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Specialized Automated Tool Grinding Machine

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Abstract— This paper is focused on the design of an Automated fixture for Grinding of Single Point cutting Tool (SPCT). This aims to reduce tool grinding time, improve tool geometry, tool life, surface finish of job. The automation is achieved by use of Arduino Micro-controller. Precise angle of orientation and feed is given by the use of stepper motors to actuate a fixture holding the tool .This paper focus on design of a low cost and specialized automatic grinding machine capable of grinding complex geometry of tools for use in small industries , small workshops .

Keywords— Automated, Grinding, Single Point Cutting Tool, Gear Box, Lead Screw, Angles,CNC.

INTRODUCTION

Single Point Cutting Tools (SPCT) are widely used for lathe operations such as turning, facing and tapering of metal. Their cutting action depends upon Shear force exerted by proper cutting tool tip geometry. Optimum cutting tip geometry is essential for resisting cutting forces as well as dissipating frictional heat generated at the work piece tool interface. These tools undergo wear as a result of constant friction and heating at the work piece-tool tip interface. . Currently SPCT (Single Point Cutting Tool) machine tools are available pre-fabricated , with no room for customisation and at a higher cost or are ground by hand Grinding. Manual Grinding has the following draw backs :It is not possible for an operator to consistently reproduce the tool geometry with accuracy leading to variation in surface finish of jobs produced on individual machines i.e. reduced uniformity.The tool grinding performance will vary between operators depending on their experience leading to variation in performance from machine to machine which again reduces uniformity and quality conformance.It requires the operator to stop operations leading to increased downtime and inefficient utilization of time.In order to manage the above mentioned problems a low cost, specialized CNC TGM is the proposed solution. Using a fixture improves the economy of production by allowing smooth operation and quick transition from part to part, reducing the requirement for skilled labor by simplifying how workpieces are mounted, and increasing conformity across a production run. A fixture differs from a jig in that when a fixture is used, the tool must move relative to the workpiece; a jig moves the piece while the tool remains stationary. Automation of Grinding fixtures is possible through the use of actuation mechanism and drives such as stepper motors controlled through programmable micro-controllers. Micro-controllers afford high precision and holding torque which is used to orient the tool to be ground in the correct position and maintain this position against grinding force. This ability of Automated grinding fixtures is invaluable for achieving optimum tool geometry with maximum precision. The program used for actuating the fixture can be specialized for each individual tool so that the same fixture can be used for re-grinding a wide range of tools and complex geometries .

EXPERIMENTAL SETUP

Machine structure is the “backbone” of the machine tool. It integrates all machine components into a complete system. The machine structure is crucial to the performance of the machine tools since it is directly affecting the static and dynamic stiffness, as well as the damping response of the machine tool. A carefully designed structure can provide high stiffness, result in higher operation bandwidth and more precise operation. A small-scale machine tool generally requires even higher stiffness than the ordinary large-scale machine tool since it is usually operated at higher speeds. Lower frame is made up of standard angles of 65*5mm dimensions. Other Upper frame are made up of mild steel as its cost is low and it gives high strength. All frames are made with high precision and with high accuracy. Other components are mounted on this rigid frame of mild steel.

DESCRIPTION OF COMPONENTS

WORM AND WORM GERA BOX- A **worm drive** is a gear arrangement in which a **worm** (which is a gear in the form of a screw) meshes with a **worm gear** (which is similar in appearance to a spur gear). The two elements are also called the **worm screw** and **worm wheel**. This type of gear box are use for low rpm and high torque.

BALL/ LEAD SCREWS- A ball screw is a mechanical linear actuator that translates rotational motion to linear motion with little friction. A threaded shaft provides a helical raceway for ball bearings which act as a precision screw. As well as being able to apply or withstand high thrust loads, they can do so with minimum internal friction.

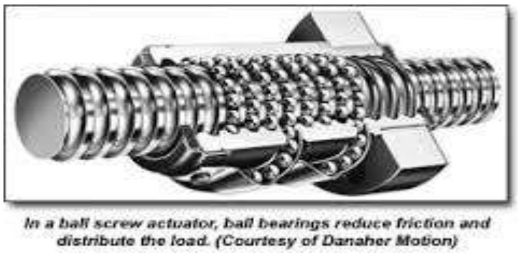

Fig.1., BALL/LEAD SCREW

BALL BEARINGS-A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races.The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads

Fig.2., BALL BEARING

LINEAR RODS- Linear rods are rigid strong Mild Steel shafts which are used to carry the load without affecting the motion and supports linear movement. Linear rods with linear bearing assembly are used to carry the loads and supports the structures in linear motions the total load of the structure is taken away by the linear rod bearing assembly and therefore the load on ball screw is reduced and causes precise smooth linear motion.

Fig.3 LINEAR ROD

LINEAR BALL BEARINGS- A linear bearing is to provide free motion in linear direction. The load is carried away by the linear bearing and reduces friction slides over linear rods. A linear-motion bearing or linear slide is at features smooth motion, low friction, high rigidity and long life. They are economical, and easy to maintain and replace.

SHAFT END SUPPORTS- Shaft supports are used to support linear rods /shafts rigidly without slip. Shaft support blocks are used for end or intermittent support where loads are light and slight shaft deflection is not a concern

SHAFT COUPLINGS- A Shaft Coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power.. The primary purpose of couplings is to join two pieces of rotating equipment N

Fig.4., SHAFT V. COUPLER.

POWER SUPPLY- 24V 10.4AMPS SMPS(Switch Mode Power Supply) adapters are used for stepper motors and for powering micro-controller.

MICROCONTROLLER BOARD –Micro stepper motor driver (RMCS_1102) 18 to 50V,5 Amps board is used as the motion control board. RMCS-1102 is micro-stepping drive designed for smooth and quiet operation is chosen to drive the NEMA 23 stepper motorRMCS-1102 achieves micro-stepping using a synchronous PWM output drive.RMCS-1102 receives PULSE/STEP, DIRECTION inputs from the microcontroller and generates high rated PWM output signals to stepper motor

FIG.5 MICRO CONTROLLER

STEPPER MOTOR- A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation in a number of equal steps .The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller).A NEMA 23 stepper motor is a stepper motor with a 2.3 x 2.3 inch size is chosen to drive the motion of the axes. NEMA 23 stepper motors are high torque about 19KG-Cm holding torque .NEMA 23 stepper motors have 1.8 degree step angle with 2.5A rated current.

BENCH GRINDER-A **bench grinder** is a type of benchtop grinding machine used to drive abrasive wheels. These types of grinders are commonly used to hand grind cutting tools and perform other rough grinding. Depending on the grade of the grinding wheel it may be used for sharpening cutting tools such as lathe tools or drill bits.

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FIG.6 BENCH GRINDER

CALCULATIONS

Worm and Worm Drive-In proposed design, we required to move the shaft at 3 rpm. But Motor Speed is 150 rpm. Therefore for achieving the reduction ratio of 50:1 we are employing a worm drive. Where the input data are as follows,

P = 8 Watt.

N_1 = 150 rpm.

N_2 = 3 rpm.

No. of Teeth on Worm and Gear

As the operation is light duty, from design data bookwe have, service factor = 1.2

[P] = 9.6 Watt.

i = 50

No. of starts $Z_1 \geq \frac{40}{i+1}$

Hence, Z_1 =1 and Z_g= 50

Helix Angle

Let, q = 11

Hence , $\lambda = tan^{-1}(\frac{1}{11}) = 5.19^0$

$\beta_w = 90 - 5.19 = 84.81^0$

$\beta_g = 5.19^0$

Virtual Teeth

$Z_{wv} = \frac{Zw}{(\cos \beta w)^3} = 1350.98$

$Z_{gv} = \frac{Zg}{(\cos \beta g)^3} = 50.62$

Weaker Material

From design data book we have,

For worm : Case hardened steel (C-45)

$\sigma_b = 135\ N/mm^2$ $\sigma_u = 630\ N/mm^2$ $\sigma_c = 149\ N/mm^2$

For wheel : Bronze steel (Chilled)

$\sigma_b = 110\ N/mm^2$ $\sigma_u = 390\ N/mm^2$ $\sigma_c = 149\ N/mm^2$

Worm gear are always 20^0 Full Depth Involute.

$y_{wv} = 0.154 - \frac{o.912}{1350.98} = 0.1533$

$y_{wv} = 0.154 - \frac{o.912}{50.62} = 0.13598$

Hence, $\sigma_{bw*} y_{wv} = 20.695$

$\sigma_{bg} * y_{gv} = 18.36$

Therefore, Gear is weaker.

Module Determination

From design data book we have,

$a = (\frac{50}{11} + 1)*((\frac{540*11}{50*1490})^2 * 305.6)^{\frac{1}{3}}$

a = 6.92 cm = 0.692 mm

But, $a = 0.5 * m_x * (q + Z_g)$

Hence, $m_x = 0.227$ cm = 2.27 mm

Selecting standard module from PSG, hence $m_x = 3$ mm.

CACULATION OF LEAD SCREW TORQUE

Nominal Diameter-20 mm

Mean Diameter- 19 mm

Core Diameter- 18 mm

Pitch- 5 mm

Assuming coefficient of friction between nut and screw-

μ=0.15

α=$\tan^{-1} 0.15$

α=8.58

Helix Angle-β

$\tan\beta = p/\pi *$ Mean Dia.

B=$\tan^{-1} 5/\ \pi * 19$

B=4.788

α > β ,hence it is SELF-LOCKING.

Weight Of Fixture- 60Kg~589N

Reaction Force- F= μR

Assuming coefficient of friction between Ball bearing and linear rod-

μ=0.15

F=0.15*589

=88.35N

Total weight to be push by lead screw-

=Weight of fixture + back pressure

Assuming back pressure=100N

Total weight=100+88.35

=188.35N

Torque required

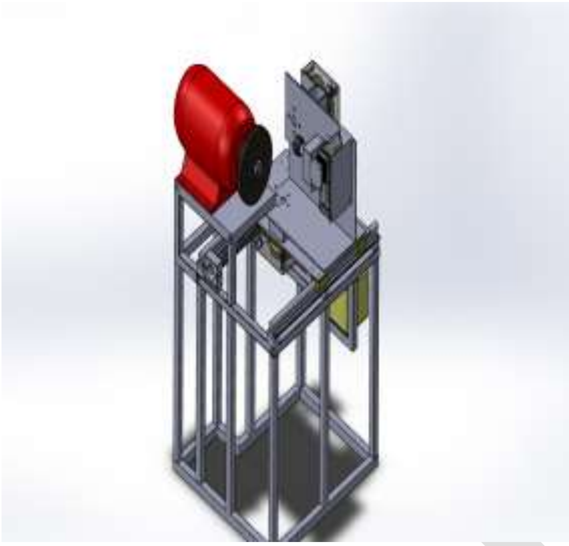
$$W * \frac{Dm}{2} * \tan(\beta + \alpha)$$

$$T = 188.35 * \frac{0.019}{2} * \tan(4.78 + 8.58)$$

$T = 0.42Nm$~0.5Nm

Selecting Stepper Motor of 1Nm torque

ACTUALDESIGN



OBSERVATION TABLE

DESCRIPTION (ANGLES)	IDEAL ANGLES	AUTOMATED ANGLES
Side Rake	**15º**	**14.8º**
End Cutting Edge	**5º**	**5.1º**
End Relief	**5º**	**4.8º**
Back Rake	**0º**	**0.1º**
Side Relief	**5-6º**	**5º**
Nose Radius	**0.5-3mm**	**1.5mm**

CONCLUSION:

With the increasing demand for small scale high precision parts in various industries, the market for small scale machine tools has grown substantially. Using small machine tools to fabricate small scale parts can provide both flexibility and efficiency in manufacturing approaches and reduce capital cost, which is beneficial for small business owners. In this thesis, a small scale three axis CNC milling machine is designed and analyzed under very limited budget. X

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