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Design and Development of Jig for Drilling of Circular Part Periphery

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ABSTRACT

The product quality, manufacturing time, cost and interchangeability of products are occupied the manufacturing systems planners. Work holding devices are the tooling elements that have a large effect in all of these problems. Fixture is a special holding device use to help in controlling these problems. The lack of fixture flexibility decrease the flexibility of the whole manufacturing system to face rapid change in products design and high competitive between products. Modular fixture is the preferred flexible fixture systems to solve these problems in job or small batch lot size systems. Performing operations on surface of the cylindrical components is always been a challenging job. Jigs and fixtures are serving as one of the most important facility of mass production system.

It is very difficult to indexing and positioning of circular component by index plate with crank and sector mechanism. In this project an attempt has been made for the design and fabrication of jig and fixture for indexing and positioning of cylindrical component in drilling machine at lesser cost. Quality of the performance of a process largely influenced by the quality of jigs and fixtures used for this purpose. The main purpose of a fixture is to locate and in the cases hold a work piece during an operation. A jig differs from a fixture in the sense that it guides the tool to its correct position or towards its correct movement during an operation in addition to locating and supporting the work piece.

Keyword:-fixture, accuracy, clamping, productivity.

1. INTRODUCTION

The most common problem facing any company is to produce its products with the highest quality, in the shortest time and with the minimum cost. The ways to achieve these goals are, in some manner, conflicted (the high quality with the shortest time and minimum cost), while other ways are coincide (the shortest time with the minimum cost). The use of suitable holding device can achieve all these goals together to a certain high degree. Nowadays, another problem facing the manufacturing companies are the interchangeability of the products. This interchangeability are affected by the manufacturing procedures, and holding devices used in producing these parts.

2. PRINCIPLES OF LOCATIONS

The principle of location is being discussed here with the help of a most popular example which is available in any of the book covering jigs and fixtures. It is important that one should understand the problem first. Any rectangular body many have three axis along x-axis, y-axis and z-axis. It can more along any of these axes or any of its movement can be released to these three axes. At the same time the body can also rotate about these axes

too. So total degree of freedom of the body along which it can move is six. For processing the body it is required to restrain all the degree of freedom (DOF) by arranging suitable locating points and then clamping it in a fixed and required position. The basic principle used to locate the points is desirable below. Six Points Location of a rectangular block. It is made to rest on several points on the jig body. Provide a rest to work piece on three points on the bottom x-y surface. This will stop the movement along z-axis, rotation with respect to x-axis and y-axis. Supporting it on the three points is considered as better support then one point or two points. Rest the work piece on two points of side surface (x-z), this will fix the movement of work piece along y-axis and rotation with respect to z-axis. Provide a support at one point of the adjacent surface (y-z) that will fix other remaining free movements. This principle of location of fixing points on the work piece is also named as 3-2-1 principle of fixture design as numbers of points selected at different faces of the work piece are 3, 2 and 1 respectively. If the operation to be done on the cylindrical object requires restriction of the above mentioned free movements also than some more locating provisions must also be incorporated in addition to use of the Vee block. Guohua Qin focuses on the fixture clamping sequence. It consists of two parts:

3. DESIGN CONSIDERATION IN FIXTURES

a. The main frame of fixture must be strong enough so that deflection of the fixture is as minimum as possible. This deflection of fixture is caused because of forces of cutting, clamping of the work piece or clamping to the machine table. The main frame of the fixture should have the mass to prevent vibration and chatter.

b. Frames may be built from simple sections so that frames may be fastened with screws or welded whenever necessary. Those parts of the frame that remain permanently with the fixture may be welded. Those parts that need frequent changing may be held with the screws. In the situation, where the body of fixture has complex shape, it may be cast from good grade of cast iron.

c. Clamping should be fast enough and require least amount of effort.

d. Clamps should be arranged so that they are readily available and may be easily removed.

e. Clamps should be supported with springs so that clamps are held against the bolt head wherever possible.

f. If the clamp is to swing off the work, it should be permitted to swing as far as it is necessary for removal of the workpiece.

g. All locator's clamps should be easily visible to the operator and easily accessible for cleaning, positioning or tightening.

h. Provision should be made for easy disposal of chip so that storage of chips doesn't interfere with the operation and that their removal during the operation doesn't interfere with the cutting process.

i. All clamps and support points that need to be adjusted with a wrench should be of same size. All clamps and adjustable support points should be capable of being operated from the fronts of the fixture.

j. Work piece should be stable when it is placed in fixture. If the work piece is rough, three fixed support points should be used. If work piece is smooth, more than three fixed support points may be used. Support point should be placed as farthest as possible from each other.

k. The three support points should circumscribe the centre of gravity of the workpiece.

l. The surface area of contact of support should be as small as possible without causing damage to the workpiece. This damage is due to the clamping or work forces.

4. PROBLEM DEFINITION

As per the requirement of "Ghore Engineering works Pvt Ltd, Paratwada"

1) To drill hole on circular part periphery at different angles ranging from 0˚ to 60˚.
2) Flexible and cost effective method for drilling.

5. OBJECTIVE OF THE PROJECT

With the help of this literature survey and in order to obtain an efficient drilling jig and fixture, following objectives are considered.

1) Studying the existing drilling jig and fixture, there parameters and machining processes for drilling holes on periphery of circular job.
2) Modeling the assembly of drilling jig and fixture in CAD software with accurate dimensions.
3) Simulation of the assembly with the help of DMU kinematics in CATIA software.
4) Observing the chances of improvement in the assembly and modification of design.
5) Fabrication of Drilling jig and fixture.

7. DMU KINEMATICS

DMU Kinematics is a workbench that is used to create and edit different mechanisms. Also, it is used to study and check the working of mechanisms. In this workbench, you can simulate and analyze the mechanisms dynamically. Therefore, it is easy and convenient to check the limits and interferences of different parts of the mechanism. In DMU Kinematics, minimum two parts are required to create a mechanism. You can keep one part of the mechanism fixed and move the other part with respect to the fixed part to analyze various functions of the mechanism.DMU Kinematics is an independent CAD product dedicated to simulating assembly motions. It addresses the design review environment of digital mock-ups (DMU) and can handle a wide range of products from consumer goods to very large automotive or aerospace projects as well as plants, ships and heavy machinery. Youcan design mechanisms by creating joints manually using the tools available in the Kinematics Joints sub-toolbar in the DMU Kinematics toolbar. Alternatively, you can create them automatically by using assembly constraints. In this chapter, we will learn about both the methods used for designing a mechanism.

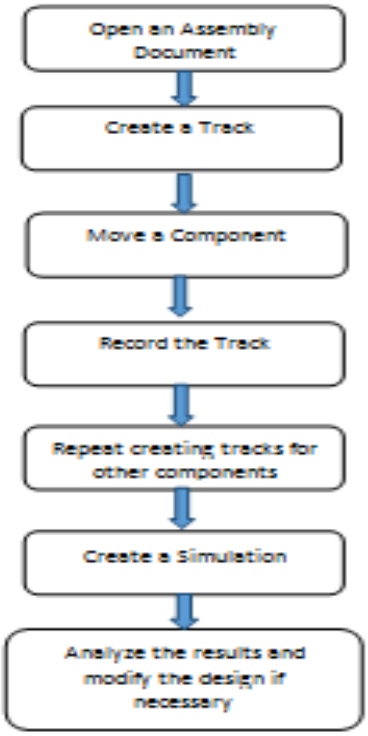

Fig 1: Flow chart for simulation

8. DESIGNINGA MECHANISM

The procedure to create a mechanism involves the following five major steps: invoking the DMU Kinematics workbench, placing / creating parts in this workbench, starting a new mechanism, making a part of the mechanism fixed (stationary), and creating joints.

These steps are discussed next:

1) The first step to create a mechanism is to invoke the DMU Kinematics workbench. To invoke this workbench, choose Start > Digital Mockup > DMU Kinematics from the menu bar.
2) After invoking the DMU Kinematics workbench, you need to place the parts required for creating the mechanism in this workbench. You can do so by placing an existing part or by creating a new part as you did in the assembly environment. To place a part in the DMU Kinematics workbench, choose Insert > Existing Component from the menu bar and select Product1 from the Specification tree; the File Selection dialog box will be displayed. In this dialog box, browse to the location of the desired part and place it in the DMU Kinematics workbench.
3) To create a new part in the DMU Kinematics workbench, choose Insert > New Part from the menu bar and select Product1 from the Specification tree; the new Part node will be added to the Specification tree. Now, create a new part as you did in the top-down assembly design approach in the Assembly Design workbench.

Now, you need to start a new mechanism. To do so, choose Insert > New mechanism from the menu bar; the Mechanism.1 node will be created under the Mechanisms node, this in turn, is a sub node of the Applications node in the Specification tree. The Mechanisms node is called the parent mechanism node. One product can have multiple mechanisms. Therefore, a parent mechanism can have multiple child mechanisms. These nodes are known as child mechanisms. For creating a mechanism, you need to create joints and commands, define all degrees of freedoms (DOFs) for each part, and make one part fixed. On doing so, all joints and commands used for creating the mechanism will be listed automatically under their respective nodes as the Joints and Commands sub nodes. Also, all undefined DOFs will be displayed beside the child mechanism node, see Figure

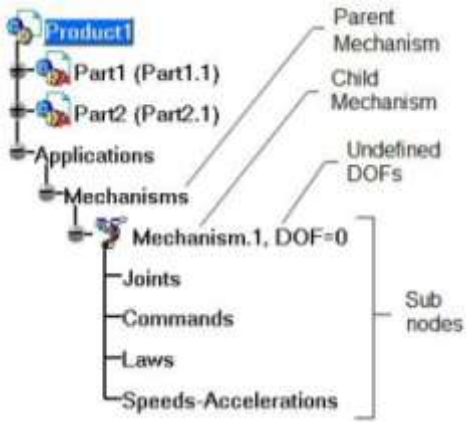

Fig 2: The Specification tree showing all commands

9. DIFFERENT KINEMATIC JOINTS IN CATIA

Revolute Joint

1) Prismatic joint
2) Cylindrical joint
3) Screw joint
4) Spherical joint
5) Planar joint
6) Rigid joint

7) Point curve joint
8) Slide curve joint
9) Roll curve joint
10) Point surface joint
11) Universal joint
12) Gear joint
13) Rack joint
14) Cable joint

10. METHODOLOGY ADOPTED

This project is focused on creating holes on the periphery of the workpiece at a specified angle. The assembly of different parts used in this project was first prepared using CATIA software and then simulation is done with the help of DMU (Digital Mockup) kinematics. Specification of heavy duty high torque drilling machine used for drilling holes on the work is given in below table:

Table: Specifications of drilling machine

Specifications	Value
Drill Diameter	23mm
Power Input	1150W
No Load Speed	280/640rpm
Weight	4.8kg

The material selected was of mild steel. During drilling operation a lot of force acts on the job as well as its holding device used in the holding of the job. The materials for fabrication should be selected such that this can be hardened to resist wear. The dimensions of the material required for the production of the work holding device is shown in chapter Design and Development.

Fig. 3: Shows the drilling machine used in this project

11. DESIGN AND DEVELOPMENT

The assembly created by CATIA software consists of following parts:

11.1 Main body:

Main body consists of holder which is directly welded on the frame. This holder is used to hold workpiece and it restricts linear motion of the work only rotational motion is allowed.

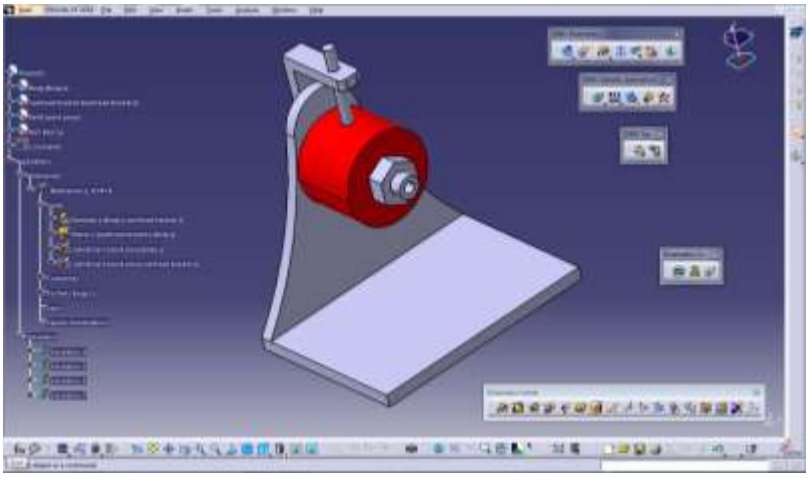

Fig. 4: Screenshot of assembly created in CATIA V5 R19 software

1) Overhead Bracket

Overhead bracket is fixed at an end and it has an arrangement of rotation at an angle. Angle measurement is done with help of scale only.

2) Pin

Pin is used for locking the workpiece at a specified angle, one end of pin is in the drilled hole and another end is fixed in overhead bracket.

3) **Spacer block**

Spacer is typically used in order to support, adjust for better fit, or provide a level surface of workpiece. Between spacer block and nut workpiece is kept for machining.

4) **Nut**

Nut is used restricted linear as well as slippage of workpiece from the holder

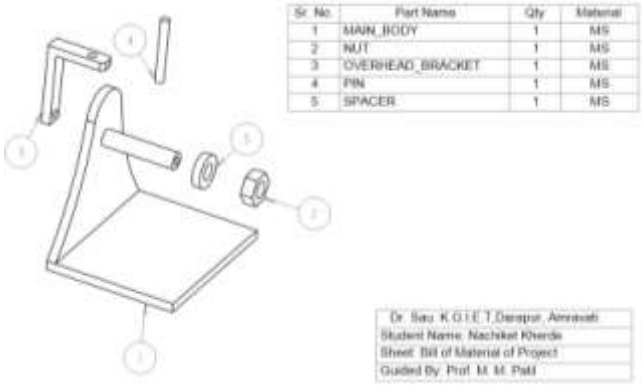

Fig. 5: Image shows Exploded view of the fixture design

12. GENERAL PROCEDURE USED FOR DRILLING HOLE

1) First workpiece is fixed on holder through nut and spacer.
2) Marking is done on periphery of workpiece and first drill is done.
3) Next for second drill, workpiece is rotated by specified angle. This rotation is done by pin and overhead bracket.
4) Second hole is done, next repeat step 3 for consecutive holes on periphery of workpiece.

12.1 DMU kinematic joints used for simulation are

1. Revolute joint between overhead bracket and main body workpiece holder.
2. Planar joint between overhead bracket and main body.
3. Cylindrical joint between workpiece and main body.
4. Cylindrical joint between workpiece and overhead bracket.

13. FABRICATION

Main body consists of holder which is directly welded on the frame. This holder is used to hold workpiece and it restricts linear motion of the work only rotational motion is allowed.

Fig. 6: Image shows fabrication of main body

13.1 Drilling operation on different angle:

- **Trial 1 for 30º angle:**

For this setup workpiece is set on 30º and consecutive holes are drilled on work. Below figure shows the result of drilling operation.

Fig. 7: Image shows drilled hole on workpiece for setup of 30º angle.

13.2 Cost of Fabrication

1) M.S raw material: 5kg = 60rs/kg = 300rs
2) Lathe Machining for turning operation: 60rs
3) Milling Machining: 100rs
4) Drilling Machining: 80rs
5) Labour charges: 500rs

Total cost of fabrication = 1,040rs

14. CONCLUSION

According to the study of project it is very cheap method to adopted drilling operation on periphery of workpiece. Comparing with indexing mechanism this method is very easy and most superior for work. Indexing mechanism requires more skilled labor, but indexing mechanism is more accurate as compared to our project, for example to drill 30.1º or 30.5º angle to drill on periphery of job, it is not capable to drill more precisely. This project is more flexible in order to set different angle ranging from 0º to 60º on both side. This project has certain limitations, maximum rotation angle is 60º and center of the overhead bracket, job and holder has to be same i.e. rotational axis has to be same.

This project is helpful for roadside workshop for drilling on different angle. It dose not require skilled workerer and it is easy to operate. From this explicit we made our drilling operation in the work piece as very easy and comfortable and without geometrical error occurring while drilling and it avoids human error also.

It provides more accuracy in the work piece while drilling operation. It is really a very good experience for every one of us, by successfully accomplishing this project. In addition to theoretical experience, we had a very good practical experience by doing this project. We hope that this project will be very economical and a useful product for customers. We are sure that there will be a great demand if it is introduced in the market.

15. RECOMMENDATIONS AND FUTUER WORK

The results show that the using of computer saves the money and effort of the company and the designer, the recommendation is to follow the working in this field and added the following items to the present work in the future:

1- Extend the designing effort to another workpieces configuration to the present work.
2- The design can be made more modular i.e. more flexible combination can be done.
3- Decided To Design And Manufacture Jigs By Using ACRYLIC Material. Why Acrylic Material? Excellent mechanical machining, Lightness and toughness, Dimensional stability, Strength, Heat resistance, Availability, Safety, Weather resistance and Color verity.
4- Design, Analysis and Manufacturing of Fixtures for Aerospace Component

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