

Study on Cutting Processing Characteristics and Precision of CNC Internal Power Honing Gear

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KEYWORDS: Internal Power Honing; Hardened Gear Tooth; Processing Characteristics; Precision

ABSTRACT: CNC internal meshing power honing processing technology is based on the traditional honing techniques developed on a high-quality hardened gear finishing method. In addition to the traditional advantages of internal honing outside, not only shorten the gear finishing process, improve production efficiency and reduce finishing costs, and the work force after honing has better wear characteristics, lower transmission noise, and more long service life. Based on the analysis of the meshing honing processing characteristics proposed by improving the precision honing wheel, honing wheel reasonable modification is to improve the honing cutting speed, increasing the degree of coincidence four ways to achieve high precision hardened gear machining, in order to promote a powerful honing gear development of tooth technology.

Introduction

Precision hardened gear cars, wind power, shipbuilding, machine tools, aerospace, high-speed rail and other areas essential mechanical transmission components. According to China Gear Association statistics, China gear market is expected to reach 2015, 2200-2500 billion, thanks to the rapid development of the automotive, wind power, high-speed rail and other industries, more than 50% of new gear market demand from these industries. State key support base member gear such "second five" long-life, anti-fatigue, weight loss structure, no stress concentration and other manufacturing and assembly breakthroughs in key technologies. The main purpose of hardened precision gear finishing process (Figure 1) is to achieve maximum carrying capacity of the gear transmission and minimal noise [1]. Hardened precision gear finishing process is to achieve efficient production technology of high-quality gear maximum capacity and minimum transmission noise. Currently abroad working to promote the use of hobbing - heat treatment - internal power honing this new processing technology [2], it promotes and popularize extensive domestic difficulties. Domestic and foreign scholars on honing focused on honing gear the meshing theory, modification, tooth surface quality, life, noise, technology and other aspects of research [3], and it has made a wealth of research results. This paper summarizes the traditional honing processing technology, based on internal power honing focuses on cutting processing key

technical characteristics, improve strength and made four kinds of precision honing cut four ways to promote the development of strong hardened inner honing processing technology .

Strong Engagement Honing

Honing process (Figure 1), coarse / fine honing wheel and workpiece gear into a certain space shaft angle Σ , when the coarse / fine honing wheel drive work gear at a certain speed around the workpiece spindle is rotated, a relative slip between the engagement point speed and pressure, irregular surface of the cement in the honing wheel geometry abrasive (cutting edge) by a certain trajectory from across the tooth surfaces of the workpiece at the role of external pressure honing cut abrasive cut metal layers, wear under extreme one kind of fine-tooth chip finishing methods. Drive gear rotates the workpiece along the tooth width and axial reciprocation by honing wheel, after reaching the precision processing requirements, will complete the entire tooth surface finishing.

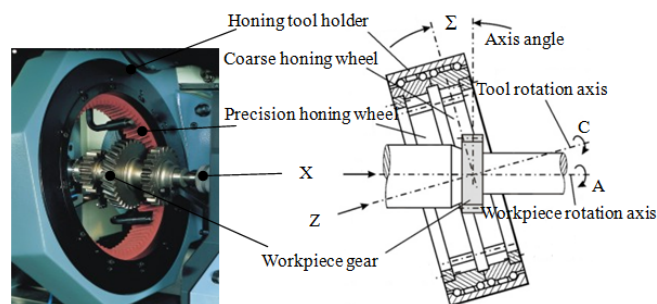


Figure 1 CNC internal power honing processing principle

Honing gear motion by the cutting process and found that the ring is a direct application of force honing gear type honing wheel and the workpiece gear after the heat treatment to make double-sided engaging within the forced movement of the honing wheel and the workpiece has a certain angle of the shaft to form a staggered axis with state hyperbolic helical gear, the use of indirect contact along the tooth flank to the relative sliding speed and high contact pressure on the tooth profile direction superimposed on the tooth surface gear left a large allowance for multi-blade cutting, honing process produces a typical arc textures [4] on the tooth surface, in order to achieve the traditional process of honing finishing process for independent fundamental improvements.

Noise and gear tooth surface morphology are closely linked, but the small allowance conventional honing, gear noise reduction effect is limited. Power honing the ring in addition to a conventional internal honing coincidence degree big, stronger error correction; tooth profile sliding velocity uniformity, stability tooth; Tooth contact length is longer than the outer and precision honing high [5] addition to the advantages, it will not only shorten the traditional grinding finishing process, to improve production efficiency and reduce finishing costs, and the tooth surface strength after honing texture (Figure 2) so that the gear has good wear characteristics and lower noise. Furthermore, since the honing speed (0.5-10m/s) much lower than the grinding speed (20-40m/s), low thermal stress, no common phenomenon of grinding burn, and produce 1600N when a power cut-honing high residual stress / mm^2 compressive stress in the tooth surface is formed to improve the life of the gear.

As research and technology honing theory further development, and constantly upgrading honing device, the power honing ring technique represents one of the latest technological developments in the direction of honing processing. This process can remove larger allowance, reduced gear noise, heat treatment to reduce the residual stress of the tooth surface, and enhance

tooth surface compressive stress, increase gear life, geometric shape accuracy and surface roughness [6].

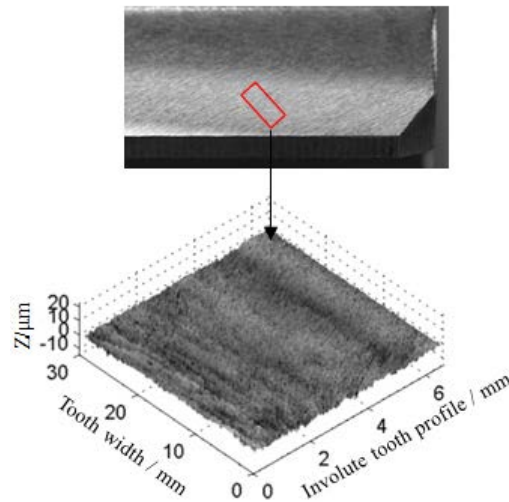


Figure 2 After honing flank macroscopic and microscopic 3D topography

CNC internal power honing is a special form of honing processing, but also high-quality hardened finishing in a highly efficient processing method. Compared with ordinary internal honing CNC honing inner strength mainly in the following three differences: First, epoxy resin honing wheel is cast by a different proportion of mixed epoxy resins, abrasives, fillers, hardeners and thinners made . The presence of tooth accuracy is poor, large deformation, uneven distribution of grain, short life, cut a small amount of honing, deburring commonly used to improve the tooth surface roughness and reduced gear noise. CBN honing wheel is on a steel substrate by plating, physical vapor deposition, chemical vapor deposition and the like deposited on the surface of the honing wheel higher hardness, wear resistance and better CBN particles, can effectively solve the problems of the polyester honing wheel, and changed the honing processing results from the nature. That CBN honing wheel cutting mechanism of CBN particles are honing the cutting forces are strong squeeze honing surface and at a relative speed of sliding action, combined with the irregular shape of the CBN grains along the contact line scratch the workpiece tooth surface metal layer, fine cut chips. Second, after adding "electronic gear" function numerical control systems, it is in accordance with programmable gear honing wheel with the movement of the gear shaft coupling ratio with high accuracy. If the honing wheel as a guide shaft, linear or nonlinear coupled via a fixed gear ratio, or by a characteristic form, in order to achieve honing axle with the gear shaft link. Under the control of the electronic gear, the honing wheel and is made according to a certain ratio relationship forced engagement space, including the main rotating motion gear honing wheel and axial reciprocation effect, within the honing machining to complete the work gear. So with ordinary honing NC honing forced into by the free honing, machining accuracy improved significantly. In addition, CNC honing machine installation Precision diamond standard dressing wheel, when the honing wheel machining time, lose their precision, in the synchronous control of an electronic gear honing wheel Dressing, honing wheel accuracy and performance will be further guaranteed. ensure part accuracy consistently. The third is to change the honing process. For example, in the field of processing gear transmission, automotive gear transmission noise and lower manufacturing costs also rising, the traditional hobbing / Shaper - shaving - Heat Treatment - Light tooth honing process exist some limitations. If hardened tooth grinding, and then finally honing method, manufacturing costs are too high. The honing process is CNC heavy hobbing / Shaper - heat treatment - CNC

power honing. It shortens the processing technology for high-quality gear is provided a hardened high-performance processing technologies, but also to overcome the small ordinary honing allowance tooth surface, not completely improved gear tooth geometry, tooth surface modification can not be shape, precision and quality depends entirely on the quality of the processing of the previous step, you cannot control the accuracy of the tooth surface in the desired range.

Methods to Improve the Precision of Honing Gear

In addition to the common by increasing the precision honing machine, honing optimize cutting parameters to improve the work gear before honing methods to improve the accuracy of CNC machining strength inside honing precision, but also can improve the ring strength honing precision cut four ways.

Precision honing wheel is one of the determinants power honing machining accuracy of the key factors. In the round honing tool design, as shown in Table 1-3, the general should ensure that the tool and the workpiece modulus, pitch, pressure angle, base section equal in order to correct the error by honing gear wheel. Toothed honing wheel pitch and pitch limit cumulative error, and tooth profile angle error will be directly reflected in the work gear, thus improving the accuracy of the honing wheel, will effectively improve the ring strength honing machining accuracy.

Table 1 In the precision honing wheel

Precision Gear	Honing tooth shape within tolerance	Within the honing wheel base pitch deviation
8	0.006	± 0.006
7	0.005	± 0.005
6	0.004	± 0.004

Within honing wheel is divided into "A" and "B" two specified accuracy and precision of the movement of the ring gear precision reference holes.

Table 2 In the honing ring gear teeth test items and tolerance

Nominal pitch diameter d/mm	Test items	Normal module/ m_n	Tolerance value/ μm	
			A	B
180 or 240	Ring runout F_t	1-3.5	71	90
		3.5-6	90	112
		6-8	100	125
	Common normal length change F_w	1-8	50	71

Table 3 Reference holes precision, the support surface runout tolerance

Within the honing wheel accuracy class	Reference hole tolerance/ μm	Supporting surface runout tolerance/ μm
A	30	7
B	46	10

Honing wheel Dressing principle is a work gear geometric parameters exactly the same, manufacturing precision gear higher than standard diamond honing wheel dressing wheel mounted gear honing machine the workpiece position and meshing with the internal teeth honing wheel. Modification of the honing wheel is also an effective means to improve the strength honing accuracy [8]. On the one hand, the error is determined by the work gear hobbing, gear

shaping and heat deformation caused by the error, the error is varied. Practice shows that only one standard toothed honing wheel, is not able to adapt to a variety of profile error correction needs. Thus, the honing wheel should accordingly be made various modifications tooth, in order to meet a variety of different tooth error correction. Thus, the honing process will be more proactive, flexible, and effectively improve the precision honing. On the other hand, numerical strength within the honing process, when the workpiece to a certain number, in the honing wheel wear, sociable cut difficult to ensure accuracy, the need for honing wheel dressing. Within the honing wheel Dressing tools generally work gear tooth profile substantially the same size and the diamond wheel. At the time of modification, since the diamond dressing wheel tooth surface hardness greater than honing the tooth surface hardness, according to Fanqie principle, to achieve the modification honing wheel. In this process, the present generation should make the work gear tooth error, are reflected in the honing wheel, so that the corresponding parts of the round honing modification, it is no longer the standard tooth involute. When used after the modification and then machining the workpiece gear wheel honing process reference system is not changed, the work gear tooth error can be compensated effectively improve the precision honing cut.

Honing cutting speed is determined by the honing wheel and workpiece are honing meshing relative sliding velocity points (Figure 4). The meshing point C honing cutting speed v_C decomposed along the tooth profile v_H speed and velocity along the tooth v_L synthesis.

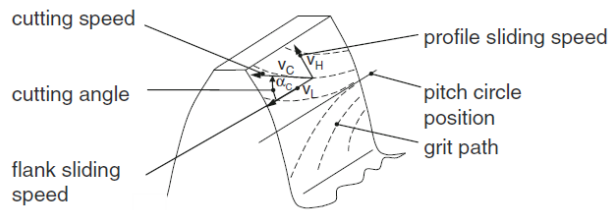


Figure 4 Honing cutting velocity analysis

$$v_H = 2\pi(\rho_W n_W - \rho_{HR} n_{HR}) \quad (1)$$

Formula 1 for the work gear teeth ρ_W to the radius of curvature of the workpiece speed n_W , honing wheel ρ_{HR} is the radius of curvature of the tooth, n_{HR} is honing wheel speed

$$v_L = 2\pi n_W r_W \frac{\sin \Sigma}{\cos \beta_W} = 2\pi n_{HR} r_{HR} \frac{\sin \Sigma}{\cos \beta_W} \quad (2)$$

Formula 2 r_W is the radius of the work gear, helix angle is honing wheel β_{HR} , honing wheel is the radius r_{HR} of the workpiece helix angle β_W .

$$v_C = \sqrt{v_L^2 - v_H^2} \quad (3)$$

From Formula 3, by increasing the velocity v_L teeth, tooth profile to reduce speed v_H , increase cutting speed honing not only increase productivity, but more importantly, after the

tooth profile v_H speed decreases, honing wheel tooth profile along the direction of sliding wear uniform, precision honing wheel is not easy to reduce, not easy to be honing the workpiece tooth distortion, honing wheel life expectancy, sociable cutting performance improved greatly enhanced gear error correction capabilities.

Increasing the degree of coincidence

Has the effect of increasing the degree of coincidence base section and profile error correction is mandatory honing gear is essential to improve the precision honing. Internal power honing is the use of electronic gear box function forced honing wheel and the workpiece according to a precise GEARING Machining and than the inner achieved through proper base section precision honing wheel to fix a gear base pitch error [8]. When honing the ring, the number of teeth z_2 between the inner honing α_{at2} , addendum circle α_{t2} end face pressure angle λ_{h2} , face pitch circle pressure angle z_1 , and round wire mesh line α_{at1} inside honing wheel angle. α_{t1} honing was among the gear λ_{h1} , the end face addendum circle pressure angle, face pitch circle pressure angle, the engagement line and the angle between the gear honing. The degree of coincidence is calculated as follows:

$$\varepsilon = \frac{1}{2\pi} \left[\frac{z_1 (tg \alpha_{at1} - tg \alpha_{t1})}{\sin^2 \lambda_{h1}} - \frac{z_2 (tg \alpha_{at2} - tg \alpha_{t2})}{\sin^2 \lambda_{h2}} \right] \quad (4)$$

Wherein, honing wheel and the workpiece end face addendum circle pressure angle:

$$\alpha_{ati} = \cos^{-1} \frac{z_i \cos \alpha_{ti}}{z_i - 2 \cos \beta_i} \quad (i=1, 2)$$

Under any conditions, $tg \alpha_{at2} - tg \alpha_{t2} < 0$. By the Formula 4, when the workpiece gear z_1 is determined, if the workpiece and honing wheel the tooth tip circle end face pressure angle and face pressure angle constant pitch circle, this time to reduce the number of teeth z_2 in the honing, can increase the degree of overlap in honing process, the number of teeth simultaneously engaging online more contact form and interfere with each other constraints. Therefore, increasing the degree of inner strength honing coincidence that the increase in online engagement simultaneous contact points, while the more points engagement force base section and the work gear tooth profile error correction effect is more obvious.

Conclusion

Hardened precision gear finishing process is to achieve efficient production technology of high-quality gear maximum capacity and minimum transmission noise. The results showed that the high-precision gear production, the strong honing machining process has obvious advantages. In comparison with other methods hardened gear finishing, honing having a uniform processing quality, high efficiency, small impact surface processing zones, noise quality improved significantly and economic characteristics. Generating forms of forced engagement between the

NC system electronic gear function can be controlled CBN honing honing wheel and the work gear is linked to the development, to achieve the traditional honing process for independent fundamental improvement in the finishing process, and therefore engaging within strong honing technique It represents one of the latest technological developments in the direction of honing processing. Honing process, by improving the precision honing wheel, honing wheel reasonable modification to improve the honing cutting speed, increasing the degree of coincidence four ways to achieve high-precision machining hardened gear. The quality of honing wheel honing accuracy, correct pitch errors has important influence on the increase. Honing wheel Dressing puzzle cracks, which can effectively solve the "concave" and "dig roots" error defect. But the development of domestic high-precision honing machine, the ring gear mechanism and technological research strength sociable, cutting efficiency, intelligent honing, high-precision, long life and other aspects of research and honing wheel further studies are needed in order to promote a strong internal honing process the development of technology.

Acknowledgements

Project: This article won the National Natural Science Foundation of China (No: 51575154); State Ethnic Affairs Commission science research project (14BFZ009); Ningxia universities science project (No: NGY20140146); 2016 Beifang University of Nationalities of foreign Experts bring wisdom project" based on precision honing wheel surface coating phase field model microstructure research;High-end CNC machine tools and basic manufacturing equipment technology major projects (No: 2012ZX04001021).

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