Design and Modification of Bench Vice by Increasing the Degrees of Freedom

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Abstract

A Bench vice or fixture is a production tool. The main aim is to locate, support and hold the work securely so we can perform the required machining operations. Feeler or thickness gauges and set blocks are also used to provide reference of the cutter with the work piece. A bench vice must be easily fastened with the machine and the table. As a result, the work can be done. It can be used for the other operations on most of the standard machining tools like drilling machine. Bench Vices are available in different size and shapes ranging from cheap and simple devices to very expensive and complicated devices. Bench Vices can also help to simplify the metalworking operations which are performed on the special equipment. Considering the advantages of fixture and jigs, a fixture was designed to cater to our needs. We are going to design a work holding device which will be able to hold the work piece in any direction. The one-part bottom assembly is free to rotate and other part of bottom assembly fixed to bench. This type of assembly will assist to top assembly which consist jaws. These jaws are likewise pipe vice & conventional bench vice. Lead screw is provided for engagement & disengagement of the jaws.

Keywords- Cutter, Gauges, Metal working operation, Jigs and fixture, Jaws, Lead screw, Industrial applications

I. INTRODUCTION

Increasing the accuracy and productivity are the two basic aims of mass production. As we know the solution to this is by reducing the manual fatigue and also reducing the set up cost of the machine. In this case the device that fulfils our needs is the use of jigs. Let us take one example. Let us consider that one gets an order of say 1000 products. There need to be drilled three holes on this product. In such a case the designer tries to draw out every single hole with the help of square, straightners, scribers and center hole. In order to align the axis of the drill with the axis of the hole we generally go for trial and error method. Accuracy is the main problem in such cases. In doing so accuracy increases the work load on the operator. Hence using of jig to position and guide the tool to its right path is preferred rather than using scribers, square, straightners or center punch etc. Thus, the productivity is increased which is done by eliminating individual marking, positioning and frequent checking. Interchangeability is the chief advantage here. All the parts fit in properly except only the similar components are interchangeable. One does not need to repeatedly unclamp and clamp the object for various purposes like positioning as the locating, guiding and clamping of the tool is done by the jig itself. Bushing is used which is a tool guiding tool. So, it reduces the presence of skilled laborer. Drill jig helps to ream, drill and tap at a much faster speed and with great accuracy as compared to holes done conventionally by hand. The responsibility to maintain the accuracy of the hole is now shifted from the operator and given to the jig. May it be a drill fixture or a drill jig the necessity of a clamping device is inevitable. In case of a drill jig bushings are used. These drill bushings guide the drill bit during the drilling operation. Generally, work piece is held by a fixture and the fixture is arranged in such a way that the loading and unloading of the job is fast. As we all know a fixture is a production tool which is mainly used to hold, locate and support the work piece firmly to the table. Feeler and Set blocks are sometimes used to provide reference of the cutter to the work piece. The main concern is the fastening of the fixture. These fixtures also help in simplifying the network operations which are performed on special equipment.

II. DESIGN

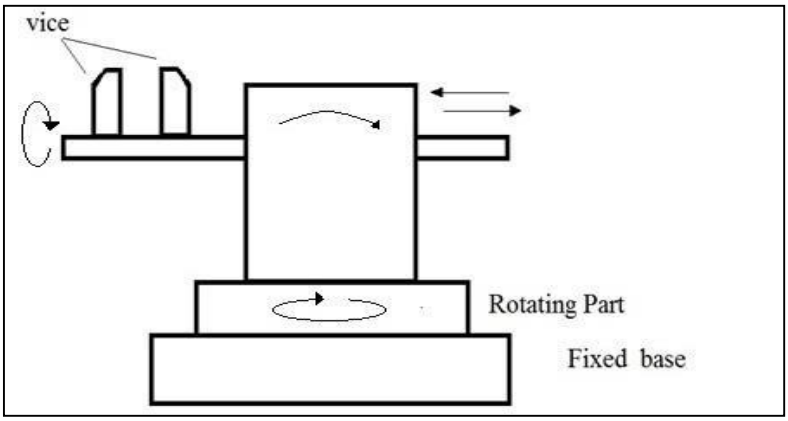

Fig. 1: Block Diagram of Bench Vice

A. Components Used

1) Jaws

Machine vises are mounted on grinding machines, drill presses and milling machines. Abrasive chop saws have a special type of machine vise built in to the saw. Some people use a machine vise as a bench vise because of the low cost and small size.

2) Lead Screw

The screw is the part that is in control of opening and closing the jaws of the vice. A lead screw, also known as a translation screw or power screw, is a screw used as a linkage in a machine, to convert the turning motion into linear motion. Because of the large area of sliding contact between their female and male members, frictional energy losses in the screw thread are more compared to other linkages. They are not typically used to carry high power, but more for intermittent use in low power actuator and positioned mechanisms. Common applications are linear actuators, machine slides (such as in machine tools), vises, presses, and jacks.

3) Handle

Machine vice commonly has a small crank handle which allows the user to get maximum clamping force when working without turning the handle excessively. This is because the crank handle provides extra leverage when rotating, meaning the screw can provide the greater pressure onto the jaws but without any extra effort from the user.

4) Base

Machine vices are mostly manufactured with a flat bottom base design which fits firmly against the machine's table. This allows the vice to fit firmly on the table in horizontal alignment with the drill bit.

5) Swivel Arrangement

Spherical or Rolling pair is required to tilt both jaws in desired angle. Fixed jaw can be tilt without any extra effort because of the swiveling attachment is provided.

6) Locking Pins

Once desired angle is achieved movable jaw is fixed with help of locking Pins.

7) Advantages

1) It can be used for diff angle
2) It provides better grip on work piece
3) It can be reducing manufacturing time
4) It also used for bending operation

8) Disadvantages

1) May be having less rigidity due to many moving parts.

III. MATHEMATICS

Selecting,
SAE 1020 as material of lead screw
Syt = 246 N/mm^2, E= 250 $\times 10^3$N/mm^2

Assume F.O.S = 2, W= 600N
Design of screw spindle
By Rankin formulae

$Syt = \frac{Fcr}{A}[1+\frac{1}{\alpha_n}(\frac{l}{k})^2] = 246\ N/mm^2$

$Fcr = W \times F.O.S = 600 \times 2 = 600 \times 2 = 1200N = 1.2\times 10^3 N$

$k = \frac{dc}{4}$

$246 = \frac{1.2\times10^3}{\frac{\pi}{4}\times dc^2}[1+1\ (300/\frac{dc}{4})^2/\ 10.03 \times 10^3 \times 0.25]$

dc = 7.93mm
Nominal diameter of screw
dc = 0.84 do

$do = \frac{7.93}{0.84}$

do = 9.44 = 10mm
Screw terms

Mean diameter, $dm = do - \frac{P}{2}$

$dm = 24 - \frac{5}{2} = 21.5mm$

Lead = 2P = 10

$\alpha = \tan^{-1}[\frac{lead}{\pi dm}] = \tan^{-1}[\frac{2\times3}{\pi\times21.5}]$

$\alpha = 5.07^0$

$\beta = \tan^{-1}[\frac{\mu}{\sin\beta}] = \tan^{-1}[\frac{0.12}{\sin 90}] = 6.84^0$

Load on screw thread
Torque,

$T = [\frac{W\ dm}{2}]\tan(\alpha + \beta)$

$= [\frac{W \times 21.5}{2}]\tan(5.07+ 6.84)$

$T = 2.267\ W$, N-mm …… (1)

Torque due to applied force by lever

$T = 600 \times 200 = 120000$ N-mm

$T = 120 \times 10^3 Nmm$…… (2)

Put the value of 'T' in equation (1), we get,

$120 \times 10^3 = 2.267W$

$W = \frac{120\times10^3}{2.267} = 52933.39N$

Power required
To engage the load

$T_1 = [\frac{W\ dm}{2}]\tan(\alpha + \beta)$

$= [\frac{52.933\times10^3\times21.5}{2}]\tan(5.07+ 6.84)$

$T_1 = 120017.1049$N-mm
$= 120.017$N-m

Torque require to disengage

$T_2 = \frac{W\ dc\times\mu c}{2} = \frac{52.933\times10^3\times7.93\times0.12}{2} = 25185.52$N-mm

$T_2 = 25.18552$N-m

Total Torque

$T = T_1 + T_2$
$T = 120.017 + 25.18552$
$T = 145.2026$N-m

Power Required
(N= 20 rpm) Assume for human being

$P = \frac{2\pi NT}{60}$

$P = \frac{2\pi\times20\times145.2025}{60}$

P = 304.11KW

Stresses in lead screw

dc= 7.93mm
do= 10mm

$\sigma_{comp} = \frac{W \times 4 \times dc^2}{\pi} = \frac{600 \times 4 \times (7.93)^2}{\pi} = 12.14 N/mm^2$

$\tau = \frac{16T}{\pi dc^3} = \frac{16 \times 1645}{\pi \times (7.93)^3}$

$= 16.800 N/mm^2$

Principal stresses

$\sigma_{max} = \frac{1}{2} (\sigma comp + \sqrt{\sigma comp + 4 \square^2})$

$= \frac{1}{2} (12.14 + \sqrt{12.14 + 4(16.800)^2})$

$\sigma_{max} = 22.96 N/mm^2$

$\tau_{max} = \frac{1}{2} (\sqrt{(\sigma comp)^2 + 4 \square^2}) = 16.89 N/mm^2$

Number of thread in engagement

$P_b = \frac{4W}{\pi(do^2 - dc^2)h}$

$P_b = \frac{4 \times 59.933 \times 10^3}{\pi(do^2 - dc^2)h}$

Take Pb= $15 N/mm^2$

Safe bearing pressure

h= 121.05 = 121×3 = 363 mm

Table 1: Results

SR. No	*Quantity Name*	*Description or Conversion*
1	*Nominal diameter of screw*	*10 mm*
2	*Mean diameter*	*21.5 mm*
3	*Core diameter*	*7.93 mm*

IV. CONCLUSIONS

For the project the required research work has been completed and the validation of project has been proved. Hence it can be said that the aim of the project "Design and modification of bench vice by increasing the degrees of freedom" can be achieved successfully.

ACKNOWLEDGMENT

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