Design and Development of Slide and Spindle Unit of Rotary Boring Machine

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Abstract— **This paper deals with designing of slide and spindle unit of rotary boring machine. Components used for this project are shown in the report. 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. Additionally the varieties of measurements in work -piece to work piece ought to be low so it will be simpler to amass in engine. At the same time, it has been watched that in the majority of the cases the process duration needed for machining (boring) the connecting rod was an excess of furthermore with the lower resilience precision in exhausting operation because of traditional installation. The diameters required of the smaller end and the bigger end of the said connecting rod is 43±0.010mm and 71±0.1mm respectively. The aim of this project is to design and development of a slide and spindle unit for machining (Boring).**

Keywords*— *Connecting rod, Spindle, Slide 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. In this dissertation work an attempt is made to combine operations to enhance the productivity. In this special purpose machine two work pieces will bored simultaneously. This will save time and as well as increase the productivity. The spindle shaft used in this machine is critical part so static and modal analysis of spindle shaft will be done to know stress distribution.

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 (Transfer machine). 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 and be withdrawn clear of the turret before it starts to index similarly the turret index precisely and come to rest before tools and units begin their work.

II. SLIDE UNIT

Slide Unit mainly consists of 5 parts such as bed, bedways, keeper plate, wedge plate, slide. These all parts are assembled in such a way that spindle operation will perform in smooth manner.

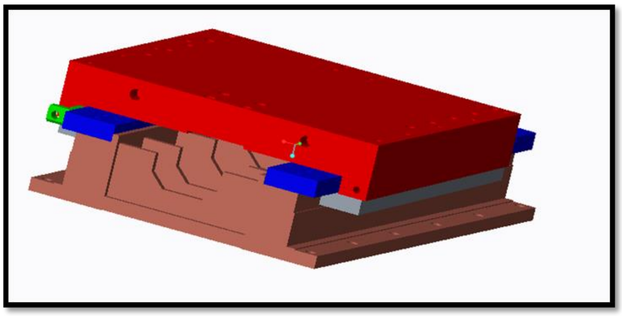

Fig No.1 CAD model of Slide Unit

A. Vertical Bed

It is made up of mild steel and it is fabricated one. Parallel plates are arranged to provide strength to the vertical bed. These plates are going to weld to vertical bed.

B. Bedways

It is made up of O.H.N.S. (Oi Hardened Non Shrinkage Steel) material and 06 pieces of bedways are used. Dowel pins are also going to be used in order to fix them. O. H. N.S. steel is general purpose tool steel that is typically used in applications where alloy steels cannot provide sufficient strength and hardness.

C. Keeper Plate

It restricts the slide movement in upward direction because it locks with the slide with the help of nut and bolt arrangement. There is an arrangement of slot at the top which helps in oil circulation and due to which lubrication will takes place.

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D. Wedge Plate

If slide and bed fits with no gap means having no clearance, then there is a problem of wear. Due to this slide unit will not perform its operation smoothly. So there is a need of change in slide which is costly. In order to avoid that replacement wedge plate is kept at one side. That means in future if wear happens then replacement of wedge plate will takes place only.

E. Slide

It is the sliding member, it is made up of cast iron. There is layer of Terside material is pasted with help of an alredite. This is a kind of material which does not wear out rapidly.

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 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. The main spindle is usually biggest one. Some machine tools that specialize in high volume mass production have a group of 4,6 or even more main spindles.

Cutting Speed (V) = $\frac{3.14Dn}{1000}$

$= \frac{3.14*40*1500}{1000}$

$= 188.49 \frac{m}{minute}$

Metal Removal Rate (Q) = S*t*V

= 0.033*3*188.49

$=18.849 \frac{cm^3}{minute}$

Power at Spindle (N) = UK_hK_fQ

$= 69*10^{-3}1.57*1.13*18.849$

= 3 Kw.

Power of Motor = 12.5 HP.

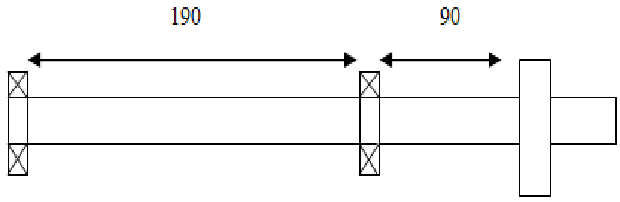
A. Design of Belt and Pulley

Motor is mounted above spindle housing hence distance between spindle shaft and motor shaft is less, so it is preferable to select V belt and V pulley for power transmission. During power transmission, belt tension acts radial load on spindle shaft. So, bending moment due to belt tension should be considered during design of shaft Corresponding values of belt and pulley are calculated as follows,

Sr.No.	Properties	Values
1	Mass of belt	0.1144 Kg/m
2	Velocity of belt	7.22 m/s
3	Centrifugal tension in belt	5.96 N
4	Maximum tension in belt	260 N
5	Tension in tight side	254.04 N
6	Angle of contact of belt over pulley	3.02 rad
7	Tension in slack side	19.48 N

B. Calculation of Bending Moment

The driven pulley is overhang to extent of 90 mm from the nearest bearing center. The layout of shaft and bending moment diagram are shown in figure below.



Therefore, bending moment on the shaft due to the belt tension is calculated below, the total upward force acting at the center line of pulley is given by, For single belt,

$F_1 = T_1 + T_2 = 254.04 + +19.48$ = 273.52 N

=

Two V belts are used so total force = F_1*2 = 273.52*2

= 574.04 N

C. Calculation of Torsional Moment

$$M_t = \frac{60 * 10^6 * Kw}{2 * 3.14 * N}$$

= 78885.49 N–MM

D. 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.

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}) is,

$$\tau_{max} = \frac{16}{3.14 d_o^{\,3}(1-C)^4}\sqrt{(K_bM_b)^2 + (K_tM_t)^2}$$

$$d_o^{\,3} = \frac{16}{3.14\tau_{max}(1-C)^4}\sqrt{(K_bM_b)^2 + (K_tM_t)^2}$$

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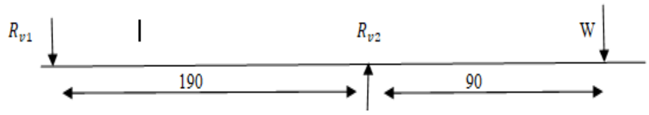
Considering available diameter of adapter which fits into inner diameter of spindle, selection of do = 60 mm, di = 40 mm, d1 = Shaft diameter where pulley fits = 50 mm.

E. Bearing Selection

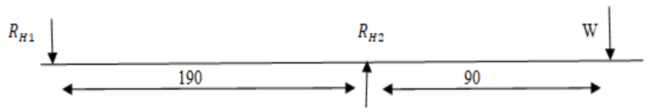
Radial load is exerted by pulley and there is no any axial load is exerted because of absence of gear mechanism in operation. These radial is transferred on bearing through spindle. Thus, it is suitable to select bearing such that it carry radial load. Hence the single row deep groove ball bearing is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

For vertical plane



$R_{v1} = 14.37\ N$, R_{v2} = 44.72 N.

For horizontal plane



$R_{H1} = 271.91\ N$, R_{H2} = 845.95 N.

Bearing life calculation

$$L_{10} = \frac{60nL_{10h}}{10^6}$$

= 4140 million rev.

Dynamic load carrying capacity

$C = P(L_{10})^{\frac{1}{3}}$

C_1 = 2093.041 N and C_2 = 16297.94 N.

So, 61810 and 61812 single row deep groove ball bearing is selected.

Machining time calculations

Machining time (T_m) = $\frac{L}{f_r}$

Where, L = Feed length in mm,

f_r = Feed rate (mm/minute)

$$T_m = \frac{50}{100}$$

= 30 sec.

Slide rapid movement = 8 seconds.

Time require for one part = 38 seconds

Total cycle time is 76 seconds

IV. RESULT

Finite element analysis of the Shaft is carried out in following steps preprocessing, processing, post processing. Three dimensional model of spindle is created by using Solid works 2015 and analysis is done on the ANSYS Workbench 18.2.

Analysis of slide:-

After meshing analysis is done and it is found that the material used for slide having tensile strength is in between the range of values which obtained from the results. Hence design is going to be safe.

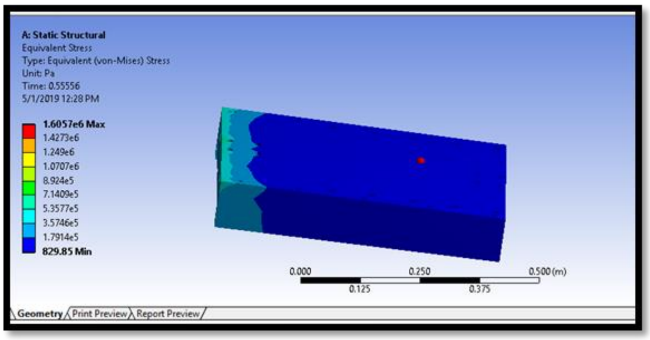


Fig No.3 Analysis of slide

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 [13]. 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 Solid works 2015. 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.

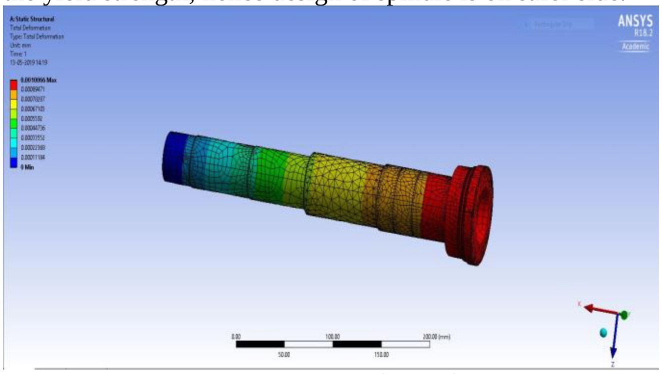


Fig No.2 Analysis of the shaft

CONCLUSION

In current research work, design and analysis of spindle for special purpose rotary boring machine was carried out which is used for boring 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 38 seconds so productivity gets increases and cycle time will also get reduced.

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REFERENCES

[1] A M Badadhe, "Optimization of cutting parameters in boring machine" IOSR Journal of Mechanical and Civil Engineering ISSN (e) 2278-1684.June 2017.

[2] Broke Jaya, "Design and manufacturing of spindle of universal milling head" International journal of applied science and Engineering technology volume 5 February 2017.

[3] "Design and development of boring fixture of connecting rod" International journal of scientific development and research. June2017 Volume 6.

[4] "Central Machine Tool Institute (CMTI), Bangalore Catalogue Page no 638-652.

[5] "Simplified time estimation booklet for basic machining operations" by K.C.Polgar and G.W.Wentworth. June 2000.

[6] "Machine tool spindle design" by Jamie Hoyt Rochester Institute of Technology. May 2000.

[7] "Design and analysis of spindle of a special purpose drilling machine by using Solid works" Journal of Mechanical and Mechanics Engineering, Volume 2 Issue 1, May 2016.

[8] "Design and analysis of machine tool spindle" International journal of engineering trends and technology, Volume 48, November 2017.

[9] Manish Kale, "Design, Fabrication and Analysis of Special Purpose Machine for Drilling and Riveting Operation" ISSN 2321 – 2705 Volume II, Issue VI, June 2015.

[10] "Design of Machine Elements" by V.B.Bhandari, third edition, Mcgraw Hill Education (India) private limited.

[11] "Machine tool spindle design" by Jamie Hoyt Rochester Institute of Technology. May 2000.