$

$$\frac{1}{2u} \times \frac{0.9^3}{1.9^2}\,\dot{m}_{wj} V_{wj}^2$$

$$\frac{1}{2\times4.1} \times \frac{0.9^3}{1.9^2} \times 0.152 \times (774.6)^2$$

$$MRR = \cancel{2.24}\ 2.25 \text{ mm}^3/\text{s}$$

$$\frac{\frac{\text{kg}}{\text{mm}^3}\ \frac{\text{m}^2\text{s}^{-2}}{\text{kg}}}{\text{Nm}}$$

c) $MRR = hwv_c$

$hwv_c = 2.25$

$h \times 2 = 2.25$

$h = 1.125\ mm$

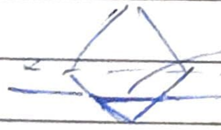
3) Volume of each abrasive $= \frac{s^2 h_1}{3}$

Mass flow rate $= \dot{m}_{ab}$

Density $= \rho_p$

$$N = \frac{\dot{m}_{ab}}{\rho_p \frac{s^2 h_1}{3}}$$

Ductile will take the shape of abrasive penetrated.



s'

h

$s' = \frac{h}{h_1} s$

$$\text{Volume} = \frac{1}{3} s'^2 h = \frac{1}{3} \frac{h^2}{h_1^2} s^2 h$$

$$= \frac{1}{3} \frac{h^3}{h_1} s^2$$

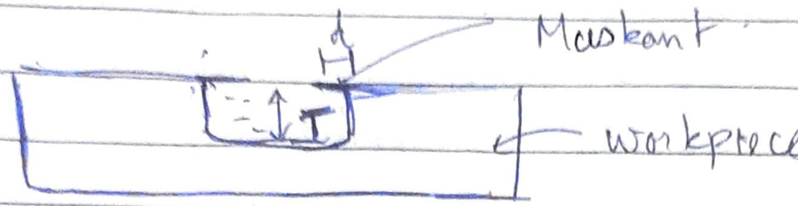
$MRR = N \times \text{Volume}$

$$= \frac{\dot{m}_{ab}}{\rho_p \frac{\cancel{s^2} h_1}{\cancel{3}}} \times \frac{1}{\cancel{3}} \frac{h^3}{h_1^2} \cancel{s^2} = \frac{\dot{m}_{ab} h^3}{\rho_p h_1^3}$$

$h = s \sin 45^\circ = s/\sqrt{2}$

$$MRR = \frac{\dot{m}_{ab}}{\rho_b} \frac{h^3 2\sqrt{2}}{s^3}$$

4)

a) 

$$\frac{d}{T} = \text{etch factor}$$

$T = \cancel{*}15 \text{ mm}$

$w\cancel{d} = 40\text{mm}$

$$\frac{d}{T} = 0.01 \times 9 = 0.09$$

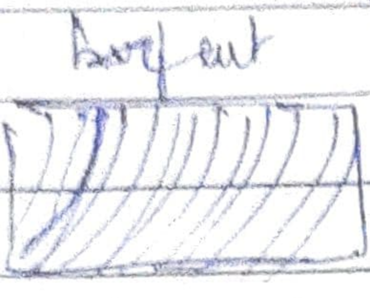
$$d = 0.09 \times 15 = 1.35 \text{ mm}.$$

width to removed $= 40 - 2 \times 1.35 = 37.3$ mm.

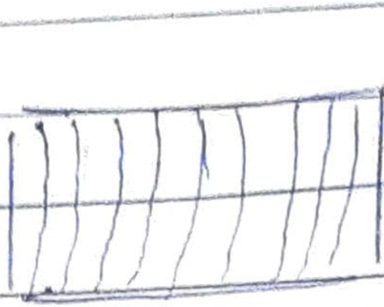
5) * ~~Abrasi~~ In Abrasive flow machining gradual mechanical abrasion because of abrasive in the slurry ~~finishes the~~ performs surface finishing.

* In this the slurry is ~~p~~ forced through the slot and because of variable area as shown, the velocity changes and hence increases ~~the~~ or decreases maching force. and the provides a gradual multipoint finishing.

b) As the the traverse ~~rate~~ rate increases the surface quality reduces as the jet ~~is~~ does not get enough time to give a proper surface finish. when traverse rate decreases the quality improves as there is more time to give a proper finish.



high speed



low speed.

kerf quality at high traverse and low traverse speed.