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ANDANTEX

精密控制谐波减速器
选型技术资料

Technical Data On The Selection Of
Precision-Controlled Harmonic Drives



HARMONIC DRIVE
谐波减速器

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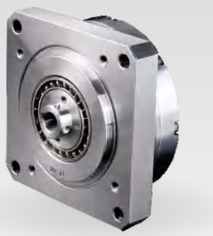
系列产品图
Series product picture



CS-I



CD-I



FS-I



LFB-I



ST-I



ST-III



ST-IV



SD-I



YT-I



YC-I

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PRINCIPLE OF HARMONIC GEAR REDUCER
谐波传动原理

> 谐波传动是由美国发明家C.Walt Musser马瑟于上世纪50年代发明创造的
>
> Harmonic drive was invented by American inventor C. Walt Musser in mid-1950s

1 谐波传动装置的组成
Composition of harmonic gearbox

谐波传动装置主要由三个基本零部件构成，即波发生器、柔轮和刚轮。

波发生器：由柔性轴承与椭圆形凸轮组成，波发生器通常安装在减速器输入端，柔性轴承内圈固定在凸轮上，外圈通过滚珠实成弹性变形成椭圆形。

柔轮：带有外齿圈的柔性薄壁弹性体零件，通常安装在减速器输出端。

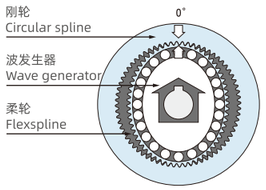
刚轮：带有内齿圈的刚性圆环状零件，一般比柔轮多两个轮齿，通常固定在减速器机体上。

Harmonic gearbox has three basic components: a wave generator , a flexspline and a circular spline .

Wave generator : it is made up of a ball bearing and an elliptical cam . The wave generator is usually attached to the input end , the inner ring of the bearing is fixed around the cam causing the outer ring of the bearing deforms to an elliptical shape .

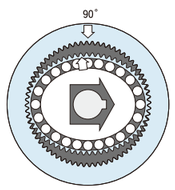
Fexspline : it is an elastic thin-walled component with gear teeth on outer surface . It is usually fitted to output end.

Circular spline : it is a rigid steel ring with internal teeth . It usually has two more teeth than the flexspline , and generally mounted onto a housing .



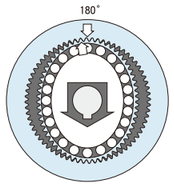
柔轮被波发生器弯曲成椭圆状。因此，在长轴部分刚轮和齿轮啮合，在短轴部分则完全与齿轮呈脱离状态。

The flexspline is forced into an elliptical shape by the wave generator causing the flexspline teeth to engage with the tooth profile of the circular spline along the major axis of the ellipse, with the teeth completely disengaged across the minor axis of the ellipse.



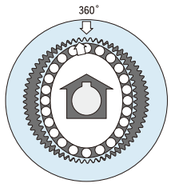
固定刚轮，使波发生器按顺时针方向旋转后，柔轮发生弹性形变，与刚轮啮合的齿齿轮位置顺次移动。

As the wave generator rotates clockwise with the circular spline fixed, the flexspline is subiected to elastic deformation and its tooth engagement position moves turning relative to the circular spline.



波发生器向顺时针方向旋转180度后，柔轮仅向逆时针方向移动一齿。

As the wave generator rotates 180 degrees clockwise, the flexspline moves counterclockwise by one tooth relative to the circular spline.



波发生器旋转一周（360度）后，由于比刚轮减少2齿，因此柔轮向逆时针方向移动2齿。一般将该动作作为输出执行。

For every one full rotation clockwise (360 degrees)of the wave generator, the flexspline moves counterclockwise by two teeth relative to the circular spline because the flexspline has two fewer teeth than there are on the circular spline. In general, this movement is treated as output performing.

2 谐波传动特点
Characteristics of harmonic gearbox

- 精度高：多齿在两个180度对称位置同时啮合，因此齿轮齿距误差和累积齿距误差对旋转精度的影响较为平均，可得到极高的位置精度和旋转精度。
- 传动比大：单级谐波齿轮传动的传动比可达i=30~500，且结构简单，三个在同轴上的基本零部件就可实现高减速比。
- 承载能力高：谐波传动中，齿与齿的啮合是面接触，加上同时啮合齿数比较多，因而单位面积载荷小，承载能力较其他传动形式高。
- 体积小、重量轻：相比普通的齿轮装置，体积和重量可以大幅降低，实现小型化、轻量化。
- 传动效率高、寿命长。
- 传动平稳、无冲击，噪音小。

- High accuracy: a good percentage of its teeth are meshed at all times, and are engaged at two zones 180 degrees apart. This means influences of tooth pitch errors and accumulated pitch errors on rotational accuracy are neutralized, which assures high positional and rotational accuracy.
- High speed reduction ratio: a harmonic gearbox has high single-stage reduction ratios of 1/30-1/500. Three basic components along same axle without complex structures can provide high reduction ratios.
- High torque capacity: each tooth is subjected to a negligible amount of force yet provides a high torque capacity because of the way the teeth come into contact with each other and because a good percentage of the teeth in the flexspline are engaged at all times.
- Small-sized and light weight: while being less the size of conventional gearing mechanisms and less the weight, the harmonic gearbox provides the same levels of torque and speed reduction ratios as its conventional counterparts enabling machinery and equipment to be made smaller and lighter.
- Superior efficiency and long life time.
- Quiet and minimal vibration operation.

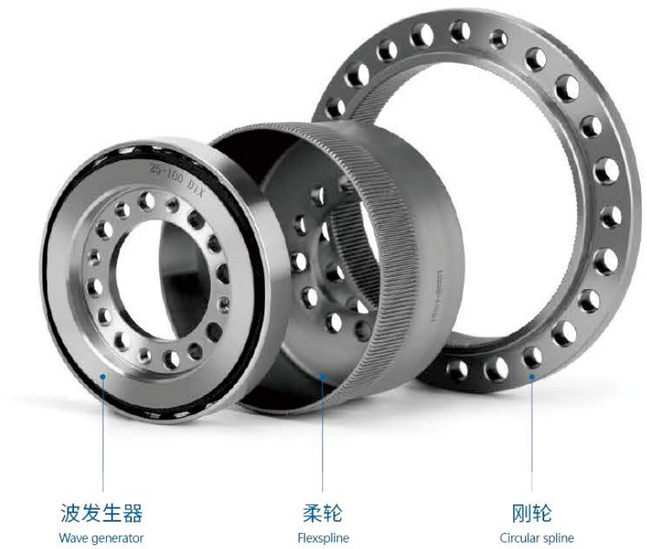
3 谐波减速原理
Principle of harmonic gearbox

谐波作为减速器使用，通常采用波发生器主动、刚轮固定、柔轮输出形式。

当波发生器装入柔轮内圆时，迫使柔轮产生弹性变形而呈椭圆状，使其长轴处柔轮轮齿插入刚轮的轮齿槽内，成为完全啮合状态；而其短轴处两轮轮齿完全不接触，处于脱开状态。由啮合到脱开的过程之间则处于啮出或啮入状态。当波发生器连续转动时，迫使柔轮不断生产变形，使两轮轮齿在进行啮入、啮合、啮出、脱出的过程中不断改变各自的工作状态，产生了所谓的错齿运动，从而实现了主动波发生器与柔轮的运动传递。

As a reducer, the harmonic gearbox is often in a status as: the wave generator drives, the circular spline is fixed. the flexspline is output end.

When the wave generator is put inside of the flexspline, the flexspline is forced into an elliptical shape causing the flexspline teeth to engage with the tooth profile of the circular spline along the major axis of the ellipse, with the teeth completely disengaged across the minor axis of the ellipse. The rotation of the wave generator makes the flexspline deform continuously, the teeth change operating state in the process of engagement and disengagement, thus the motion transmission between wave generator and flexspline is realized.



TOOTH PROFILE
齿形介绍

15%
承载能力提高15%
Gear toothing capacity increased by 15%

15000 hours
寿命超过15000小时
Service time exceeded 15000 hours

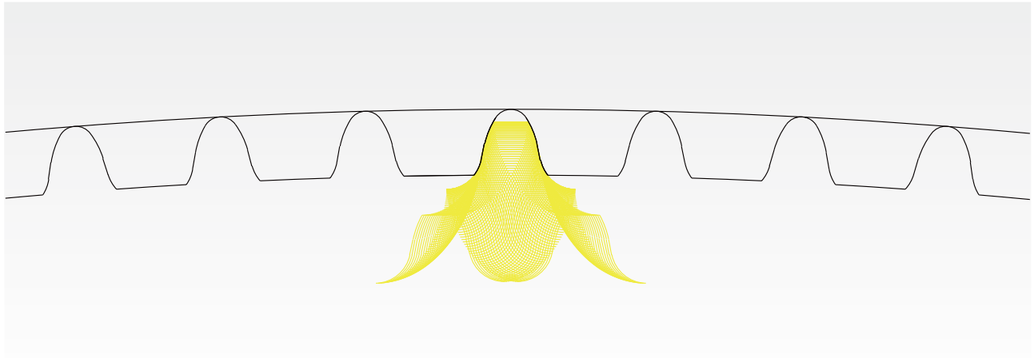
8-10℃
温升降低8-10℃
Temperature rise decreased by 8-10 degrees

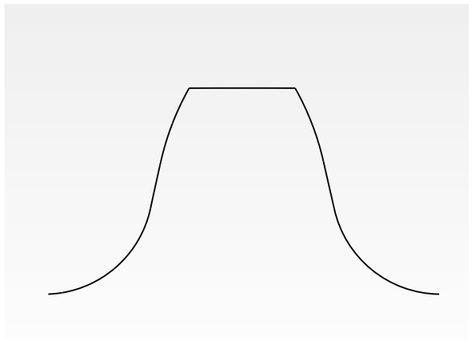
接触面积
减小齿轮疲劳点蚀接触面积
Reduced gear fatigue pitting contact area

关于 C齿形
About C tooth profile

将传统理论上的双圆弧齿形进一步优化，由原有的两段曲率连续的圆弧曲线所形成的齿形优化为多段曲率连续的圆弧曲线，保证减速器齿轮的正确啮合同时通过降低相对滑动摩擦来保护润滑脂极压后油脂失效的风险。基于δ齿形的产品，承载能力提高15%，温升降低8-10℃，齿轮疲劳点蚀接触面积减小30%以上，连续跑合使用寿命超过15000小时，提高了谐波减速器的综合性能。

We have made some upgrades based on the traditional theoretical double arc profile. The tooth profile formed by the original two curve continuous arc curve is optimized as a continuous arc curve with multiple segments of curvature. To ensure that the gears of reducer are properly meshed, while protecting the risk of grease failure after grease is squeezed by reducing relative sliding friction. Based on the δ tooth shape， the load capacity is increased by 15%，the temperature rise is reduced by 8-10 degrees. the gear fatigue pitting contact area is reduced by more than 30%, continuous running and service life is over 15000 hours, which improves the overall performance of the harmonic gearbox.





在开发过程当中，柔轮齿型的形成可根据发生器的径向位移量来确定，不同的减速比可拟合出多种的齿型配合，同时可以方便的根据实际情况调整啮合背隙，使减速器始终处于最佳的工作状态。

During development, the formation of the soft tooth profile can be determined by the radial displacement of the genera tor. Different gear reduction ratios can be fitted with various tooth profiles and the mesh backlash can be conveniently adjusted according to actual conditions. Keep the gearbox in the best working condition.

NAMING RULES
命名规则

CS - 14 - 100 - U/C - I

机型名称 Series	规格 Type	减速比 注① Reduction ratio(Note1)						结构代码 Structure code	I：简易标准型 I：Simple standard type
CS CN CG CD FS	11	50	80	100	-	-	-	U：整机 C：部件 U：Completely unit C：Component	I：简易标准型 I：Simple Standard type
	14	50	80	100	120	-	-		
	17	50	80	100	120	-	-		
	20	50	80	100	120	160	-		
	25	50	80	100	120	-	-		
	32	50	80	100	120	-	-		
	40	50	80	100	120				

注①:减速比表示的是输入：波发生器，固定：刚轮，输出：柔轮时的情况。
Note 1：Reduction ratio indicates of wave generator as inputting , fixing circular spline , and flexspline as outputting.

SEAL RING'S SIZE DESCRIPTION
密封圈尺寸说明

单位unit： mm

型号 Series	规格 Model	刚轮侧 Circular spline		柔轮侧 Flexspline	
		密封圈尺寸 Seal ring size	开槽尺寸 Slot size	密封圈尺寸 Seal ring size	开槽尺寸 Slot size
ST-I	14	36.5*0.6	$\Phi36.5_{-0.1}^{0}$ * $\Phi38^{+0.1}_{0}$ * $0.45^{+0.1}_{0}$	53*1.5	$\Phi53_{-0.1}^{0}$ * $\Phi56.8^{+0.1}_{0}$ * $1.15^{+0.1}_{0}$
	17	45*1	$\Phi45.5_{-0.1}^{0}$ * $\Phi48^{+0.1}_{0}$ * $0.75^{+0.1}_{0}$	64*1	$\Phi64_{-0.1}^{0}$ * $\Phi66.6^{+0.1}_{0}$ * $0.75^{+0.1}_{0}$
	20	54*1	$\Phi53.8_{-0.1}^{0}$ * $\Phi56.2^{+0.1}_{0}$ * $0.75^{+0.1}_{0}$	73*1.5	$\Phi73_{-0.1}^{0}$ * $\Phi76.8^{+0.1}_{0}$ * $1.15^{+0.1}_{0}$
	25	68*1	$\Phi68_{-0.1}^{0}$ * $\Phi70.6^{+0.1}_{0}$ * $0.75^{+0.1}_{0}$	90*1.5	$\Phi90_{-0.1}^{0}$ * $\Phi94.2^{+0.1}_{0}$ * $1.15^{+0.1}_{0}$
	32	88*1.5	$\Phi88_{-0.1}^{0}$ * $\Phi92^{+0.1}_{0}$ * $1.15^{+0.1}_{0}$	119*1.5	$\Phi119_{-0.1}^{0}$ * $\Phi123.1^{+0.1}_{0}$ * $1.15^{+0.1}_{0}$
	40	108*1.75	$\Phi108_{-0.1}^{0}$ * $\Phi113^{+0.1}_{0}$ * $1.5^{+0.1}_{0}$	143*2	$\Phi142.6_{-0.1}^{0}$ * $\Phi148^{+0.1}_{0}$ * $1.5^{+0.1}_{0}$

※ 为了充分发挥 ST-I型的优良性能，请确保如下图所示的推荐精度。
In order to give full play to the excellent performance of ST-I, please ensure the recommended accuracy as shown in the figure.

TERMS AND DEFINITIONS
额定用语表

术语和定义
Terms And Definitions

启动扭矩
Starting torque

能使用谐波减速器空载启动时，输入端需施加的最小力矩

It is the minimum torque value applied to the input end at which the harmonic gearbox first starts to rotate with no load

背隙
Backlash

柔轮齿廓与刚轮齿廓之间的间隙

The clearance between flexspline tooth profile and circular spline tooth profile

输出额定转矩
Rated torque

谐波减速器在保持其正常的性能指标下，能长时间运行的输出扭矩

It indicates allowable continuous output torque at rated input speed

启动停止时的容许峰值转矩
Permissible peak torque at start and stop

启动停止时的容许峰值转矩指的是谐波减速器在启动或停止时的最大冲击转矩

It's the maximum torque as a result of the moment of inertia of the output load during acceleration and deceleration

容许最大平均负载转矩
Permissible maximum value for average load torque

容许最大平均负载转矩指的是谐波减速器能长时间工作的最大转矩

It's the maximum torque when the harmonic gearbox keeps continuous operation

容许最大瞬时转矩
Permissible maximum momentary torque

容许最大瞬时转矩指的是谐波减速器短时能承受的最大转矩

It is the momentary peak torque the harmonic gearbox may be subjected to the event of a collision or emergency stop

容许最大输入转速
Permissible maximum input rotational speed

容许最大输入转速指的是谐波减速器容许输入转速的最大值

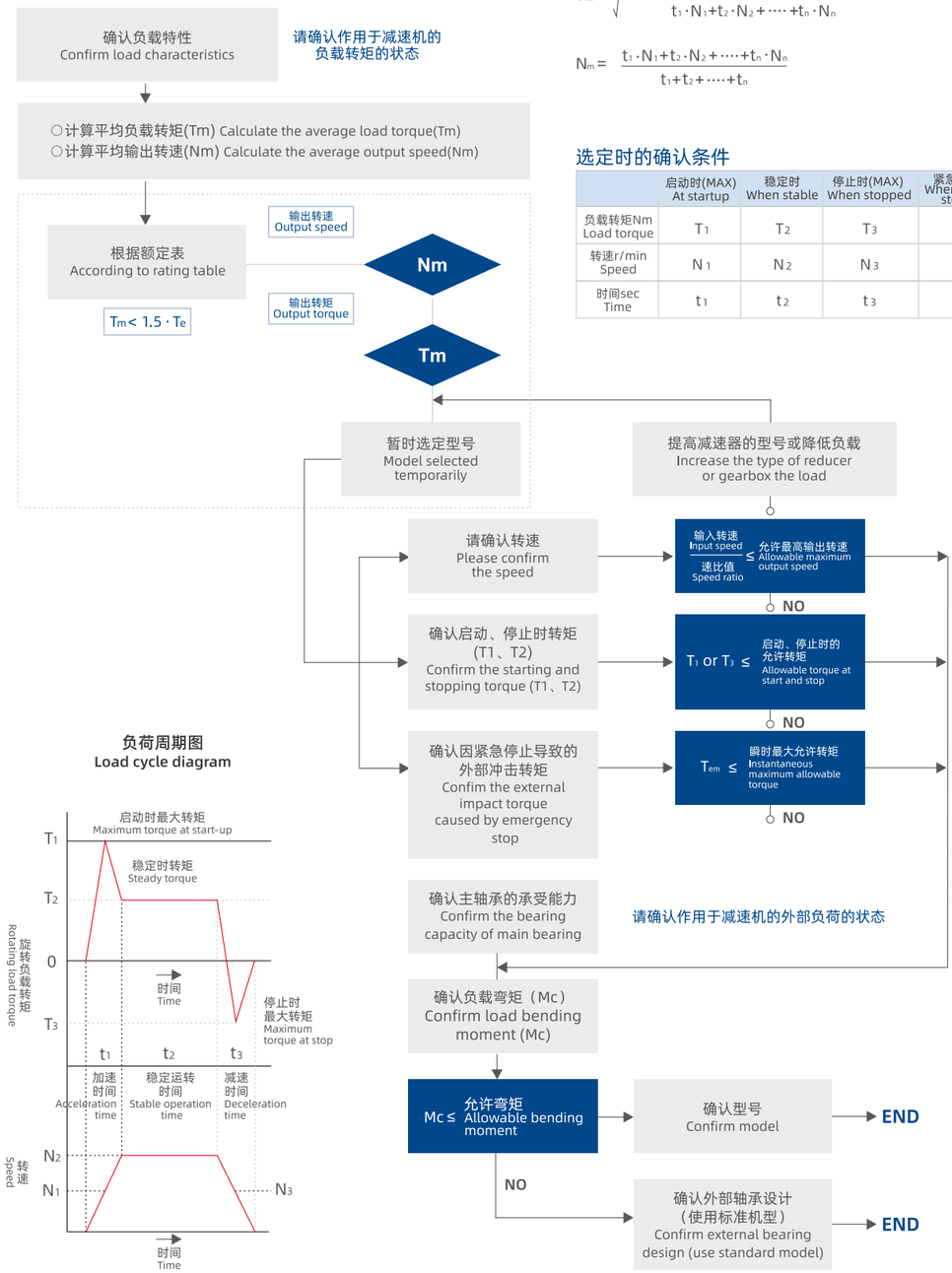
Don't exceed the permissible rating

容许平均输入转速
Permissible average input rotational speed

容许平均输入转速指的是谐波减速器输入转速的平均值

It's the average value of input speed

SELECTION PROCESS
选型流程



$$T_m = \sqrt[10/3]{\frac{t_1 \cdot N_1 \cdot T_1^{10/3} + t_2 \cdot N_2 \cdot T_2^{10/3} + \cdots + t_n \cdot N_n \cdot T_n^{10/3}}{t_1 \cdot N_1 + t_2 \cdot N_2 + \cdots + t_n \cdot N_n}}$$

$$N_m = \frac{t_1 \cdot N_1 + t_2 \cdot N_2 + \cdots + t_n \cdot N_n}{t_1 + t_2 + \cdots + t_n}$$

选定时的确认条件

	启动时(MAX) At startup	稳定时 When stable	停止时(MAX) When stopped	紧急停止冲击时 When emergency stop impact
负载转矩Nm Load torque	T_1	T_2	T_3	T_{em}
转速r/min Speed	N_1	N_2	N_3	N_{em}
时间sec Time	t_1	t_2	t_3	t_{em}

负荷周期图
Load cycle diagram