DESIGNING AND MANUFACTURING OF DRILLING JIG AND FIXTURE

Prajakta.B.Pimpalkar[1], Poonam P.Kathar[2], Tejaswini P.Chalakh[3], prajakta A. joge[4]

1. Prajakta .B.Pimpalkar, Assistant Professor, Automobile Engineering, GCOEARA, Maharashtra, India.
2. Poonam P.Kathar[2], student of Automobile Engineering, GCOEARA, Maharashtra, India.
3. Tejaswini J.Chalakh[3], student of Automobile Engineering, GCOEARA, Maharashtra, India.
4. Prajakta A. joge[4], student of Automobile Engineering, GCOEARA, Maharashtra, India.

ABSTRACT:

Manufacturing in its broadest sense is the process of converting raw material into products. It encompasses the design of the product, the selection of raw materials and the sequence of processes through which the product will be manufactured. Manufacturing is the backbone of any industrialized nation. Its importance is emphasized by the fact that, as an economic activity, it comprises approximately 20% to 30% of the value of all goods and services produced. Manufacturing also involves activities in which the manufactured product is itself used to make other products. For this industrial project it is focus on the problem of drilling machine usually used in industry. The problem here in the drilling machine is holding the circular work piece and to perform the accurate drilling operation is quite difficult. It is possible to overcome from this problem by designing a new product of jig and fixture for drilling machine.

Index Terms: *Jig, Fixture, Drilling machine, chuck, spindle, Bearing, Indexing plate etc.*

INTRODUCTION

The people's quest for manufactured goods has been growing rapidly over the years. Therefore, to meet up with the high demand, manufacturers have reacted by introducing innovative ways of manufacturing high quality products at a faster rate .The production processes has witnessed numerous changes and evolution with the introduction of numerous innovative manufacturing concepts which include Lean Production System, Cellular Manufacturing, Single Minute Exchange of Dies. These creative approaches have necessitated the need for a reliable and cheaper tools and work-holding devices.

As the efficient running of a manufacturing company which demands a prompt and simple work positioning strategy for correct operations depends largely on the interchangeability of machine components and work-pieces, to ensure un-complication of assembly, and unit cost reduction, as well as to become competitive, reduce the enormous manufacturing cost, and also increase their profitability, the industry has resorted to streamlining its supply chain in a bid to maintaining a very low amount of inventory. This has also led to the demand for a better and cost effective work-holding devices which will ensure better quality products, reduce lead time, and also increase throughput. Also, although some machining operations are so straightforward, like in turning where the job is secured tightly on the chuck while the turning operations are easily performed, some jobs in other operations may not be easily held on either the three or four jaw chucks, and may also require the tools to be guided by the means of a different device. This explains the need for production of standard work-holding devices to increase the rate of manufacturing in our project. Jig is the device which guides the tool, while fixture is a device that securely holds the job in position during machining operations.

*Jigs and Fixtures

Jigs and fixtures are manufacturing tools that are employed to produce interchangeable and identical components. They are unique tool-guiding and work-holding devices designed specifically for machining and assembling large number of parts. The purposes of jigs and fixtures reduction of production cost, increase of production rate, high accuracy of products without any manufacturing defects, provision of interchangeability, easy machining of complex shaped parts, reduction of quality control costs, etc. Jigs and fixtures eliminate the need for a special set up for every work-piece thereby facilitating production and also ensuring that every work piece is manufactured within a predetermined tolerance. Jigs and fixtures eliminate the necessity of a special set up for each individual part. Once a jig or fixture is appropriately set up, that any number of duplicate components can be readily produced without additional set up. The main advantages of Jigs and fixtures are durability, setup reduction, improvement in productivity, reduced decision making in operation selected from the standard components. The major difference between a jig and a fixture is that jigs guide the cutting tool to its precise position, as well as locating and supporting the work-piece during operations. The application of jigs and fixtures in manufacturing operations lead to the production of faster, more accurate, and reliable products at a reduced cost.

*Jig

A jig is a work-holding device that supports, holds, locates a work-piece and also guides the Cutting tool for the desired machining operations. Its main objective is to ensure high degree of precision, interchangeability, and duplication in products' manufacturing. It is also applied to manipulate the location and movement of other tools. A jig is a type of custom-made tool used for the location and motion of another tool. They observed that the primary purpose of a jig is to provide repeatability, accuracy, and interchangeability in the manufacturing of products. Although the most common jigs are the drilling and boring jigs, they are all identical except for the shape, type, and the position of the bushings for drilling or boring.

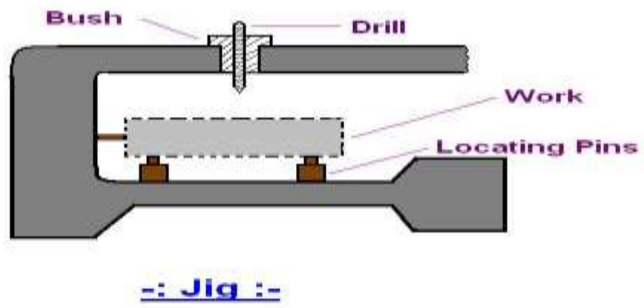

Fig-1: A typical Jig

*Fixtures

Fixtures are rigid and sturdy mechanical devices which allow fast and precision machining with reliable quality, interchangeability, and lead time reduction. As a work holding device, fixtures do not position, guide, and locate the cutting tool, as it is achieved by making necessary adjustments on the machine. Main purpose of a fixture is to locate and in some cases hold a work-piece during either a machining operation or some other industrial processes what makes fixtures unique is that they are all manufactured to fit a particular shape or part. Fixtures often fastened to the machine table, are made to hold the work piece firmly and in the desired position during machining operations. There are sometimes arrangements in the fixture for adjusting the tool with respect to the work-piece/fixture, although the tool is not guided like in a jig. While fixtures are always identified by the machine tool where they are applied, they have broader applications than jigs, and also manufactured for operations where the cutting tools cannot be easily maneuverer like the drilling or boring tools. The different types of fixtures are welding fixture, tapping, fixture, milling fixture, boring and drilling fixture, milling fixture, turning fixture, etc.

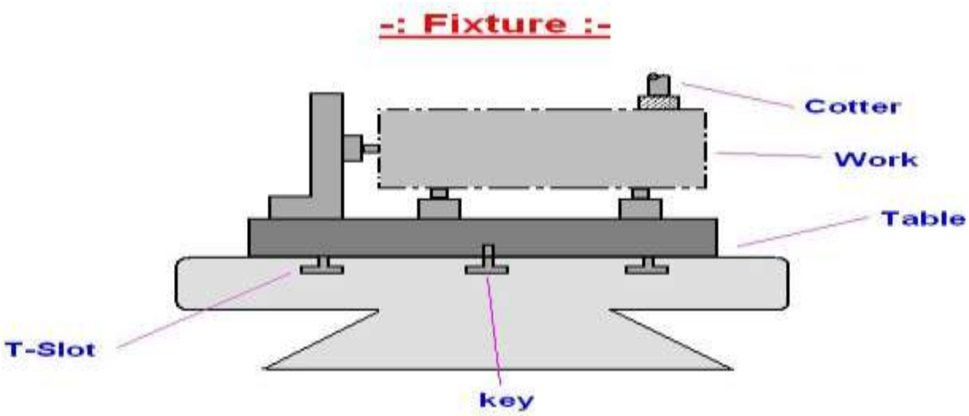

Fig-2: A typical fixture

MATERIALS USED FOR MANUFACTURING OF JIGS AND FIXTURE:

Jigs and fixture are made from a variety of materials, some of which can be hardened to resist wear. It is sometimes necessary to use nonferrous metals like phosphor bronze to reduce wear of the mating parts, or nylons or fibre to prevent damage to the work piece.

*Mild Steel:

It is most widely used material in jigs and fixture. It contains less than 0.3% carbon. It is economical to make parts which are not subjected too much wear and is not highly stressed from mild steel. Considering the properties of mild steel it is used for the fabrication of the device.

DESIGN CONSIDERATIONS

Jigs and fixtures are manually or partially power operated devices. To fulfil their basic purposes, jigs and fixtures are comprised of several elements:
• Base and body or frame with clamping features
• Locating elements for proper positioning and orientation of the blank
• Supporting surfaces and base
• Clamping elements
• Tool guiding frame and bushes (for jig)
• Indexing plates or systems, if necessary
• Auxiliary elements
• Fastening parts

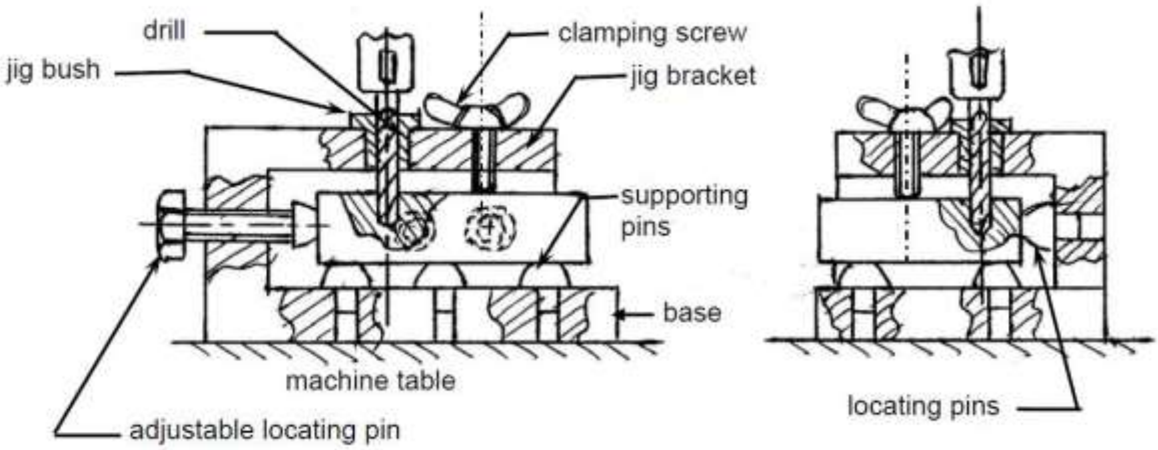

Fig-3: Major elements of jig and fixtures.

Therefore keeping in view increase in productivity, product quality, repeatability i.e. interchangeability and overall economy in batch production by machining, the following factors are essentially considered during design, fabrication and assembly of jigs and fixtures: Easy, quick and consistently accurate locating of the blank in the jig or fixture in reference to the cutting tool.

* Providing strong, rigid and stable support to the blank.

*Quick, strong and rigid clamping of the blank in the jig or fixture without interrupting any other Operations.

* Tool guidance for slender cutting tools like drills and reamers.

* Easy and quick loading and unloading the job to and from the jig or fixture.

* Use of minimum number of parts for making the jig or fixture.

* Use of standard parts as much as possible.

* Reasonable amount of flexibility or adjustability, if feasible, to accommodate slight variation in the job -dimensions.

* Prevention of jamming of chips, i.e. wide chips-space and easy chip disposal.

* Easy, quick and accurate indexing system if required.

*Easy and safe handling and moving the jig or fixture on the machine table, i.e., their shape, size, weight and sharp edges and corners.

*Easy and quick removal and replacement of small parts.

*Manufacturability i.e. eases of manufacture.

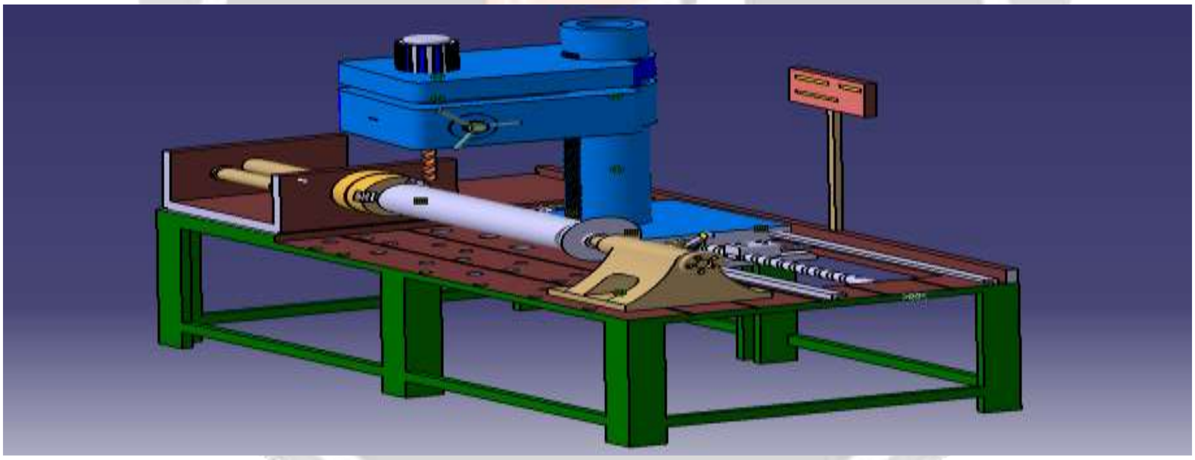

Fig-4: Design of New system

The CAD diagram shown above consists of following component, namely base plate, spindle, bearings, supports, indexing plate, indexing lever, chuck, tail stock, drilling machine, slider, ball screw, digital read out (DRO). Base plate takes up all the load of the system. Two supports are mounted on the base which supports the spindle placed in it. Two bearing are also given for smooth and easy operation. Indexing plate is mounted just after the spindle arrangement. Direct indexing is done to rotate the tube by 120^0 for drilling three holes circumferentially. Just after that chuck is mounted where work piece will be held. For end support tail stock is provided. Slider with ball screw is placed under the drilling machine which supports the movement of drilling machine at desired place.

CONSTRUCTION

*Base plate

Fig-5: Base plate

Dimensions of base plate: 3000mm*800mm*50mm
Density of base plate: 7800kg/m3
Weight calculation: 3*0.8*0.05*7800=936 N

*Supports

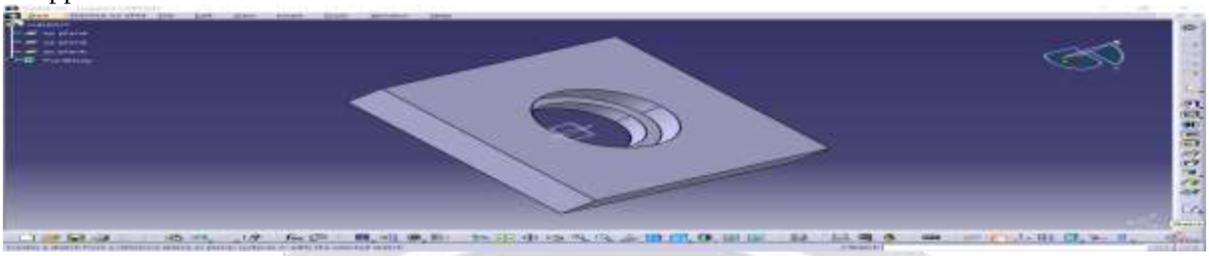

Fig-6: Supports

Square cross-section
No. of supports = 2
Centre distance = 100mm
Length = Breath = 2*100 = 200 mm
Bearing will be placed inside the supports. Width of bearing is 18mm. Clearance of 22mm is provided for safety.
Width = 18+22 = 40 mm
Dimension of support 200*200*40 mm

*Spindle housing

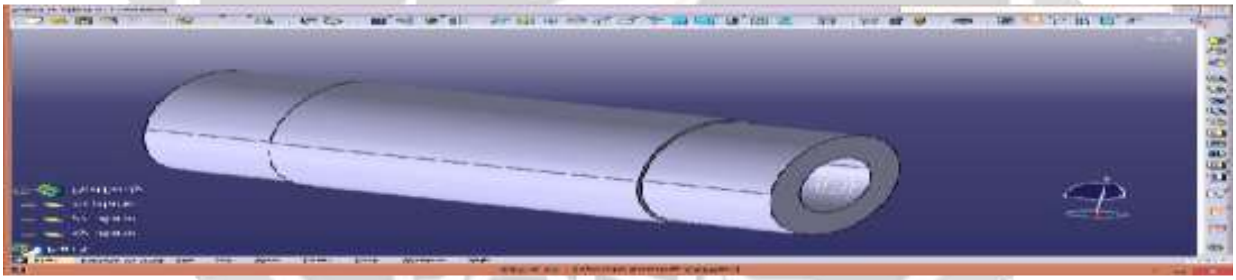

Fig-7: Spindle housing

*Bearing

As a shaft diameter is 60 mm hence bearing ID will be 60mm and hence there is no minimum load on bearing, hence we are considering light series no hence bearing no is 6012zz Bearing single row deep groove ball bearing (SRDG).Bearing number -6012zz ZZ: Double shield (self-lubrication)

Fig-8: SRDG Ball Bearing

d = 60mm
Fr = 16.28 KN
Fa = 0
Type of bearing used is single row deep groove ball bearing.

$L10 = 60\ nL10^{th} / 10^{6} = 60*10*10000/10^{6}$
$= 6$ million rev
$C = P\ (L10)^{1/3}$
$= 16289.50(6)^{1/3} = 29600$
Bearing no. 6012 ZZ is selected.
di = 60mm
do = 95mm
B = 18mm

*Indexing plate

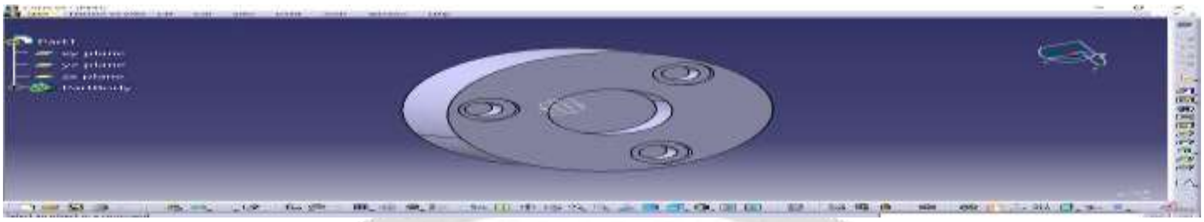

Fig-9: Indexing Plate

It is a specialized tool that allows a work piece to be circularly indexed that is easily and precisely rotated to 120^{0}. So we use direct indexing plate 3 holes of 8mm at 120^{0} to be drilled on tube. Direct indexing plate is selected for this purpose.

*Indexing lever

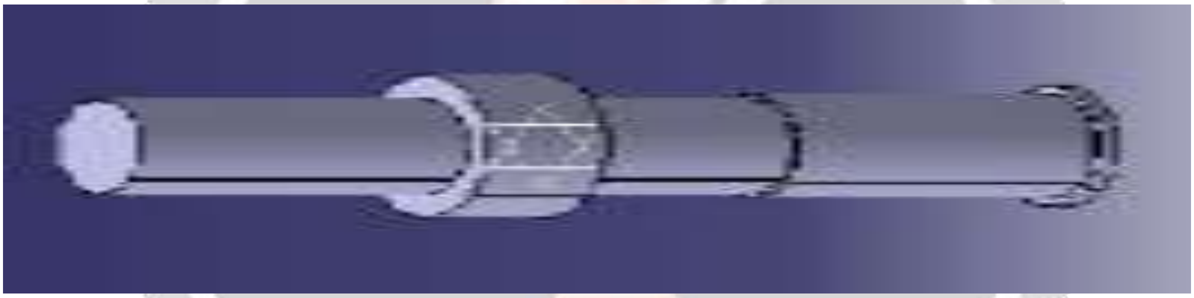

Fig-10: Indexing lever

*Chuck
3 jaw chuck of 180mm diameter is used because it is easy for alignment and self-centering.
Clamping force:
$T = KDPc$
Where, T = torque
K = constant to account for friction (0.15-0.2)
D = Bolt Diameter
P = clamping force
161 = 0.2*16* P
Pc = 50.31 N

CALCULATION

*Calculating lead angle

$\tan ß = Ph/\pi dp = \beta = 2.23°$

*Driving torque required to gain thrust
$T = F_a * Ph / 2\pi * \eta_1$
T= 4.91 Nmm

*Thrust generated when torque is applied

$Fa=2\pi * n_1 * T/Ph$
Fa= 5.861 N

*For shear stress consideration
$\tau = 16\ T/\pi d^3$
T= F*r
= 700*(150+80)
= 161 KNm
$\tau = Syt*0.5$
$FOS=0.5*400/3$
= 66.67 N/$mm2$
$66.67 = 16*161*103/\pi d^3$
di = 23.08mm

*For bending consideration
$\sigma b = 32\ Mb/\pi d^3$
$165 = 32*774.4*10^{3/}\pi d^3$
di = 36.29mm

Shaft diameter achieved by the calculation is 36.29mm maximum diameter for MT3 taper according to machine tool design hand book by CMTI states that maximum diameter of MT3 is 23.8mm which is not possible to inner diameter shaft. But even MT3 is too small for holding our back plate and chuck. Hence we have to go for MT4 whose minimum diameter is 36.29mm. Hence we have to increase shaft diameter wall thickness as 12 mm hence shaft diameter becomes 60.29mm but 60.29mm but available bearing size is 60mm. Hence we use 60mm outer diameter

*Total mass – 200 kg

*Stroke length - ls- 1000 mm

*Maximum speed - $Vmax=displacement/time$= 56/0.15 =373.33 mm/s = 0.37 m/s

*Acceleration time $t1$= 0.15 sec

*Deceleration time $t2$= 0.15 sec

*Average axle load
$Fm1$= 75.981 N
$Fm2$ = 75.981 N

*Average load
Average load =$Fm1$+$Fm2$/2
= 75.981 N

*Nominal service life -
L= $(caFw*Fm)^3 * 10^6$
= $(29*1031.5*75.981)^3 * 10^6$
= $1.6474*10^{13}$ million rev

*Drilling force
Cutting force:
Fc = S*t*kc
= 0.18*(8/2)*2.60
= 1.87 KN
Thrust force:
$Ft = 1.16\ KD\ (100S)^{0.85}$
= $1.16*(2.03)*8*(100*0.18)^{0.85}$
= 2.19 KN
Resultant force:
FR = 2.88 KN

CONCULSION

It is concluded that the project design and manufacturing of a drilling jig and fixture for hollow cylindrical component is to overcome the difficulty of holding and positioning of hollow cylindrical component by index plate while drilling external holes on the component. By making the use of this newly designed jig and fixture, the holding and indexing of the circular job is made easy. Also holes at different length on component can be drilled with ease. This saves time that leads to the increase in the rate of production and reduce the fatigue of the workers. It provides more accuracy in the work piece while drilling operation.

ADVANTAGES

*Productivity

Jig and fixtures eliminate individual marking, positioning and frequent checking. This Reduces operation time and increase the productivity.

*Interchangeability

Jig and fixtures facilitate uniform quality in manufacture. There is no need for selective assembly. Any part of the machine fit properly in to the assembly. And all similar components are interchangeable.

*Skill reduction

Jig and fixtures simplify locating and clamping of the work piece. Tool guiding elements ensure clamping of the work piece. There is no need for skilful setting of the work piece of tool. Any average person can be trained to use Jig and fixtures. It saves the labour cost.

*Cost reduction

Higher production, reduction in scrap, easy assembly and savings in labour costs result in substantial reduction in the cost of work pieces produced with jigs and fixtures.

REFERENCES

1. Charles Chikwendu Okpala, Ezeanyim Okechukwu C.,(2015) 'The Design and Need for Jigs and Fixtures in Manufacturing' Science Research.
2. IIT Kharagpur,**"**Purposes of jigs and fixtures and their Design principles".
3. Gurumukh Das and Padam Das, 'Cutting Forces in Drilling Operation'.
4. Midhun.R Vignesh.A, 'Design and Fabrication of Jigs and Fixtures for Drilling Operation'.
5. Mr. Aditya Arvind Yadav, Mr. Akshay Vilas Arekar, 'Design and Fabrication of Turning Fixture and Drilling Jig for Exhaust Manifold'.
6. Mr. Rushikesh D. Bhosale, Mr. Suyash S. Nalawade, 'Study & Design of Jig and Fixture for Base frame of Canopy Fabrication of Generator'.
7. MTI, 'Machine Tool Design Data Book'.
8. THK, 'Linear Motion Guide Selection Handbook'.