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Design of Fixture for Testing of Spindles

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Abstract

Nowadays, fixtures are used in many manufacturing industries. Fixtures are an essential element of the machining system. In manufacturing industry, fixtures have a direct impact on product manufacturing quality, productivity and cost. Fixtures reduce the operation time and increases productivity and high quality of operation is possible. Various types of fixtures are used for different operation such as milling, drilling etc. The main objective of the project is to design a test fixture on which the spindle is to be mounted. Various parameters of the spindle will be tested such as temperature, vibrations and stability etc.

Keywords— Fixture, Spindle, Design, Manufacturing, Testing.

I. INTRODUCTION

This Fixture is a work-holding or support device used in a manufacturing industry. Fixtures are used to securely locate (position in a specific location or orientation) and support the work, ensuring that all parts produced using the fixture will maintain conformity and interchangeability. Fixtures are mostly designed for a definite operation to process a specific work piece. In order to hold parts in precise manner the parts must be firmly and perfectly fixed to the fixture. To do this a fixture is designed and built to hold and locate the work piece to ensure the work piece is machined within the specified limits.[1]

The design of a fixture is a highly complex and intuitive process, which require knowledge. Proper fixture design is crucial for developing product quality in different terms of accuracy, surface finish and precision of the machined parts. In existing design, the fixture set up is done manually, so the aim of this project is to replace with fixture to save time for loading and unloading of component. Fixture provides the manufacturer for flexibility in holding forces and to optimize design for machine operation as well as process function ability. This holds the Spindle in correct position. Fixture is attached to the bed. fixture consists of the base, clamps, rest blocks or nest, locating points and gauging surfaces. The base of fixture consists of a base plate. A base plate has a flat and accurate under surface and forms main body on which various components are mounted. It may be constructed of steel plate or cast iron, depending upon the size and complexity of the part. The slots are provided in the base for clamping the fixture. The base plate also has keyways along with length of the base for two keys. These keys are used to align the fixture on the bed. The keys are pressed into the keyway at both ends of fixture and held there by socket head caps screw.[2],[3]

Fixtures must correctly locate a work piece in a given orientation with respect to a cutting tool or measuring device. They are normally designed for a definite operation to process a specific work piece and are designed and manufactured individually. Widely used in manufacturing, fixtures have a direct impact upon product quality, productivity and cost. Traditionally, the design and manufacture of a fixture can take several days or even longer to complete when human experience in fixture design is utilized. And a good fixture design is often based on the designer's experience, his understanding of the products, and a try-and-error process. Generally, the costs associated with fixture design and manufacture can account for 10%–20% of the total cost of a manufacturing system. Approximately 40% of rejected parts are due to dimensioning errors that are attributed to poor fixture design.[4]

The methodologies of fixture design are intended to capture the dynamic behaviour of a work piece under moving and dynamic force exerted by manufacturing process. This methodology is split into three distinct phases. Work discretisation, model formation, optimization. In the first phase a computer aided model of the workpiece is formed. And by using the resulting system matrices the model can be expressed by a system of second order ordinary differential equations. There are three steps in the second phase, in the first step both the active and passive elements are considered. In the second step the boundary condition is applied, in the third step, there is generation of force vector. [5]

Machine tool spindle is the most important mechanical component in removing metal during machining operations. The structural dynamics of spindle are evaluated at the tool tip since it directly affects the material removing rate. Spindle is a rotating axis of the machine, which frequently used has a shaft at its heart. The shaft itself is called spindle. Requirements of spindle are spindle should rotate with high degree of accuracy, spindle unit must have high dynamic stiffness and damping, spindle unit must have high stiffness, wear resistance of mating surface should be as high as possible, spindle bearing should be selected in such a way that the initial accuracy of the unit should be maintained during the life of the machine tool.[6],[8]

As of today, the need for rapid production and mass production is increased but the machines offering higher flexibility were not suitable for such production. The gap between the highly specialized and the general purpose can be filled by the rigidness of the machines. Three parameters should be taken into consideration for the design of a fixture, these include geometry, tolerance and dimension. Following steps explain the studies of fixture, 1) Basic requirement of fixture, 2) Phase of fixture design, 3) Flexible mechanical fixtures, 4) Locating and clamping considerations, 5) Fixture design process, 6) Computer aided fixture design. Fixtures implement an impact upon manufacturing quality, productivity and cost. So, the department of computer aided fixture design is a major contributor for the above factors.[7]

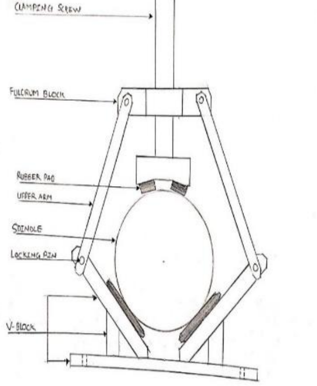

Fig. 1 Initial Idea for Fixture Design

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II. DESCRIPTION

The adjustable fixture for the purpose of testing spindles consists of various components. The major components are Base plate, Base assembly, V-brackets/blocks, clamping screw, Vee block for clamping, Connecting arms, Coolant tank. Other items include Locking pins, screw handle, t-nuts, dampers. Spindle is mounted on the V-brackets and is then clamped from above by the Clamping screw. The base plate is provided with T-slots and the V-brackets can be adjusted depending on the length of the spindle. The locking pin connecting the brackets to the arms can be moved to provided locations to adjust the fixture according to the diameter of the spindle.

III. DESIGN OF COMPONENTS

A. *Design of V-bracket:*

V-bracket design for 460*65*60 mild steel arms at an angle of 45 degrees.
I = 460mm, b = 65mm, d = 60mm.
Consider maximum load on each arm at
Midpoint = 64 Kg
Endpoint = 21.62 Kg
As the arms are inclined at an angle of 45 degrees, therefore, the load changes to;
W(mid) = 52.256*9.81*cos45 = 444.06 ≡ 444 N
W(end) = 21.62*9.81*cos45 = 147.78 ≡ 148 N
Maximum Bending moment
=force*perpendicular distance
= (444*223) + (148*446)
= 165020 N-mm
We know,
$M / I = \sigma b / y$
Where,
M = Bending moment
I = Moment of Inertia about axis of bending i.e. x-x
y = Distance of the layer at which the bending stress is considered.
Now,
$I = (bd^3) / 12$
$= (65*(60)^3) / 12$
I = 1170000 mm4
Now,
$\sigma b = My / I$
$\sigma b = (165020*37.5) / 1170000$
$\sigma b = 5.289$ N/mm2
The allowable shear stress of the material is σ(allowable) = Syt / F.O.S
Where,
Syt = yield stress = 210 MPa = 210 N/mm2
F.O.S = factor of safety = 2
So,
σ(allowable) = 210/2 = 105MPa = 105N/mm2

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By comparing the values, we get,
σb < σ(allowable) i.e. 5.289 < 105 N/mm2
So, design is safe.

B. Base Plate:

Checking the strength of the base plate for safety. The base plate is the intermediate between the upper structure and the base of the structure.
Dimensions of the mild steel base plate are 1000*700*85
l = 1000 mm, b = 700 mm, t = 85 mm
Consider the maximum load on the base plate (Wp)
Wp = 633 kg = 633*10 = 6330 N
We know that,
Strength due to yielding = (Ap*Syt) / F.O.S
Where,
Ap = Area of the Base plate in mm2
Therefore,
Strength due to yielding
= ((700*1000) *210) / 2
= 73.5 MN
Now, to check the strength or for the design to be safe, the load on the base plate should be less than the strength due to yielding.
Therefore,
Wp < Strength due to yielding
i.e. 6330 N < 73.5 MN
So, the base plate is able to support the load
(or) Design is safe.

C. Base Assembly:

Checking the strength of the C-channels against compressive loads.
Four C-channels are placed at the four corners of the base plate. These channels bear the entire load of the structure and the base plate. These vertical C-channels are supported by horizontal C-channels for structural integrity and stability of the base structure.
Now,
Vertical C-channel = 150*75*550
We know,
Compressive St. = Load / Cross-section Area
Total load on the base = Weight of the upper structure + Weight of base plate
W(total) = 633 kg + 550 kg
W(total) = 1183 kg = 1180*10 = 11830 N.
Load on each C-channel = 11830 / 4
Cross-section area of C-channel (150*75) = 2327 mm2
Now,
σc = 11800 / 2327*4
σc = 12.70 N/mm2
For C-channel to be safe under compressive load σc should be less than the allowable compressive stress.

σ(allowable) = Syc / F.O.S

= 250 / 2

σ(allowable) = 125 MPa = 125N/mm2

So, by comparing the values we get,

$\sigma c < \sigma$(allowable)

So, the design is safe.

D. Clamping Screw:

Determining the maximum permissible load allowed on the screw.
Maximum diameter of the screw = 38 mm.
Maximum diameter of the screw at the point of contact = 28 mm.
Consider the diameter of the screw at the point of contact.

Therefore,

Maximum area of cross-section is,

$A = (\pi/4) *(d^2)$

A = 615.75 N/mm2.

Now,

The yield strength of the screw is,

Syt = 415 Mpa

Therefore,

σ(allowable) = Syt/fos

σ(allowable) = 415/2

σ(allowable) = 207.5 N/mm2.

Now,

We Know,

$\sigma c = W/A$

Where,

W = Load on the Screw (N),

A = Area of Cross-section (mm2)

σc = Compressible stress (N/mm2).

Now,

The maximum allowable load on the screw can be calculated by replacing σc with σ(allowable).

Therefore,

W(max) = σ(allowable) *A

W(max) = 207.5 *615.75

W(max) = 127.7 KN

This is the maximum allowable load on the clamping screw. As there are no external forces acting on the spindle, the vibrations are less compared to the actual working vibrations of the spindle. So, the load on the clamping screw is less than the maximum allowable load.

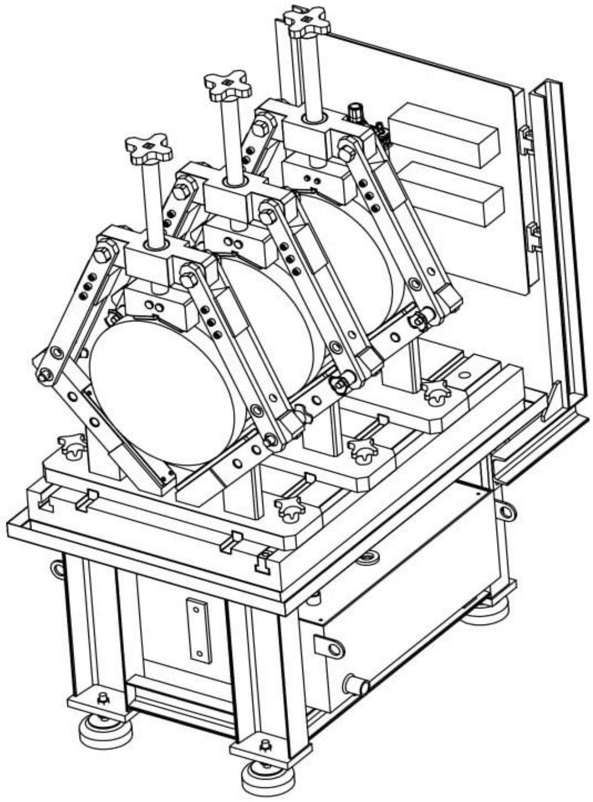

Fig. 2 Finalized Design of Fixture

IV. RELEVANCE

Testing of any spindle after maintenance is an important step in the process. Different types of spindles are used for various purposes. Mounting different spindles on different fixtures consumes more time and cost. By using a single fixture, the time for the testing process can be reduced. Also, the this eliminates the use for fixtures manufactured for specific types of spindles.

V. MOTIVE

The motive of this project is to reduce the time and cost of the testing process of spindles, by designing an adjustable fixture. Different spindles of distinct diameters and lengths can be mounted on this for the testing process.

VI. SUMMARY

The adjustable fixture is suitable for mounting distinct types of spindles in various industries. It reduces the cost of testing of spindles and also reduces human effort. It increases the efficiency of the testing process.

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