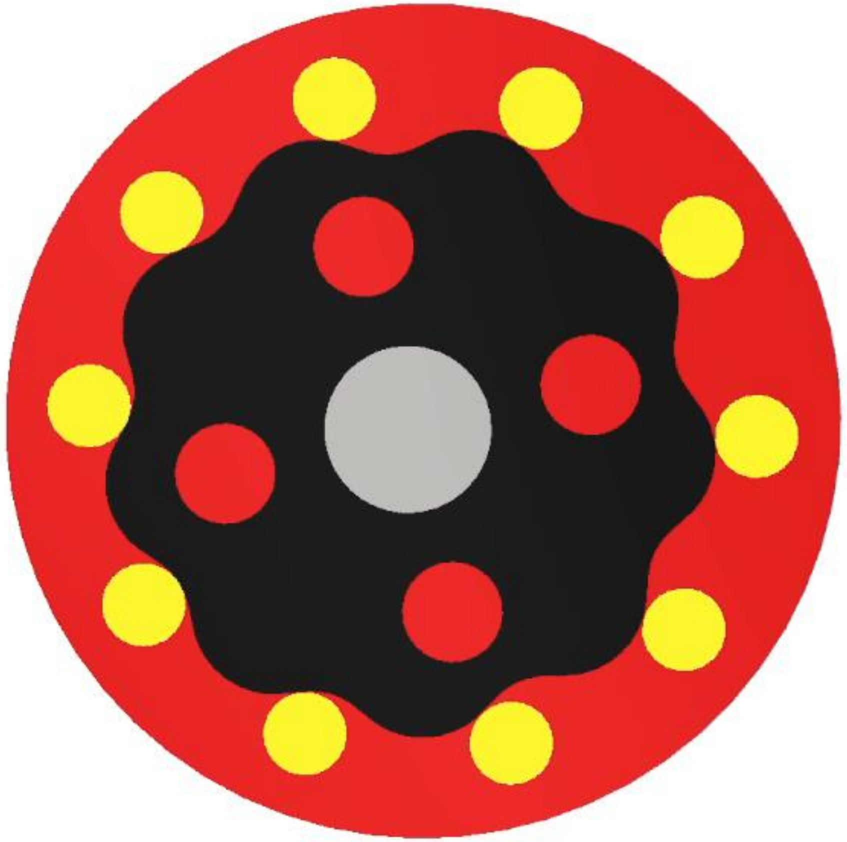
Cycloid Reducer

周奕彬

研究目標

- 擺線減速機誤差分析
- 求等校連桿簡化分析



大綱

- 新擺線輪輪廓解析式
- 等效連桿&曲率半徑
- 位移方程式
- 未來目標

新輪廓解析式

- 原外擺線解析式

$$C_x = R\cos\phi - R_r\cos(\phi + \psi) - E\cos(N\phi)$$
$$C_y = -R\sin\phi + R_r\sin(\phi + \psi) + E\sin(N\phi)$$

$$\psi = \tan^{-1}\left[\frac{\sin(1 - N)\phi}{(R/EN) - \cos(1 - N)\phi}\right] \quad (0^\circ \leqslant \phi \leqslant 360^\circ)$$

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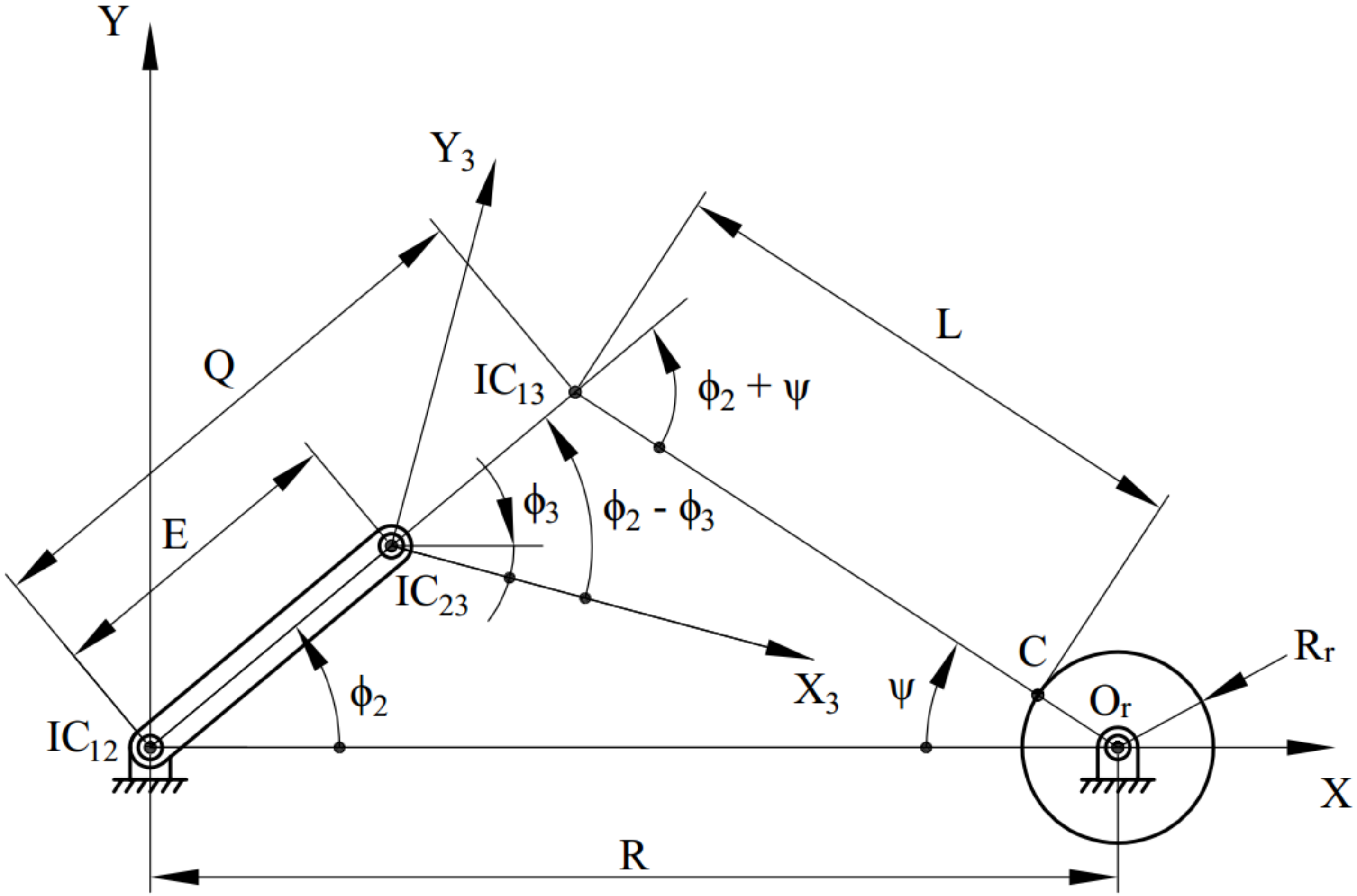
外擺線解析式



- $\overrightarrow{IC_{23}IC_{13}} + \overrightarrow{IC_{13}O_r} - \overrightarrow{CO_r}$
- $\overline{IC_{23}IC_{13}} = \mathrm{Q} - \mathrm{E}$
- $\overline{IC_{13}O_{\mathrm{R}}} - \overline{CO_{\mathrm{R}}} = \mathrm{L}$

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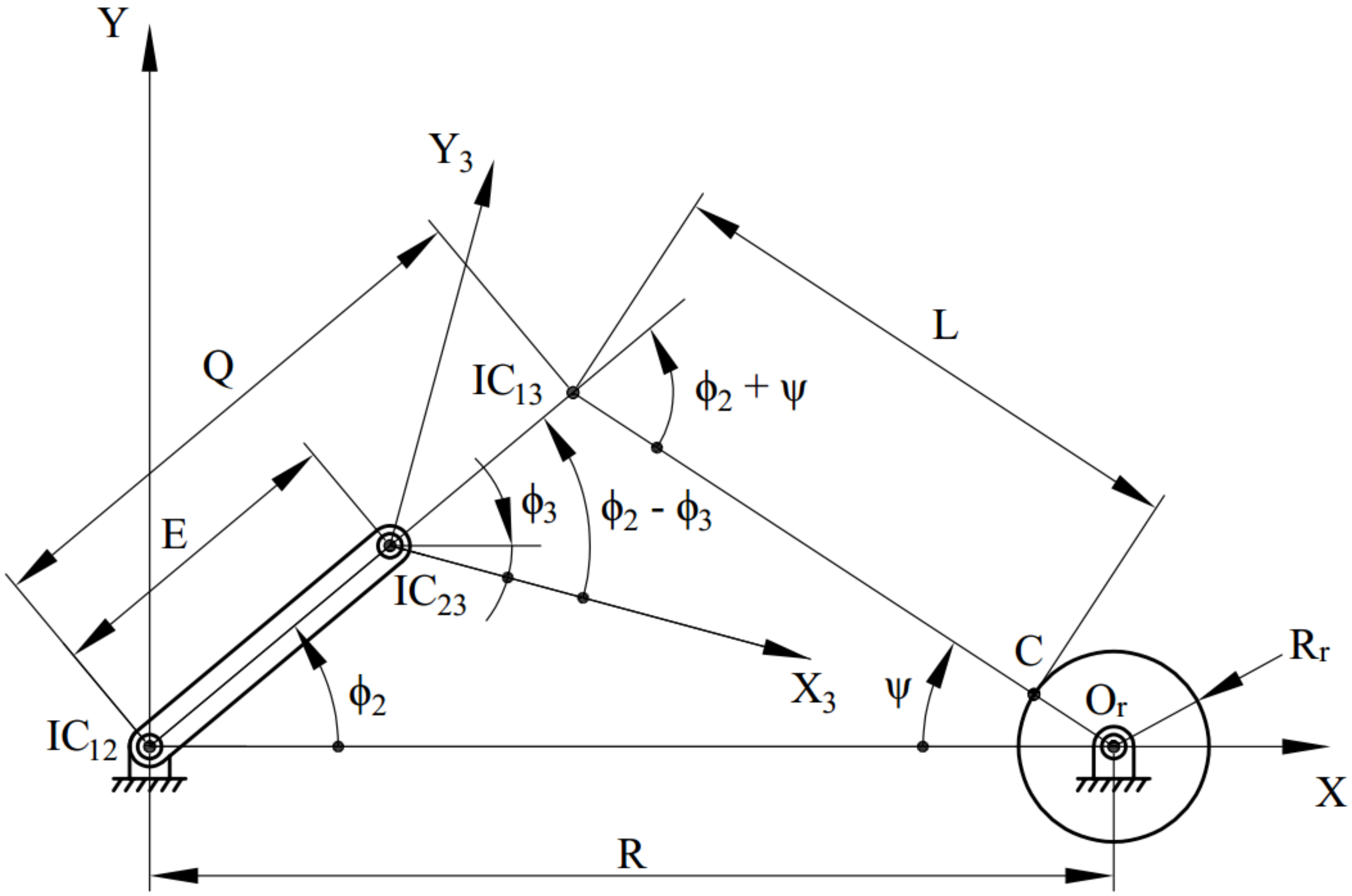
外擺線解析式



- $\overrightarrow{IC_{23}IC_{13}} + \overrightarrow{IC_{13}C}$
- $C_x = (Q - E)\cos(\emptyset_2 - \emptyset_3) + L\cos\big((\emptyset_2 - \emptyset_3) - (\emptyset_2 + \psi)\big)$
- $C_y = (Q - E)\sin(\emptyset_2 - \emptyset_3) + L\sin\big((\emptyset_2 - \emptyset_3) - (\emptyset_2 + \psi)\big)$

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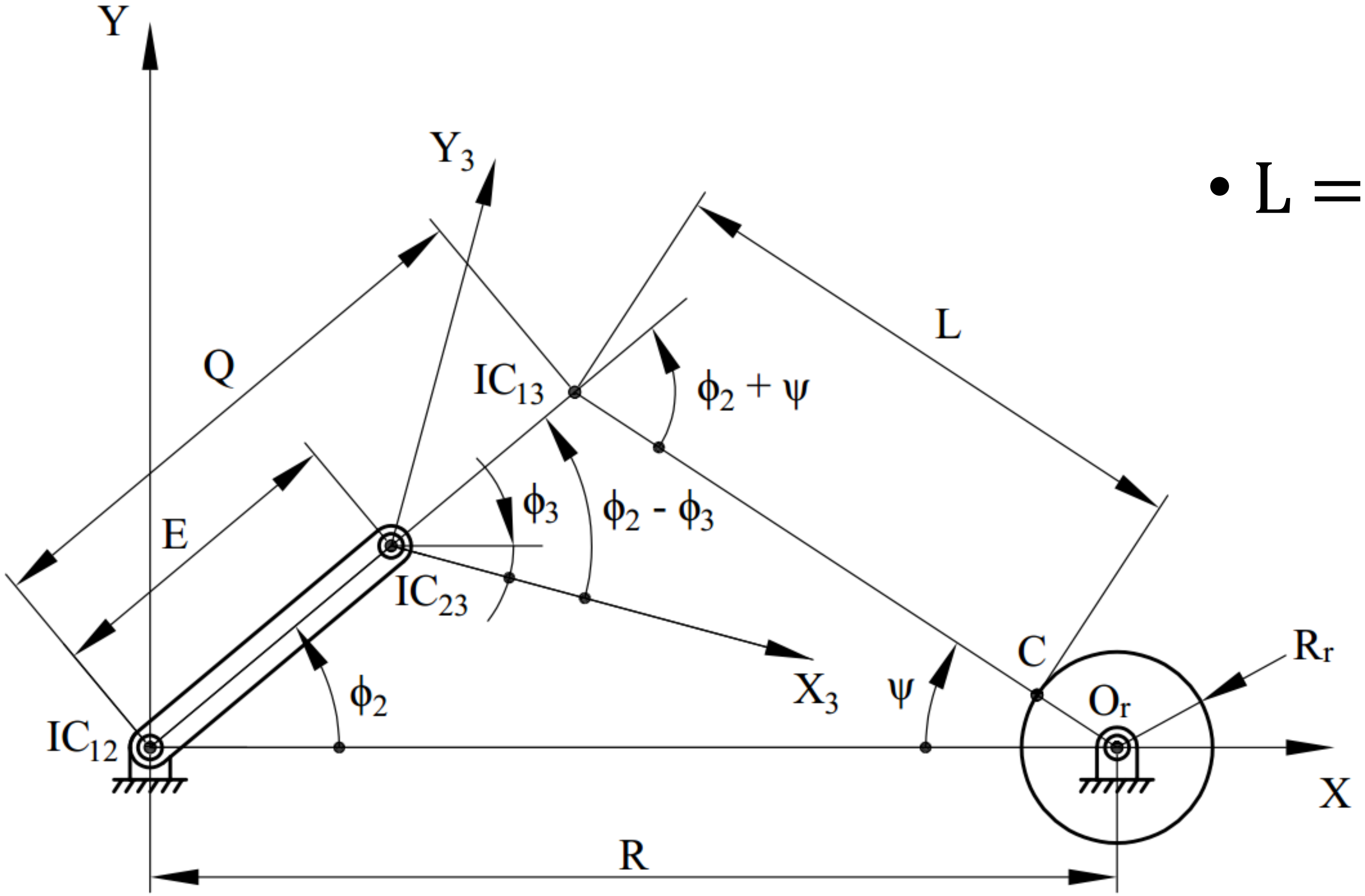
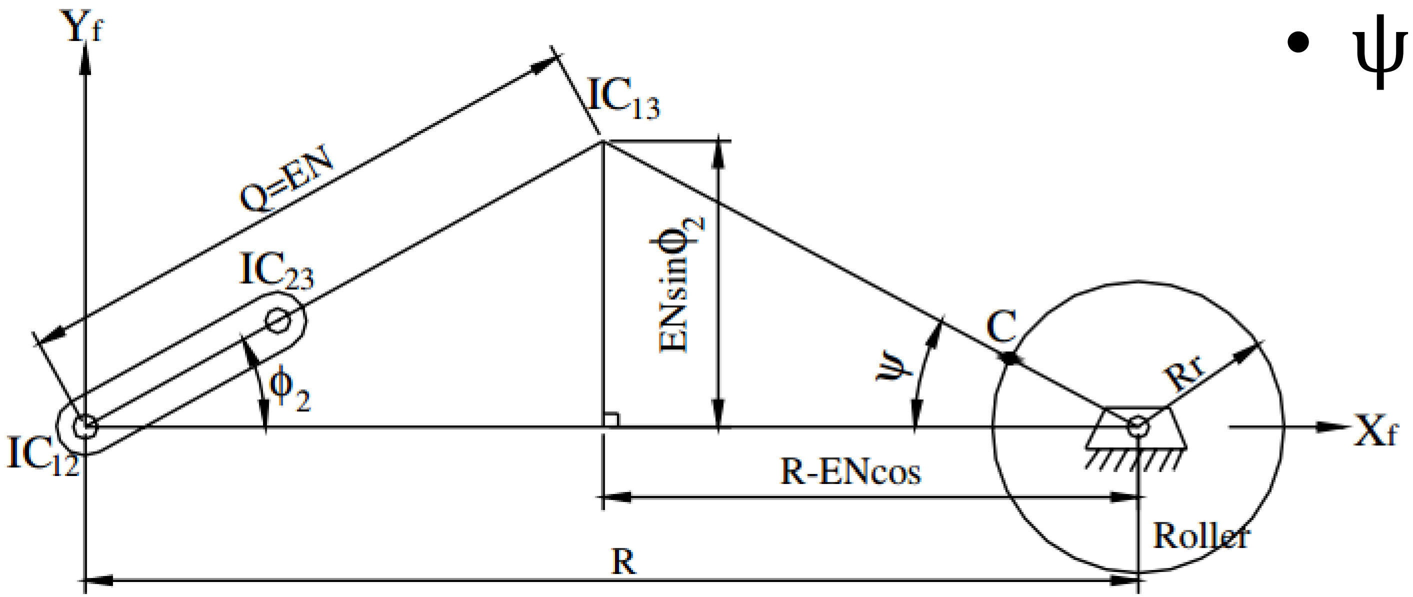
外擺線解析式



- $L = \sqrt{R^2 + Q^2 - 2RQ\cos(\phi_2)} - R_r$

外擺線解析式



- $\psi = \tan^{-1}\frac{Q\sin(\emptyset_2)}{R-Q\cos(\emptyset_2)}$

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外擺線解析式

- $C_x = (Q - E)\cos(\emptyset_2 - \emptyset_3) + L\cos\big((\emptyset_2 - \emptyset_3) - (\emptyset_2 + \psi)\big)$
- $C_y = (Q - E)\sin(\emptyset_2 - \emptyset_3) + L\sin\big((\emptyset_2 - \emptyset_3) - (\emptyset_2 + \psi)\big)$
- $L = \sqrt{R^2 + Q^2 - 2RQ\cos(\emptyset_2)} - R_r$
- $\psi = \tan^{-1}\frac{Q\sin(\emptyset_2)}{R - Q\cos(\emptyset_2)}$

- $\emptyset_3 = \emptyset$; $\emptyset_2 = (1 - N)\emptyset$; $Q = EN$;

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外擺線解析式

$$C_x = \mathrm{E}\cos(\mathrm{N}\varnothing)(\mathrm{N}-1) + \mathrm{L}\cos(\varnothing + \psi)$$ $$C_y = -\mathrm{E}\sin(\mathrm{N}\varnothing)(\mathrm{N}-1) - \mathrm{L}\sin(\varnothing + \psi)$$
$$\mathrm{L} = \sqrt{\mathrm{R}^2 + (\mathrm{EN})^2 - 2\mathrm{REN}\cos((1-\mathrm{N})\varnothing)} - \mathrm{R_r}$$
$$\psi = \tan^{-1}\frac{\sin((1-\mathrm{N})\varnothing)}{((\mathrm{R}/(\mathrm{EN})) - \cos((1-\mathrm{N})\,\varnothing))}$$

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新輪廓解析式

- 原內擺線解析式

$$C_x = R\cos\phi + R_r\cos(\phi - \psi) + E\cos(N\phi)$$
$$C_y = R\sin\phi + R_r\sin(\phi - \psi) - E\sin(N\phi)$$

$$\psi = -\tan^{-1}\left[\frac{\sin(N+1)\phi}{(R/EN) - \cos(N+1)\phi}\right]$$

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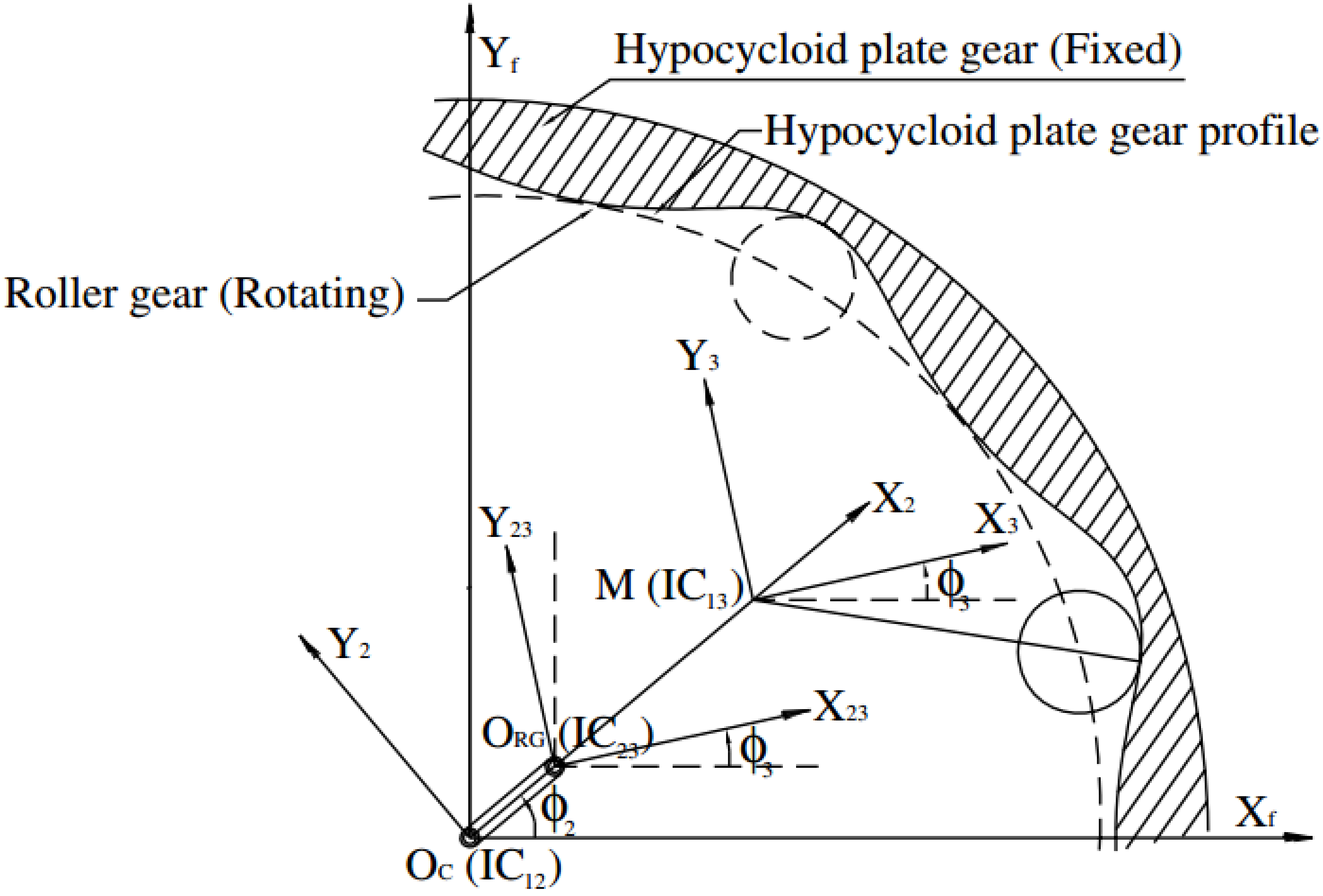
內擺線解析式



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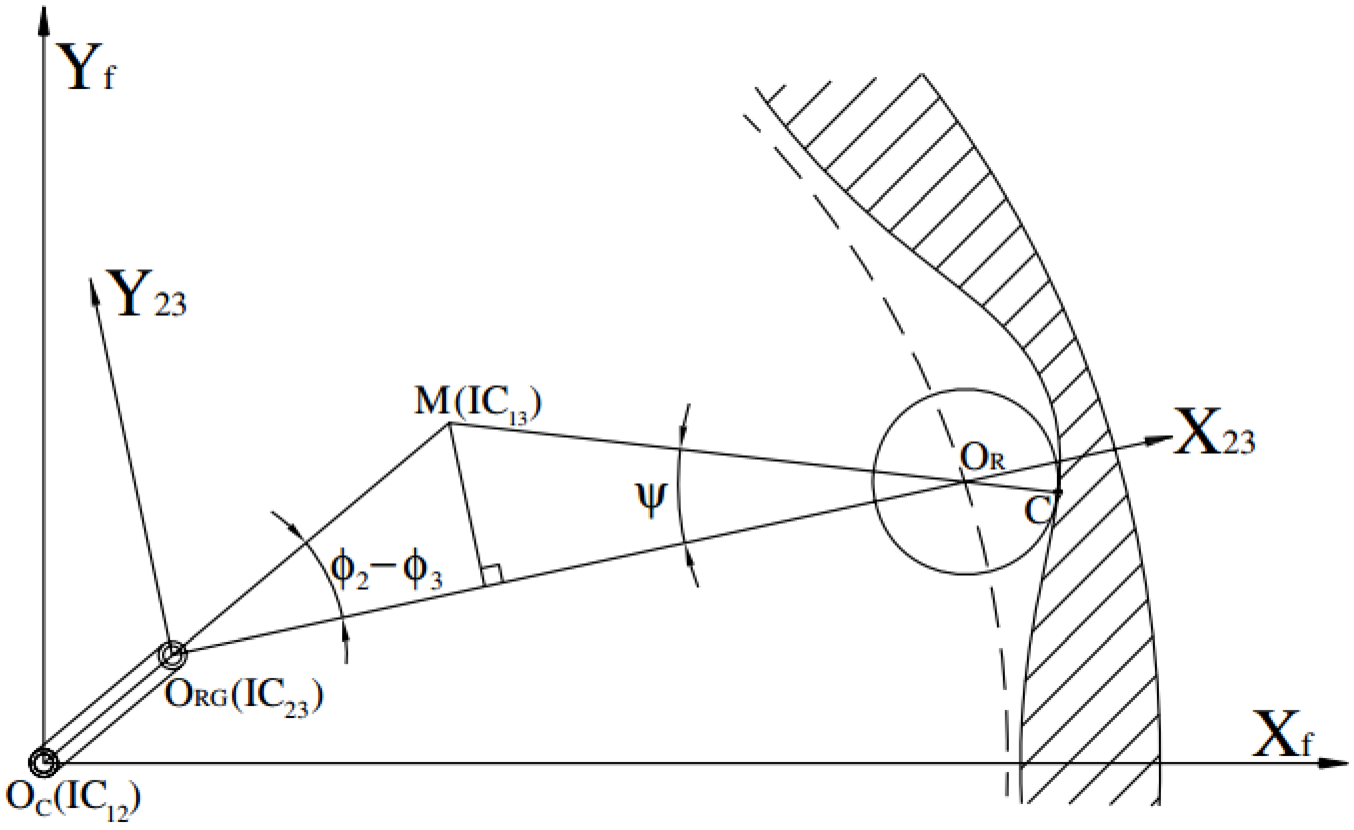
外擺線解析式



- $\overrightarrow{IC_{12}IC_{13}} + \overrightarrow{IC_{13}O_{\mathrm{R}}} + \overrightarrow{O_{R}C}$
- $\overline{IC_{12}IC_{13}} = \mathrm{Q}$
- $\overline{IC_{13}O_{\mathrm{R}}} + \overline{CO_{\mathrm{R}}} = \mathrm{L}$

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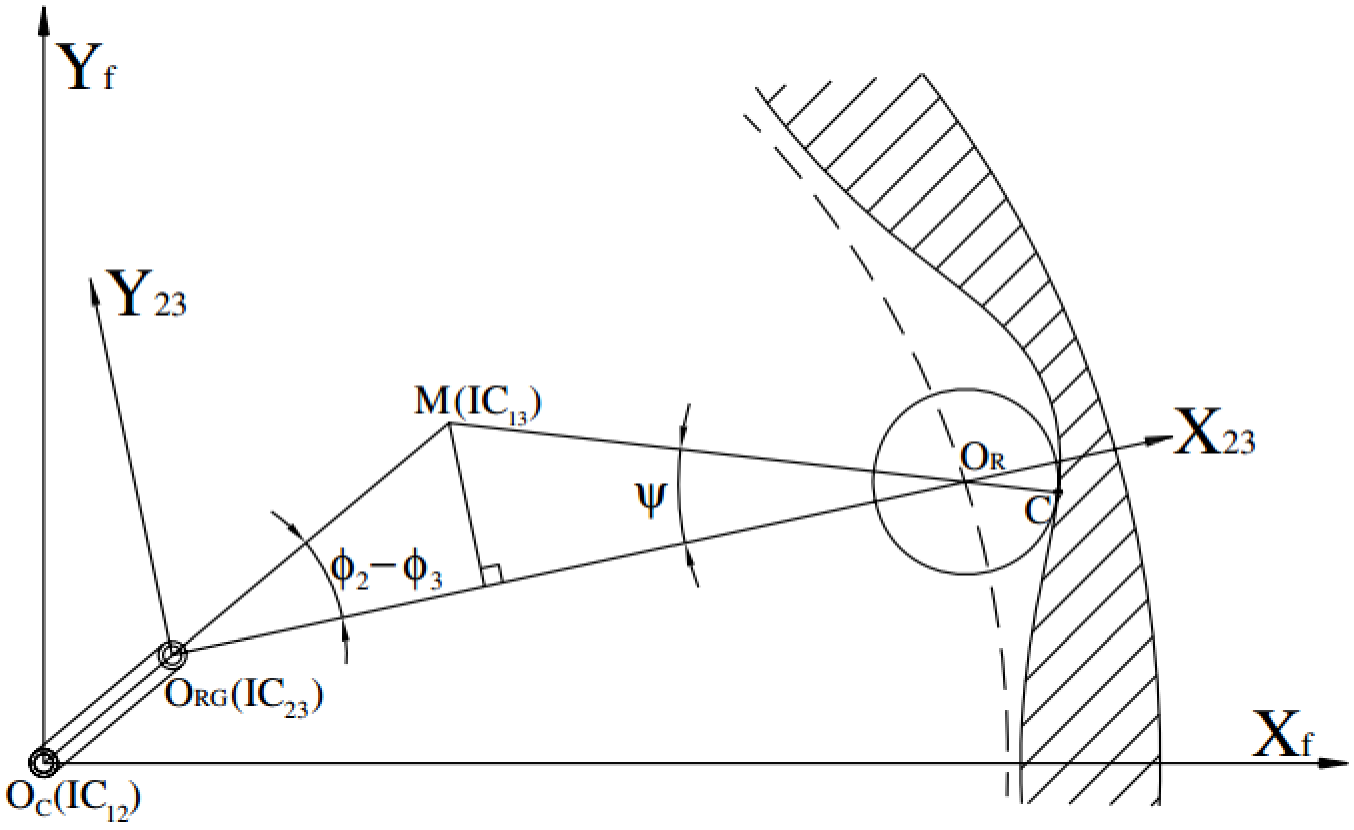
外擺線解析式



- $\overrightarrow{IC_{12}IC_{13}} + \overrightarrow{IC_{13}C}$

- $C_x = Q\cos(\emptyset_2)$
  $+ L\cos\left(\emptyset_2 - (\emptyset_2 - \emptyset_3 + \psi)\right)$

- $C_y = Q\sin(\emptyset_2)$
  $+ L\sin\left(\emptyset_2 - (\emptyset_2 - \emptyset_3 + \psi)\right)$

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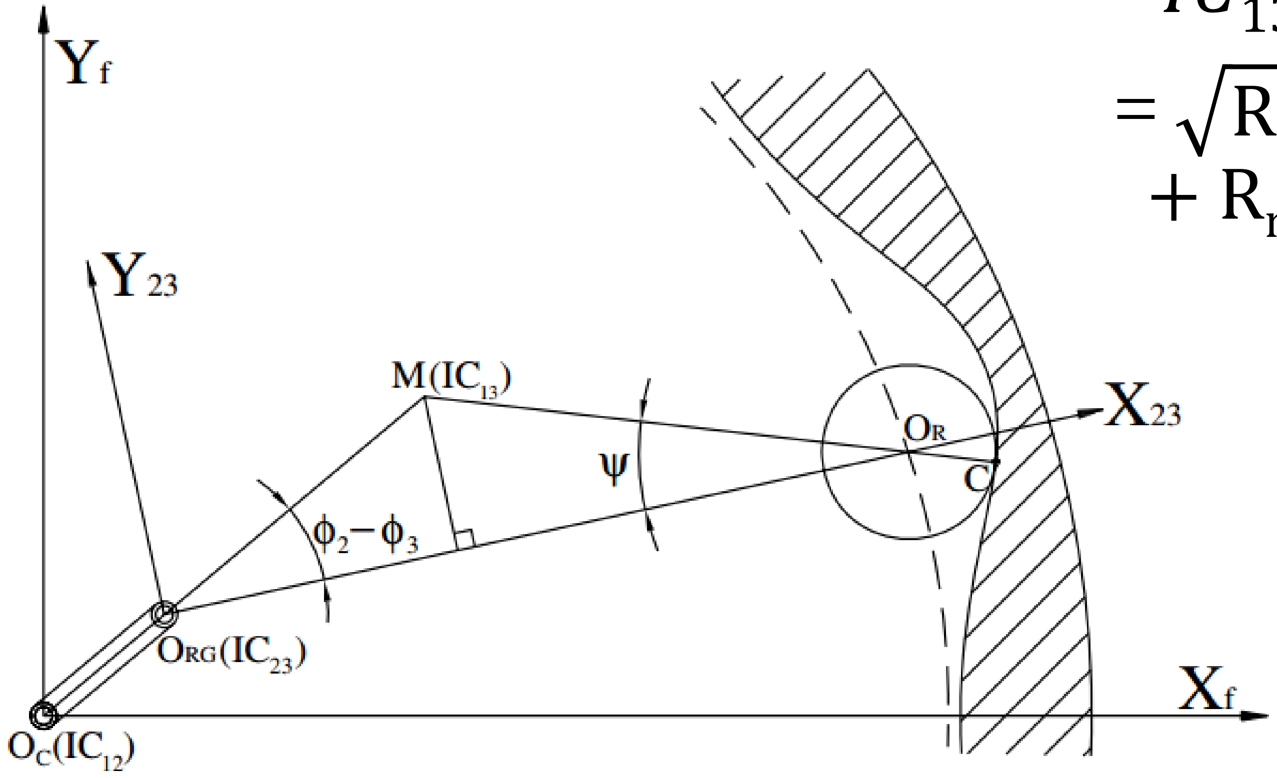
外擺線解析式



- $\overline{IC_{13}O_r} + \overline{CO_r} = L$

$$= \sqrt{R^2 + (Q - E)^2 - 2R(Q - E)\cos(\emptyset_2 - \emptyset_3)} + R_r$$

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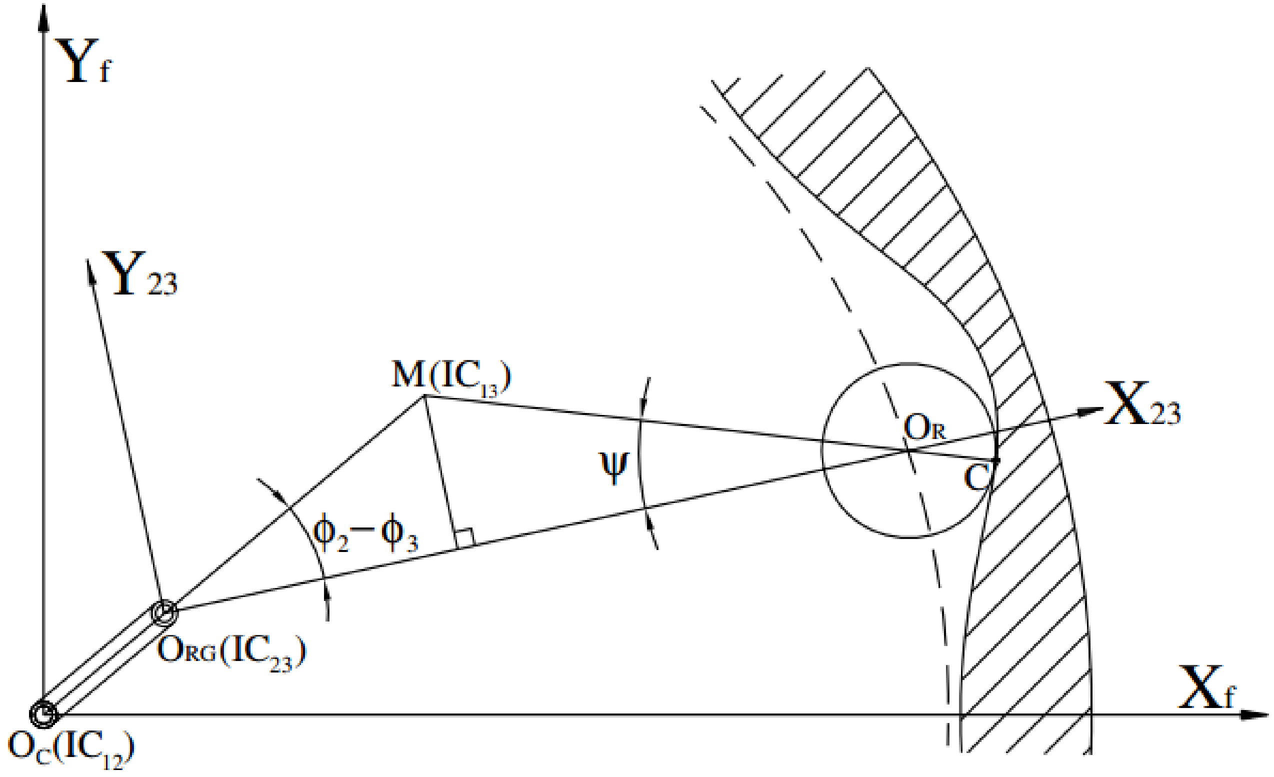
外擺線解析式



- $\psi = \tan^{-1}\dfrac{(Q-E)\sin(\emptyset_2-\emptyset_3)}{R-(Q-E)\cos(\emptyset_2-\emptyset_3)}$

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外擺線解析式

- $C_x = \mathrm{Q}\cos(\emptyset_2) + \mathrm{L}\cos\left(\emptyset_2 - (\emptyset_2 - \emptyset_3 + \psi)\right)$
- $C_y = \mathrm{Q}\sin(\emptyset_2) + \mathrm{L}\sin\left(\emptyset_2 - (\emptyset_2 - \emptyset_3 + \psi)\right)$
- $\mathrm{L} = \sqrt{\mathrm{R}^2 + (\mathrm{Q} - \mathrm{E})^2 - 2\mathrm{R}(\mathrm{Q} - \mathrm{E})\cos(\emptyset_2 - \emptyset_3)} + \mathrm{R_r}$
- $\psi = \tan^{-1} \frac{(\mathrm{Q}-\mathrm{E})\sin(\emptyset_2 - \emptyset_3)}{\mathrm{R}-(\mathrm{Q}-\mathrm{E})\cos(\emptyset_2 - \emptyset_3)}$

- $\emptyset_3 = \emptyset$; $\emptyset_2 = -\mathrm{N}\emptyset$; $\mathrm{Q} = \mathrm{E}(\mathrm{N} + 1)$;

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外擺線解析式

$$C_x = E\cos(N\emptyset)(N+1) + L\cos(\emptyset - \psi)$$ $$C_y = -E\sin(N\emptyset)(N+1) + L\sin(\emptyset - \psi)$$
$$L = \sqrt{R^2 + (EN)^2 - 2REN \times \cos((1+N)\emptyset)} + R_r$$
$$\psi = \tan^{-1}\frac{-\sin((1+N)\emptyset)}{((R/(EN)) - \cos((1+N)\emptyset))}$$

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Stationary ring gear type epicycloid reducer		Stationary ring gear type hypocycloid reducer	
$\emptyset_3 = \emptyset$	$\emptyset_2 = (1 - \mathrm{N})\emptyset$	$\emptyset_3 = \emptyset$	$\emptyset_2 = -\mathrm{N}\emptyset$
$\mathrm{L} = \sqrt{\mathrm{R}^2 + (\mathrm{EN})^2 - 2\mathrm{REN} \times \cos((1 - \mathrm{N})\emptyset)} - \mathrm{R_r}$		$\mathrm{L} = \sqrt{\mathrm{R}^2 + (\mathrm{EN})^2 - 2\mathrm{REN} \times \cos((1 + \mathrm{N})\emptyset)} + \mathrm{R_r}$	
$\mathrm{C}_x = \mathrm{E}\cos(\mathrm{N}\emptyset)(\mathrm{N} - 1) + \mathrm{L}\cos(\emptyset + \psi)$ $\mathrm{C}_y = -\mathrm{E}\sin(\mathrm{N}\emptyset)(\mathrm{N} - 1) - \mathrm{L}\sin(\emptyset + \psi)$		$\mathrm{C}_x = \mathrm{E}\cos(\mathrm{N}\emptyset)(\mathrm{N} + 1) + \mathrm{L}\cos(\emptyset - \psi)$ $\mathrm{C}_y = -\mathrm{E}\sin(\mathrm{N}\emptyset)(\mathrm{N} + 1) + \mathrm{L}\sin(\emptyset - \psi)$	
$\psi = \tan^{-1} \frac{\sin((1 - \mathrm{N})\emptyset)}{((\mathrm{R}/(\mathrm{EN})) - \cos((1 - \mathrm{N})\,\emptyset))}$		$\psi = \tan^{-1} \frac{-\sin((1 + \mathrm{N})\emptyset)}{((\mathrm{R}/(\mathrm{EN})) - \cos((1 + \mathrm{N})\,\emptyset))}$	

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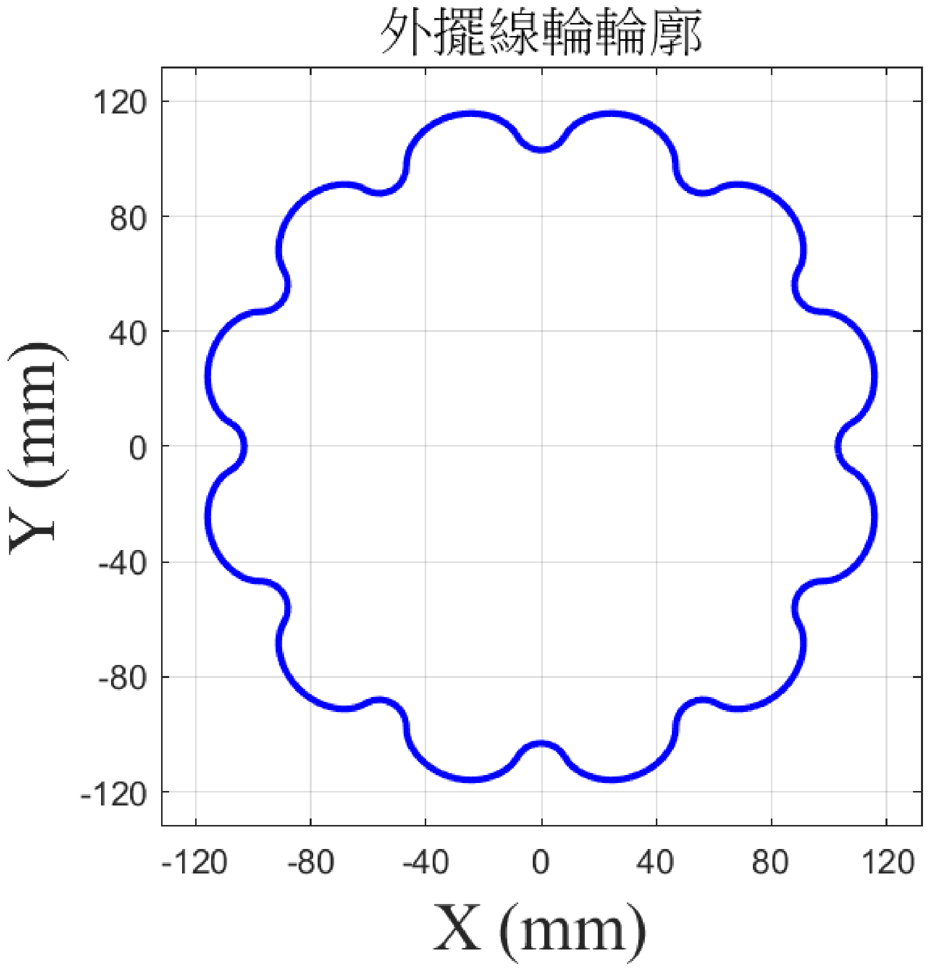
曲率半徑



- N = 13
- R_r = 9 mm
- R = 120 mm
- E =8 mm

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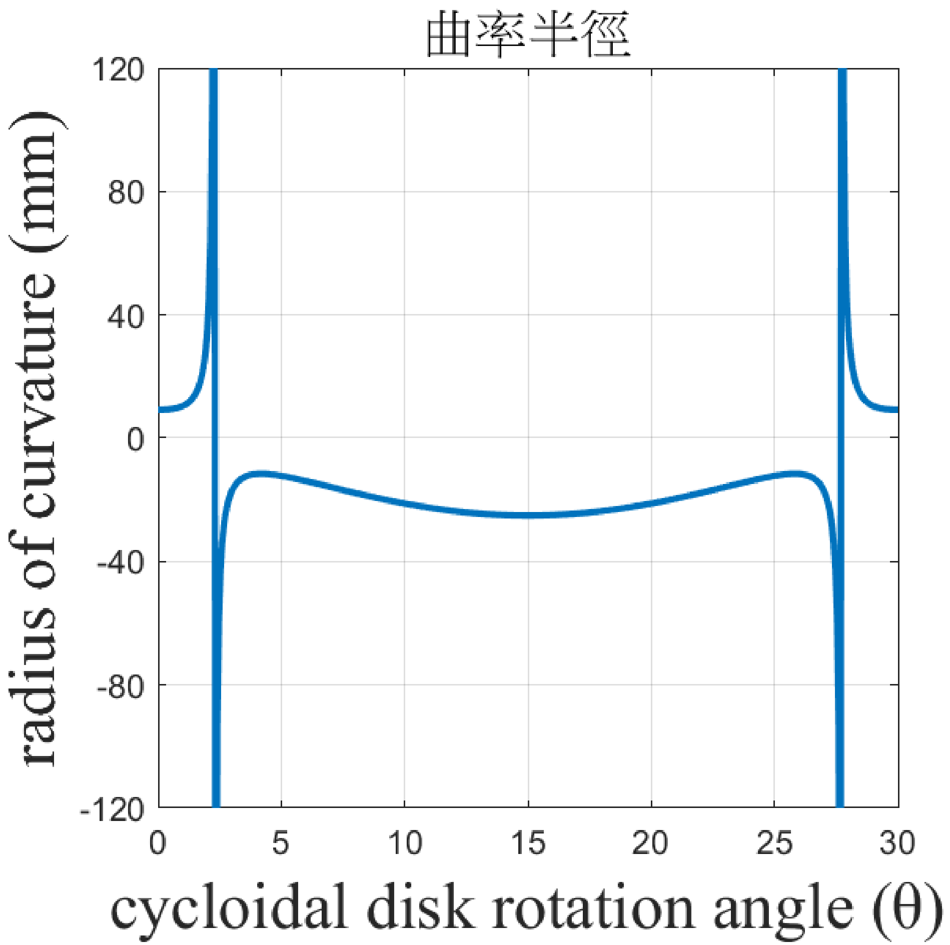
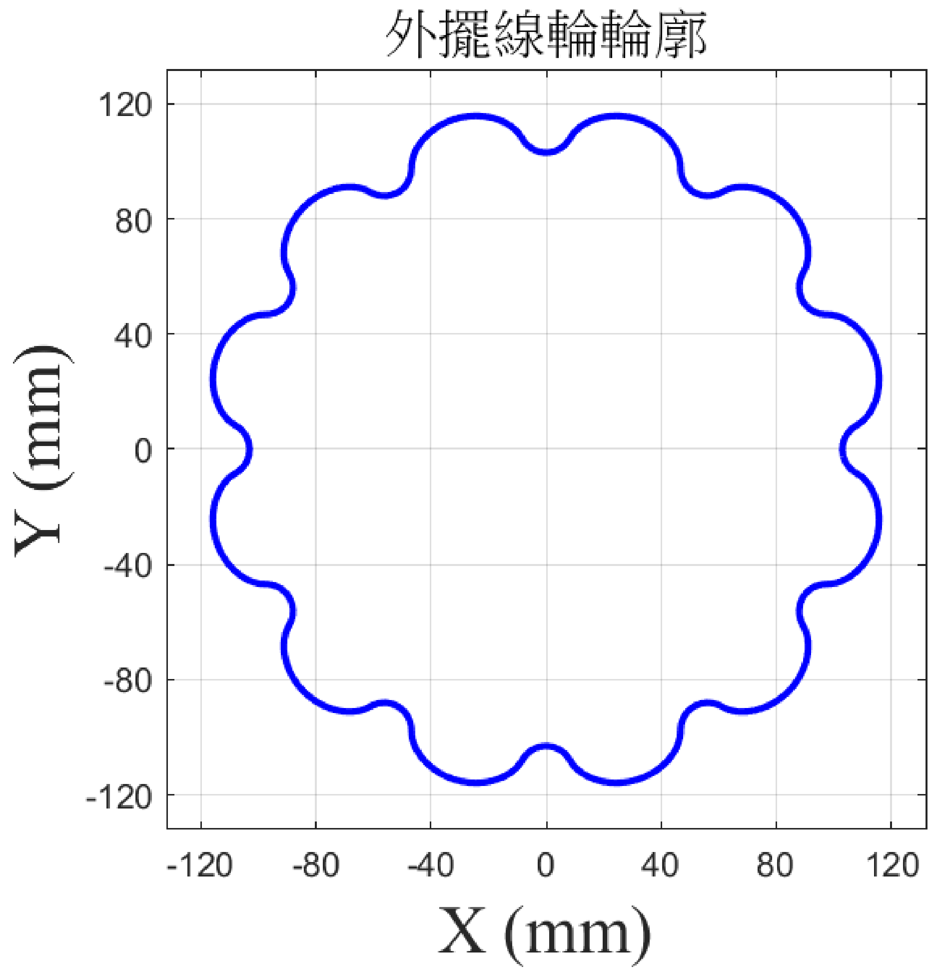
曲率半徑





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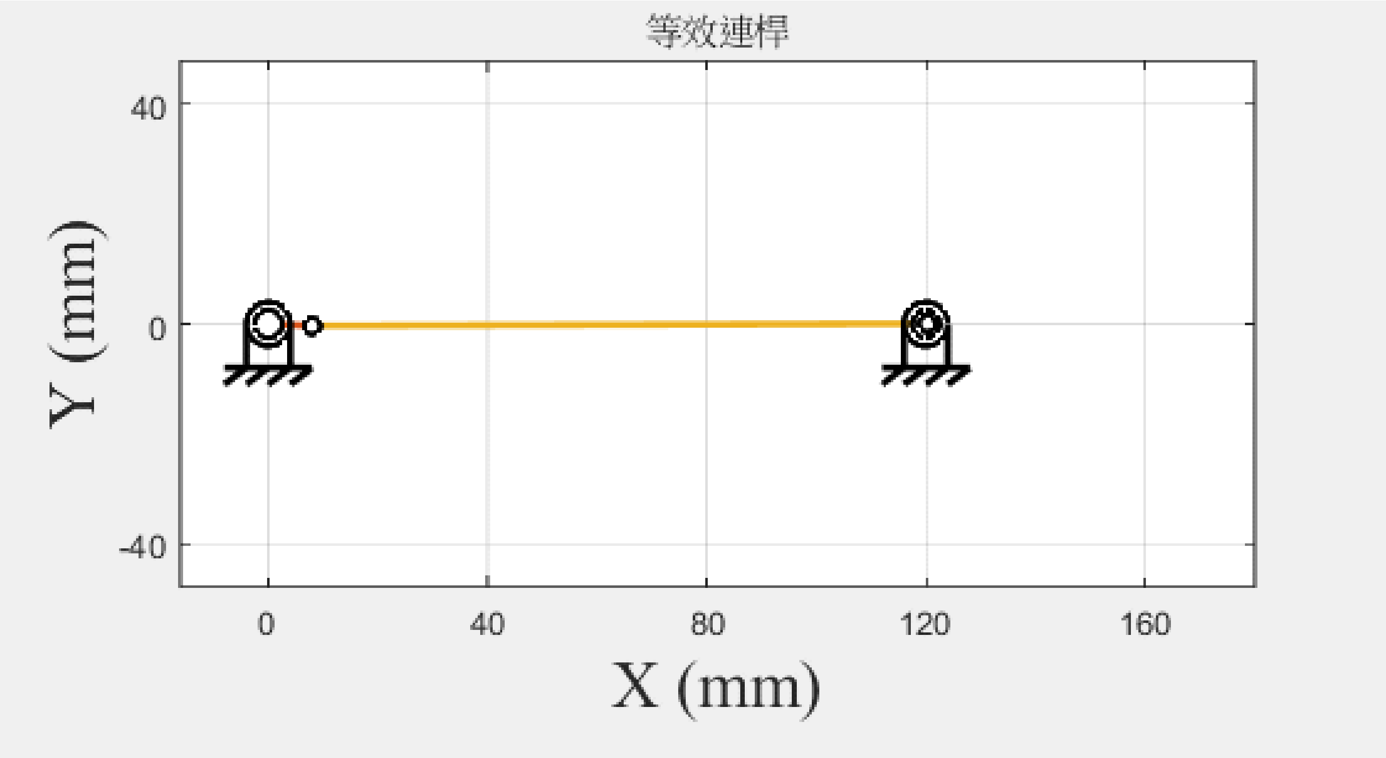
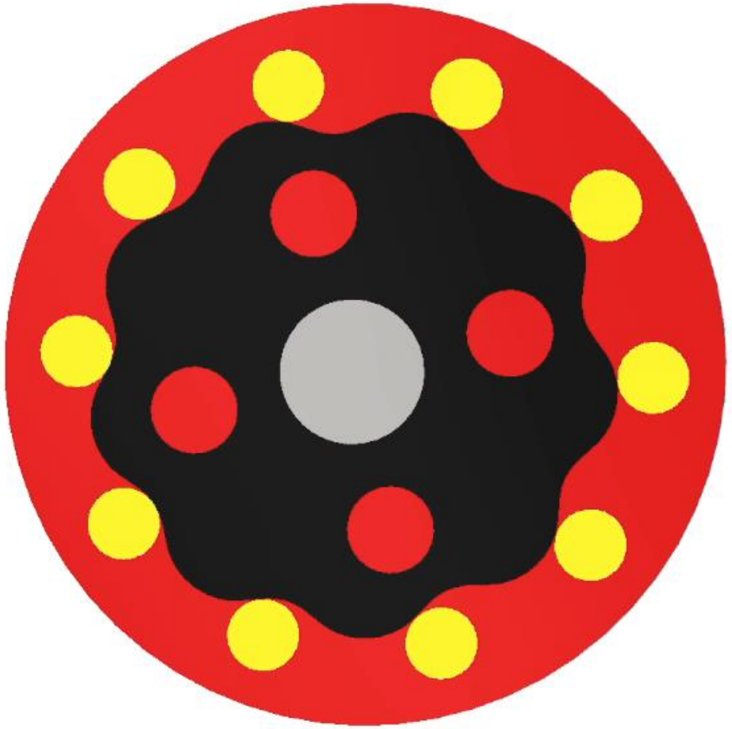
等效連桿





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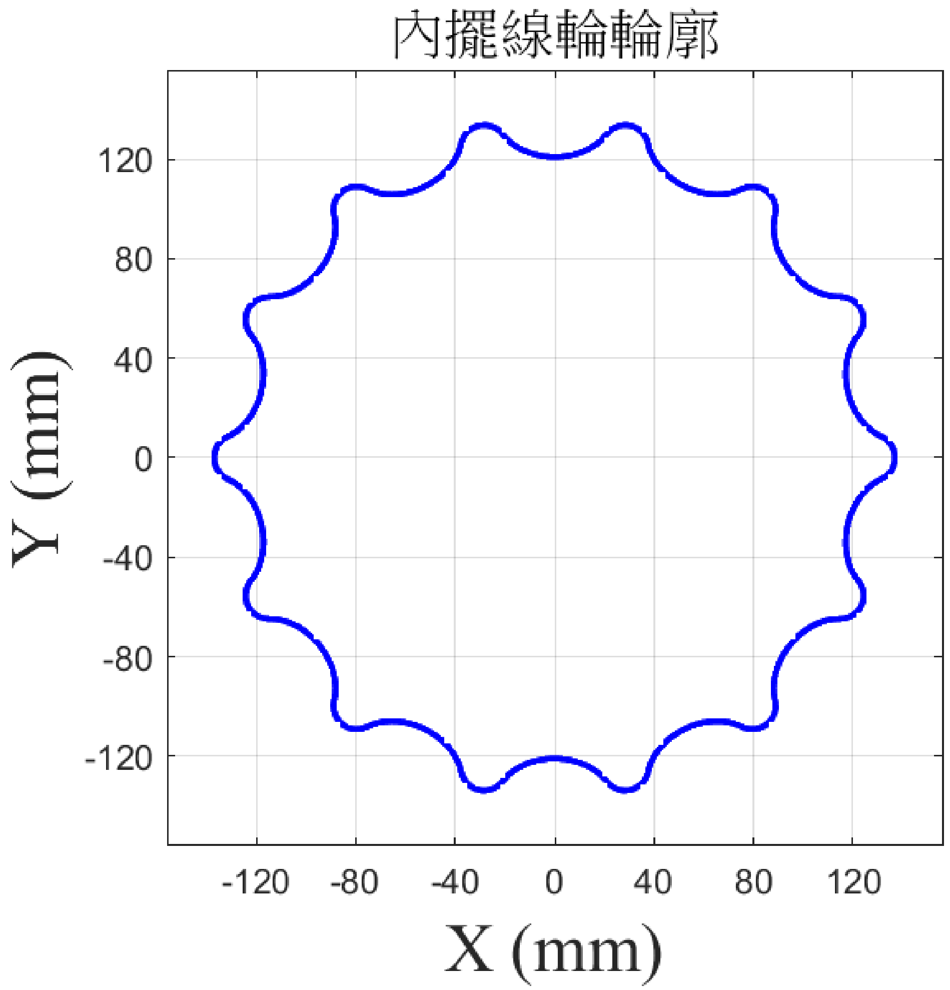
曲率半徑



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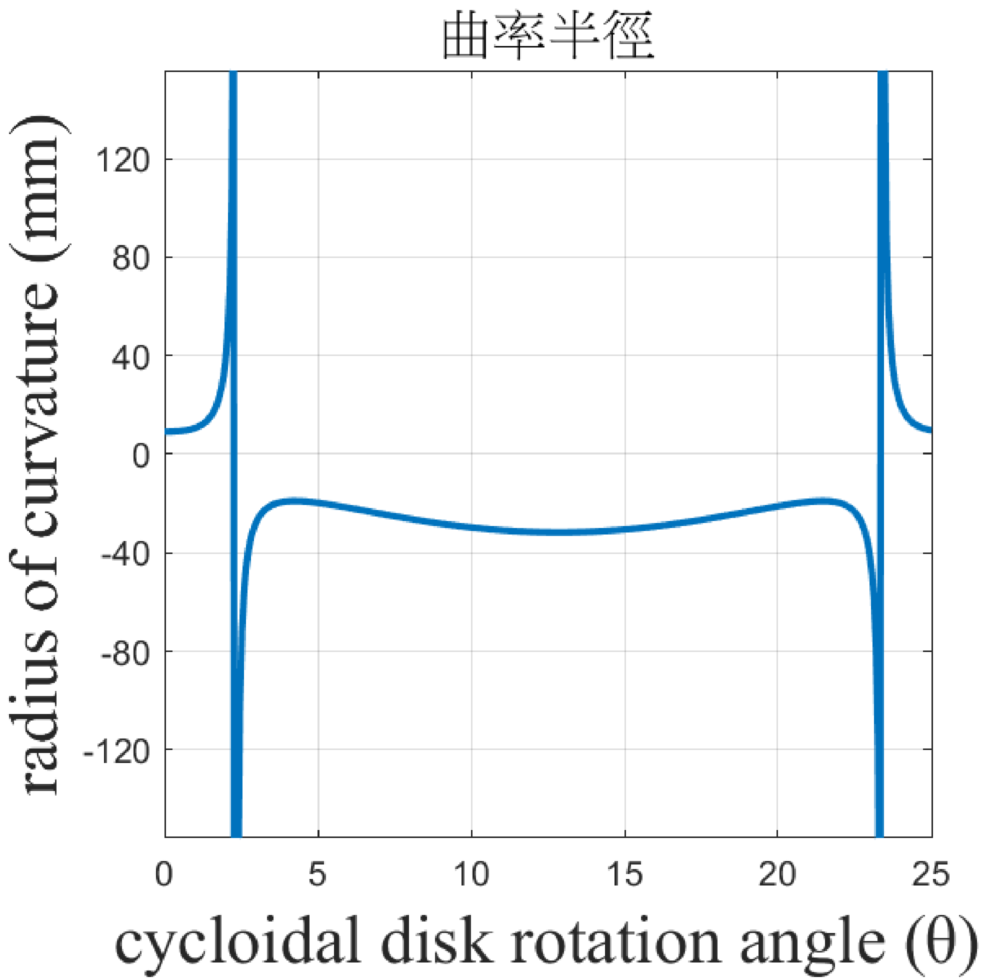
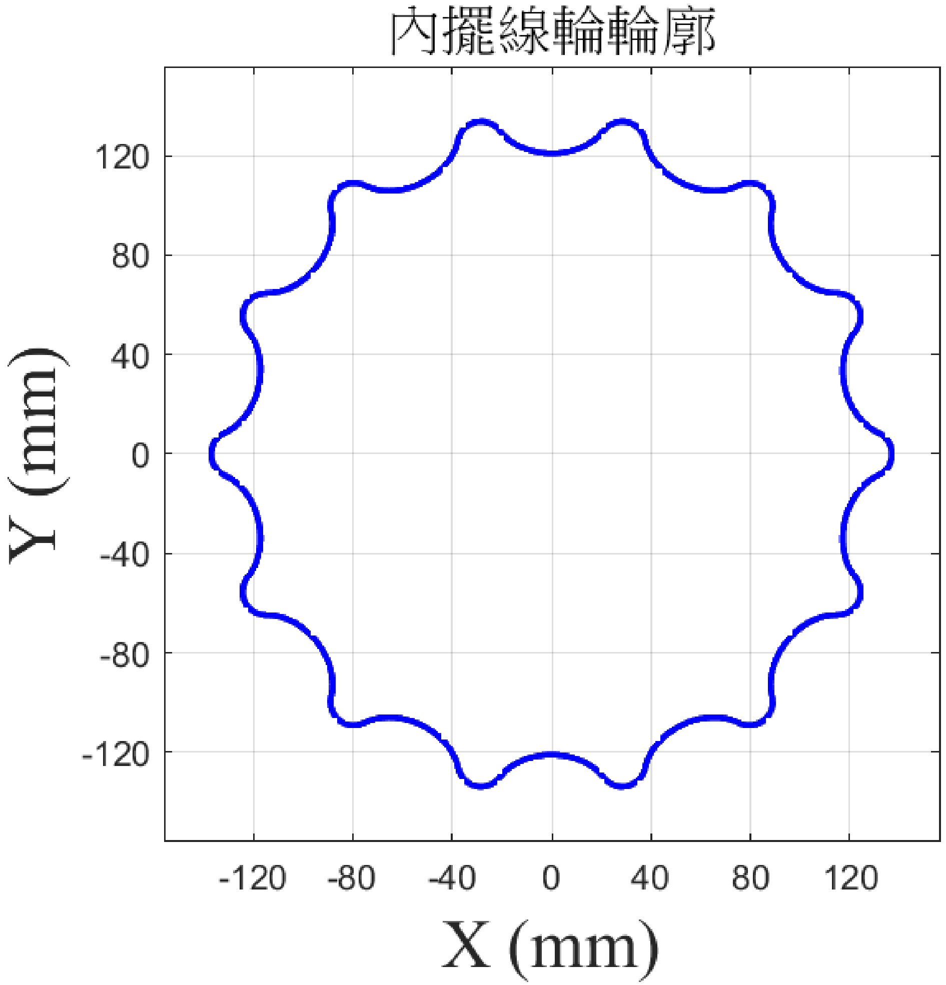
曲率半徑





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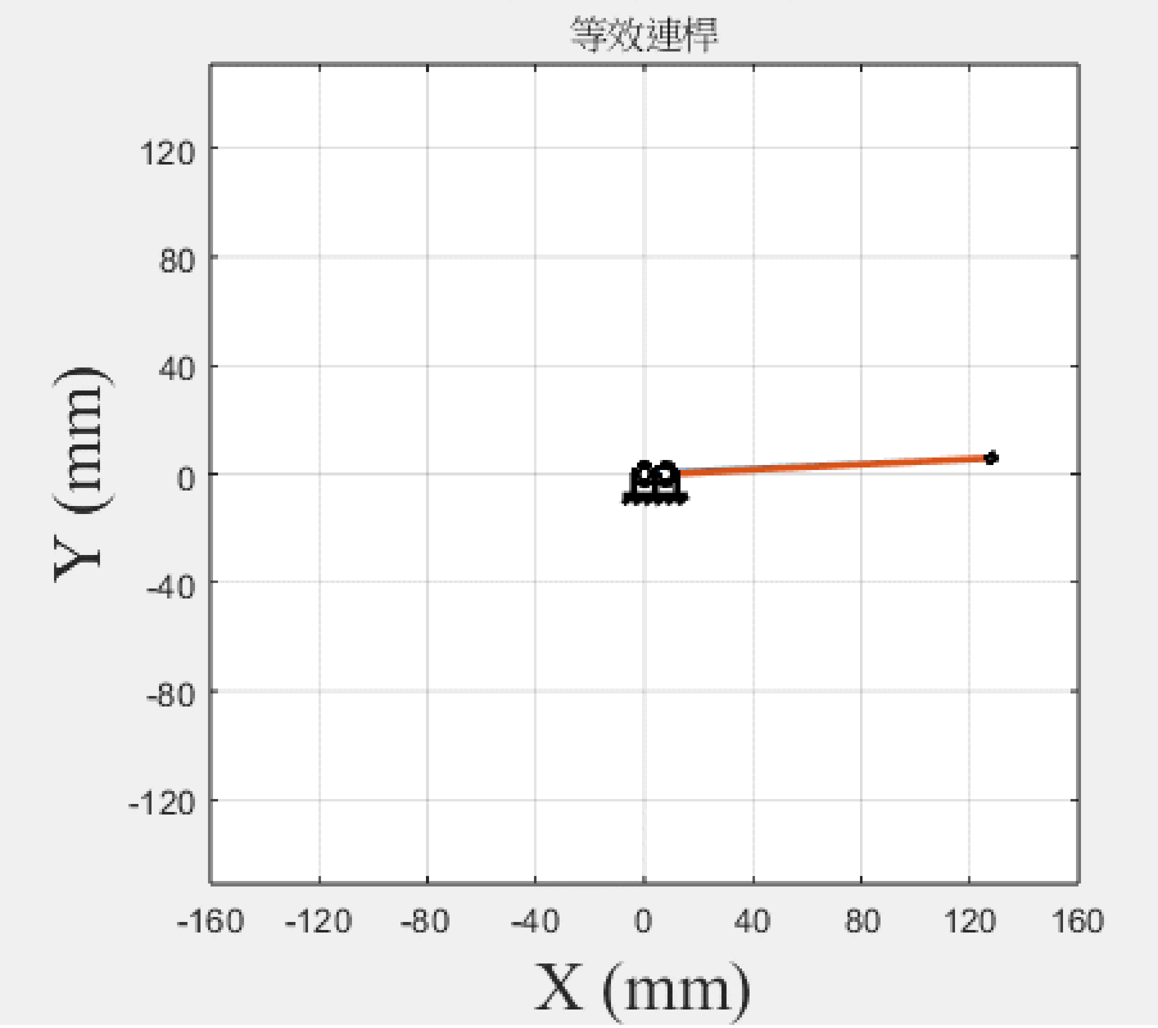
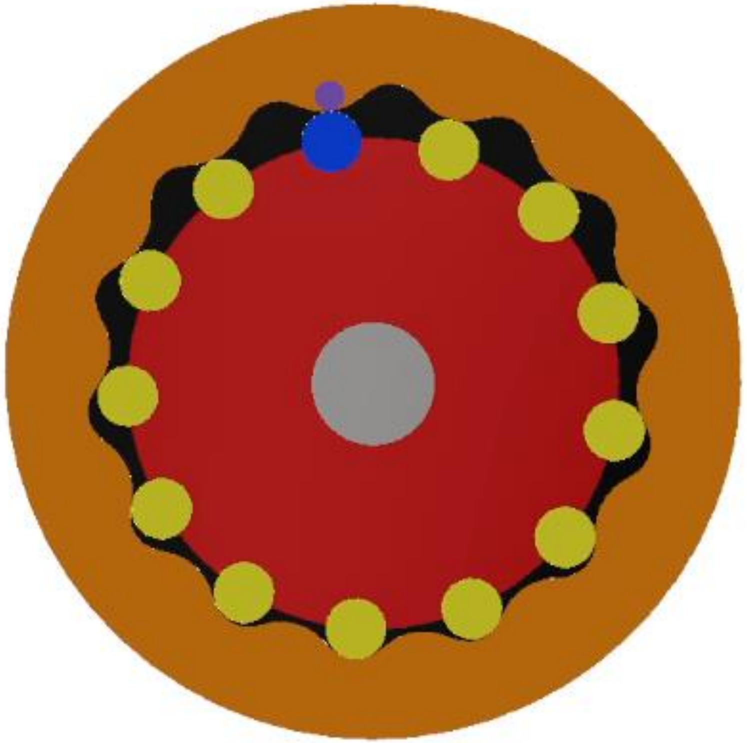
等效連桿





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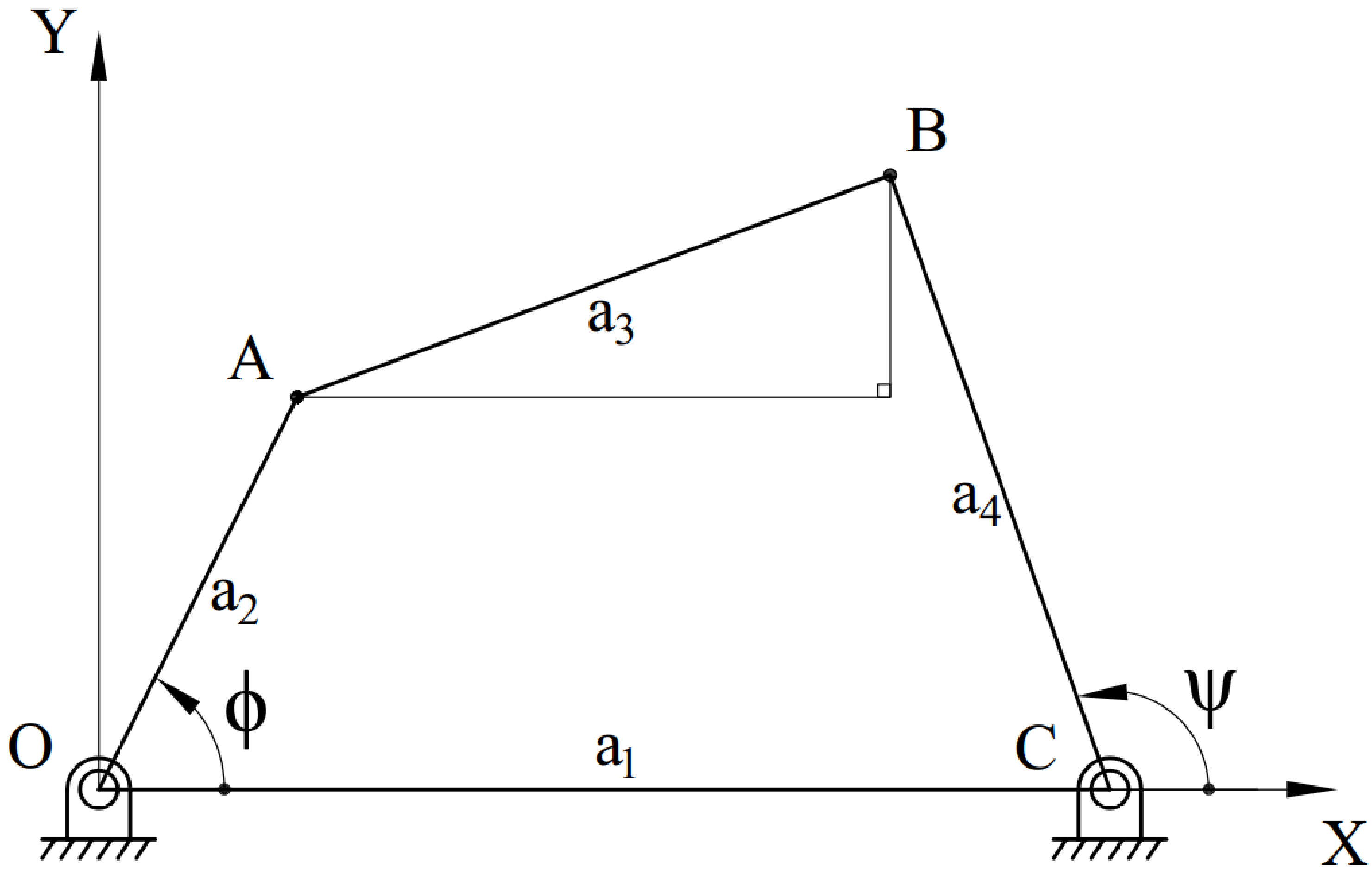
位移方程式



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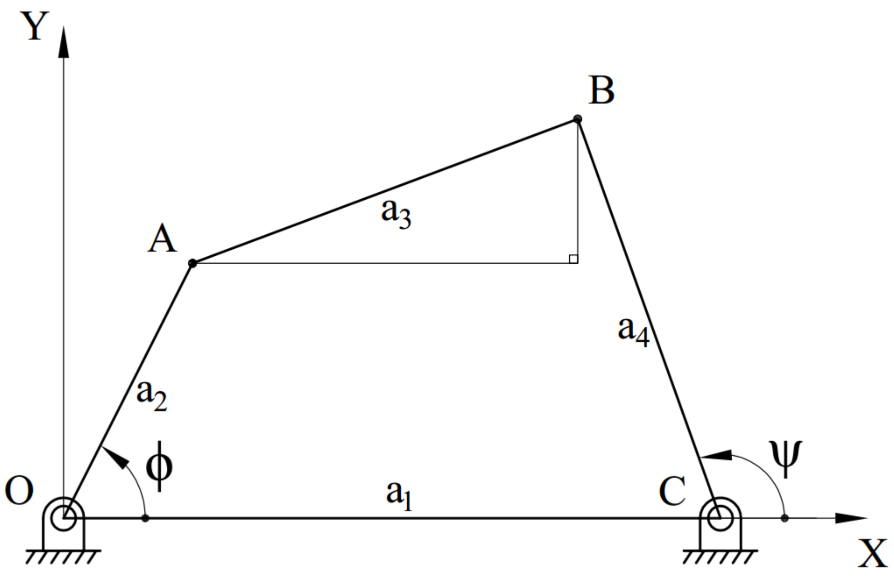

$$A(a_2\cos\phi,\ a_2\sin\phi)$$

$$B(a_1 + a_4\cos\psi,\ a_4\sin\psi)$$

$$(a_1 + a_4\cos\psi - a_2\cos\phi)^2 + (a_4\sin\psi - a_2\sin\phi)^2 = a_3{}^2$$

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未來目標

- 轉換角
- 將等效連桿參數代入位移方程式
- 做各接觸點誤差分析