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Design and fabrication of jig for angular drilling

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ABSTRACT

In drilling process the tool and work piece both are perpendicular to each other means the drilling axis parallel and horizontal to machine axis, but in Vertical machine centre (VMC) the radial and angular drilling is easy task but in small machine shop and workshop we can not afford the VMC machines. For that we are trying to design and fabrication a fixture for angular drilling. This proposed method has to design and fabricate the Multipurpose Jig and Fixture, for that component Which has been to reduce the manufacturing cycle time.

Keywords: *Jig, Vertical Machine Centre*

1. INTRODUCTION

The Jigs and Fixtures are special purpose tools which areused to maintain accuracy and ensure mass production in manufacturing any component. The mass production is based on interchangeability by which every part will be produced with given tolerance. Jigs and Fixtures relates between the references which is taken in consideration for initial phase of design .Once a Jig or Fixture is designed we can produce identical parts of specific object without additional setup. The accuracy is also maintained throughout the parts[1]

1.1 Jigs

It is a work holding device that holds, supports and locates the work piece it also guides cutting tool for specific operation. The jig may or may not be fastened to the machine table whereas the fixture should be fastened to the machine table precisely. As far as jigs are concerned, the cumulative output in terms of production units, manufacturing time, labour required and ease of operation is more important.[2]

1.2 Fixtures

It is a work holding device that holds, supports and locates the work piece for operation but does not guide cutting tool. The task of fixture is to provide a reference surface. Purpose of fixture is to locate and hold the workpiece. The fixture is similar device to jig but as name suggests it is fixed. Utilizing the concept of standardization, fool proofing will reduce the manufacturing cost of jigs and fixtures. Similarly, suitable[3]

2. ELEMENTS OF JIGS

The most-common jigs are drill and boring jigs. These tools are fundamentally the same. The. Difference lies in the size, type, and placement of the Drill bushings. Boring jigs usually have larger Bushings. These bushings may also have internal oil Grooves to keep the boring bar lubricated. Often, Boring jigs use more than one bushing to support the Boring bar throughout the machining cycle. The two Type of jigs, they are open and closed. Open jigs carry Out operations on only one, or sometimes two, sides Of a work-piece. Closed jigs, on the other hand, Operate on two or more sides of work-piece.[4]

2.1 Importance of jigs

Jigs are very important in manufacturing industry. These tools needed to make sure that manufacturing Process in production line going smooth and easier to Operator doing their job. Jig helps operator to holding Part which will be processing or in operation. In Production rate, using jigs increased the productivity Because it will minimize the production time.[5]

3. MATERIALS AND METHODS

From a variety of materials, some of Which can be hardened to resist wear. The materials Often used in jigs are steel, iron, nylon, fiber and Bronze.[6]

3.1 Carbon Steels

These contain 0.85-1.18% carbon and can be oil Hardened to RC 62-63. These can be used for tools For cutting softer materials like woodwork Agriculture, and also for hand tools such as files, Chisels and razors.

3.2 High Speed Steels (HSS)

These contain 18% (or 22%) tungsten for toughness And cutting strength, 4.3% chromium for better Harden ability and wear resistance and 1% vanadium For retention of hardness at high

temperature (red Hardness) and impact resistance. HSS can be air or oil Hardened to RC 64-65 and are suitable for cutting Tools such as drills, reamers and cutters.

4. LITERATURE SURVEY

[1] Mr. Rushikesh D. Bhosale –This paper gives us information about jig It is a work holding device that holds, supports and locates the work piece it also guides cutting tool for specific operation. The jig may or may not be fastened to the machine table whereas the fixture should be fastened to the machine table precisely. As far as jigs are concerned, the cumulative output in terms of production units, manufacturing time, labour required and ease of operation is more important.

[2] Karthikeyan P.- This paper gives us information about Jigs are made from a variety of materials, some of which can be hardened to resist wear. The materials often used in jigs are steel, iron, nylon, fiber and bronze.

[3]Hamad Mohammed Abouhenidi-This paper gives us information aboutjig is usually made of metal which locates and holds the work-piece(s) in a positive manner and also guides the cutting tool(s) such that it is in the correct relationship to the work when machining commences. It is usually necessary for the work to be held in the jig by clamping. The jig is not fixed to the machine table by clamping but is held by hand. Jigs are use for quantity drilling, reaming and tapping for example.

[4] Raghavendra H-This paper gives us information about Indexing Jig This tool is needed to make sure that the production line is going Smoother and easier for the operators doing their job in manufacturIng process. Processing or in operation, jig helps operator by holding The work piece. Production rate can be achieved by using jigs, which Increases the productivity by minimizing the production time.

[5] Diksha R. Bahadure - This paper gives us idea about the design of the product is safe and easy to use when designing jig and fixtures. Sharp corners should be avoided on the jig or fixture body. When designing the semi-auto insertion jig in this project, each design component uses chamfers in each corner to ensure that there is no sharp corner that can damage the operator when using the jig Bolt and groove should be inside the body and should not protrude the surface The surface of this semi-auto insertion is well built as something bold is placed inside the jig which makes the work surface clear and can prevent injury and obstacles while doing the job.

[6]Kataria Mahendra B - This paper gives us information about there are many types of jigs and fixtures are used in industries. Jig is device which is used to hold the work piece or fix the work piece and guide the cutting tool. The purpose of the jigs is to provide strength, holding, accuracy and interchangeability in the manufacturing of product.

[7]Hendro Prassetiyo-This paper gives us information about the tools used today it is still not optimal as operators still feel inconvenience in the use of tools. Design of jig and fixture Made to drilling process at the side plate component. There are several stages in doing the design, one of them is by choosing and designing the components needed in the design of jig and fixture such as base plate, locator, support and clamping.

[8]Mahendra H S A-This paper gives us information about drill jig is designed which suits to the effective production of the component i.e. seat bracket for Seating arrangement. A detailed procedure of drill jig design by considering all the requirements of tool engineering has been carried out throughout the study. There are many types of drill jig s which are already available in market have to be considered before going to the design of complete drill jig. The factors like time, cost economy, production life cycle, operator skill, availability of the machines, quality is to be considered before designing of the drill jig. All standards which are substantially standardized by international standard organization (ISO) long with tool engineering standards had referred before completion of drill jig design. Effective degree of freedom considering all 6 DOF was considered before design

[9]Jayesh Vijaykumar Kumbhar-This paper gives us idea about the jig is used for guiding the cutting tool (like a drill bit), and for doing so, jigs have components like a bush, which comes in contact with the cutting tool. On the other hand, a fixture never comes in direct contact with the cutting tool. Fixtures assure the position and alignment of the work pieces for getting the required machining operation done.

[10]M. Fathil C. Ibrahim-This paper gives us information about understanding jig and fixture mechanize offers economical way to produce a specific product especially in mass production system. The jig component can be used and served with pneumatic or hydraulic system as power driven. This is easily controlled, consistent and results in quick operation.

[11]Shubham Misal,Kalpesh Tatar and Amol Vyavahare-This paper gives us information about I the target of the mass production is to increase the productivity and increase the accuracy. This is done by reducing the set up cost and manual fatigue. Thus mass production can be achieved by the use of jigs and fixture. For large scale production of different material, a lot of time is wasted in set up of the device and clamping the device. This paper work aims at design and analysis of a Jig and Fixture for drilling an inclined hole at an angle of 45°.

[12]Prof. Mr. Sangale Prabhakar-This paper gives us information about Advantages – It reduces or sometimes eliminates the efforts of Marking, measuring and setting of work piece on a Machine and maintains the accuracy of performance.

[13]Mohsin lalabhai Shaikh-This paper gives us information about IMPORTANT CONSIDERATIONS WHILE DESIGNING JIGS AND FIXTURES –

1. Study of work piece and finished component size and geogeometer
2. Type and capacity of the machine, its extent of automation. © Provision of locating devices in the machmachin
3. Available clamping arrangements in the machine. € Available indexing devices, their accuaccurac
4. Evaluation of variability in the performance results of the machine.
5. Rigidity and of the machine tool under consideration.
6. Study of ejecting devices, safety devices, etc.et
7. Required level of the accuracy in the work and quality to be produce

5. CONSTRUCTION

The body of a jig can be constructed by any of the following method

1. Casting
2. Fabrication
3. Welding

Fabrication offers the following advantages:-

1. Standard parts can be used to built up body.

2. Quickness of manufacture.
3. Easy to repair because disassembly is comparatively easy.
4. Light weight compared to casting.
5. Less cost compared to casting.

In fabricated construction the body is made up of separate parts. Since machining is done prior to assembly required accuracy could be held. In fabrication method the construction is held together by screws.

1. Base plate:-

The base plate is the base member of the jig that holds rest of the assembly. The base plate is provided with holes to be clamped on the drilling or milling machine table. The base plate carries an circular T-slot in which the indexer pins are placed and they engage in the holes provided on the primary indexer. The base plate allows the primary indexer to be rotated about the vertical axis in 360 and then clamped at any desired position.

2.Primary Indexer:-

The primary indexer is an circular plate mounted on the base plate. It is provided with counter sunk holes that receive the bolts to clamp the pillars on to it. The primary indexer can be rotated about the vertical axis in 360 and then clamped at any desired position.

3. Pillars:-

These are vertical members bolted to the primary indexer, that serve to hold, index and clamp the secondary indexer. The secondary indexer is received at its boss element in the respective bores of the pillars, and the pillars are split in two to provide for the clamping arrangement.

4.Secondary indexer:-

The secondary indexer is received at its boss element in the respective bores of the pillars, and can be clamped at any angle o to 45 on either side of the vertical mean. On the top of the secondary indexer the tertiary indexer plate is bolted.

5.Secondary indexer plate:-

The Secondary indexer plate is mounted on the secondary indexer with the help of elans and nuts. The bench vice is mounted on the secondary indexer plate with the help of elans and nuts.

6.Indexer pins:-

Indexer pins serve as indexing and clamping elements for the primary and tertiary indexers

7. Clamping Vice:-

The clamping vice is an standard drilling vice with 2 inch holding capacity, mounted on the tertiary indexer plate. It is used to clamp the job on to jig

Working process

- Clamp the jig to drilling / milling machine table. The jig is clamped to the machine table by means of t-bolts and nut.
- Index the primary indexer to the given angle. The primary indexer is indexed by first loosening the indexer pin nuts and then turning it about the central pivot such that it is indexed to the required angle, then this position is fixed by tightening the index pin nuts.
- Clamp the primary indexer nuts.
- Index the secondary indexer to the given angle. This is done by first loosening the pillar bolts on either of the pillars and then turning the secondary indexer about the central hinge such that given angle is achieved.
- Clamp the pillar bolts.
- Clamp the tertiary indexer nuts.
- Clamp the job on to the drilling vice.
- Perform the drilling or milling operation.

Design

Design consists of application of scientific principles , technical information and imagination for development of new or improvised machine or mechanical system to perform specific function with maximum economy and efficiency.
Hence a careful design approach has been adopted.
The total design work has been split up into two parts-

1 System Design
2 Mechanical Design

1.System design:-

System design mainly concerns with various physical constraints ergonomics, space requirement arrangement of various components etc.
In system design we mainly concentrated on following parameters;
System selection based on physical constraints.
The mechanical design has direct norms with system design hence system is designed such that distinctions obtained after mechanical design can be well fitted into it.
Arrangement of various components made simple to utilized every possible space.
Ergonomic consideration in,
Design of screw handle.

2.Mechanical design:-

In mechanical design the components are listed down and stored on the basis of their procurement design in two categories namely,

- Designed parts.
- Parts to be purchased.

For designed parts, detailed design is done and distinction thus obtained are compared to next highest dimensions which is readily available in market.

This simplifies the assembly as well as post production and servicing work. The various tolerances on the work are specified. The process charts are prepared and passed on to the manufacturing stage.

The parts which are not to be purchased directly are selected from various catalogues and specified so that anybody can purchase the same from retail shop with given specification.

Design of screw

Power screw is mechanical device meant for converting rotary motion into translation motion and for transmitting power.
The main application of power screw are;
To raise load, eg. Screw jack
To clamp a work piece eg. Vice, etc.
Power screws are simple to design, easy to manufacture and give smooth & noiseless service.
They provide large mechanical advantage and highly accurate motion.
Square thread profile is favorably used in applications like vices; clamps etc, due to its property of maximum efficiency and minimum radial or bursting pressure on nut. We shall design a machine vice having a single start, square threads screw with no collar friction.

Data

Let us assume that the machinist/assembler can comfortably exert a force of 50N on the handle at mean radius of 80mm.Let the maximum clamping force desirable at jaw end by 3KN.

The total external torque applied to handle is (50x80) N-mm

Therefore,

$$(M_t)=50x80 \text{ N-mm}$$

$$W \times C = 50x80$$

Where;

$$C=(dm/2)\tan(\downarrow+\alpha)$$

$$3X10^3XC=50x80$$

$$C=1.33$$

$$(dm/2)\tan(\downarrow+\alpha)=2$$

Now;
Assumin

$$g\ \mu=0.8\&\alpha=5^{\circ}$$

$$dm=\underline{1.33x2}$$

$$\tan(10.2+5)$$

$$\underline{\mathbf{dm=9.81mm}}$$

selecting basic dimension for squre threadsRef.PSG(5.71)
Normal series (IS:4694-1968)

Normal Dia.=12mm

Design check:-

d=Nominal/outer dia.(mm)=12mm
dc=core/inner dia(mm)=10mm
dm= mean dia(mm)=11mm

$$M_t = W \times (dm/2)\tan(\downarrow+\alpha)$$

Where,
W- Axial Load
↓- Friction angle
α- Helix Angle

Helix Angle:-

$$\text{Tan } \alpha = L/\pi.dm$$

for the single start square thread lead is same as pitch = 2

$$\tan \alpha = 2/\pi \times 11$$

$$\text{so, } \alpha = 3.3^{\circ}$$

Friction Angle:-
Coefficient of friction under different condition .

Condition	Average coefficient of friction (μ)	
Average quality of material and work man Ship And average running condition	Starting	Running
	0.18	0.13

So,

$$\mu = \tan\text{Ø}$$

$$0.18 = \tan\text{Ø}$$

$$\text{Ø} = 10.2$$

$$M_t = 3 \times 10^3 \times 11/2 \times \tan(10.2 + 3.3)$$

$$M_t = 3.96 \times 10^3 \text{ N-mm}$$

Material Selection
Selected material combination :-
Hardened Steel – mild steel

For Screw :-

Designation	Tensile Strength(N/mm^2)	Yield Strength (N/mm^2)
EN24	800	640

Direct Tensile or compressive Stress due to an Axial load:-
A) Compressive shear stress :-

$$Fc_{act} = W/(\pi/4) \times dc^2$$

$$Fc_{act} = 3 \times 10^3 / (\pi/4) \times 10^2$$

$$\underline{Fc_{act} = 38.19 N/mm^2}$$

As ; $fc_{act} < fc_{all}$, Screw is safe in compression.

B) Tensional shear stress:-

$$T = M_t = \pi/16 \times fc_{act} \times dc^3$$

$$4 \times 10^3 = \pi/16 \times fc_{act} \times dc^3$$

$$\underline{Fc_{act} = 20.17 N/mm^2}$$

As; $fc_{act} < fc_{all}$, screw is safe in torsion.

C) Bearing Pressure:-

$$P_b = W / (\pi/4)(do^2 - dc^2) n$$

Where;

P_b=Bearing Pressure($N/mm^{2)}$

N=Number Of threads in contact.

Limiting values of bearing pressure:-

$$Pb = 3x10^3/(\pi/4)(12^2-10^2)n$$

$$n = 3x10^3/(\pi/4)(12^2-10^2)17.5$$

$$n = 4.96$$

So,**n=5**

Shear strees due to Axial Load:-

$$Fc_{act} = W / \pi\, n\, dc\, t$$

Where,
t = width thread =p/ 2
t = 4mm

$$fc_{act} = 3 \times 10^3/(\pi/4) \times 1 \times 10 \times 5$$

$$fc_{act} = 19.08 N/mm^2$$

As ; $fc_{act} < fc_{all}$, the screw threads are safe in shear

Design of Nut:-
In design of nut the major dimension is the height or length of the nut. It is decided by considering the bearing criterion. Nut is also required to be safe under shearing. The failure of nut in shearing takes place at its core diameter and the area of core diameter of screw resisting shear is less than the area at the core diameter of nut. Secondly the materials for nut and screw are different to avoid greater friction at contacts.

Marerial Selection:-

Material	Allowable tensile stress N/mm^2	Allowable shear stress N/mm^2
CI	420	180

$$F_{bearing} = W/\pi/4(d^2-dr^2) \times n$$

$$=(5 \times 10^3) / \pi/4\,(12^2-106^2) \times 17.5$$

$$n = 4.96$$

$$n = 5$$

n = no. of threads in contact
Ln = length of nut

$$P = \text{pitch}$$

$$N = Ln / p$$

$$\text{So , } Ln = n\, xp$$

$$= 5 \times 2$$

Ln=10

Normally it is recommended that ratio of length or height of nut(n) to core diameter(dc)

Should be between 1.2 to 2.5 for solids nuts.

Ln=1.5 x10

=15mm

b)Shear stress due to axial load:-

Fs nut(act) =w/πdt x(Ln/p)

=3 x103/(π x10 x7.5)

Fs nut(act)=12.7 N/mm^2

As fs act< fs all the nut is safe in shear

Design of indexer pins:-

MATERIAL SELECTION :-

Ref :- (PSG 1.10 , 1.12, & 1.17)

Indexers are located in three holes on primary indexer at an PCD of 106mm. They can be designed similar to the bush pins in the bush pin type flexible flange coupling.

'Three pins'transmit the entire torque;

These pins are located at PCD (Dp) =106mm

Tangential force on each bolt (Fp) =T/ Dp x n/2

The maximum drill size that can be drilled on fixture is 12mm, and the torque resulting due to cutting force is 1.8 N-m and axial force is 1.7 KN

Now;

Shear stress = Shear force/Shear area

Fs_{act}= Fb/π/4 xd^2

Fb =fs xπ/4d^2

T=n x (fs x(π xd^2)/4) x Dp/2

Assuming Pin diameter = 3.2mm

1.8 x10^3 =2 x(fs act x(π/4) x(10.2^2/2) x106

So,

Fc $_{act}$ =0.2078N/mm^2

AS;fc_{act}<fc all, Pins are safe under shear load.

5. CONCLUSION

It gives us immense pleasure to have completed our project, "Design and Fabrication of jig for angular drilling", as per time estimate.

DESIGNATION	TENSILE STRENGTH N/mm^2	YEILD STRENGTH N/mm^2
EN24	800	680

Our project, "Design and Fabrication of jig for angular drilling", was designed and fabricated bearing in mind its use in small scale industries, so we adopted and choose all the channels that reduced the overall cost. Therefore the fixture fabricated by us can well meet the economic demand and multiple tasks of small scale industries due to its low initial cost. Another notable aspect is that the maintenance is minimal. In conceiving, planning, designing & manufacturing. This multipurpose assembly fixture has given us ample practice experience.

6. FUTURERE LEVANCE

In drilling we can drill in any required angle. In this jig future enhancement can be done by using servomotors .We can decries the setup time with the help of servomotors. Servomotors are very useful in reducing the non-productive time i.e. setup time is compared to manual setup time. Servomotors can be used for precise drilling and milling operation.

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