ISBN: 978-1-948012-06-5

Contents List available at VOLKSON PRESS

World Symposium on Mechanical and Control Engineering (WSMCE)

ANALYSIS OF SPINDLE MOTOR OPTIONS FOR DESKTOP FIVE - AXIS ENGRAVING AND MILLING MACHINE TOOL

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ARTICLE DETAILS

Article History:

Received 02 october 2017
Accepted 06 october 2017
Available online 11 november 2017

Keywords

Profile Spindle motor, Five-axis engraving machine, Design ideas

ABSTRACT

Due to the continuous innovation of manufacturing technology, the appearance of five-axis linkage engraving machine has changed the traditional engraving industry. However, there is an issue of selectivity in designing the spindle motor of engraving machine. The design ideas are roughly divided into two types: The first one is to select the spindle motor according to the designer's experience to check, and the second is to select the spindle motor according to the calculation method of the design parameter formula. Through comparative analysis of excellent design ideas, will increase the design speed of industrial design.

1. Introduction

Design parameters given by the subject, with reference to the general three-dimensional advertising mechanical engraving machine spindle motor design parameters to determine the five-axis engraving machine design tasks, as shown in Table 1.

Table 1: Five axis engraving machine design task book

project	parameter	unit
Spindle speed	n=24000	r/min
The maximum feed rate	$v_f = 2000$	mm/min

1.1 SPINDLE MOTOR PRESELECTION

In the high-precision machining centers and high-speed machining centers are usually used as a spindle spindle drive [1]. In general, the spindle speed is less than 3000r / min, usually the spindle coupling connected to the asynchronous motor, the machine can change the motor pole number to change the motor speed; spindle speed is less than 8000r / min situation, the spindle Connect the motor with the coupling and then adjust the motor speed with the inverter [2]. If the spindle speed is more than 8000r / min, the motor and the spindle can be manufactured as a whole. The spindle is installed inside the motor, and the spindle becomes the rotor shaft. As the engraving machine speed requirements to reach 24000r / min so choose the spindle drive.

At this time, we consult the relevant information shows that the preselection of Jiangyin Jiangjin Motor Co., Ltd. pre-production model for the JGD-85 / 1.5 spindle, the spindle has been equipped with the tool no longer need to design tool holder, ER16 chuck can Tool diameter d is 1-10mm [3]. Details are shown in Table 2 below. Selection of Design Parameters for Female-Male Rotor.

Table 2: Spindle parameters

Model	The maximum speed (r/min)	Motor Table 2parameters				Dimensions					Chuck models	cooling method	Weight (KG)
		Power (kW)	Voltage (V)	Frequency (HZ)	Current (A)	D	D1	L	L1	L2			
JGD-85/1.5	24000	1.5	220	400	4.2	85	76	214	7	26	ER16	Water-cooled	7.5

2. CUTTING (DRILLING) CUTTING FORCE, CUT (DRILL) CUTTING TORQUE AND CUT (DRILL) CUT POWER CHECK CALCULATION

The subject of processing is the main target of wood (the main object) and aluminum, low carbon steel and other materials processing. Under normal circumstances, five-axis CNC engraving machine is processed under the condition of no cutting fluid. After consulting the information, we should know that the carbide milling cutter should be used. The machining material used in this subject is carbon structural steel $\sigma_b = 650MP_a$, d_0 = 10mm hard Alloy end mills, high-speed steel straight shank twist drills with z = 3 and = 6 mm. In the processing of materials milling, drilling force analysis, to calculate the engraving machine cutting (drilling) cutting force, cutting (drilling) cutting torque and cutting (drilling) cutting power (due to metal and non-metallic materials have Characteristics, under normal circumstances, if the processing of metal materials can be processed non-metallic materials, so we choose the carbon structural steel $\sigma_b = 650MP_a$ processing calculation).

As the processing characteristics of the five-axis engraving machine are different from the cutting (drilling) cutting modes in the machining process, the distribution in the processing time is differentiated. The cutting modes can be divided into four types: high speed fast feed cutting (cutting), medium The speed of feed cutting (engraving), high-speed slow feed cutting (engraved) and the proportion of rapid feeding should also be different.

3. MILLING FORCE, TORQUE AND POWER CALCULATION

Reference Wang Xianfan editor of the "machining process manual" second edition of the second chapter, get the milling force of Table 3, milling torque, milling power calculation formula, the resulting data into the formula, you get the engraving machine-related calculation formula Fill in the results of Table 3.

Table 3: Milling force, torque and power of the simplified formula

Calculate the name	Calculation formula	Calculation results
Milling force	$F_c = \frac{C_F a_p^{x_F} a_f^{y_F} a_w^{u_F} Z}{d_o^{q_F} n^{w_f}} k_{F_c}$	$F_C = 158 a_p V_f^{0.75} n^{-0.62}$
Milling torque	$M = \frac{F_c d_0}{2\times10^3}$	$M = \frac{F_C \times 10}{2\times10^3} = 5\times10^{-3} F_C$
Milling power	$P_m = \frac{F_c v}{6\times10^4}$ (	$P_m = \frac{F_C \times 3.14\times10\times n}{6\times10^7} = 5.23\times10^{-7} F_C n$

Among them: Torque M , circumferential milling force F_c, milling force correction parameters when milling conditions change K_{F_c} , the milling width a_w is usually 70% ~ 80% of the diameter, where 75%, milling power p_m , milling depth a_p , feed rate $V_f = a_f zn = fn$ and milling speed $v = \pi d_0 n/1000$, Diameter $d_o = 10$, feed per tooth a_f , cutter tooth number $Z = 3$, cutter speed n .

Check "Machining Handbook Volume II" Chapter II Table 2.1-78 relevant parameters of the selected tool $C_F = 116$ ’ $x_F = 1$ ’ $y_F = 0.75$ ’ $u_F = 0.85$ ’ $q_F = 0.73$ ’ $W_F = -0.13$ ’ $k_C = 1$(45 steel processing) were related data were substituted into the calculation, the results of the calculation table As shown in Table 4 below.

Table 4: Milling force, torque and power calculation results

Cutting way	Percentage of working time t %	Parameters			Calculation results			
		a_p	v_f	n	$n_{丝}$	F_c	M	P_m
Milling	10%	2.5	100	9000	20	44.15	0.221	0.209
Carving	30%	1	600	18000	120	44.06	0.22	0.415
engraved	50%	0.5	1200	24000	240	30.99	0.155	0.389
Fast feed	10%	—	2000	—	400	0	0	0

4. Drilling force, torque and power calculation

By referring to the second edition of "Machining Handbook of Process Technology" edited by Wang Xiangyuan, the data is substituted into the formula to obtain the related calculation formula as shown in the following Table 5.

Table 5: Calculation of drilling force, torque and power

Calculate the name	Calculation formula	Calculation results
Drilling force	$F = C_F d_0^{Z_F} f^{y_F} K_F$	$F = 600\times6^1\times1\times(v_f/n)^{0.7} = 3600(v_f/n)^{0.7}$
Drilling torque	$M = C_M d_0^{Z_M} f^{y_M} K_M$	$M = 0.305\times6^2\times1\times(v_{f/n})^{0.8}$ $= 10.98({}^{v_f}\!/_{n})^{0.8}$
Drilling power	$P_m = \frac{Mv}{30 d_0}$	$P_M = \frac{M\times3.14\times6\times n}{30\times6\times1000} = 0.0001Mn$ （kw）

In addition, drilling axial force F , force correction parameters when machining conditions chang K_F , drilling torque M , drilling force correction parameters when drilling conditions change K_M, drilling power P_m, feedrate $v_f = fn$, drilling speed $v = \pi d_0 n/1000$, drill diameter $d_0 = 6$, drilling feed Volume f , drilling speed n .

Check the "Machining Handbook Volume II" Chapter III Table 3.4-10 selected with the twist drill bit calculation related parameters $C_F = 600$, $z_F = 1$, $y_F = 0.7$, $C_M = 0.305$, $z_M = 2.0$ ’ $y_M = 0.8$ ’ $k_F = k_M = 1$(processing 45 steel) will check the calculation results will be filled in the table 6.

Table 6: Calculation of drilling force, torque and power

Drilling way	Percentage of working time	Parameters		Calculation results			
		v_f	n	$n_{丝}$	F	M	P_m
Strong drilling	10%	200	9000	40	250.64	0.522	0.4698
Ordinary drilling	30%	360	18000	72	232.82	0.48	0.864
Fine drilling	50%	500	24000	105	239.57	0.496	1.19
Fast feed	10%	2000	—	400	0	0	0

5. CALCULATION OF SPINDLE MOTOR VERIFICATION

As already know the required maximum torque and power, in accordance with safety considerations to a certain degree of safety factor, ignoring the transmission efficiency, spindle calculation results shown in Table 7.

Table 7: Spindle motor calculation results

Serial number	Calculation items	symbol	unit	Calculation formula	Comparing results

1	Motor torque calculation	M_0	Nm	$M_0 \geq iMAX\{M_i\}$ Check Table 4 and Table 6, take i = 2 to get the larger value ：M0≥0.522	Selected motor rated torque $M_e \geq 1$ Meet the requirements
2	Motor power calculation	P_0	kW	$P_0 \geq MAX\{P_i\}$ Look up Table 4 and Table 6, take big values get rounded ： $P_0 \geq 1.19$	Selected motor rated power $P_e \geq 1.2$ Meet the requirements

6. CONCLUSION

Through the above calculation process and results, we can draw some conclusions in this. The advantage of the first design idea is that the first selection of components can quickly get the parameters of the components, which can be easily corrected in the process of checking and calculating. The difficulty is that the design of the way needs some design experience. The second design road has the advantage of being able to more accurately calculate the range of results, the difficulty is that there is no detailed prerequisite parameters, the calculation process is very cumbersome. Therefore, I think that the first design ideas for the design of the more excellent design ideas.

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