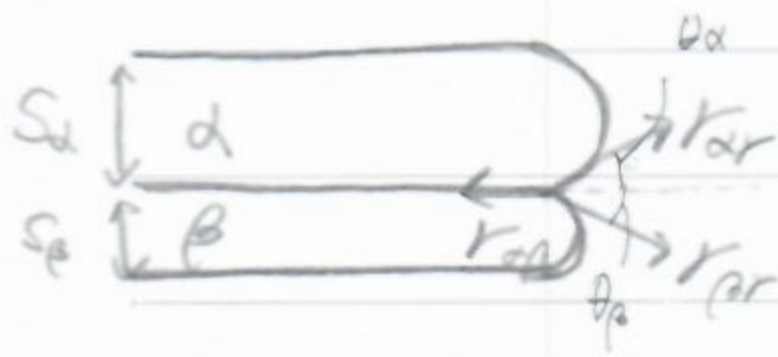


(a)



$$r_{dp} = r_d \cos \theta_d + r_p \cos \theta_p, \quad r_d \cos \theta_d = r_p \cos \theta_p \Rightarrow \text{Force balance,}$$

curvature가 같을 때  $\theta_d$  와  $\theta_p$  는  $90^\circ$  이다

이 때 force balance 가 되기  $r_{dp}$  가 0이 되기 때문이다.

$r_{dp}$  가 0이 되기 위해서는  $0 < \theta_d, \theta_p < 90^\circ$  이다

(b)



$$S_d = 2r_d \cos \theta_d, \quad S_p = 2r_p \cos \theta_p$$

$$r_d \sin \theta_d = r_p \sin \theta_p \Rightarrow r_d^2 \sin^2 \theta_d = r_p^2 \sin^2 \theta_p \Rightarrow r_d^2 (1 - \cos^2 \theta_d) = r_p^2 (1 - \cos^2 \theta_p)$$

$$\Rightarrow \cos \theta_p = \sqrt{1 - \frac{r_d^2}{r_p^2} (1 - \cos^2 \theta_d)}$$

$$r_{dp} = r_d \cos \theta_d + r_p \cos \theta_p = r_d \cos \theta_d + r_p \sqrt{1 - \frac{r_d^2}{r_p^2} (1 - \cos^2 \theta_d)}$$

$$r_{dp} - r_d \cos \theta_d = r_p \sqrt{1 - \frac{r_d^2}{r_p^2} (1 - \cos^2 \theta_d)}$$

$$r_{dp}^2 - 2r_p r_d \cos \theta_d + r_d^2 \cos^2 \theta_d = r_p^2 - r_p^2 (1 - \cos^2 \theta_d) \Rightarrow \cos \theta_d = \frac{r_{dp}^2 - r_p^2 + r_d^2}{2r_p r_d}$$

$$\therefore r_d = \frac{S_d}{2 \cos \theta_d} = \frac{S_d r_{dp} r_p}{r_{dp}^2 - r_p^2 + r_d^2}, \quad r_p = \frac{S_p r_{dp} r_d}{r_{dp}^2 - r_d^2 + r_p^2}$$

(L)

$$\Delta f = \frac{r_{ar}}{r_a} V_a + \frac{r_{ar}}{r_b} V_b = \left( \frac{S_a r_{ar}}{r_a} + \frac{S_b r_{ar}}{r_b} \right) \frac{V_m^r}{5} \quad \left( V_a = \frac{S_a}{5} V_m^r, V_b = \frac{S_b}{5} V_m^r \right)$$

$$= \left\{ \frac{S_a r_{ar} (r_{ar}^2 - r_{ar}^2 + r_{ar}^2)}{S_a r_{ar} r_{ar}} + \frac{S_b r_{ar} (r_{ar}^2 - r_{ar}^2 + r_{ar}^2)}{S_b r_{ar} r_{ar}} \right\} \frac{V_m^r}{5}$$

$$= \frac{2 S_a r_{ar} V_m^r}{5} = \underline{\underline{\Delta f_{ZF}}}$$