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Design and Development of Spindle and Fixture Unit of Vertical Notch Milling Machine

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***Abstract*— This paper deals with designing of fixture and spindle unit of vertical notch milling machine. Connecting rod is key piece of engine. It ought to be precisely machined with the obliged resilience. A connecting rod may also convert rotating motion into reciprocating motion, its original use. Earlier mechanisms, such as the chain, could only impart pulling motion being rigid; a connecting rod may transmit either push or pull, allowing the rod to rotate the crank through both halves of a revolution. In a few two-stroke engines the connecting rod is only required to push.Connecting rods from the link between the crankshaft and the pistons and transfer the gas and inertial forces to the crankpins on the crankshaft. The connecting rod pushes and pulls the piston into and out of the cylinder.At the same time, it has been watched that in the majority of the cases the process duration needed for machining (milling) the connecting rod was an excess of furthermore with the lower resilience precision in exhausting operation because of traditional installation. The radius and depth required are 15mm and 1.40mm respectively. The aim of this project is to design and development for discrete component of special purpose machine.**

Keywords*— *Connecting rod, Spindle, Fixture Unit

I. INTRODUCTION

The Special Purpose Machines (SPM) have crucial role in manufacturing industries to enhance the productivity. In most of the operations are performed differently for each end of side of connecting rod i.e. for small end and big end. Earlier work has been done by considering two distinct processes for two different ends. The special purpose machine tools could be classified as those in which jobs remain fixed in one position and those in which job moves from one station to other. Rotary intermittently motion transfer machine is very popular production machine. Such a machine comprises a turret on whole periphery several heads are mounted to receive and locate the components for working. The turret rotates intermittently about its central axis which is provided with fine and sophisticated mechanisms to control its motion so that before stopping it is properly decelerated and desired positioning accuracy is attained at stationary positions around the usually mounted on a table are the several tools and unit which perform the machining operation. It is essential that all movements be completely synchronized in order to obtain desired product it is essential that all tools and units must have completed their operation. In this dissertation work an attempt is made to combine operations to enhance the productivity.

In this special purpose machine milling of two connecting rod will takes place simultaneously. This will save time and as well as increase the productivity. The special purpose machines (spm) and automatic machines are designed to operate continuously for 24 hours a day, with minimum supervision. Sometimes it may be possible to cater to the jobs having similar features but differing in dimensions by using change tooling concept. These special purpose machines (spm) are either cam operated machine or they use hydraulics & pneumatics as actuating elements or combination of all the three of them. Many times a dedicated programmable logic controller is used in conjunction with positional sensors & transducers, to give commands to the actuating elements sometimes different special motors like stepper motor & servo motors are used.

II. FIXTURE UNIT

Fixture Unit mainly consist of 05 parts such fixture resting bracket, component clamp plate, spacer for swing cylinder, component locator. [1]. These all parts are assembled in such a manner that the connecting rod is fixed at particular position and it does not move when the notch milling operation is carried out.

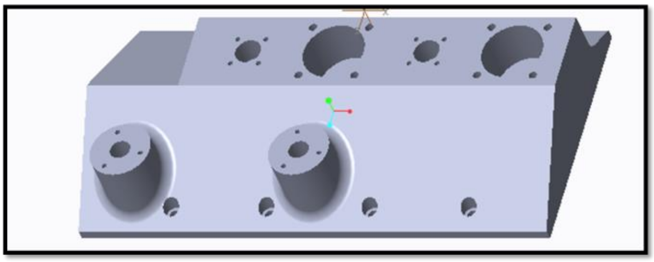

Fig No.1 Fixture Resting Bracket

Fixture resting bracket
It is made up of cast iron (FG 260) and it is fabricated one. This bracket fit in between fixture plate and fabricated base.

III. POWER CALCULATIONS

In machine tools, a spindle is rotating axis of the machine, which often has a shaft at its heart. The shaft itself is called a spindle, but also, in shop floor practice, the word often is used metonymically to refer to the entire rotary unit, including not only shaft itself, but its bearings are also attached to it. A machine tool may have several spindles, such as the headstock and tailstock spindles. The main spindle is usually biggest one.[2]

As Per work material and tool available the cutting velocity of toll will be 150 to 210 $\frac{m}{minute}$ taken from CMTI catalogue.

Now Selection of the motor:-

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Cutting speed (V) = $\frac{3.14DN}{1000}\frac{m}{minute}$

Let, V = 180 $\frac{m}{minute}$ and put this value in above equation

$$N = \frac{140 * 1000}{3.14 * 30}$$

N = 1486.199 rpm.

Now this value is compared in the catalogue table, the value from catalogue will be 1500 rpm.

Cutting Speed (V) = (3.14*D*N)/1000
= 3.14*30*400/1000
= 37.68 $^{m}/_{minute}$

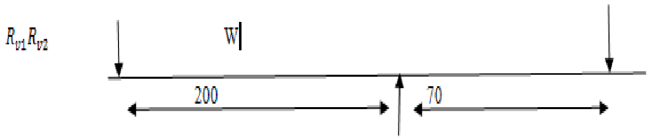
Metal Removal Rate (Q) = b*t*s_m/1000
= 104*4.476*60/1000
= 0.3998 $\frac{cm^3}{mim}$

Power at Spindle (N) = U$K_h K_t$Q
= 69*10^{-3}*1.2*0.93*0.399
=2 Kw.

Power of Motor = 5 HP.

A: Calculations of Bending Moments

Radial load is exerted by pulley and there is no any axial load is exerted because of absence of gear mechanism in operation. These radial is transferred on bearing through spindle. Thus, it is suitable to select bearing such that it carry radial load. Hence selecting single row taper roller bearing. For selecting bearing following forces are taken,



Now balance the vertical forces

$$-R_{v1} + R_{v2} - W = 0$$

Calculate bending moment about A,

$$R_{v2} * 200 + W * 270 = 0$$

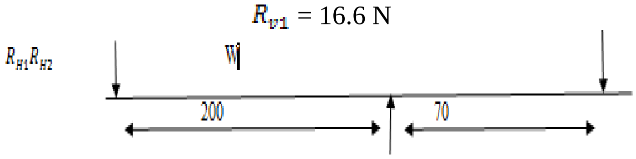
$$R_{v2} * 200 = -47.43 * 270$$

R_{v2} = 64.03 N

Put the value of R_{v2} = 64.03 in above equation we get,

$$-R_{v1} + 64.03 - 47.43 = 0$$

R_{v1} = 16.6 N



Now balance the vertical forces

$$R_{h1} + R_{h2} - T = 0$$

Calculate bending moment about at A

$-R_{h2}$*200 + T*270 = 0
$-R_{h2}$*200 = - 557.44 *270
R_{h2}* = 752.544 N

Now put the value of R_{h2} in above equation to get the value of R_{h1} ,

$$R_{h1} + 752.544 - 278.52 = 0$$
$$R_{h1} = -474.024$$

B: Calculations of Torsional Moments [8]

$$M_t = \frac{60 * 10^6 * Kw}{2 * 3.14 * N}$$
$$M_t = \frac{60 * 10^6 * 3.7}{2 * 3.14 * 400}$$
= 88375.796 N-mm

C: Design of shaft on Strength basis

The spindle shaft is designed by considering axial, bending and torsional load. When the shaft is subjected to an axial load in addition to torsion and bending loads, then the stress due to axial load must be added to the bending stress. Shaft is made of ductile material; hence here Maximum shear stress theory is applied for design of shaft.[6]

Kb = Combined shock and fatigue factor applied to bending moment
Kt = Combined shock and fatigue factor applied to torsional moment
di = Inner diameter of shaft
do = Outer diameter of shaft
C = Ratio of inside diameter to outside diameter
τ_{max}= Maximum permissible shear stress
F.S. = Factor of safety

Shaft is made up of SAE 8620 material having ultimate tensile strength is 660 N/mm^2 and yield tensile strength is 385 N/mm^2.

$$\tau_{max} = \frac{0.5\, S_{yt}}{FS} = 64.16 \text{ N}/mm^2$$

Pulley is keyed on the shaft hence, τ_{max} = 0.75 × 64.16 = 48.12 N/mm^2.

Assume $C = \frac{d_i}{d_o}$ = 0.6

According to ASME code shaft design, the bending and Torsional moments should be multiplied by factors Kb and Kt respectively, to consider for shock and fatigue in shaft during operating condition. Hence, maximum shear stress (τ_{max}) [8] is,

$$\tau_{max} = \frac{16}{3.14 d_o{}^3(1-C)^4}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$
$$d_o{}^3 = \frac{16}{3.14\tau_{max}(1-C)^4}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$
$$= \frac{16}{3.14*1-0.6^4}\sqrt{(2*42340.8)^2 + (1.5*88375.796)^2}$$
= 27.81 mm

But, $\frac{d_i}{d_o}$ = 0.6

d_i= 30*0.6 = 18 mm

This is the inner diameter of shaft in which adapter of drill fits in it, so for suitable standard diameter of adapter select next standard inner diameter = 40 mm

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$$d_o = 40/0.6 = 66 \text{ mm}$$

Select standard diameter, considering inner diameter of bearing which fits on the shaft.

$$d_o = 70 \text{ mm}$$

Another side end where another bearing is going to fit, that side diameter is 60 mm. this value chosen such that it is less than that of 70 mm and where another bearing is going to fit.

D: Bearing Selection

1] Approach distance (A)

$$A = \sqrt{d(D-d)}$$

$$A = \sqrt{30(58-30)}$$

$$A = 28.98 \text{ mm}$$

2] Machining time (T_m) = $\frac{L+A}{f_r}$

Where, L = Feed length in mm.

f_r = Feed rate (mm/minute)

$$T_m = \frac{6+28.98}{60}$$

= 35 sec.

Slide rapid movement = 8 seconds.

Total cycle time is 86 seconds and for one part it will take 43 seconds.

IV. RESULT

Analysis of spindle :-

The spindle is analyzed by using ANSYS software. In static analysis the effect of steady loading on a structure is considered while inertia and damping effects, such as those caused by time varying loads are ignored. Static analysis can include steady inertia loads such as gravity and rotational velocity and time varying loads can be approximated as equivalent to static load. The static analysis is used to determine the, von Mises stresses by applying various forces in structures or components. The spindle 3D model is imported in ANSYS from PTC Creo. Standard bearings with required inner and outer diameter and having dynamic and static load carrying capacity as per designed calculation are selected and mounted at specified location on the spindle. Material of the shaft is SAE 8620. According to distortion energy theory the ductile solid material yields when the von Mises stress exceed the yield value exceeds the yield stress value of the materials. The von Mises stress is less than the yield strength; hence design of spindle is on safer side.

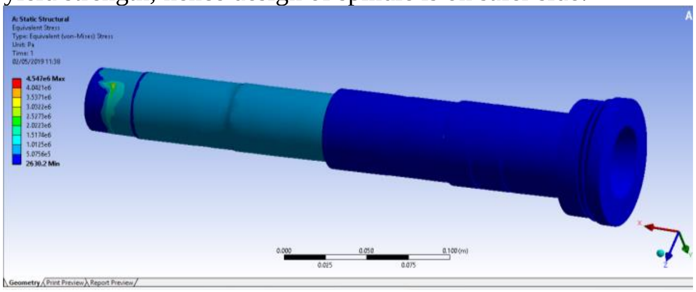

Fig No.2 Analysis of the shaft

CONCLUSION

In current research work, design and analysis of spindle for special purpose notch milling machine was carried out which is used for notch milling of connecting rod. The obtained value of von Mises stress is less than yield tensile strength of the spindle material. Time required for single job is 43 seconds so productivity gets increases and cycle time will also get reduced.

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