General Introduction of Harmonic Drive Product Technique

Classification of Drive Technique:

In broad users’ actual environment, prime mover (such as motor or gas engine) cannot connect with load directly because its rotation speed or output power and torque cannot reach requirement.

Therefore, a middle link must exist between primer mover and load, this link is drive device, through transformation of drive device, the main parameter of prime mover original output character will adapt to user’s loading environment, and make system work normal.

In drive and speed regulating technique, according to the difference of realizing method, it can be divided into two kinds, electric speed regulating system and mechanical speed regulating system. These two kinds of system have each suitable range respective. Motor speed regulating system mostly be used in the state of less load, and has the character of light weight and flexible speed regulating, but cannot be used in the environment of heavy load. Correspondingly, mechanical speed regulating equipment is mostly used in the state of large load, although system’s weight increased for the added mechanical equipment, it can satisfy the speed regulating requirement of larger speed ratio range and constant power.

There into, working process of harmonic drive is as follows: Harmonic gear drive structure consists of circular spline, flex spline and wave generator these three basic components:

The three components’ sequence from exterior to inner is:

**Circular spline**: Rigid and undeformed annular wheel gear.

**Flex spline**: Shell component, has flexible external gear. Along with inner cam (wave generator)'s running, shell bearing’s outer annulus will do elliptic deformation movement.

**Wave generator**: Generally is elliptic cam. When it’s circumvolving, it will cause periodically wave extrusion to the around shell bearing (flex spline).

Harmonic Drive Technical Theory

In the current mechanical speed regulating system, according to its inner structure’s difference can be divided into cylinder cone pulley drive structure, planet drive structure, double helical gear drive and harmonic drive structure etc.
Drive Principle

We take the most familiar drive gear’s application for example, to introduce harmonic drive principle. When wave generator is driving, cam runs inside the flex spline, and make flex spline and shell bearing occurring deformation (controllable flexible deformation), now flex spline’s teeth will engaging-in or engaging-out between circular spline’s teeth during the course of deformation, and it’s in complete engaging-in at wave generator’s major axis, and teeth at minor axis in complete disengagement.

Wave generator usually is elliptic cam, put the cam in shell bearing, and then put them into flex spline. Now, flex spline will change from original circle to ellipse, flex spline at two ends of elliptic major axis and the matched circular spline teeth are at the complete engaging-in state, namely flex spline’ s external gear and circular spline’s annular gear engaging-in along tooth depth. This is engagement area, usually about 30% teeth are at engagement state; flex spline at two ends of elliptic minor axis and circular spline are at the state of complete disengagement, short for disengagement; flex spline teeth between wave generator major axis and minor axis, along the different section of flex spline perimeter, some exit the circular spline teeth gradually, and at the semidisengagement state, we call it engaging-out.

When wave generator running inside flex spline, compel flex spline occurring continuous flexible deformation, now wave generator’s continuous running will make flex spline teeth’s four states of engaging in engagement engaging out disengagement to and fro change each original engaging state continuously. This phenomenon is called alternate tooth, just for this alternate tooth movement, reducer can change input high speed running into output low speed running.

For double-wave generator’s harmonic gear drive, when wave generator run 1/8 circle clockwise, flex spline teeth and circular spline teeth will change to engagement state from the original engaging-in state, and the original disengagement state will change to engaging-in state. The same principle, engaging-out become disengagement, engagement become engaging-out, this way flex spline runs (angular displacement) 1/4 tooth relative to circular spline; same way, when wave generator runs 1/8 circle again, repeats the above course, now flex spline displace a pitch. The rest may be deduced by analogy: wave generator runs a circle relative to circular spline, and flex spline’s displacement relative to circular spline is two pitches.

Wave generator’s continuous running compels flex spline’s point change position continuously, now at any point of flex spline’s pitch, follow the course of wave generator angular displacement, form a harmonic wave which up and down, left and right is symmetrical, so call it “harmonic”.

The above three components’ different combination in harmonic transmission product, can form decelerating drive, increasing drive or differential mechanism etc several different shift drive mechanism.

When wave generator is driving, flex spline is driven, and circular spline is fixed, system realizes high speed ratio’s decelerating output.

When circular spline is driving, flex spline and wave generator is driven, and system can realize increasing movement of running.

When generator and circular spline is driving, and flex spline is driven, system can form differential mechanism (that is algebra composing of generator and circular spline’s rotation speed).
Advantage of Harmonic Drive Technique

- Simple Structure, Small Volume and Light Weight.
  The main components of harmonic gear drive are only three: wave generator, flex spline and circular spline.
  Compare with the common mechanical reducer with corresponding drive ratio, its parts reduce 50%, volume and weight all reduce about 1/3 or more.

- Large Range of Drive Ratio
  Unipolar single wave harmonic drive ratio can reach 50-300, optimizing can reach 75-250;
  Multiple wave harmonic drive ratio can realize 300-150,000.

- More Teeth of Engagement at the Same Time
  Harmonic drive’s joggle teeth at the same time can reach 30%, or even more.
  But in common gear drive, joggle teeth at the same time only can be 2-7%, for spur involute gear mechanism joggle teeth at the same time is only 1-2 pair.
  Just because the special character of joggle teeth are more at the same time, the number of joggle teeth will directly influence mechanical decelerating device’s precision and load capability. Therefore, compare with common mechanical decelerating device, harmonic drive’s precision is higher, load capability of tooth is larger, and then realize large speed ratio and small volume.

- Larger Load Capability
  It’s well known that harmonic gear drive joggle teeth at the same time are more, namely teeth bearing load are more, and at the circumstance that material and speed are the same, load capability will exceed other drive greatly.
  Power range pass by it can from several watts to tens of Kw.

- Better Moving Precision
  Because multiple teeth joggle, in common cases, harmonic gear compare with common gear with the same precision, its moving precision can improve four times.

- Smooth Moving, Without Impact, Smaller Noise
  Engaging-in and engaging-out of gear teeth are gradually come into and exit among circular spline teeth along with deformation of flex spline, during the course teeth surface contact, slip speed is small, and without suddenly change.

- Clearance of Tooth Side Can be Adjusted
  During engagement of harmonic gear drive, clearance between flex spline and circular spline mainly lie on the biggest dimension of wave generator shape and tooth dimension of two gears, so, can make drive’s gear backlash very small, In some cases, it even can be zero gear backlash.

- Better Drive Efficiency.
  Compare with other drive with the same speed ratio, harmonic drive has less moving components, and joggle tooth’s speed is very low, so efficiency is very high, at different speed ratio (such as 60~250 range), efficiency is about 65%-96% (harmonic multiple drive efficiency is less), tooth’s abrasion is very little.

- Well Coaxiality
  Harmonic gear drive’s high speed shaft and low speed shaft are at the same axes.

- Can Realize Passing Movement and Motivity to Air-tight Space
  Adopt airtight flex spline harmonic drive decelerating device, can drive mechanism work in high vacuum, corrosive and other deleterious medium space, the special excellence of harmonic drive is unaccessible for other drive mechanism.

- Can Realize High Increasing Speed Movement
  Because harmonic gear drive’s efficiency is high and character of mechanism, together with the excellence of small volume and light weight, it’s the ideal high increasing speed device. For hand motor and wind power motor etc equipment which need high increasing speed, it has wide application spectacle.

- Can Realize Compensating Gear Easily
  Because the three basic components of harmonic gear drive, any two can be driving and another one driven, then can form a differential drive mechanism, accordingly realize fast and slow speed working condition easily. This point has very practical value on many machine tools’ advance mechanism, through proper design, can change machine tools advance part’s structure performance greatly.
All of HanZhen company’s harmonic drives fall under two principal categories, both derivatives of XB1 and XB2, which differ from one another in terms of their respective drive structures. Drives under the single wave series mechanism employs single wave decelerating drive structure, while multi wave series utilizes multi wave decelerating drive structure. For the structure specifications, please refer to the product series diagram.

As the most popular model on the market, the single wave serial products, which includes a total of three types, viz. XB1, XB3-A, XB3-B. This serial products are capable of providing a range of 50~300 speed ratio, which is better refined to meet the requests of most customers.

Multi wave serial products utilize tubby flex spline drive structure, which belongs to the products family of multi wave harmonic drive with XB2 and XB6 models altogether. The principal feature of the serial products lies in the wide range of output speed ratio from 300 to 150,000 so as to accommodate customers’ special needs.

Comparing with other companies’ products, our company products have following features:

- **Improved Speed Ratios**
  The speed ratio of our products has been raised to cover the broad range from 50 to 150,000. As is widely known, the harmonic drive could not reach the speed ratio between 300 and 2000 in the past. And thus, the customers with particular demands in this regard cannot but choose as a substitute drives with different ratio speed so that customers’ resources are wasted and costs are raised. With a view to meet the technical deficiency in this speed ratio range, our company has developed XB6 model harmonic drive with its distinct technology entitled to patent protection, which can easily accomplish the drives at various speed ratio grades between 300 and 2000.