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DESIGN AND ANALYSIS OF TWO DIMENSIONAL CNC LATHE MACHINE TOOL SPINDLE

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Abstract- ***The power utilization capacity of machine tool spindles depends mainly on stiffness at tool point. It is known in machine tools for instance in machining centers the spindle system could alone account for about 30 to 40% of stiffness at cutting point between tool and work piece. Even though there are 2 or more bearings as a pack at each front or rear location even then an approximate or equivalent stiffness is given at front and rear locations. This is because it is not possible to compute shaft deformations supported on more than 2 supports on a shaft it is not represented further each bearing has a number of rolling elements like ball or roller around 15 to 20.It is possible to predict the stiffness of a bearing by computing hertizian contact stresses at each rolling element going through nonlinear procedure In view of above it is necessary to develop a simplified methodology for modeling spindle system with bearings in a machine tool spindles. The methodology should facilitate 3D modeling the bearing in a large machine tool mesh at the same time the methodology should ensure the design of spindle for 2-axis CNC lathe machine. The spindle axis is horizontal in lathe machine.***

Indexed Terms- ***spindle, CNC Lathe, shaft, module, face width.***

1. INTRODUCTION

Computer Numerical Control (CNC) is among the fastest growing fields in manufacturing today. The CNC technology was applied on basic conventional machines like lathes and milling machine. In 2-axis CNC lathe machine the main four portions are as following,

1) Design of spindle assembly
2) Design of carriage and tool post
3) Design of bed-way and
4) Design of axis drive system

In this research paper is how to design of spindle assembly.

2. CNC MACHINE COMPONENTS

The controllable components of CNC machine are feed axis system, feed drive unit, machine work spindle drive unit, spindle chuck unit, tool turret and tool changer, tailstock and CNC control unit as shown in Fig. 1.

Fig. 1.CNC Lathe Machine [4]

3. SPINDLE DRIVE UNIT

Spindle assembly contain shaft, spur gear, bearings and key as shown in Fig. 2.

Fig. 2. Spindle Assembly

The work spindle generates work piece rotation of turning lathe and tool rotation of milling and drilling machines. The spindle can be driven by a three-phase AC or DC motor. In three-phrase AC drives spindle speed selection is obtained through the gearbox.

However, in most case the work spindle of CNC machines are driven by DC motors whose speed is infinitely variable by means of a tach generator. Work holding equipment is provided to secure the work piece to the work table (milling) or the spindle (turning). On turning lathe the jaws generally can be opened and closed by the NC program, and it is possible to set various clamping pressure. Since CNC machines are frequently work with very high speeds and

since chucking pressure cannot be increased at will on account of work piece distortion.

4. FUNCTION OF MACHINE SPINDLE

A spindle may locate and hold the work piece or the outer and rotate the same. A spindle is a shaft which mounted on bearing supported in the machine tool housing. In order to avoid deflection and run out, the spindle have to be well supported in true bearing. Any slackness in the bearings will clearly affect the location of the spindle

5. MANUFACTURING PROCESS OF SPINDLE SHAFT

The spindle shaft is manufactured by pipe system. Stainless steel shaft up to 48 inches in diameter to be used as boiler headers and other high pressure purpose is made by forging and drawing. The hollow forging is then transferred to the draw bench, where it is placed over a mandrel and forced through a die to be reduced and elongated. Except for some size limitation, any casting or metal may be centrifugally cast

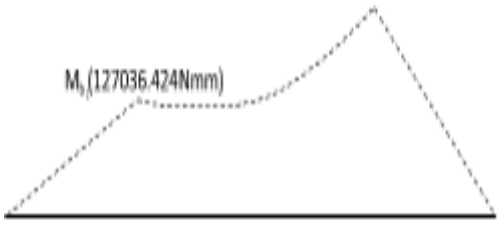

Fig. 3. Result of Shaft Design

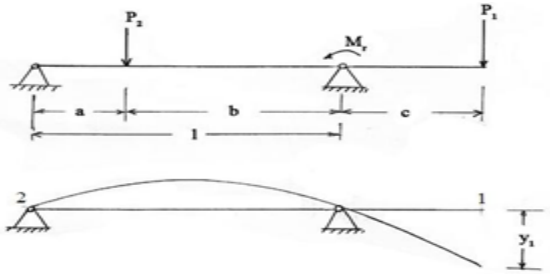

Fig .4. Deflected Axis of the Spindle due to Bending Forces

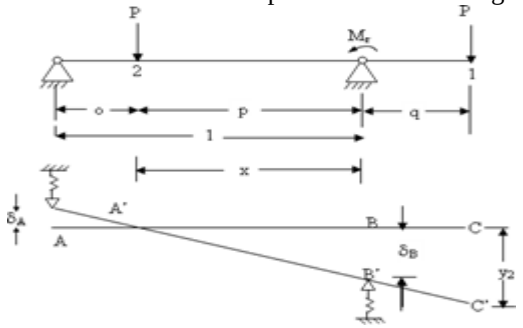

Fig. 5. Deflected axis of the Spindle due to Compliance of the Spindle Support

Table 1.Design Specifications

Item	Data	Portion
Material	Stainless steel	Shaft
Power	5kW 1500rpm	
Speed	11402.126 N	
Cutting force P_z	2985.324N	
Cutting force P_y	5240.35 N	
Cutting force P_x	265.56N	
Chuck weight	3610N	
Workpiece weight		
Material of pinion	Cast iron	Spur
Material of gear	Cast iron	
Speed of pinion	1500 rpm	
Diameter of pinion	155 mm	
Allowable stress	55 MN/m^2	
Power	5kW	
Pressure angle	20 deg,stub	
Velocity ratio	2	
Material	AISI cold-drawn	Key
$T_s=T_c$	steel	
B	$31.833x10^3$Nmm	
t S_y	20mm	
F.S	10mm	
	351.633MPa	
	5	
Left bearing of the shaft	Tapered roller	Bearing
Type of bearing	bearing	
Speed	1500rpm	
Axial load F_a	5240.35 N	
Radial load F_r	1411.516N	
Life	30000hr	
Loading ratio	10.601	
Right bearing of the shaft	Tapered roller	
Type of bearing	bearing	
Radial loadF_r	13265.589N	

Bending force P_1	11436.826N	Deflection
Bending force P_2	437.114N	
Distance, o	90mm	
Distance, p	775mm	
Distance, q	135mm	
Distance, l	865mm	
Reactive moment M_r	$540.390x10^3$Nmm	
Modulus of elasticity E	$206.01x10^3N/mm^2$	
Moment of inertia I	$2.040x10^6mm^4$	
Stiffness, K_A	3000kg/mm	
Stiffness, K_B	4000 kg/mm	

Table 2.Results Data

Item	Data	Portion
Bearing Number	30216	Bearing
Inner diameter	80mm	
Outer diameter	140mm	
Right bearing of the shaft		
Bearing Number	30220	
Inner diameter	100mm	
Outer diameter	180mm	
Module	5 mm	Spur
Face width	63 mm	
Dynamic force	5751.628 N	
Wear force	25512.820N	
Endurance force	7565.505 N	
y_1	0.133mm	Deflection
y_2	o.367mm	
y_t	0.480mm	

6. CONCLUSION

The design of Spindle assembly for CNC lathe machine was fabricated by using Fagor CNC lathe machine. Design of machine plants is concentrated on cutting for aluminium and stainless steel, because only 5kW load and available stepper motor can drive. The dimension of work piece to be operated on designed CNC lathe machine is 200mm in diameter and 1500mm in length. Spindle assembly contains shaft, gear, bearing, key and chuck. All design calculations are dependent on shaft design. Shaft is hollow shaft and made of stainless steel. In spur gear design, pinion and gear are made with cast iron. Taper roller bearings are used in this system and give high rotating accuracy. In Key design, rectangular key is used. Key is made with AISI cold- drawn steel.

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