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Application of Computer Aided Process Design in CNC Machining of Spiral Bevel Gears

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Abstract

Use of computer aided process planning in CNC machining of spiral bevel gear, not only can improve overall parts manufacturing level, but also can greatly improve the quality of the products, by the driving bevel gear, planning process of driven bevel gear and the assembly process, understanding calculation computer aided process design can improve the work efficiency, accelerate the market response speed, shorten technical preparation cycle. At the same time, promote the standardization of the construction process, improve the process design. Optimizing design process, promote technological progress. Will bring greater social and economic benefits.

Keywords*: Computer aided process design; spiral bevel gear; CNC machine tool; machining process; simulation*

1. Introduction

With the continuous development of industry, output of spiral bevel gear production also in rapid growth. In gear transmission, especially in the axis of intersection of mechanical transmission, straight bevel gear is applied widely. Because of the straight bevel gear spiral bevel gear is easy to design and processing, the tooth line in mechanical transmission also does not produce axial force. However, in the process of mechanical transmission, in terms of motion stability and bearing capacity. Straight bevel gear is not spiral bevel gear. Spiral bevel gear has high strength, able to work more steadily, suitable for relatively large gear deceleration, tooth wear uniform, improve the contact area, can improve the tooth face roughness and a significant reduction in noise. So in the car almost universal use of spiral bevel gear. To this end, we propose spiral bevel gear design and processing theory parameters and simulation research is very necessary. Computer aided process design, in the spiral bevel gear NC machining plays very important role, to improve the product quality.

2.Design Requirements of the Active Bevel Gear and its Processing Technology

2.1.The Design Requirements of the Spiral Bevel Gear Drive Gear Are Shown in Figure 1.

The spatial staggered axis drives the spiral motion of the relative motion, and the spiral axis rotates around the axis of the gear to form a double curved surface.

To burr and sharp edge.

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Heat treatment: carburizing and quenching.

Surface hardness: 59HRC above, the effective depth of hardening layer: tooth root, DC 550 H1V 1.0-2.0; DC 550 H1V 1.6-2.2;core hardness 30-40HRC; metallographic test, the residual austenite is not greater than A0.8, M-6.5. by shot before grinding tooth: shot treatment pill for cast steel shot or shot. The average particle size is ø 0.8, the hardness by 550-650HV according to YB/T5149., the rest of the shot intensity above 0.6, coverage of more than 300%, parts of the surface after shot at 0.05-0.10, hardness is 750HV, then, according to the backlash, contact and noise matching gear, after lapping. After matching, on the surface with a pencil cut out the assembly sequence matching gear, according to the contact in the test machine, adjust the backlash and noise, the difference from the actual assembly and theory. From the actual assembly is larger than the distance theory assembly is positive, otherwise negative. At the same time in the table Face to make the company mark, series.

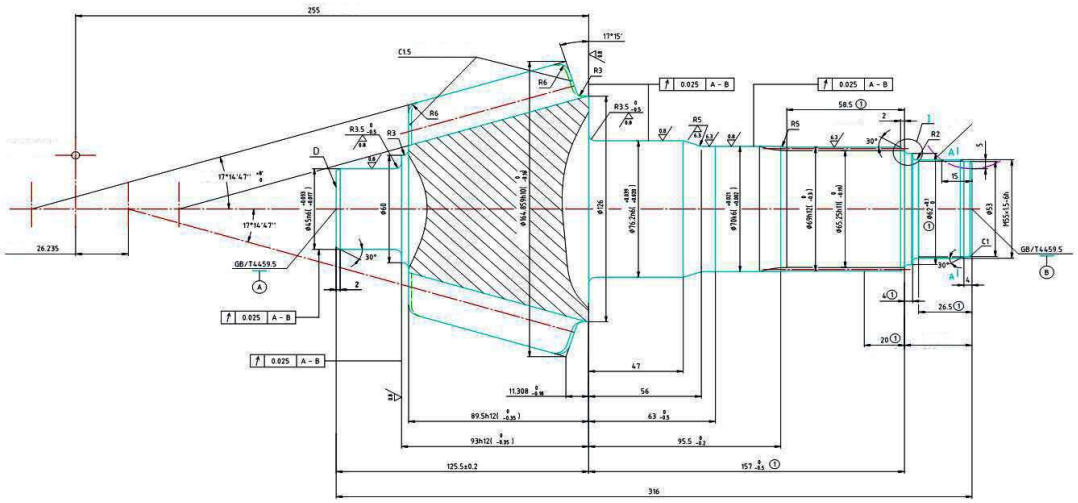

Figure 1. Active Bevel Gear Parts

2.2. Active Bevel Gear Design Parameters

With the development of computer technology, electronic form software, database in accelerating development, for spiral bevel and hypoid gear, quasi hypoid gear tedious data computing and intelligent use, providing great convenience. The use of modern computer spreadsheet software can be quasi hyperboloid gear form customization, rapid processing of complex data, very convenient, high-efficient data analysis and calculation.

Table 1. Design Parameters of Active Bevel Gears

Offset of hyperbolic gear	30
Tooth number	9
Midpoint normal modulus	9.649
Tooth top height	14.252
whole depth	21.71

Average pressure angle	22°30'
Spiral angle	40°36'
Spiral direction	Left
Diameter of cutter head	320
Tooth side gap	0.3-0.4
The tooth gap variable of the same pair of gears is not larger than the one.	0.08
Tooth surface accuracy	8(GB/T 11365)
Tooth surface roughness	
Tooth number of paired gears	Z=37

2.3. Machining Process of Drive Bevel Gear

Table 2. Machining Process of Drive Bevel Gear

									Part drawing change mark				Part number	2402036DA6A						
	Gear workshop			Process engineering					Advice note	SZ2006-009										
									Sign				Part name	Drive bevel gear						
Route	Calcine-Gear- Heat up-Gear-Heat up	Assembly unit	Gear	Part materia	FAS3226H	Types of embryo	Calcine	Rough hardne	Rough hardness	165-185HB	Net weigh	13.6KG		Motorcycle	SR130498	Each car number	1			
No.	Process name		Plan No	Equipment	Equipment Name				Clamping	s	n	v	coolant liquid	T test	burthen%	Remarks				
1	end milling,hit center		D6-001	E2U696	end milling,hit center machine				D33-20213	Milling150	350	154		2						
										Hit75	860	17								
2	Rough、Fine vehicle end face outer circle		D6-006	CK7820B	CNC lathe				D31-14288	0.3		150	Emulsified liquid	7						
3	Rough、Fine vehicle conical surface、excircle		D6-010	CK7820B	CNC lathe				D31-14287	0.3		150	Emulsified liquid	7						
4	Milling flutes		D6-011	X6132A	Horizontal milling machine				D3314105	100	150	38		1.5						
5	Milling spline		D6-013	YB6212	Universal spline machine				D33-20165	1.6	200	47	32#Total system loss	13						
			D6-014	YB6212	Universal spline machine				D33-20165	1.6	200	47	32#Total system loss	13						
6	Mowaiyuan		D6-018	MK1632	CNC angular approach cylindrical grinding machine				DC-50	0.005	120	50		4.5						
7	Liquid extrusion screw thread		D6-021	ZA28-20	Liquid filament machine				D32-20070	0.1	16	8	32#Total system loss	1.2						
8J	Intermediate survey																			
9	Gear milling		D6-030	C60	CNC bevel gear milling machine				D33-20156	0.03-0.15			32#Total system loss	20						
10	Longitudinal correction		D6-043		Bevel gear chamfering machine				D33-14191	12sec/gear		55-85		1.2						
11	Clean		D6-153	ZQ2106	Cleaning machine						50	13		1.3						
12J	Intermediate survey		D6-111	600HTT	CNC bevel gear testing machine				D33-20157											
13	Heat treatment			Y9250																
14	Longitudinal correction		D6-044	YMDV-50	Bevel gear chamfering machine				D33-20282	3sec/gear	50	50		2.5						
15	Fine grinding outer circle、end face		D6-048	MK1632	CNC angular approach cylindrical grinding machine				DC-50	0.003	120	50	Soda water	1.8						
16	Fine grinding outer circle 、end face		D6-051	MK1632	CNC angular approach cylindrical grinding machine				DC-50	0.003	120	50	Soda water	1.8						
17	Correct thread								36-14488					3						
18J	Final inspection																			

3.Design Requirements of the Driven Bevel Gears and its Processing Technology

3.1. The Design Requirements of the Driven Bevel Gears are shown in Figure

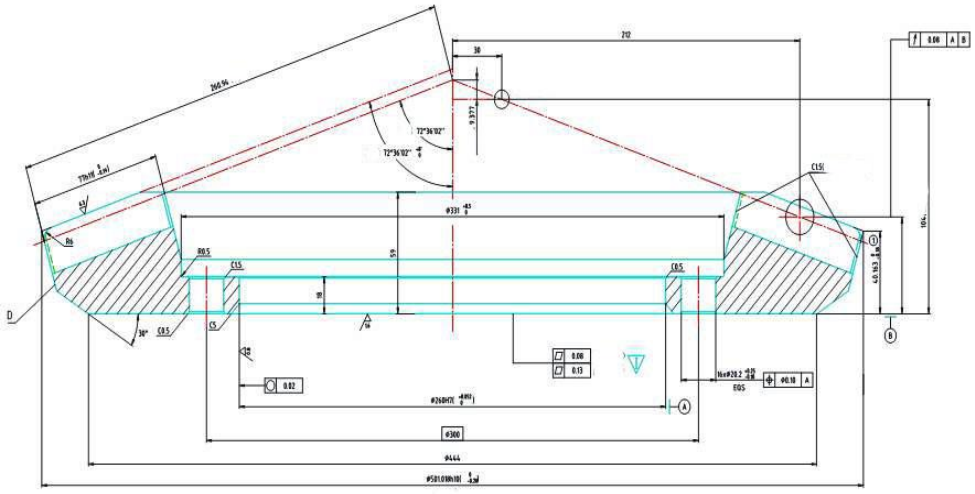

Figure 2. Driven Bevel Gear Parts

Heat treatment: carburizing and quenching, surface hardness: 59HRC above, the effective depth of hardening layer, tooth root: DC 550 H1V 1.0-2.0; the pitch circle, DC 550 H1V 1.6-2.2; 30-40HRC core hardness; metallographic test, the residual austenite is not greater than A0.8, M-6.5. by Shot: grinding teeth root shot treatment pill for cast steel shot or shot, average particle size isø0.8, the hardness by 550-650HV according to YB/T5149. the rest of the shot intensity above 0.6, coverage of more than 300%, parts of the surface after shot at 0.05-0.10, hardness is 750HV, then, according to the tooth gap, the contact pattern and noise matching gear, after lapping after pairing. On the surface, with a pencil cut out assembly serial mating gear, according to the contact in the test machine, adjust the backlash and noise, the difference from the actual assembly and theory. From the actual assembly is larger than the distance theory assembly is positive, reverse As a negative value, and at the same time to make the company's mark on the surface, the series.

3.2. The Design Parameters of Driven Bevel Gears

The use of computer software, driven bevel gear form customization, rapid processing of complex and cumbersome data, very convenient and fast data analysis and calculation.

Table 3. Design Parameters of Driven Bevel Gears

Offset of hyperbolic gear	30
Tooth number	37
Midpoint normal modulus	9.649
Pitch circle diameter	498
Tooth top height	5.046

Tooth full height	21.71
Average pressure angle	22°30'
Spiral angle	32°45'22"
Spiral angle	Right
Diameter of cutter head	320
Tooth side gap	0.3-0.4
The tooth gap variable of the same pair of gears is not larger than the one	0.08
Gear precision grade	8(GB/T11365)
Tooth surface roughness	
Tooth number of paired gears	Z=9

3.3.Machining Process Of Driven Bevel Gear

Table 4. Machining Process of Driven Bevel Gear

					Part drawing change mark				Part number	2402036DA6A			
					Advice note	SZ2006-009							
Gear workshop		Process engineering			Sign				Part name	Driven bevel gear			
							Net weight						
Route	Calcine-Gear- Heat up-Gear-Heat up Assembly unit	Gear	Part material	FAS3225H Types of embryo Calcine Rough hardne	ough hardness	165-185HB		38.89KG		Motorcycl	SR130498	Each car number	1
No.	Process name	Plan No	Equipment	Equipment Name	Clamping	s	n	v	Coolant liquid	T test	Burthen%	Remarks	
1	Face cutting、Bore、 Chamfering	D6-054	CK516A	Vertical CNC lathe	516AA1001T	0.35			Emulsified liquid	7.5			
		D6-359	LZ-KH/QB-KHB	Cantilever crane									
2	Surface cone、Back cone、Eendocone	D6-059	CK516A	Vertical CNC lathe	516AA1004T	0.35			Emulsified liquid	7.5			
		D6-361	LZ-KH/QB-KHB	Cantilever crane									
3	Drill hole、Chamfering	D6-065	ZK7640	Digital controlled drill	D32-20185	0.16	400		Emulsified liquid	10			
		D6-328	DHK40	Digital controlled drill	DH-805-20001	0.16	400		Emulsified liquid	10			
		D6-212	Z3025	Drilling machine with pivoted arm	D32-150024	0.16	400		Emulsified liquid	10			
4J	Intermediate survey												
5	Gear milling	D6-042	C60	CNC bevel gear milling machine	WH145910A	0.05	75		32#Total system lo	20			
		D6-376	0.25T	Cantilever crane									
6	Longitudinal correction	D6-093	Y9250	Bevel gear chamfering machine	D33-14395	2sec/gear	50			2.5			
7	Clean	D6-045	ZQ2107	Cleaning machine						2			
8J	Intermediate survey	D6-111	600HTT	CNC bevel gear testing machine	D33-20157								
9	Heat treatment												
10	End relief	D6-093	YMDV-50	Bevel gear chamfering machine	J02-2037	2sec/gear	50			3.5			
11	Grinding hole	D6-095	MR60-GH	Vertical numerical control inner hole end surface g	D31-20123	0.004	60		Emulsified liquid	4.5			
		D6-290	0.25T	Cantilever crane									
12J	Final inspection												

4. Technical Specification for Matching Between 4 Bevel Gears and Driven Bevel Gears

Computer aided process design provides a platform for information analysis of NC machining. Parts database contains all the parts processing process knowledge of the process, and lays the foundation for numerical control (CNC) machining. Because CNC system can determine the parts required for processing all kinds of information. Therefore, computer aided process planning is in NC machining of parts is one of the most important a part of the, can directly affect the quality of the product.

Also in the NC machining, machining process is an important link between the contact part and product processing, and the traditional process does not apply to the requirements of modern machining. To determine the above parts processing all kinds of information, select a processing method, right click on the processing method of button, can automatically generate processes, can also choose to process list. Computer aided process planning (CAPP) is the

intermediate link of CAD and CAM, can generate technology document is processing procedures.

Table 5. Technical Regulation of Driven Bevel Gear and Driven Bevel Gear

					Part drawing change mark				Part number	2402036DA6A		
Gear Workshop		Process Engineering			Advice note	SZ2006-009						
					Sign				Part name	Driven bevel ge		
oute	gear assembly unit assembl Part material	Types of embryc	calcine	Rough hardness	lotorcycle type	SR130498	Each car number		1			
No.	Process name	Plan No.	Equipment	Equipment Name	Clamping	s	n	v	Coolant liquid	T test	Burthen%	Remarks
1	Pair、Burring	D6-100	YBX9550	Bevel gear testing machine	D33-20158		740			8		
2	Grind	D6-101	600HTL	CNC gear grinding machine	D33-20159		1200		Imported grinding	10		
3	Clean	D6-109	ZQ2105	Cleaning machine					HX-Mundificant	25		
4	Bonderizing											
5	Measuring installation distance、Noise measuren	D6-110	600HTT	Bevel gear testing machine	D33-20160		1200			8		
6	Marking	D6-330	JWL-2000B	Marking machine	M0414912-J8					3.5		
7	Final inspection	D6-110	600HTT	Bevel gear testing machine								

5. Computer Aided Process Design in the Process of Application

Computer aided process design of CAPP, with CAD, CAPP, CAM cell technology has become increasingly mature, and because the proposal and development of CIMS and IMS, prompting CAPP to the intelligent, integrated and practical direction. CAPP in modern manufacturing industry, has important theoretical significance and wide practical needs because. The application of CAPP system can not only improve the process design efficiency and quality, shorten the preparation period of technology, for the majority of technical staff from the tedious, repetitive labor provides a feasible way to process can put more in process testing and process research, but also can be standardized to ensure consistency of the process. Design, is conducive to promote standardization of technology. More important is the process of BOM data is to guide enterprises in the procurement of materials, production scheduling, production organization, resource balance, cost accounting and other important Basis, the application of CAPP system will lay a solid foundation for the integration of enterprise data information. Will CAPP Technology Application in the NC machining, can greatly improve the design and manufacture level of enterprise. On machined surface quality produced direct effect on. CAPP technology can guarantee the standardization of process design and standard. With the wide application of computer technology in modern enterprise, to computer as the carrier of aided process design has been by the theory gradually to practice. Application of computer aided process planning in NC machining: the application of NC machining of computer aided process planning, will greatly enhance the quality of process documents.

Application of CAPP system for process design, can:

1.To improve the efficiency of process design, speed up the market response speed and shorten the technical preparation period.

2.To improve the quality of process design, reduce the cost of product maintenance. 3.To help process engineers from the tedious, repetitive low levels of labor liberation, there is more energy into the process of testing, process research, optimize the process design, and promote technological progress.

4.To promote the standardization of the construction process, improve the design of the process of scientific, accurate and standardized.

5.For the enterprise management information system in real time to provide the correct process data, for the enterprise information construction to improve the source information. 6.To promote the reform and development of computer related process technology.

6. Spiral Bevel Gear Simulation

Before NC machining, through repeated simulation processing in the software can not only detect process parameters setting, tool, work piece deformation and an overload situation. Moreover, but also the use of CNC machining simulation, geometric parameters on the processing and mechanical properties make analysis and evaluation, in order to improve the numerical control cutting conditions, improve the processing quality.

6.1. Forming Process Driven Bevel Gear

In CATIA software or UG software, based on the adjustment of the parameters, the establishment of the machine tool coordinate system, the driven bevel gear coordinate system, the cutter wheel coordinate system. According to the adjustment parameters, complete the modeling.

6.2. Optimize the Surface Processing Technology, Determine the Reasonable Parameters

Repeated parameter setting, the simulation of CNC machining, select the optimal parameters, determine the best plan. Spiral bevel gear simulation processing as shown in Figure 3:

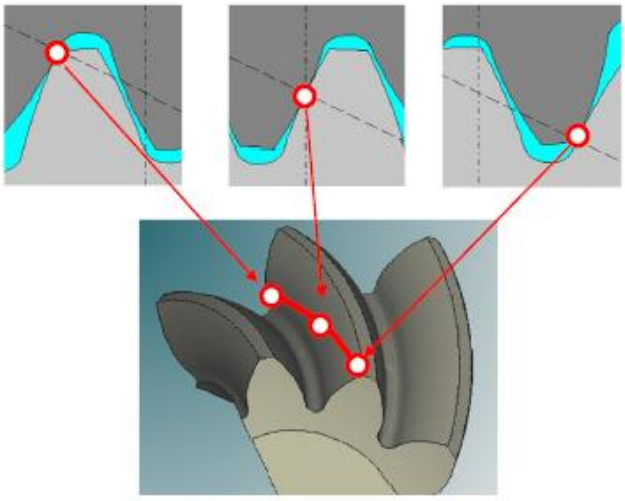

Figure 3. Design of Active Spiral Bevel Gears

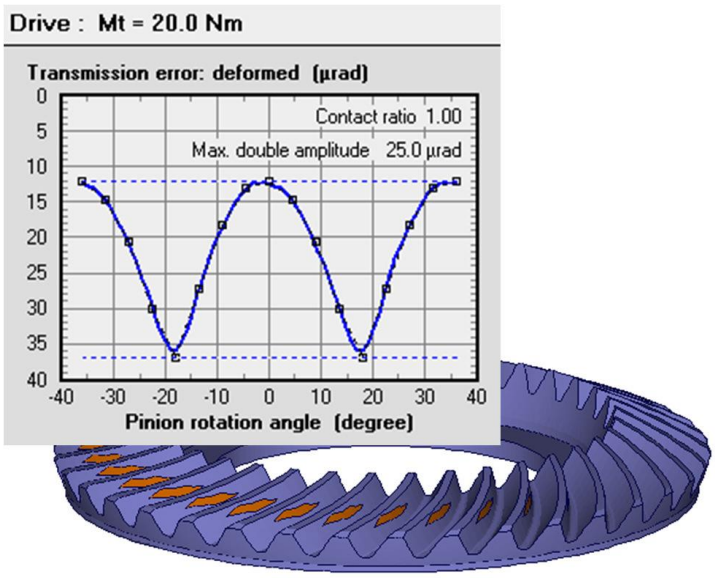

Figure 4. Design of Driven Spiral Bevel Gears

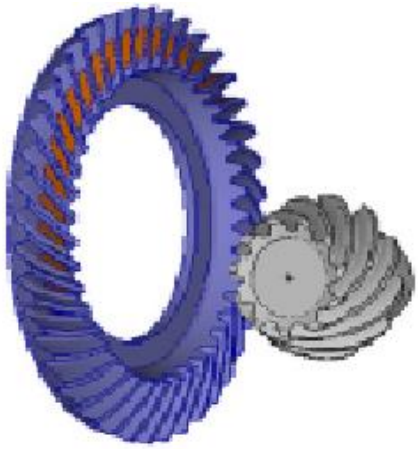

Figure 5. Simulation of Spiral Bevel Gears

7. Concluding Remarks

Through the active bevel gear, planning process of driven bevel gear and the assembly process, using computer aided process planning in NC machining of parts can not only improve overall parts manufacturing level, but also can greatly improve the quality of the products, so that the processing craft and the quality of the products guarantee.

In addition, the computer aided process design can improve the efficiency of process design, speed up the market response speed and shorten the technical preparation period. Promote the process standardization construction, improve the level of process design and optimize the process design, and promote technological progress. As long as the appropriate adjustment and modification according to different tool specifications and materials, can be

applied in the field of numerical control processing, will bring greater social and economic benefits.

References

[1] X. Y. Lu, "J. Research on Machining Theory of Spiral Bevel Gear NC Machine Tool",Scientific Publishers American, **(2002)**.
[2] W. Zhang, T. Wang, H. He and H. Deng, "J. Network Improvement Scheme of Numerical Control Simulation System", Machine Tool and Hydraulic Pressure, vol. 10, **(2006)**, pp. 165~166,199.
[3] K. Wang and J. Feng, "J . High Efficiency Machining Technology for Large Forgings", Journal of Harbin University of Science and Technology, vol. 2, **(2013)**, pp. 65-67.
[4] Y. Cheng, L. Liu, J. Qian, Y. Gong and H. Shi, "J . Automotive Panel Die Machining Technology of Hardened Steel", Journal of Harbin University of Science and Technolog, vol. 2, **(2013)**, pp. 13-15.
[5] F. L. Litvin and A. Fuentes, "Gear geometry and applied theory, Cambridge University Press", Cambridge, **(2004)**.
[6] Z. Wei and W. Taiyong, "A Virtual System Solution of CNC Machine for Spiral Bbevel and Hypoid Gears", Transaction of Tianjin University, vol. 12, no. 5, **(2006)**, pp. 373~377.
[7] W. Zhang, "J. The Theory and Simulation of NC Machining of The Quasi Hyperbolic Gear", TianJin University, **(2007)**.
[8] J. He, "Application of computer aided process design in The Mold NC", J. Educational Technology and Equipment in China, **(2012,06)**.
[9] J. Chen, "Application of Computer Aided Process Design Technology in Numerical Control Mold Processing", J.Coal Mining Machinery, **(2013,10)**
[10] L. Song, "The Development of CAD/CAPP/CAM Integrated System Based on 2D Graphics", Hunan University, **(2009,04)**.

