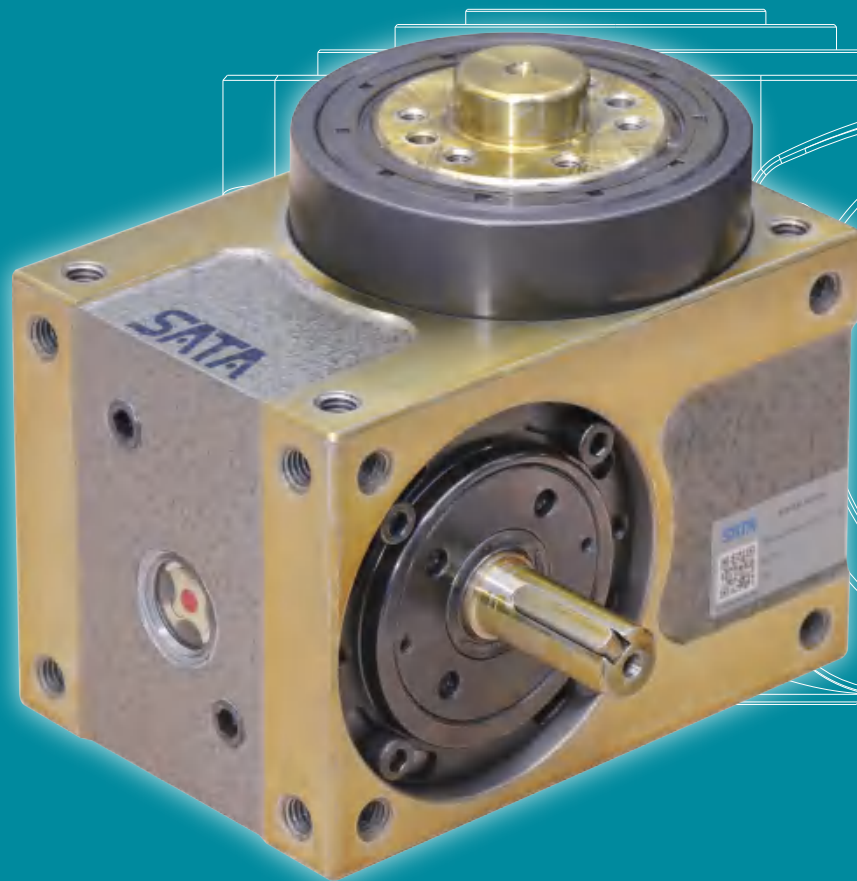


精密分割器 Cam Indexers

具有分度精度高、高速性能好、運轉平穩、傳遞扭矩大、定位時自鎖、結構緊湊、體積小、噪聲低、壽命長等顯著優點的間歇分割器，可搭配伺服電機或步進電機，展示獨特的性能。

The intermittent splitter with high indexing accuracy, good high-speed performance, high speed, high transmission torque, self-tuning during positioning, high structure, small system, low noise, long life, etc., can be matched with servo computers or step computers to demonstrate unique performance.



Elements 機構原理

運動曲線 Motility curves

在空間連接的兩點有無數的曲線。對於分割器使用的每一種運動都有無數的曲線連接起點和終點。當設計分度運動時，曲線的運動應當盡量平穩。為此，應考慮材料的振動、噪音和剛性。也要考慮負載和速度。

There are innumerable curves at 2 points spatially connected, with innumerable curves connecting the start and end points for each motion used by the segmenter. When designing the indexing motion, the motion of the curve should be as smooth as possible. To this end, material shock, noise, and rigidity should be considered. Load and speed are also to be considered.

在考慮了所有因素后，一般采用強調速度、加速度和跳躍性能的曲線。加速對於分割精確度和凸輪及滾輪的壽命有着非常重要的影響。位移曲線表示輸入軸位移（旋轉時間、角度等）與輸出軸位移間的關係，如圖2所示。圖中的橫坐標軸表示輸入軸的位移，豎坐標軸表示輸出軸的位移。

After taking into account so factors, curves emphasizing velocity, acceleration, and jump performance are generally adopted. Acceleration has a very important impact on segmentation accuracy and longevity of cams and rollers. The displacement curves represent the relationship between input axial displacement (rotarod time, angle, etc.) and output displacement as shown in Fig.2. The abscissa axis in the figure represents displacement of the input axis, and the erect axis represents displacement of the output axis.

1.非連續曲線：包括等速度曲線和等加速度曲線。這些曲線並不是合乎需要的，因為速度和加速度不連續，會導致較大的沖擊。

1. Non continuous curve: includes velocity curve and isoacceleration curve. These curves are not desirable because velocities and accelerations are discontinuous, resulting in large impingement.

2.雙暫停對稱曲線：包括修正正弦曲線和修正梯形曲線。就速度和加速度而論，這些曲線連續，因此它們符合需要。

如果輸入軸的旋轉方向為反向，也可以獲得相同的運動。

2. Double pause symmetry curve: includes correction of sinusoids and correction of trapezoids. In terms of velocity and acceleration, the curves are continuous, so they fit the need to obtain the same motion if the direction of rotation of the input axis is reversed

3.雙暫停非對稱曲線：包括非對稱曲線和非對稱修正梯形曲線。這些曲線適合高速旋轉。因為減速範圍比加速範圍長，以便控制減速範圍內的振動。

3. Double pause asymmetric profile: includes asymmetric wireless and asymmetric modified ladder profiles. These curves are fit for high-speed rotation. Because the deceleration range is longer than the acceleration range in order to control the shock in the deceleration range.

當選擇凸輪曲線時，有必要考慮下面特性數值：

When selecting a cam curve, it is necessary to consider the following characteristic values:

Vm-----最大速度 Vm----- maximum velocity

Am-----最大加速 Am----- maximum acceleration

Jm-----最大跳動 JM ----- maximal beating

如果Vm較大，在突然停動時會受到較大的力，因此，一般最好是Vm數值小。特別是，如果負荷重，更有必要選擇小的Vm。另外，Vm與凸輪的尺寸密切相關。因此，如果曲線有較小的Vm，則凸輪的尺寸必須相應減少。另外，V於1。

If VM is large, it is subjected to large forces during sudden absenteeism and, therefore, is generally best to have small VM values. In particular, if the load is heavy, it is more necessary to choose a small VM. In addition, the VM is closely related to the dimensions of the cams. Therefore, if the curve has a smaller VM, the cam must have decreased accordingly in size. In addition, V at 1.0.

如果凸輪的曲線有最大的Am最大可允許負荷變得較小。因此在高速下傳動，就有必要選擇較小的Am曲線。在這種情況下，Am不能小於4。Jm與振動有關，因此最好Jm的數值較小。

If the curve of the cam has the largest am the maximum allowable load becomes smaller. So at high speed Fu Qin, it is necessary to swing a smaller am curved line. In this case, am cannot be less than 4. JM is related to the shock, so the value of JM is smaller at best.

華馳凸輪分度傳動裝置標準曲線由下面三種類型組成：

The Chi Chi cam indexed Fuqin device standard curve consists of the following three types:

修正臺形曲線（MT）：適合高速和輕負荷-----（圖3）

Modified milli Ni (MT): dropping high speed & tonshaho ----- (Fig. 3)

修正正弦曲線（MS）：適合中、高速和中度負荷----（圖4）

Modified sinusoidal margin (MS): wide middle, high velocity and moderate xiaho ---- (Fig. 4)

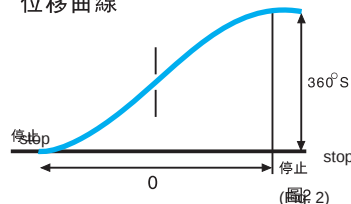
修正等速度曲線（MCV）：適合低速和重負荷----（圖5）

Modified isokinetic nickel Trasylol (MCV): drip low velocity and heavy summer ho ---- (Fig. 5)

如有需要，可提供上述曲線以外的任意特殊曲線。

Arbitrary features beyond the above mentioned margins are provided if required

Motility curves
位移曲線



(圖2)

Correction of sinusoids

修正正弦曲線（MS）

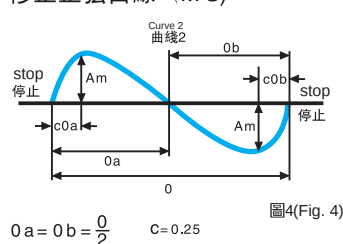


圖4(Fig. 4)

$$0a = 0b = \frac{0}{2} \quad C = 0.25$$

Modified isokinetic nickel Trasylol

修正正等速度曲線（MCV50）

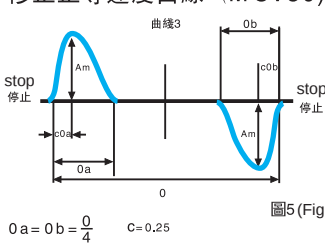


圖5(Fig. 5)

$$0a = 0b = \frac{0}{4} \quad C = 0.25$$

Acceleration curve

(modified table type curve MT)

加速度曲線（修正臺型曲線MT）

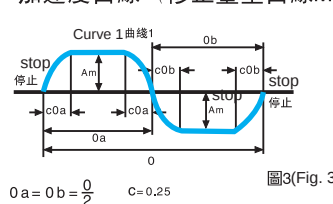


圖3(Fig. 3)

$$0a = 0b = \frac{0}{2} \quad C = 0.25$$

性能 Performance

1. 機構結構簡單

1. Simple structure

機構採用輸入凸輪和輸出軸組成,能提供任何曲線運動。

The mechanism is composed of input cam and output shaft, which can provide any curve movement.

2. 高精密度

2. High precision indexing

滾輪和凸輪無間隙配合,能保持較高的分割精度和高扭矩的情況下確保有承擔重負載的能力。

標準型號的分割精度在 ± 30 秒, 按要求可提供更高的分割精度。

There is no clearance between the roller and the cam, which can ensure the function of bearing heavy load while maintaining high segmentation accuracy and high torque. The segmentation accuracy of the standard model is ± 30 seconds, which can provide higher segmentation accuracy as required.

3. 正確的傳動裝置機構

3. Correct transmission mechanism

在分度或停止的時候, 滾輪能精確鎖定在設定的位置, 故不需要其它任何鎖定元件。

When indexing or stopping, the roller can be accurately locked at the set position, so no other locking elements are required.

4. 運動平穩

4. Smooth movement

由於輸出軸的設計是在任何位置連續旋轉(無論是角度、速度和加速度), 因此, 傳動裝置

運轉平穩, 極少的振動和噪音

Because the output shaft is designed to be continuously selected at any position (regardless of angle, speed and acceleration), the transmission operates smoothly with little vibration and noise.

5. 高速性

5. High speed

在精密加工的滾輪和凸輪的錐度支撐筋上施加預壓負荷, 完全避免產生間隙。使分割運行平穩和高速。完全受控的加速度減少由負荷或振動產生的衝擊。

Pre-pressing load is applied on the taper support rib of the precision machining roller and cam to completely avoid clearance. Make the segmentation run smoothly and at high speed. Fully controlled acceleration reduces impact caused by load and vibration.

6. 規格多樣性

6. Diversity of specifications

我們可以根據客戶需要提供各種型號的產品。

We can provide samples of various models according to customers' needs.

7. 運動曲線

7. Motion curve

根據相應所需的用途, 可提供①修正臺形曲線, ②修正正弦曲線, ③修正等速度曲線, 等任意曲線。

According to the purpose required, it can provide ① correction table curve, ② correction sine curve, ③ correction constant velocity curve, and other arbitrary curves.

8. 獨特的安裝

8. Unique installation

凸輪的分度傳動裝置, 可按各種不同的角度進行安裝。

The indexing transmission device of cam can be installed at different angles.

9. 免保養機構

9. Maintenance-free mechanism

除更換潤滑油以外, 100000小時以內無需進行維修。

In addition to the replacement of lubricating oil, no maintenance is required within 100000 hours.

名詞解釋 Noun interpretation

轉位凸輪: 能使輸出軸滾輪作相應位移的凸輪。

Indexing cam: a cam that can make the output shaft roller move accordingly.

錐度支撐筋: 位於凸輪的圓周上, 在凸輪凹槽之間, 與滾輪的圓周作線性接觸的筋。

Taper support rib: the rib located on the circumference of the cam, between the cam grooves, and in linear contact with the rolling circumference.

滾輪: 在凸輪的輪廓面上作滾動的輪子。

Roller: a wheel that rolls on the contour surface of the cam

輸出軸: 使凸輪轉動產生的力, 加以傳遞輸出的軸。

Output shaft: the shaft that transmits the force generated by the cam rotation

停動數: (分割數) 輸出軸每旋轉一周的動停次數。

Number of stops: (division number) number of stops per rotation of output shaft

驅動角(凸輪分度角): 輸入軸執行一次分度運動的輸入旋轉角。

Drive angle (cam indexing angle): input rotation angle for input shaft to perform one indexing motion

停止角: 當輸出軸停止運動時, 輸入軸所運動的角度。其與驅動角的和為 360°

Stop angle: when the output shaft stops moving, the sum of the driving angles of the input shaft is 360°

旋轉數: 輸入軸每分鐘的旋轉周數。

Number of revolutions: enter the number of revolutions of the shaft per minute

靜態扭矩: 分度凸輪在停止角時, 外部可施加在輸出軸上的最大扭矩。

Static torque: when the indexing cam is at the stop angle, the maximum torque that can be applied to the output shaft externally

動態扭矩: 在分度運動中, 作用在輸出軸上的最大扭矩。

Dynamic torque: the maximum torque acting on the output shaft during indexing movement

Numeration 選型計算

型號選擇計算 符號及其代表意義

a4	間隙通數 Clearance pass	P _s	最大馬達功率 Maximum motor power
A _m	無次元最大加速度 Dimensionless maximum acceleration	Q _m	最大輸入軸扭矩係數 Maximum input shaft torque speed
A _{max}	最大加速度 (mS ⁻²) Maximum acceleration	R	隨動件間距半徑 (m) Follower spacing radius
C	加速度係數 (C≥1) Acceleration coefficient	R	速度比 Speed ratio
D	旋轉直徑 (m) Rotation diameter	S	制動器數目 Number of brakes
E	旋轉器能量 (Kgf. m. rpm ⁻²) Rotor energy	T _c	輸入軸扭矩 (Kgf. m) Input shaft torque
E _o	放轉器能量 (Kgf. m. rad ⁻²) Release energy	T _d	啟動/停動扭矩 (Kgf. m) Start/stop torque
E _e	直線運動體能量 (Kgf. m. S ⁻²) Start/stop torque	T _f	摩擦扭矩 (Kgf. m) Friction torque
F	離心力 (Kgf) Centrifugal force	T _i	慣性扭矩 (Kgf. m) Inertia torque
G	重量 (Kgf) Weight	T _t	輸出軸所需的總扭矩 (Kgf. m) Total torque required for output shaft
Gd ²	轉動慣量 (Kgf. m ²) Moment of inertia	T _W	工作扭矩 (Kgf. m) Working torque
G	重力加速 (m. S ⁻²) Clearance pass	T _X	輸入軸摩擦扭矩 (Kgf. m) Clearance pass
I	極性轉動慣量 (Kgf. m. S ⁻²) Polar moment of inertia	V _e	線性速度 (m. s ⁻¹) Linear velocity
K	旋轉半徑 (m) Radius of rotation	V _m	無次元最大速度 No secondary maximum speed
K _e	輸出軸等量旋轉半徑 (m) Equal rotation radius of output shaft	V _{maxax}	最大速度 (m. s ⁻¹) Maximum speed
L _f	壽命係數 Life factor	W	重量 (Kg) weight
L _h	預期壽命(hr) Life expectancy	α	功能角(deg) Function angle
M	質量(Kg) Quality	θ	分度周期(deg) Indexing period
N	凸輪軸速度(rpm) Camshaft speed	μ	摩擦係數型 Friction coefficient type
No	初始凸輪軸速度(rpm) Initial camshaft speed	Ω	角速度(rad. s ⁻¹) angular velocity
P	行程(m) Stroke	Ω	角加速度(rad. s ⁻²) angular acceleration
P _a	馬達平均功率(Kw) Average ampere power of motor		

表1壽命係數LF及預期壽命Lh(小時):

Table 1 Life factor and expected life Lh (hours)

預期壽命 Life expectancy	壽命係數 Life factor	預期壽命 Life expectancy	壽命係數 Life factor	預期壽命 Life expectancy	壽命係數 Life factor	預期壽命 Life expectancy	壽命係數 Life factor
2000	0.617	10000	1.00	26000	1.33	60000	1.71
3000	0.697	12000	1.06	28000	1.36	65000	1.75
4000	0.760	14000	1.11	30000	1.39	70000	1.79
6000	0.858	18000	1.19	40000	1.52	80000	1.87
5000	0.812	16000	1.15	35000	1.46	75000	1.83
7000	0.899	20000	1.23	45000	1.57	90000	1.93
8000	0.935	22000	1.27	50000	1.62	100000	2.00
9000	0.969	24000	1.30	55000	1.67		

表2 (運動曲線技術參數)

Table 2 (Technical parameters of motion curve)

運動曲線 Motion curve	修正運動曲線 Corrected motion curve	修正正弦曲線 Modified sine curve	修正等速度曲線 Corrected constant velocity curve
代碼 Code	1	2	3
V _m	2.00	1.76	1.28
A _m	+/-4.89	+/-5.53	+/-8.01
Q _m	+/-1.655	+/-0.987	+/-0.715
(A×V) _m	+/-8.09	+/-5.46	+/-5.73

裝配的注意事項

Matters needing attention

型號的選擇

Model selection

每一種機構有其各自的扭矩限制。使用我們的產品目錄的公式計算扭矩負荷，選擇最合適的產品型號。在選擇產品及其型號時如果有疑問，請與我們聯系。

Each mechanism has its own torque limit. Use the formula and technical torque load in our product catalog to select the most appropriate product model. If you have any questions when selecting the product and its model, please contact us.

安裝輸入軸和輸出軸

Installing input and output shafts

一、固定方法。傳動件如連軸器、皮帶輪、鏈輪和圓形轉台的固定方法有以下幾種：

1. 固定扳手。2. 固定銷。3. 固定凸緣面。如果采用固定銷，應注意銷之間有沒有間隙。采用如圖7所示的比率固定更加有效。

1. Fixing method. The fixing methods of transmission parts such as coupling, pulley, sprocket and circular turntable are as follows: ① fixing wrench ② fixing pin ③ fixing flange surface. If fixing pins are used, pay attention to whether there is clearance between pins. It is more effective to adopt the ratio fixed as shown in Figure 7

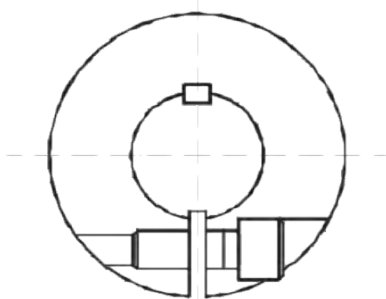
二、輸入軸傳動。如果輸入軸不能平穩

旋轉，那麼，扭矩會超載，機器振動和產生噪音，然後發生故障。

2. Input shaft drive. If the input shaft cannot rotate smoothly, the torque will be overloaded, the machine will vibrate and make noise, and then the fault will occur.

比率固定

Fixed ratio



螺釘固定有傳動扭矩的工件，請保持螺釘有伸縮性。

The screw is used to fix the workpiece with transmission torque. Please keep the screw flexible

過載保護機構

Overload protection mechanism

為避免意外和機構的損壞，增加其安全性，有必要安裝過載保護機構，請把機構的扭矩設定在合適的數值，在輸出軸的后面安裝機構。

In order to avoid accidents and damage to the machine and increase its safety, it is necessary to install an overload protection mechanism. Please set the torque of the mechanism at a reasonable value and install the mechanism behind the output shaft.

一般回轉數的最大直徑（表3）

Maximum diameter of general rotation number (Table 3)

45	60	70	80	100	110	140	180	250
225	300	350	400	500	550	700	900	1250

保養

Maintenance

第一次更換潤滑油是在裝置工作了600-1000小時后，不管使用條件如何，任何潤滑油都會降低其潤滑效果，所以需要定期換油保養。

The first lubricant change was made after 600-1000 hours of plant operation and any lubricant will reduce its lubrication regardless of service conditions, so regular oil change maintenance is required.

過載保護機構扭矩限制器

Torque limiter for overload protection mechanism

在工廠中損壞機器和危害人身安全的意外通常是由于人員的疏忽和缺乏安全措施所致。

Damage to machines and accidents endangering human safety in factories are usually caused by negligence of personnel and lack of safety measures

扭矩限制器通常充當“保險裝置”，她保護機器防止由于某些無法預期的原因而導致的過載損壞。安裝保護機構，可使機器處於正常的工作狀態下，而不會減低性能或生產效率。

Torque limiters often act as "safety devices" to protect the machine from overload damage for unexpected reasons. Installation of a protective mechanism enables the machine to operate normally without compromising performance and productivity

精度保持要素

Precision Maintenance Elements

要在輸出軸上安裝回轉臺，回轉臺的尺寸要基于扭矩 T_e 是允許輸出軸扭矩負荷。

To install a turntable on the output shaft, the dimensions of the turntable are based on the torque T_e which is the allowable output shaft torque load.

當要求高精度時，扭矩 T_e 應大于允許輸出扭矩負荷的2-3倍，因此，應減少輸出軸的扭轉。

When high accuracy is required, the Torque T_e should be greater than 2-3 times the allowable output torque load and therefore the output shaft torque should be reduced

回轉臺的最大直徑應小于標準尺寸的5倍。

The maximum diameter of the turntable shall be less than 5 times the standard size.

分度精確度為角度精確度，對於普通級別精確度保證為 $\pm 30''$ ，對於精密級別為 $\pm 15''$ 。如果回轉臺安裝在輸出軸上，位移會影響分度的精確度。

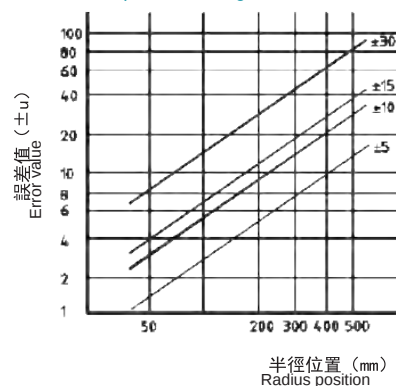
The indexing accuracy is angle accuracy, which is guaranteed to be $[30]$ for the ordinary level and $[15]$ for the precision level. If the turntable is mounted on the output shaft, the displacement will affect the accuracy of the indexing.

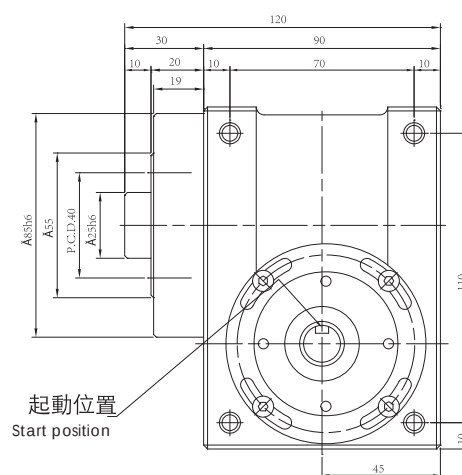
當使用回轉臺時，機架半徑的分度誤差應沒有間隙現象。

When using a turntable, there should be no gap in the indexing error of the rack radius

角度誤差和半徑誤差之間的關係：

The relationship between angle error and radius error:



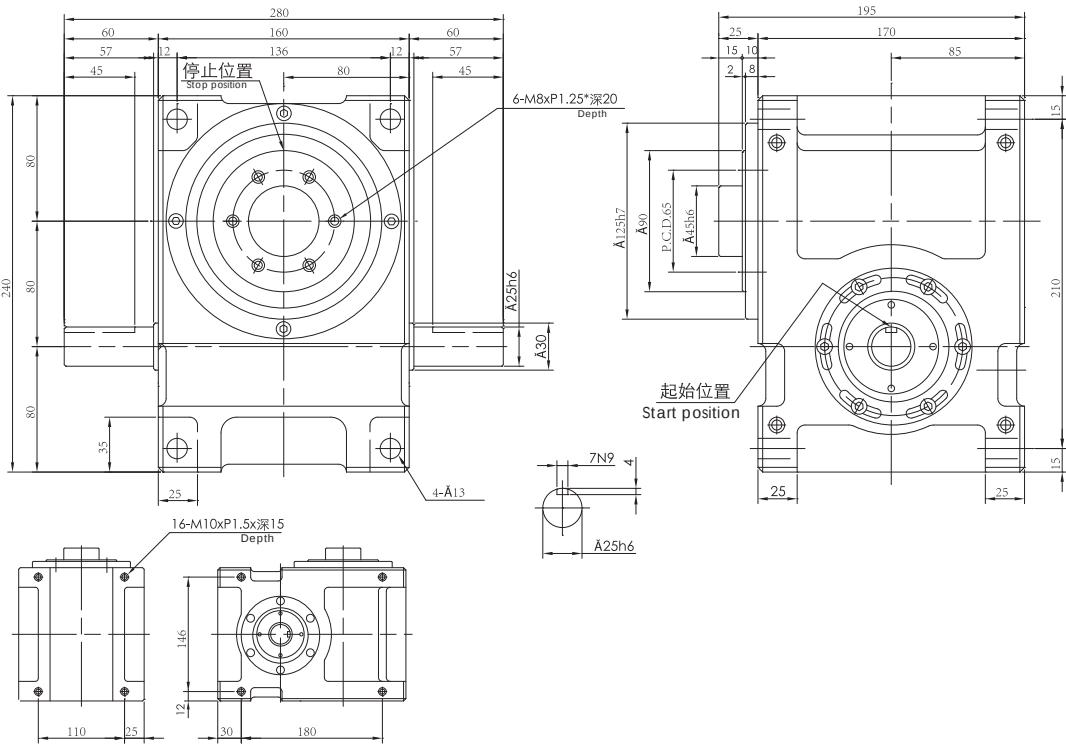
45DF

60DF

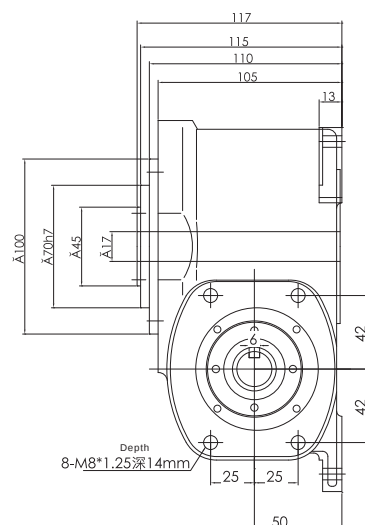
70DF

產品規格 Specification	80DF
最大承載重量 KG Maximum load capacity	30
旋轉平臺軸承 Bearings	圓柱滾子軸承 (Cylindrical roller bearing)
容許轉矩 kgf.m Permissible torque	規格眾多,請聯絡SATA (Please contact SATA)
進度壽命 h Life span	70000
出力軸容許徑向負荷 (c1) kgf Allowable radial load of output shaft	330
出力軸容許軸向負荷 (c2) kgf Allowable axial load of output shaft	420
入力軸容許徑向負荷 (c3) kgf Allowable radial load of input shaft	350
承載盤面直徑範圍 mm Diameter range of bearing plate	100-550
旋轉平台平行度 mm Rotation platform parallelism	± 0.02
旋轉平臺同心度 mm Rotation platform concentricity	± 0.02
重量 KG Weight	32

80DF

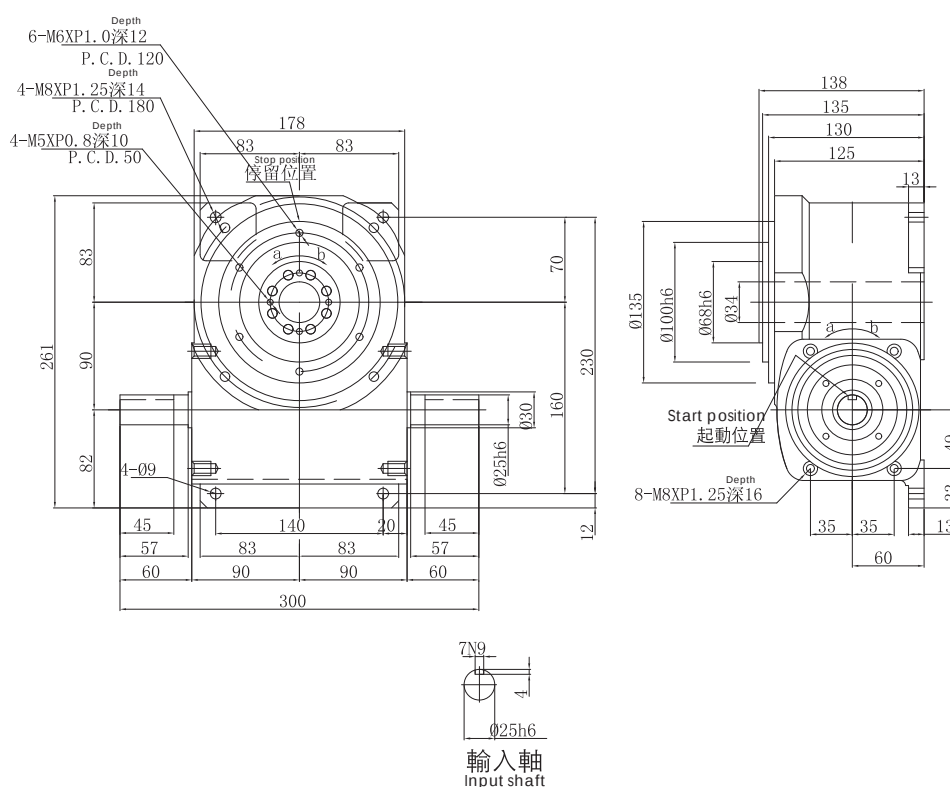


110DF

70DA

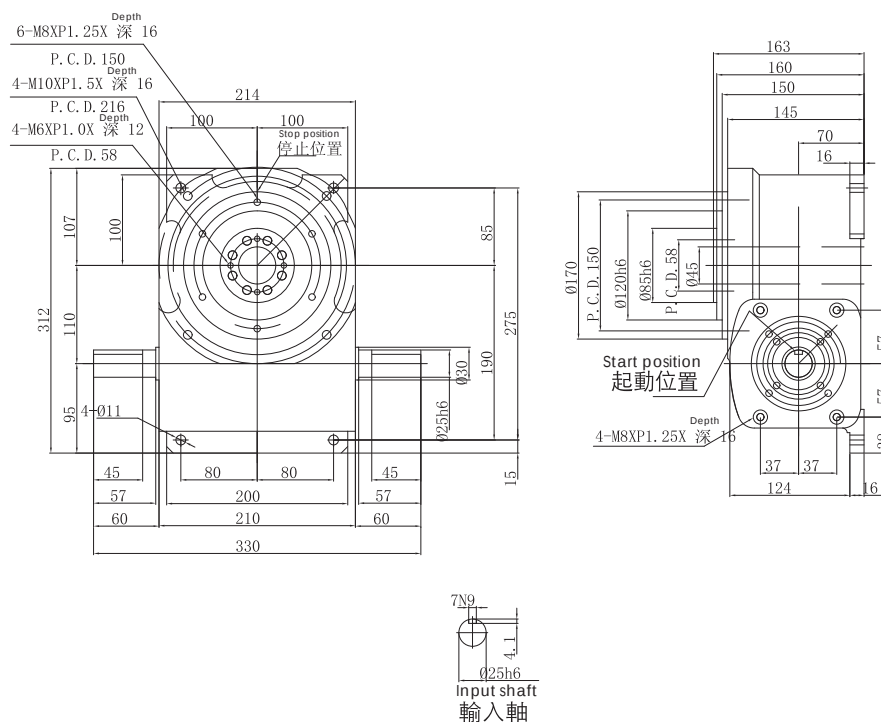
產品規格 Specification	90DA
最大承載重量 KG Maximum load capacity	30
旋轉平臺軸承 Bearings	圓柱滾子軸承 (Cylindrical roller bearing)
容許轉矩 kgf.m Permissible torque	規格眾多,請聯絡SATA (Please contact SATA)
進度壽命 h Life span	70000
出力軸容許徑向負荷 (c1) kgf Allowable radial load of output shaft	500
出力軸容許軸向負荷 (c2) kgf Allowable axial load of output shaft	210
入力軸容許徑向負荷 (c3) kgf Allowable radial load of input shaft	260
承載盤面直徑範圍 mm Diameter range of bearing plate	100-550
旋轉平台平行度 mm Rotation platform parallelism	±0.02
旋轉平臺同心度 mm Rotation platform concentricity	±0.02
重量 KG Weight	28

90DA



產品規格 Specification	110DA
最大承載重量 KG Maximum load capacity	60
旋轉平臺軸承 Bearings	圓柱滾子軸承 (Cylindrical roller bearing)
容許轉矩 kgf.m Permissible torque	規格眾多,請聯絡SATA (Please contact SATA)
進度壽命 h Life span	70000
出力軸容許徑向負荷 (c1) kgf Allowable radial load of output shaft	700
出力軸容許軸向負荷 (c2) kgf Allowable axial load of output shaft	350
入力軸容許徑向負荷 (c3) kgf Allowable radial load of input shaft	310
承載盤面直徑範圍 mm Diameter range of bearing plate	100-600
旋轉平台平行度 mm Rotation platform parallelism	±0.02
旋轉平臺同心度 mm Rotation platform concentricity	±0.02
重量 KG Weight	42

110DA



80DT

110DT



Maintain 保養

潤滑油和保養

Lube oil maintenance

應特別注意選擇潤滑油，因為不正確的選擇會降低精確度和縮短分割器的使用壽命。

潤滑油添加劑由化學復合物組成，其含量因生產廠家不同而不相同，因此避免混合不同的種類。甚至也不能混合種類不同而用途相同的潤滑油。

Special attention should be paid to the selection of lubricating oil, because incorrect selection will reduce the accuracy and shorten the service life of the divider. Lubricating oil additives are composed of chemical compounds, and their content varies with different manufacturers, so different kinds of additives should not be mixed. You can't even mix different kinds of lubricants with the same effect.

一、潤滑油選擇注意事項:

Precautions for lubricating oil option

- 錯誤地選擇潤滑油。對分割器的精度、壽命都會造成不良的影響。因此潤滑油的選擇必須特別注意。
 - 本機構採用工業齒輪油（粘度相當於460-650）。
 - 潤滑油內加入適當的極壓機油添加劑，可使油膜強度增加，防蝕、防銹，油質安全性提高，對潤滑油的提升有很大的幫助。
 - 極壓機油添加劑是一種特殊的化合物，因各種產品成分有所不同，因此，絕對避免混合使用，以免產生不良效果。
- A. Wrong selection of lubricating oil. It will adversely affect the accuracy and service life of the divider. Therefore, special attention must be paid to the selection of lubricating oil.
- B. This mechanism uses industrial gear oil (viscosity equivalent to 460-650).
- C. Adding appropriate extreme pressure oil additives into the lubricating oil can increase the strength of the oil film, prevent corrosion and rust, and improve the safety of the oil quality, which is of great help to the improvement of the lubricating oil.
- D. Extreme pressure oil additive is a special compound. Because the ingredients of various products are different, it is absolutely forbidden to mix them to avoid adverse effects.

二、保養

2. Maintenance

輸入傳動系統的間隙會導致振動和噪音，從而影響精確度和預期壽命。鏈輪和可伸縮的聯軸器特別容易有間隙和磨損，因而它們在相當短的使用期內會鬆脫。

The clearance of the input drive system will cause vibration and noise, which will affect the accuracy and expected life. Sprockets and retractable couplings are particularly prone to play and wear, so they will loose in a relatively short time.

軸連接中的軸向對準也很重要，當鎖緊連接部分時，不可留下任何的間隙，並排除在凸輪滾輪件上通過輸出軸的過載，否則有時會導致軸承的損壞。因此，我們提供了安全裝置，避免了這些故障的發生。

The axial alignment in the shaft connection is also very important. When locking the connecting part, do not leave any gap and eliminate the overload on the cam roller through the output shaft, otherwise the bearing will be damaged. Therefore, we provide safety devices to avoid such failures.

無論什麼時候如果聽到噪音，則表示軸承受損，檢查油位。也要注意，太多的潤滑劑會導致異常的溫升或漏油現象。

Whenever the noise is heard, it means that the bearing is damaged and the oil level is detected. Also note that too much lubricant will cause abnormal temperature rise and oil leakage.

無論使用的次數有多少次，潤滑油會發生變質，應定期更改潤滑油，至少每年一次。

The lubricating oil will deteriorate no matter how many times it is used. The lubricating oil should be changed regularly, at least once a year.

對於高速傳動機構，檢查分度傳動軸和其它扭矩媒體之間的連接是否鬆脫。

For high-speed transmission mechanism, check whether the connection between indexing transmission shaft and other torque media is loose.

三、潤滑油更換的注意事項:

3. Precautions for lubricating oil replacement

- 潤滑油更換周期：第一次為運轉600-1000小時後。第二次為第一次更換後，每3000小時更換一次。
 - 更換潤滑油時，請先確定潤滑油清淨，並將注油孔清潔干淨，避免水分及雜質進入。
 - 溫升使油箱內部壓力增高，造成機油外漏，需要定期清理注油螺絲通氣孔及檢查油鏡，補充潤滑油，不可忽略。
- A. Lubricating oil change cycle: after the first time is 600-1000 hours, the second time is after the first time, and every 3000 hours.
- B. When replacing the lubricating oil, please make sure that the lubricating oil is clean, and clean the oil injection hole to prevent water and impurities from entering.
- C. The temperature increases the internal pressure of the oil tank and causes oil leakage. It is necessary to regularly clean the vent hole of the oil injection screw and check the oil mirror, and replenish the lubricating oil, which cannot be ignored.
- 輸入軸回轉數有變動情形時，以使用最高回轉數(Nmax)和使用最低回轉數則。或以最長使用回轉數來決定潤滑油的粘度。(Mmin)的幾何平均數為原則。或以最長使用回轉數來決定潤滑油的粘度。
 - 輸入軸回轉數剛好在欲變化粘度界線時，應使用較高粘度油品。
1. When the rotation number of input shaft changes, the maximum rotation number (Nmax) and the minimum rotation number rule shall be used, or the maximum rotation number shall be used to determine the viscosity of lubricating oil, and the geometric average of (Mmin) shall be used as the principle.
2. When the rotation number of the input shaft just benefits from changing the viscosity limit, the oil with higher viscosity should be used.

潤滑油粘度(表4)

Lubricant viscosity (Table 4)

馬達回轉數N(rpm) Motor rotation	0-20	20-100	100-200	200-300	300-400	> 400
粘度(cst/ 40x) viscosity	> 650	650-460	460-320	320-220	220-150	150-65

使用範例 case application

1. 工作臺式

如圖所7-57所示，鐵制工作臺高度 h 為20mm，直徑 D 為 $\Phi 600$ mm，工裝和工件安裝直徑為 $\Phi 500$ mm、6工位，工裝重力為50N，工件重力為5N(1kgf=9.80665N)。在工作臺半徑250mm位置是滑動畫。工作臺支撐承受工作臺重力，1個循環為1s，分度時間為0.3s。凸輪軸和輸出軸的旋向如圖所示，壽命為20000h。

1. Work desk

As shown in Figure 7-57, the height of iron worktable h is 20mm, and the diameter D is $\Phi 600$ mm, the installation diameter of tooling and workpiece is $\Phi 500$ mm, 6 stations, tooling gravity is 5N (1kgf=9.80665N). The sliding table is located at the 250mm radius of the workbench. The workbench support bears the gravity of the workbench. One cycle is 1s, and the indexing time is 0.3s. The rotation direction of camshaft and output shaft is shown in the figure, and the service life is 20000h.

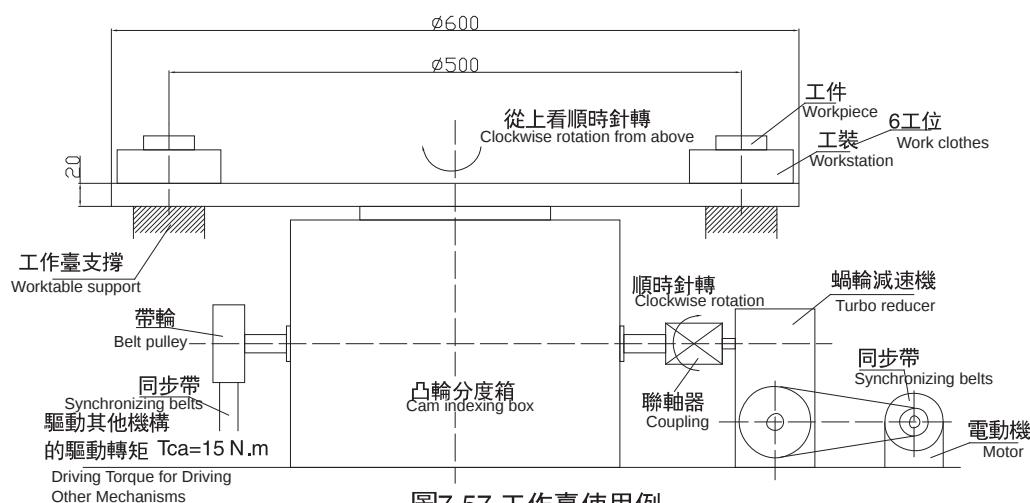


圖7-57 工作臺使用例
Figure 7-57 List of Workbench Use

(1) 分度數 n

因為是 6 工位，分度數 = 6.

(2) 分度角 θ_h

因為一個分度時間和工作循環時間之比為 $0.3/1 \approx 1/3$ ，所以 $\theta_h = 360 \times 1/3 = 120^\circ$ 。

(3) 凸輪軸轉速 N

因為一個循環為 1s，則 $N = 60/1 \text{ r/min} = 60 \text{ r/min}$

(4) 凸輪螺旋方向

凸輪螺旋方向決定于與之相連的工作臺機械的方向。因為凸輪軸和輸出軸的旋向是不能改變的，所以凸輪旋向為左旋。

(5) 凸輪曲線

一般情況選用修正正弦曲線

(6) 負荷轉矩 T_o

(1) Divisions h

Because it is a 6-position division equal to 6

(2) Graduation angle Φ

Because the ratio of a dividing time to the working cycle time is $0.3/1 \approx 1/3$ $\Phi = 360 \times 1/3 = 120^\circ$.

(3) Projected shaft speed N

Because one cycle is 1s, $N = 60/1 \text{ r/min} = 60 \text{ r/min}$

(4) Cam spiral direction

The direction of the cam screw depends on the direction of the worktable machinery connected to it. Because the rotation direction of the camshaft and output shaft cannot be changed, the camshaft is left-handed

(5) Cam curve

Generally, the modified sine curve is selected

(6) Load torque T_o

1) 慣性轉矩 T_i Inertia Torque

① 工作臺重力

$$W = 6.126 \times 10^{-5} D^2 h = 6.126 \times 10^{-5} \times 600^2 \times 20 \text{ N} = 441 \text{ N}$$

② 工作臺慣性矩

$$I_1 = \frac{WR^2}{2g} = \frac{441 \times \left(\frac{600}{2 \times 1000}\right)^2}{2 \times 9.8} \text{ kg} \cdot \text{m}^2 = 2.025 \text{ kg} \cdot \text{m}^2$$

③ 工裝慣性矩

Tooling Moment of Inertia

$$I_2 = \frac{W_2 R_e^2}{g} = \frac{50 \times \left(\frac{500}{2 \times 1000}\right)^2}{9.8} \times 6 \text{ kg} \cdot \text{m}^2 = 1.913 \text{ kg} \cdot \text{m}^2$$

④ 工件慣性矩

Tooling Moment of Inertia

$$I_3 = \frac{W_3 R_e^2}{g} = \frac{5 \times \left(\frac{500}{2 \times 1000}\right)^2}{9.8} \times 6 \text{ kg} \cdot \text{m}^2 = 0.191 \text{ kg} \cdot \text{m}^2$$

⑤ 總慣性矩

Total Moment of Inertia

$$I = I_1 + I_2 + I_3 = (2.025 + 1.913 + 0.191) \text{ kg} \cdot \text{m}^2 = 4.129 \text{ kg} \cdot \text{m}^2$$

⑥ 輸出軸最大角加速度 α

TMaximum angular acceleration of output shaft

$$a = \frac{72 \pi A_m}{n} \left(\frac{N}{\theta h} \right) = \frac{72 \pi \times 5.53}{6} \times \left(\frac{60}{120} \right)^2 \text{ rad} / \text{s}^2 = 52.093 \text{ rad} / \text{s}^2$$

⑦ 慣性轉矩

Inertia Torque

$$T_i = I_a \alpha = 4.129 \times 52.093 \text{ N} \cdot \text{m} = 215.092 \text{ N} \cdot \text{m}$$

2) 摩擦矩 T_f

Friction resistance moment

$$T_f = m W_f R_f = 0.15 \times [441 + 6 \times (50 + 5)] \times \frac{250}{1000} \text{ N} \cdot \text{m} = 28.913 (\text{N} \cdot \text{m})$$

3) 工作轉矩 T_w 。因為分度時不作功，工作轉矩 $T_w=0$ 。

Working torque T_w . Because no work is done while indexing, working torque $T_w=0$

4) 負荷轉矩

Load torque

$$T_o = T_i + T_f + T_w = (215.092 + 28.913 + 0) \text{ N} \cdot \text{m} = 244 \text{ N} \cdot \text{m}$$

(7) 實際負荷轉矩 T_e

Actual load torque

設使用系數 $f_s = 1.5$ ，則

Set usage factor $f_s = 1.5$, therefore

$$T_e = f_s T_o = 1.5 \times 244 \text{ N} \cdot \text{m} = 366 \text{ N} \cdot \text{m}$$

(8) 凸輪軸轉矩 T_c

Camshaft torque

$$T_c = k \left(\frac{360}{n \theta_h} \right) T_e + T_{ca} = \left(0.99 \times \frac{360}{6 \times 120} \times 366 + 15 \right) \text{ N} \cdot \text{m} = 196.2 \text{ N} \cdot \text{m}$$

(9) 所需動力 P

Power required

蝸輪減速機的效率 $\eta = 60\%$ ，則

Efficiency of turbine reducer therefore

$$P = \frac{T_c N}{9750 h} = \frac{196.2 \times 60}{9750 \times 0.6} \text{ kW} = 2.01 \text{ kW}$$

(3) 凸輪軸轉速 N
Torque T_1 calculated by life T_1

因為 1 個循環為 1.5 s，則 $N = 60/1.5 \text{ r/min} = 40 \text{ r/min}$ 。
Because one cycle is 1.5s, $N = 60/1.5 \text{ r/min} = 40 \text{ r/min}$.

(4) 凸輪的旋向
Rotation direction of cam

凸輪箱驅動是獨立的，無論什麼方向均可，故選標準旋向右旋。
The cam box drive is independent and can be rotated in any direction, so the right direction is selected.

(5) 凸輪曲線
Cam curve

中速中載屬一般條件，選擇修正正弦曲線。
Medium speed medium wear is a general condition, and the modified sine curve is selected.

(6) 負荷轉矩 T_0
Load torque T_0 1) 慣性轉矩 T_i
Inertia torque T_i ① 驅動齒輪慣性矩
Inertia moment of drive gear

$$I_{\text{驅}} = \frac{W_{\text{驅}} R_{\text{驅}}^2}{2g} = \frac{70 \times \left(\frac{200}{2 \times 1000}\right)^2}{2 \times 9.8} \text{ kg} \cdot \text{m}^2 = 0.036 \text{ kg} \cdot \text{m}^2$$

② 傳送帶慣性矩
Belt moment of inertia(a) 從動齒輪慣性矩
Inertia moment of driven gear

$$I_1 = \frac{W_1 (R_1^2 + r^2)}{2g} = \frac{40 \times \left[\left(\frac{100}{2 \times 1000}\right)^2 + \left(\frac{50}{2 \times 1000}\right)^2\right]}{2 \times 9.8} \text{ kg} \cdot \text{m}^2 = 0.013 \text{ kg} \cdot \text{m}^2$$

(b) 軸的慣性矩
Moment of inertia of shaft

$$I_2 = \frac{W_1 r^2}{2g} = \frac{70 \times \left(\frac{50}{2 \times 1000}\right)^2}{2 \times 9.8} \text{ kg} \cdot \text{m}^2 = 0.0022 \text{ kg} \cdot \text{m}^2$$

(c) 鏈輪慣性矩
Chain moment of inertia

$$I_3 = \frac{W_3 (R_e^2 + r^2)}{2g} = \frac{60 \times \left[\left(\frac{254}{2 \times 1000}\right)^2 + \left(\frac{50}{2 \times 1000}\right)^2\right]}{2 \times 9.8} \times 4 \text{ kg} \cdot \text{m}^2 = 0.205 \text{ kg} \cdot \text{m}^2$$

(d) 鏈條慣性矩
Chain moment of inertia

$$I_4 = \frac{W_4 R_e^2}{g} = \frac{80 \times \left(\frac{254}{2 \times 1000}\right)^2}{9.8} \times 2 \text{ kg} \cdot \text{m}^2 = 0.263 \text{ kg} \cdot \text{m}^2$$

(e) 夾具慣性矩
Fixture moment of inertia

$$I_5 = \frac{W_5 R_e^2}{g} = \frac{30 \times \left(\frac{254}{2 \times 1000}\right)^2}{9.8} \times 20 \text{ kg} \cdot \text{m}^2 = 0.987 \text{ kg} \cdot \text{m}^2$$

(f) 工件慣性矩

Workpiece inertia moment

$$I_6 = \frac{W_6 R_e^2}{g} = \frac{10 \times \left(\frac{254}{2 \times 1000}\right)^2}{9.8} \times 8 \text{ kg} \cdot \text{m}^2 = 0.132 \text{ kg} \cdot \text{m}^2$$

(g) 傳送帶的總慣性矩

Total moment of inertia of conveyor belt

$$I = I_1 + I_2 + I_3 + I_4 + I_5 + I_6$$

$$= (0.013 + 0.022 + 0.205 + 0.263 + 0.987 + 0.132) \times \text{kg} \cdot \text{m}^2$$

$$= 1.60 \text{ kg} \cdot \text{m}^2$$

2) 傳動帶的當量慣性矩。由于經過變速運動，必計算對凸輪箱輸出軸的當量慣性矩：

Equivalent moment of inertia of conveyor belt. Due to the fine speed change movement, the equivalent moment of inertia of the camshaft output shaft must be calculated

$$I_e = I \left(\frac{n}{m}\right)^2 = 1.60 \times 2^2 \text{ kg} \cdot \text{m}^2 = 6.4 \text{ kg} \cdot \text{m}^2$$

3) 全裝置慣性矩。即驅動齒輪慣性矩和傳送帶的當量慣性矩之和：

Moment of inertia of the whole device. That is, the sum of the inertia moment of the driving gear and the equivalent inertia moment of the conveyor belt

$$I_{\text{總}} = (0.036 + 6.4) \text{ kg} \cdot \text{m}^2 = 6.436 \text{ kg} \cdot \text{m}^2$$

4) 輸出軸最大角加速度 α

Maximum angular acceleration of output shaft

$$a = \frac{72 \pi A_m}{n} \left(\frac{n}{\theta_h}\right)^2 = \frac{72 \pi \times 5.53}{6} \left(\frac{40}{120}\right)^2 \text{ rad} / \text{s}^2 = 23.152 \text{ rad} / \text{s}^2$$

5) 慣性轉矩

Inertia torque

$$T_i = I_{\text{總}} a = 6.436 \times 23.152 \text{ N} \cdot \text{m} = 149.01 \text{ N} \cdot \text{m}$$

6) 摩擦矩 T

Friction moment

① 傳送帶的摩擦矩。導軌面承受了工件重力、1/2 的工裝重力和 1/2 的鏈條重力。在工作時，這些重力產生的摩擦矩為

Friction moment of conveyor belt. The guide rail surface bears the workpiece pressure, 1/2 tooling gravity and 1/2 chain gravity. When working, the friction moment generated by these gravity is

$$T = \mu WR$$

$$= 0.15 \times \left(10 \times 8 + \frac{30 \times 20}{2} + \frac{80 \times 2}{2}\right) \times \frac{254}{2 \times 1000} \text{ N} \cdot \text{m}$$

$$= 8.763 \text{ N} \cdot \text{m}$$

② 傳送帶的當量摩擦矩

Equivalent friction moment of conveyor belt

$$T_{fe} = T_f \left(\frac{n}{m}\right) = 8.763 \times 2 \text{ N} \cdot \text{m} = 17.526 \text{ N} \cdot \text{m}$$

③ 工作轉矩 T_w 。因為分度過程中不作功，所以工作轉矩 $T_w = 0$ 。

Working torque T_w . Since no work is done during indexing, the working torque $T_w = 0$

④ 負荷轉矩

Load torque

$$T_0 = T_i + T_f + T_w$$

$$= (149.01 + 8.763 + 0) \text{ N} \cdot \text{m}$$

$$= 157.77 \text{ N} \cdot \text{m}$$

(7) 實際轉矩 T_e

Actual torque

設使用系 $f_5 = 2$ ，則
Set usage factor therefore

$$T_e = f_5 T_0 = 2 \times 157.77 \text{ N} \cdot \text{m} = 315.54 \text{ N} \cdot \text{m}$$

(8) 凸輪軸轉矩 T_c

Camshaft torque

$$T_c = K \left(\frac{360}{n\theta_h} \right) T_e + T_{ca} = 0.99 \times \left(\frac{360}{6 \times 120} \times 315.54 + 10 \right) \text{ N} \cdot \text{m} = 166.2 \text{ N} \cdot \text{m}$$

(9) 所需動力 P

Power required

凸輪減速機的效率為 $\eta = 60\%$ ，則
The efficiency of the cam reducer is therefore

$$P = \frac{T_c N}{9750 \eta} = \frac{166.2 \times 40}{9750 \times 0.6} \text{ kW} = 1.14 \text{ kW}$$

因為此值為峰值，一般取其 $1/2$ ，則 $P_e = \frac{P}{2} = \frac{1.14}{2} \text{ kW} = 0.57 \text{ kW}$
Because this value is a peak value, it is generally taken as $1/2$, so

(10) 凸輪分度箱的尺寸

Size of cam indexing box

產品目錄轉矩表中的輸出轉矩，當凸輪轉速為 40r/min 時的轉矩值比實際負荷轉矩 $315.54\text{N}\cdot\text{m}$ 要大，為安全起見，選用較大尺寸。此例選用 125 型的凸輪分度箱。

The output torque in the torque table of the product catalog, when the cam speed is 40r/min , the torque value is greater than the actual load torque $315.54\text{N}\cdot\text{m}$. For the sake of safety, the larger size is selected. This example selects 125 type cam indexing box.

3. 機種選擇例 Model selection case

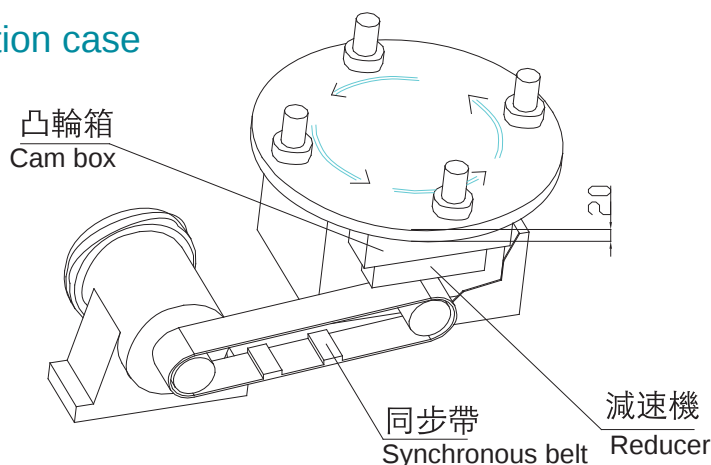


圖 6-63 轉盤式工作臺

Figure 6-63 Rotary table

已知條件

圖 7-63 所示為轉盤式工作臺，已知條件如下：

- 1) 轉盤半徑 R 為 200 mm 。
- 2) 轉盤支承半徑 $R_{支}$ 為 190 mm 。
- 3) 工件和工裝的節圓半徑 r 為 180 mm 。
- 4) 每個工件與工裝重力為 40N 。
- 5) 工裝數量為 4 個。
- 6) 循環時間（凸輪軸轉一轉的時間）為 1.5s 。
- 7) 停留時間為 1.0s 。
- 8) 停留時徑向載荷為 250N 。
- 9) 摩擦系數 $\mu = 0.15$ 。

(1) Known conditions

Figure 7-63 shows a turntable table. The known conditions are as follows:

- 1) The radius R of the turntable is 200 mm .
- 2) The radius of support R of the rotary table is 190 mm .
- 3) The pitch radius r of workpiece and tooling is 180 mm .
- 4) The gravity of each workpiece and tooling is 40N .
- 5) The number of tooling is 4.
- 6) The cycle time (the time for the camshaft to rotate once) is 1.5s .
- 7) The residence time is 1.0s .
- 8) The radial load at standstill is 250N .
- 9) Friction coefficient $\mu = 0.15$.

10) 理想壽命時間為 20000 h。
The ideal life time is

11) 轉盤厚度為 20 mm 。
The thickness of the turntable is

(2) 計算順序
Calculation order

1) 分度數 $n=4$ 。
Divisions

2) 分度角 $\theta_h = 360 \times (1.5 - 1.0) / 1.5 = 120$
Graduation angle

3) 負荷轉矩
Load torque

① 轉盤重力 W_1
Rotary table gravity

$$W_1 = 6.126 \times 10^{-5} D^2 h = 6.126 \times 10^{-5} \times (200 \times 2)^2 \times 20 \text{ N} = 196.03 \text{ N}$$

② 工件和工裝重力 W_2
Workpiece and tooling gravity

$$W_2 = 40 \times 4 = 160 \text{ N}$$

③ 轉盤慣性矩 I_1
Moment of inertia of rotary table

$$I_1 = \frac{W_2 R^2}{2g} = \frac{196.03 \times \left(\frac{200}{1000}\right)^2}{2 \times 9.8} \text{ kg} \cdot \text{m}^2 = 0.4 \text{ kg} \cdot \text{m}^2$$

④ 工件和工裝慣性矩 I_2
Inertia moment of workpiece and tooling

$$I_2 = \frac{W_2 r^2}{2g} = \frac{160 \times \left(\frac{180}{1000}\right)^2}{2 \times 9.8} \text{ kg} \cdot \text{m}^2 = 0.264 \text{ kg} \cdot \text{m}^2$$

⑤ 負荷慣性矩 $I_l = I_1 + I_2 = (0.4 + 0.264) \text{ kg} \cdot \text{m}^2 = 0.664 \text{ kg} \cdot \text{m}^2$
Load moment of inertia

4) 使用系數 $f_s = 1.5$ 。
Service factor

5) 實際負荷轉矩 q_f
Actual load torque

① 最大慣性轉矩
Maximum inertia torque

$$q_{tm} = \frac{I_l t_h}{t_h^2} A_m = \frac{0.664 \times \frac{2\pi}{4} \times 5.53}{(1.5 - 1.0)^2} \text{ N} \cdot \text{m} = 23.06 \text{ N} \cdot \text{m}$$

② 摩擦矩
Friction moment

$$f_t = \mu (W_1 + W_2) R_{支} = 0.15 \times (196.03 + 160) \times \frac{190}{1000} \text{ N} \cdot \text{m} = 10.15 \text{ N} \cdot \text{m}$$

③ 總負荷轉矩
Total load torque

$$q_f = (23.06 + 10.15) \text{ N} \cdot \text{m} = 33.21 \text{ N} \cdot \text{m}$$

④ 實際負荷轉矩

Total load torque

$$q_f' = 1.5 \times 33.21 \text{ N.m} = 49.82 \text{ N.m}$$

6) 按容許轉矩決定中心距。因為實際負荷轉矩 $q_f' = 49.82 \text{ N.m}$ ，根據產品目錄轉矩表，選擇型號為 100-N4-TH120。

Determine the center distance according to the allowable torque. Because the actual page load torque $q_f' = 49.82 \text{ N.m}$, according to the torque table in the product catalog, the model is 100-N4-TH120.

7) 按壽命時間覺得中心距。因為理想壽命時間 $L_h = 20000 \text{ h}$ ，壽命系數 $L_f = 1.32$ ，則按理想壽命的轉矩為

Center distance according to service life. Because the ideal life time $L_h = 20000 \text{ h}$ and the life coefficient $L_f = 1.32$, the torque of ideal life is

$$q_L = 1.32 \times 49.82 \text{ N.m} = 65.76 \text{ N.m}$$

查表，選型為 125-N4-TH120。

According to the table, the model selection is 125-N4-TH120.

8) 機種決定

Model decision

為滿足各參數要求，在表中選擇平行分度凸輪型號為：125-N4-TH120。

To meet the parameter requirements, select the parallel indexing camshaft model in the table as

9) 電動機功率

Motor power

輸入軸最大轉矩 q_{cm}

Maximum torque of input shaft

$$q_{cm} = \frac{I t_h^2}{\theta_h t_h} (AV)_m + f_t V_m$$

$$= \left(\frac{0.664 \times \left(\frac{2\pi}{4}\right)^2}{120 \times \frac{\pi}{180} (\times 1.5 - 1.0)^2} \times 5.46 + 10.5 \times 1.76 \right) \text{ N.m}$$

$$= 34.94 \text{ N.m}$$

電動機功率 ($n_c = 40 \text{ r/min}$)

Motor power

$$P = \frac{q_{cm} n_c}{9750} = \frac{34.94 \times 40}{9750} \text{ kW} = 0.143 \text{ Kw}$$

根據電動機手冊，選擇電動機功率為 200W。

According to the motor manual, select the motor power of 200W

使用範例 Use Cases

4. 輸出軸的許用軸向載荷和徑向載荷

Allowable axial load and radial load of output shaft

(1) 輸出軸的許用軸向載荷

Allowable axial load of output shaft

表 7-7 所示為輸出軸的許用軸向載荷，此載荷作用在輸出軸的軸心上。

Table 7-7 shows the allowable axial load of the output shaft, which acts on the shaft center of the output shaft.

凸輪分度箱型號 Model of cam indexing box	40	50	63	S80	F80	S100	F100	S125	F125	F160	F120
許用軸向載荷 Allowable axial load	450	600	1100	1300	2300	1800	3500	2200	5500	9000	13600

表 7-7 輸出軸的許用軸向載荷 (單位: N)

Table 7-7 Allowable axial load of output shaft

有時，把工作臺固定在輸出軸的軸肩面上，使輸出軸受軸向載荷。但是，當工作臺特別大，並要求工作臺的旋轉精度特別高時，或受偏心載荷時，在工作臺下面設計有軸向載荷支承，從而提高穩定性。

Sometimes the worktable is fixed on the shoulder surface of the output shaft so that the output shaft is axially loaded. However, when the workbench is particularly large and requires particularly high rotational accuracy, or is subject to eccentric loads, an axial load support is designed under the workbench to improve stability.

(2) 輸出軸的許用徑向載荷。此力垂直作用在輸出軸的一定半徑位置上，7-8 見表。

(2) Permissible radial load of Hanfei shaft. This force acts vertically on a certain radius position of the output shaft, see table 7-8.

表 7-8 輸出軸的許用徑向載荷 (單位: N)

Table 7-8 Permissible Radial Cutting of Output Shaft

凸輪分度箱型號 Cam indexing box model	40	50	63	S80	F80	S100	F100	S125	F125	F160	F200
許用徑向載荷 Allowable radial load	450	800	1200	1800	3800	3700	5400	5200	8000	12900	19500

(3) 工作臺的大小

(3) Size of workbench

當工作臺安裝在輸出軸上時工作臺大小應使實際負荷轉矩在許用輸出轉矩範圍內要求

When the workbench is mounted on the output shaft, the workbench size should allow the actual page load torque to be within the allowable output torque range.

特別高精度運動時，許用轉矩應為實際轉矩的 2-3 倍左右。盡量使輸出軸的扭曲量最小。

一般來說，工作臺的直徑大小為凸輪箱尺寸的 5 倍左右。表 7-9 所示為一般工作臺的最大直徑。

In particularly high-precision motion, the allowable torque should be about 2-3 times the actual torque. Try to minimize the distortion of the output shaft. Generally speaking, the diameter of the worktable is about five times the size of the cam box. Table 7-9 shows the maximum diameter of a typical worktable.

表 7-9 一般工作臺的最大直徑 (單位: N)

Table 7-9 Maximum Diameter of General Workbench

凸輪分度箱型號 Cam indexing box model	40	45	50	60	63	80	100	110	125	140	160	180	200	250
直徑 Diameter	200	225	250	300	315	400	500	50	625	700	800	900	1000	1250

(4) 分度精度

(4) Indexing accuracy

凸輪箱的分度精度用角度來表示，分普通級 30"± 和精密級 ±15"。必須注意，使用工作臺時，工作臺直接安裝在輸出軸上，如有偏心，則嚴重影響分度精度。

The indexing accuracy of cam box is expressed by angle. It must be noted that when installing the cam indexing box on the foundation, the working table is directly mounted on the output shaft. If there is eccentricity, the indexing accuracy will be seriously affected.

5. 使用分度凸輪的注意事項

5. Precautions for using indexing cam

(1) 概要

(1) Summary

為使凸輪分度箱滿足運動特性、高速性、重載性、分度精度等要求，必須注意使用方法。

特別是在高速情況下反復實現“轉動和停止”的動作，易產生振動，更須注意使用方法。

In order to make the cam indexing box satisfy the requirements of motion characteristics, high speed, heavy load and indexing accuracy, it is necessary to pay attention to the use method, especially to realize the action of "turning and stopping" repeatedly at high speed, which is easy to generate vibration, and pay more attention to the use method.

(2) 凸輪分度箱的安裝

(2) Installation of cam indexing box

因為負荷轉矩反復作用在凸輪分度箱上，因此把凸輪分度箱安裝在基礎上時，利用輔助板

從兩個方向固定凸輪分度箱，并把輔助板固定在基礎上，用定位銷定位。

Because the load torque acts repeatedly on the cam indexing box, when installing the cam indexing box on the foundation, fix the cam indexing box in two directions with the auxiliary plate, fix the auxiliary plate on the foundation and position it with the locating pin.

(3) 驅動軸

(3) Drive shaft

在設計凸輪箱的凸輪軸和輸出軸的驅支軸時，盡量取較大直徑，并把慣性轉矩控制在最小

範圍之內。驅動軸長充越短越好，這樣既提高了軸的轉矩剛性，又減小了軸的扭曲度。驅動

凸輪軸和輸出軸的驅動軸的直徑，按計算轉矩的 1.5-2 倍來計算。

扭轉剛度小時，分度運動時產生振動不能平穩地進行分度運，動導致凸輪從動件受到異常力對分度精度影響大。

In the design of cam box camshaft and drive pivot of handout shaft, take as large a diameter as possible and control the inertial torque to a minimum. The longer the drive shaft, the shorter the better, which not only improves the torque rigidity of the shaft, but also reduces the distortion of the shaft. The diameter of the drive shaft of the drive camshaft and output shaft is calculated as 1.5-2 times the calculated torque.

When torsional stiffness is less than indexing motion, vibration can not be smoothly indexing motion, resulting in abnormal force on cam follower, which has a great influence on the indexing accuracy.

(4) 驅動軸的聯軸器

(4) Shaft coupling of drive shaft

要求凸輪分度箱的凸輪軸和輸出軸與驅動軸的聯軸器在旋轉方向上剛性好,沒有間隙,回轉達平穩并且與被連接兩軸的同軸度好。

It is required that the camshafts of the cam indexing box and the coupling of the output shaft and the drive shaft are rigid in the direction of rotation, have no gap, rotate smoothly and have good concentricity with the connected two shafts.

當聯軸器設計裝在輸出軸上時,須注意的是,聯軸器應有一定的富裕長度。

When the coupling is designed to be mounted on the output shaft, it should be noted that the coupling should have a certain affluent length.

為安全起見,按照計算轉矩的 1.5-2 倍來計算驅動軸聯軸器的尺寸。一般常用的彈性聯軸器和鏈條式聯軸器不能滿足前述要求,應避免使用。

For safety reasons, the size of the drive shaft coupling is calculated as 1.5-2 times the calculated torque. Generally used elastic couplings and chain couplings can not meet the above requirements and should be avoided.

(5) 凸輪軸的驅動方法

(5) Driving method of camshaft

如圖 7-60 所示,凸輪軸轉矩在一轉中是變化的,由于正負符號的變化,引起很大的脈動變化。只有凸輪軸平穩的定數轉動,才能發揮凸輪特性。若凸輪軸旋轉有不平穩的脈動,作用在輸出軸上的負荷轉矩將遠遠大于計算轉矩。這對凸輪箱將產生破壞的後果。

As shown in Figure 7-60, the camshaft torque varies in one revolution, causing a large fluctuation due to the change of the positive symbol. Only when the camshaft rotates smoothly at a fixed number can the cam characteristics be brought into play. If the camshaft rotates unevenly, the payload torque acting on the output shaft will be much greater than the calculated torque. This will have destructive consequences for the cam box.

因此,要求驅凸輪軸的方法是速度恆定的無滑動的同步帶。發生脈動的鏈條傳動及有間隙的齒輪傳動是不適于凸輪軸驅動的。驅動凸輪軸的方法是:

Therefore, the method required to drive the camshafts is a constant speed, slip-free synchronous belt. Pulsating chain drives and cleared gear drives are not suitable for camshaft drive the method of driving the camshaft is:

1) 低速驅動。如圖 7-61 所示,把間隙極小的蝸輪減速機等與凸輪軸直接連接,并用同步帶來驅動減速機軸。減速機和同步帶的計算,按照計算的凸輪轉矩的 1.5-2 倍來計算。

1. Low speed drive. As shown in Week 7-61, connect the worm gear reducer with small backlash plate etc. directly to the camshaft and use the synchronous belt to drive the reducer shaft. The counting of reducers and timing belts is calculated as 1.5-2 times the cam torque counted.

2) 高速驅動。凸輪軸和驅動帶輪大小取較大尺寸,并用帶來傳遞驅動。這種同步帶的計算按計算凸輪軸的驅動轉矩的 1.5-2 倍來計算。

2. High speed drive. Camshafts and drive pulleys are larger in size and cause signal swindling. The tubing of this synchronous belt Calculate by 1.5-2 times the drive torque of the camshaft.

(6) 輸出軸和工作機械的連接方法

(6) Connection method of output shaft and working machine

1) 直接驅動。把工作機和凸輪箱的輸出直接連接起來。

1) Direct drive, which directly connects the output of the worker and the cam box.

2) 間接驅動。利用齒輪、鏈輪,在允許慣性增加的範圍內,盡量取較大的節圓直徑,把間隙控制在最小範圍內。齒輪和鏈輪的強度,按照計算轉矩的 1.5-2 倍來設計。

2) Indirect drive. With gears and sprockets, in the range of allowable increase of inertia, take the larger pitch diameter as far as possible and control the clearance in the minimum range. The strength of gears and sprockets is designed according to 1.5-2 times the calculated torque.

(7) 要求凸輪軸和輸出軸與相關零件無間隙連接

(7) No clearance connection between camshaft and output shaft and related parts is required

要求凸輪軸和輸出軸與聯軸器、帶輪、齒輪、鏈輪和工作臺等連接時沒有間隙。一旦有了間隙,將產生摩擦矩。此時,由于慣性轉矩較大,在減速時凸輪不能控制負慣性轉矩,這時慣性力將直接沖擊凸輪機構,發生異常的振動和噪聲。這樣不但不能正常工作,而且對凸輪從動件和凸輪面造成極壞的影響,導致降低壽命,破壞機構。

No clearance is required when camshafts and output shafts are connected to coupling pulleys, gears, sprockets, workbenches, etc. One day I have a back Gap, which generates friction moment. At this time, due to the large dry inertia torque, the cam can not control the negative inertia torqueduring deceleration. At this time, the inertia force will directly drive the cam mechanism, causing abnormal vibration and noise. This notonly does not work properly, but also has a very bad effect on cam followers and cam surfaces, resulting in reduced life and destructionof the mechanism.

(8) 輸出軸的被驅動體的設計

(8) Design of Driven Body for Output Shaft

被輸出軸驅動的工作臺等被驅動體盡量設計成輕而緊湊,剛性好,否則將對慣性轉矩和振動產生直接影響。如果設計不當,不但箱體大尺寸,不經濟,而且發生振動。

精密凸輪機構最適合高速化,因為可把被驅動體設計得盡量輕,緊湊大剛性。這也是實現高速化的有效方法。

Driven bodies such as workbenches driven by output shafts are designed as light and compact as possible with good rigidity, otherwise they will directly affect the inertial torque and vibration. If not properly designed, not only the box is large in size and uneconomical, but also vibration occurs.

Precision cam mechanisms are best suited for high speed because the drive body can be designed to be as light as possible, compact and rigid. This is also an effective way to achieve high speed.

(9) 過載保護機構

(9) Overload protection mechanism

為了保護凸輪機構,在一定位置設計過載保護機構是必要的。

In order to protect cam mechanism, it is necessary to design overload protection mechanism in certain position.

(10) 凸輪的起動、停止、點動

(10) Starting, stopping, clicking of cams

凸輪在分度區間發生起動、停止、點動時,對凸輪箱將產生比計算負荷轉矩還大的作用力,應盡量避免。

When the cam starts, stops and moves during indexing, the force exerted on the cam box which is greater than the direct load torque should be avoided as far as possible.

如果在分度期間必須停止運動,再起動時一定用手動方法完成停止在分度區間的分度工作,完全確認到了凸輪停止部位時再起動。不得已要在分度區間進行起動、停止或點動時,應選擇能承受比計算轉矩更大的凸輪分度箱。

If the motion must be stopped during the indexing period, the indexing work stopping in the indexing interval must be completed manually when restarting, and restarting when the cam stop position is fully confirmed. When starting, stopping or clicking during the indexing period, a cam indexing box that can withstand a higher torque than the calculated one should be selected.

(11) 凸輪箱的周圍空間

(11) Surrounding space of cam box

一般來說，分度凸輪箱是自動機械的心臟部分，均安裝在機械的中心部位，被其他機構包圍，看不見，摸不着，機構緊湊。但是，為了調整間隙，應盡量使之能看見，摸得着，以便加油、檢修方便。

Generally speaking, the indexing cam box is the heart of the automatic machine, which is installed in the center of the machine, surrounded by other mechanisms, invisible, untouchable, and compact. However, in order to adjust the back clearance, try to make it

(12) 凸輪分度箱的保修

(12) Warranty of cam indexing box

凸輪分度箱在出廠時已經過嚴格調整，沒有間隙，并按標準加油。在此應特別注意，加油時不得混入雜質，否則會損傷從動件和凸輪的接合面及軸承等，造成噪聲很大。

The cam indexing box has been strictly adjusted before leaving the factory, and there is no gap, and it is refueled according to the standard. Special attention shall be paid here that no impurities shall be mixed during refueling, otherwise the joint surface and bearing of the follower and cam will be damaged, resulting in high noise.

(13) 盡量增大分度角

(13) Increase the indexing angle as much as possible

一般情況下，為了增加工作時間而減小分度角。從輸出軸的最大角加速度公式可知，負荷轉矩與分度角的平方成反比，分度角越大，負荷轉矩越小。增大分度角對凸輪機構的許多方面均有好處。因此，在允許的工作時間範圍內，力求增大分度角。

Generally, the indexing angle is reduced in order to increase the working time. From the maximum angular acceleration formula of the output shaft, the direct load torque is inversely proportional to the square of the indexing angle. The larger the indexing angle, the smaller the load torque. Increasing the indexing angle is beneficial to many aspects of cam mechanism. Therefore, try to increase the indexing angle within the allowable working time.

7 平行分度凸輪機構的選擇計算

7 Selection and calculation of parallel indexing cam mechanism

機種選擇

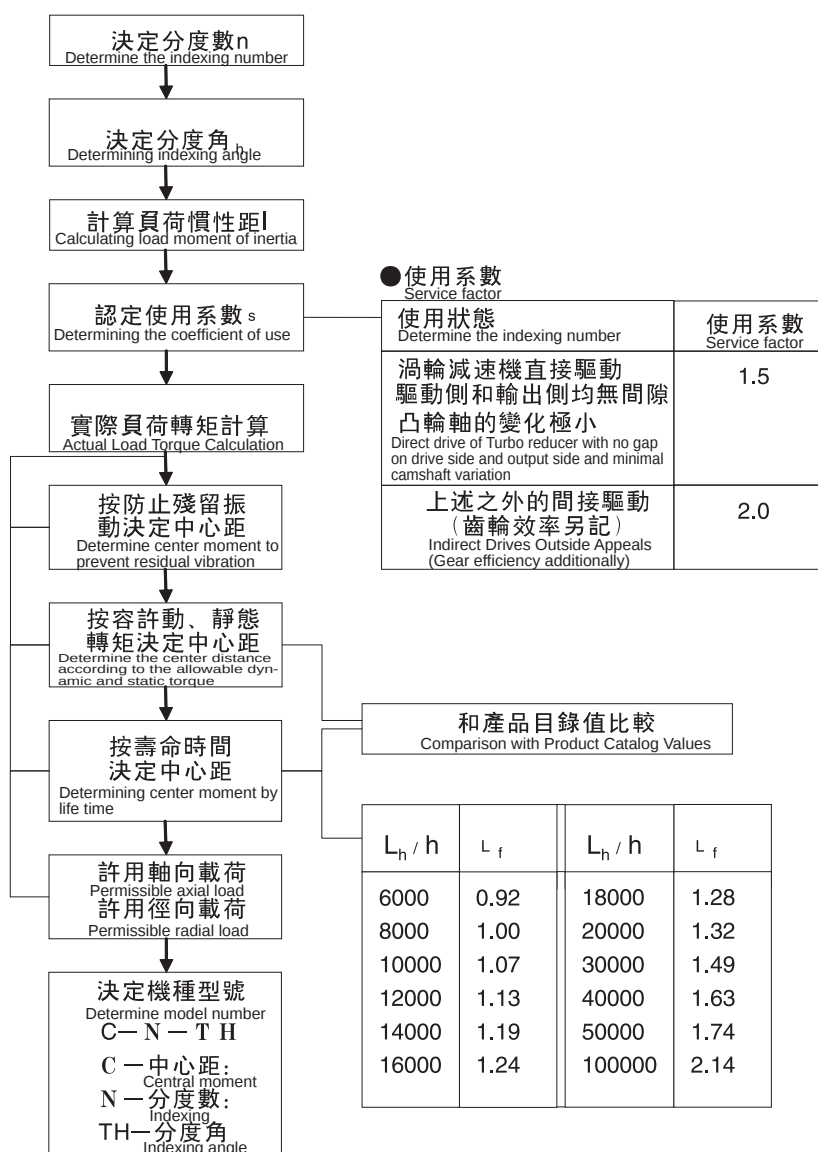
Model selection

把相當于理想壽命時間 h 的壽命系數 f 乘實際負荷轉矩 T_f ，其值由產品目錄中查得。

The life coefficient of h and the self-load torque of passenger compartment at the ideal service life are obtained from the product catalog.

圖 7-62 所示為機種選擇程序。

Figure 7-62 shows the model selection procedure.



2. 機種選擇計算

Model Selection Calculation

(1) 符號說明

Symbol Description

 n —— 分度數;
Indexing q_h —— 分度角;
Indexing angle t_{cy} —— 循環時間 (s), 即凸輪軸轉達一轉需要的時間;
Cycle time (s), the time required for one camshaft revolution t_h —— 凸輪分度時間 (s);
Cam indexing time t_h —— 轉盤擺動時間 (s);
Swing time of turntable I —— 慣性矩 (kg.m^2);
Moment of Inertia I_c —— 容許慣性矩 (n);
Moment of Inertia q_{tm} —— 最大慣性轉矩 (N.m);
Maximum Inertia Torque V_m —— 無量綱最大速度;
Dimensionless maximum speed A_m —— 無量綱最大加速度;
Dimensionless maximum acceleration $(AV)_m$ —— 最大無量綱慣性矩;
Maximum dimensionless moment of inertia f_t —— 摩擦矩 (N.m);
Friction moment m —— 摩擦系數;
Friction coefficient q_f —— 總負荷轉矩 (N.m);
Total load torque q_f' —— 實際負荷轉矩 (N.m);
Actual load torque L_h —— 理想壽命時間 (h);
Ideal Life Time q_{cm} —— 輸入軸最大轉矩 (N.m);
Maximum Torque of Input Shaft n_c —— 凸輪軸轉速 (r/min);
Camshaft speed P —— 電動機功率 (kW)。
Motor Power

(2) 計算順序

Calculation sequence

1) 分度數 n

Indexing

$$n = \frac{2p}{t_h}$$

2) 分度角 q_h

Indexing angle

$$q_h = 360 \frac{t_h}{t_{cy}}$$

3) 轉盤擺動時間 t_h

Swing time of turntable

$$t_h = t_{cy} \frac{q_h}{2p}$$

4) 實際負荷轉矩 q_f'

Actual load torque

最大慣性轉矩
Maximum Inertia Torque

$$q_{tm} = \frac{I t_h^2}{t_h^2} A_m$$

摩擦矩
Friction moment

$$f_t = mWR$$

總負荷轉矩
Total load torque

$$q_f = q_{tm} + f_t$$

實際負荷轉矩
Actual load torque

$$q_f' = f_s q_f$$

5) 輸入軸最大轉矩 q_{cm}

Maximum Torque of Input Shaft

$$q_{cm} = \frac{I t_h^2}{q_h t_h^2}$$

6) 電動機功率 P

Motor Power

$$P = \frac{q_{cm} n_c}{9750}$$

常用凸輪曲線特性值如表 7-10 所示。

Commonly used cam curve characteristic values are shown in Table 7-10

表 7-10 常用凸輪曲線特性值

Table 7-10 Common Cam Curve Characteristic Values

曲線	V_m	A_m	$(AV)_m$
修正等速曲線 (MCV) Corrected constant velocity curve	1.28	8.01	5.73
修正正弦曲線 (MS) Modified sine curve	1.76	5.53	5.46