Design of Indexing Drill Jig Using CATIA V5 R20

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Abstract- *The main aim of large scale production, which is to increase the productivity and to acquire the accuracy, can only be achieved by reducing the set up cost and manual fatigue, and this can only be done by assuring the use of jigs. Normally during mass production "Trial and error method" is being used to align the axis of the hole with the axis of the drill. This process of setting up of device and clamping the device consumes a lot of time and also increases the operator's fatigue. To solve this problem, we make sure the use of jigs which abolish the requirement of selective assembly, individual positioning and regular checking. The parts of jig fit properly in the assembly and in all similar components that are designed on interchangeable part concept because it provides the facility of interchangeability too. The jig itself locate, clamp and guide the tool thus it reduces the repetitive nature required for drilling holes. Requirement of skilled laborers is also abolished by this tool guiding element because it's main work is to guide the tool in to the correct position. The basic elements in the design of indexing type of drill jig is the component model, location, orientation and clamping. The scope of this paper is to design an indexing type of drill jig for a component having angular holes at 45 deg. such the design is validated and verified. The present paper entitled "Design of Indexing type of Drill Jig" is the work done for the design of Jig. Modeling is done on CATIA V5 R20.*

Keywords- Design, Indexing Jigs, Interchangeable Part Concept , Mass Production

I. INTRODUCTION

The rapid increase of human population is resulting into the increase in demand of almost each and every goods and services. To fulfill this demand, companies have to increase their production level. But in order to maximize their production level these companies cannot compromise with their profit margins. Thus companies have to meet the expectations of market without compromising with the quality of the product and with the profit of their own. This target can only be achieved by minimizing the production cost. For this companies have to assure the proper utilization of available resources. They have to increase the productivity and reduce the loses at the time of production. Over the last few decades companies have adopted a lot of methods and techniques to reach to their maximum level of productivity, use of jigs and fixtures is one of those processes. The basic setup for drilling process via jig is illustrated below in Fig.1.

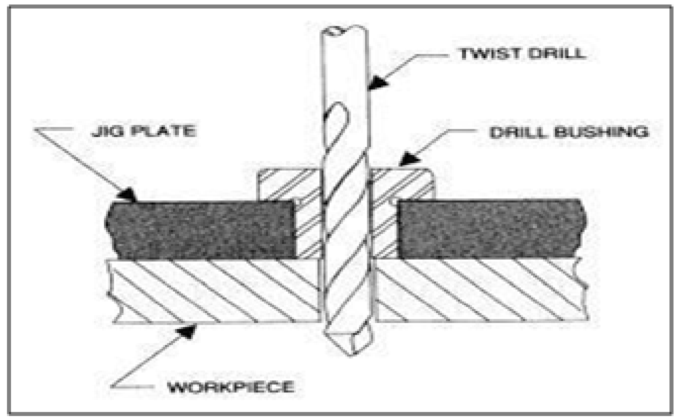


Figure1: A jig guides the cutting tool, in this case with a bushing.

A jig is known as a work holding device, which is primarily used for supporting and locating the work piece. It also guides the cutting tool to perform a particular operation. Jigs are used on drilling, reaming, milling and tapping. They are special purpose tools which facilitate production like machining, assembling and inspection operations. The main uses of jigs and fixtures are as below:

- To reduce the cost of production.
- To increase the production rate.
- To assure higher accuracy of parts.
- To provide for interchangeability.
- To reduce quality control expenses.
- Less skilled labour.
- To Save labour cost.
- Their use improves the safety at work by lowering the rate of accident.

1.1 Problem Statement

In present condition, the machining of components, i.e. all the operation like punching, marking, the setting and holding of job during machining have been done using manual process. Due to the manual machining method, the process has become time consuming and difficult task to perform. As a result of this tedious and time consuming method the production rate of the company remains slow. The present paper deals with designing of indexing drilling jig using CATIA v5 R20 software.

Table1:Time required before jig

SERIAL NUMBER	PROCESS NAME	NUMBER OF WORKERS REQUIRED	TIME REQUIRED IN SECONDS
1	MARKING + PUNCHING	1	108+72=180
2	JOB SETTING + DRILLING	1	20+45=65
	TOTAL	**2**	**245**

1.2 Objective

The primary objective of this paper is to increase the production by reducing operation time thus reduce cost which leads to enhance quality of the fabrication process methodology the design consideration of all jigs consist of Safety: Reduction Of Idle Time, Provision For Coolant, Hardened Surfaces of components, fool proofing Initially the component was designed, modeled and edited to get the necessary details for designed of the jig. Secondly the individual parts such as Base Plate, Locator, Clamping Devices Bushes Jig Plate, and Indexing Mechanism has been developed. All these parts have been designed, Modeled, Drafting has been done individually. The whole Design Procedure was completed with the help of CATIA V5 R20 software which helps for Designing, Drafting Assembly & useful for customized applications and manipulations.

II. DESIGN CONSIDERATION

The design consideration of all jigs consists of safety, reduction of idle time, provision for coolant, hardened surfaces of components, fool proofing. Initially the component was designed, modeled and edited to get the necessary details for designed of the jig. Secondly, the individual parts such as base plate, locator, clamping devices, bushes, jig plate and indexing mechanism were developed. All these parts have been designed, modeled, drafted individually. The whole Design Procedure was completed with the help of CATIA V5 R20 software.

Table 2:Specifications of indexing drilling jig

SERIAL NUMBER	COMPONENT OF JIG	DIMENSIONS IN MM	MATERIAL
1	BASE PLATE	100*100	MILD STEEL
2	SUPPORT PLATE	100*100	MILD STEEL
3	JIG PLATE	100*10: R=10	EN31
4	JIG BUSH	Outer=8, Inner=5	EN353
5	SPRING	outer8, inner5, L=36	STANDARD
6	LEVER	L=135	EN31
7	INDEXING PLATE	Cutting edge=45deg(each)	EN31
8	KNOB	R=100	MILD STEEL
9	LOCATOR	L=73, Max dia=12	MILD STEEL
10	CLAMPER	Dia=38	MILD STEEL

2.1 Component Description

The component for which the jig is designed is a cast component which is having angular holes inclined at 25 deg equi-spaced.

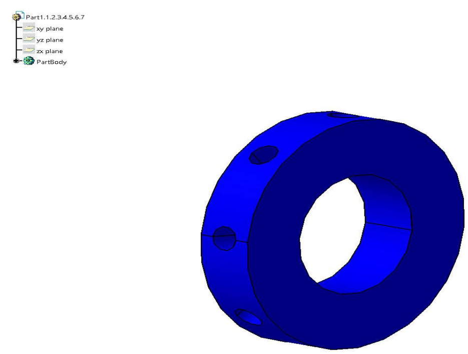
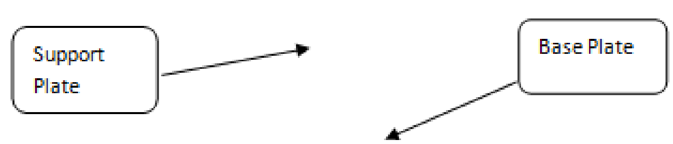


Figure 2: 3d model of the component

2.2 Design of Base Plate & Support Plate

One of the very important part in the design of jig is the Base plate. Base is generally taken as a support for the other parts. In general, base are in the form of vertical, inclined, and horizontal plates. In our model we used vertical and horizontal plates and horizontal plate is termed as Base plate where vertical plate is known as support plate. In the design, the base plate is developed as per the dimension of the work piece and it is done to prevent the distortion of the structure during the machining and non-machining process.



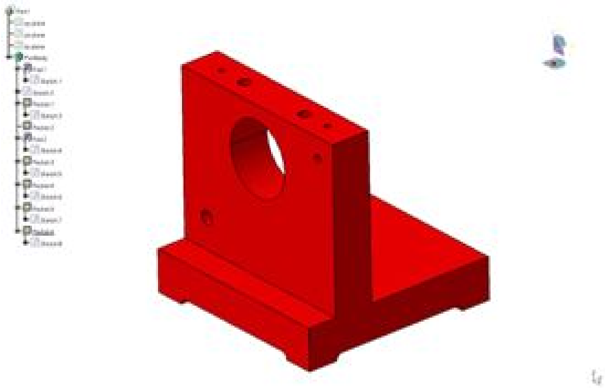


Figure 3: 3d model of base plate and support plate

2.3 Design of Jig Plate

A jig's plate primary purpose is to provide repeatability, accuracy and interchangeability in the manufacturing of products. It guide the tool and also assure the hole size with the help of drill bush.

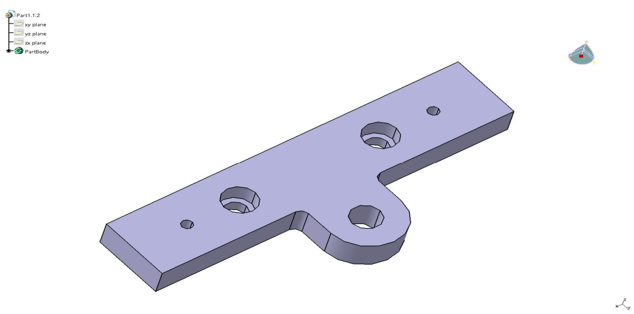


Figure 4: 3d model of jig bush

2.4 Design of Jig Bush

A drill bushing is defined as a tool which used in metalworking jigs to guide cutting tools, most commonly drill bits. Alternate tools that are generally used in a drill bushing include counter bores, countersinks, and reamers. They are mainly designed to guide, position, and support the cutting tool.

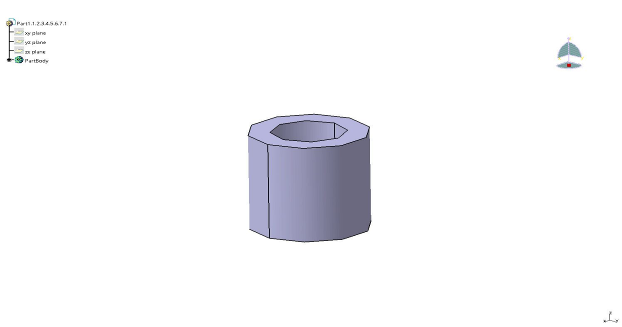


Figure 5: 3d model of jig bush

2.5 Design of Locator

To ensure accuracy and precision in any machining operation it is essential that the workpiece is properly positioned. Locators must be selected to ensure that the workpiece can be easily loaded and unloaded. It also ensures workpieces are precisely positioned and rigidly supported.

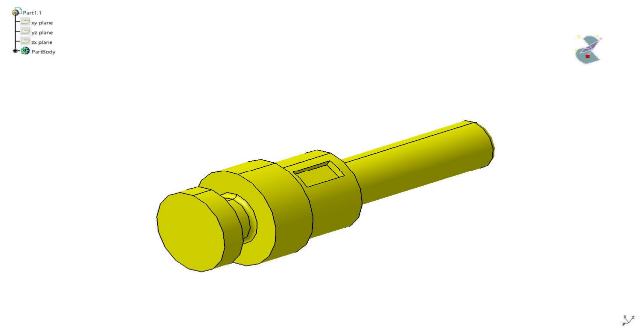


Figure 6: 3d model of locator

2.6 Design of Indexing Plate

A graduated circular plate or one with circular rows of holes differently spaced that is used in machines (as for graduating circles or cutting gear teeth).the plate can be moved round with a workpiece to facilitates the accurate location of holes or other machining operations on the workpiece.

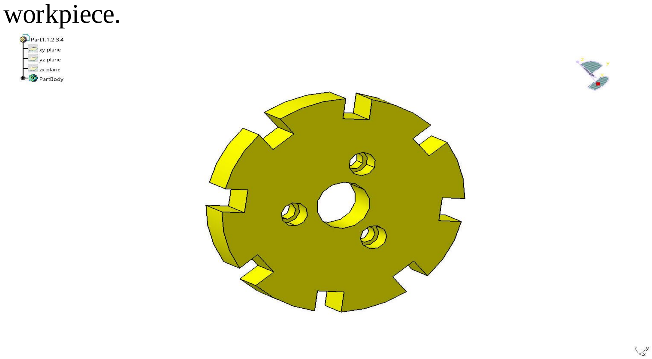


Figure 7: 3d model of indexing plate

2.7 Design of Clamper

A clamp is a fastening device used to hold or secure objects tightly together to prevent movement or separation through the application of inward pressure. From the calculation it is found that the clamping force is greater than the drilling force (machining force) hence the jig design is safe and the clamp chosen is also satisfied by its per formability.

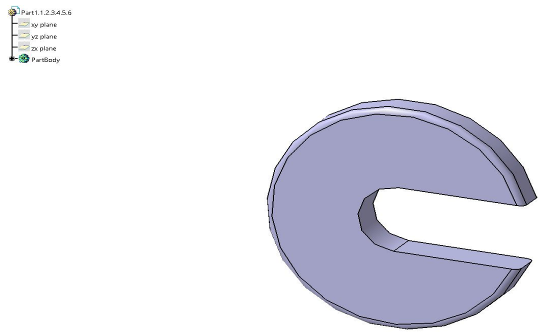


Figure 8:3d model of c-clamp

2.8 Design of Tapper Bush

The Taper Lock bush, also referred to as a Taper bush or Taper Fit bush, is a locking mechanism commonly used in Power Transmission Drives for locating pulleys, sprockets, and couplings to shafts. The Taper Lock bush is pre-bored and keyed to match the required shaft and key way diameters. The outside of the bush is tapered to match the component bore that is to be located on the shaft.

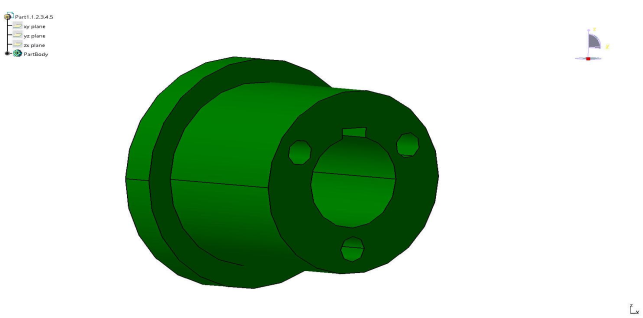


Figure 9: 3d model of tapper bush

2.9 Indexing Drill Jig Assembly

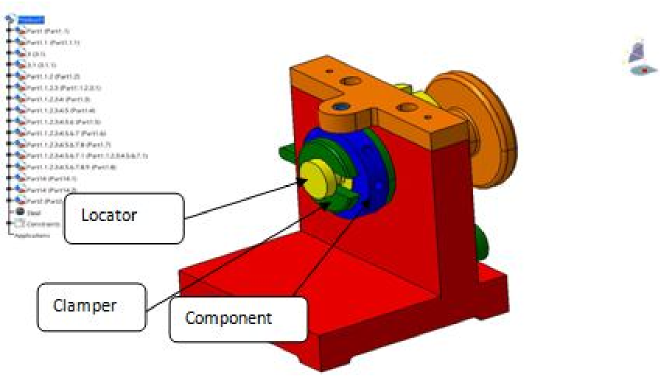


Figure 10: 3d model of complete assembly of indexing jig in isometric front view

III. INDEXING MECHANISM

For indexing, the mechanism adopted is “Indexing Plate and lever arrangement” which is explained as follows. When the lever is pulled down the spring disengages and the locator with Indexing plate is rotated such that next required position of the hole is pointed by the taper bush and the lever sits in the exact position of the hole mounted on the corner of indexing plate, in this way the indexing is achieved.

This is one of the common method of indexing which can be operated easily and here the operating time is also minimum and no skilled labour is needed. Here, it is clearly observed that the indexing plate has cut marks at 45deg. and lever assured the correct required positioning of the component for the next hole.

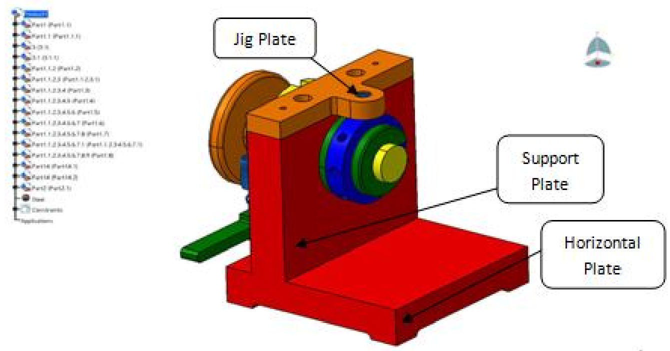


Figure 11: 3d model of complete assembly of indexing jig in isometric back view

In the design of drill jig the most vital part is the locator pin, because it is very much important that how the relationship is maintained hence for this a locator pin is used and in this design the locator pin is parallel to the jig base plate and the axis of component and axis of locator inclined perpendicularly to each other.

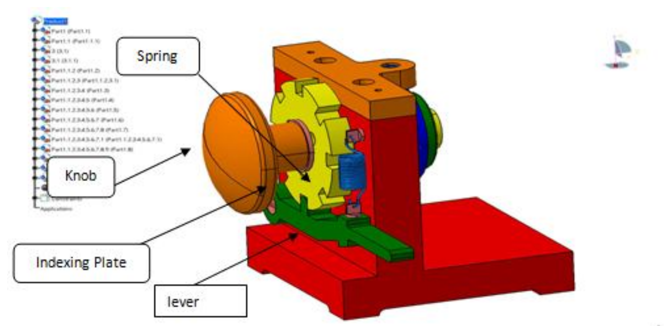


Figure 12 : 3d Model of complete assembly of indexing jig in front view

Hence the concept of fool proof design is also satisfied, it means that any unskilled operator can easily operate the jig since the component is arrested in the desired position and there is no other chance for any positional errors.

IV. CALCULATION OF DRILLING FORCES

While designing for selecting the required parts of the indexing type of drill jig the following calculations are done and compared with allowable limits for individual parameters like rpm, thrust and clamping force:

4.1 Drilling Thrust

The axial thrust F (N) can be estimated with the following formula:

$$F = \frac{k \times k_c \times f \times d}{2} \quad \text{..... (1)}$$

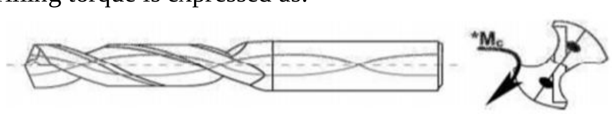
K_c = Specific cutting force ,which depends primarily on the material being machined=680 N mm^{-2}
f = Feed per rotation = 0.3 mm
d = Tool diameter =20 mm
k = The coefficient depends on the geometry of the tip of the tool, we can consider an average value of 0.5

$$F = \frac{(0.5 * 680 * 0.3 * 20)}{2}$$

=>Thrust Force =1020N

4.2 Drilling Torque

Example: drilling with a mono block carbide spiral drill
Drilling torque is expressed as:



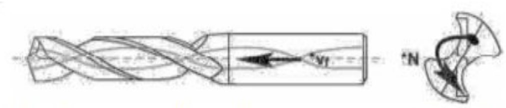
$$M_c = \frac{k_c \times f \times d^2}{8000}$$

M_c = drilling torque in Nm
K_c = Specific cutting force in Nmm^{-2}
F = feed per rotation in mm
D =Tool diameter in mm

$$M_c = \frac{(680 * 0.3 * (20)^{\wedge}2)}{8000} \quad \text{.......(2)}$$

=>Torque=10.20N-mm

4.2 Cutting Parameters



The cutting parameters, and therefore the operating parameters of a drill for drilling operations are:
d:tool and hole diameter (mm)
v_c: cutting speed (m min^{-1}) which gives the rotational speed of the tool (rev min^{-1})

$$N = \frac{1000 \times v_c}{\Pi \times d}$$

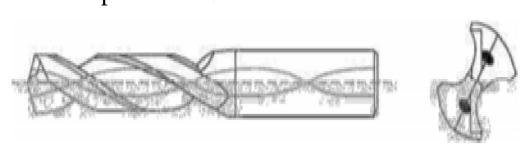
f: feed per rotation in mm rev^{-1}
N=Spindle Speed in RPM

$$1500 = \frac{1000 \times V_c}{\Pi \times 20} \quad \text{......(3)}$$

V_c=94.24 (rev min^{-1})
The resulting performance parameter is:
*V_f: feed rate in (mm min^{-1})
$V_f = f \times N = 0.3 \times 1500$
V_f =450 (mm min^{-1})
The feed rate is one of the main factors of productivity, as it conditions chip-to-chip
Time(t)= p / v_f
p: hole depth
Time= 15/450 =0.03333 min.
t =2 sec.

4.3 Power of Cut

Drilling with a mono block carbide spiral drill
Cutting power is expressed as:



$$P_c = \frac{(k_c \times f \times V_c)}{8000} \quad \text{......(4)}$$

P_c = cutting power in kW
K_c = specific cutting force (Nmm^{-2})
F = feed per rotation (mm)
D = tool diameter (mm)
V_c = cutting speed (m min^{-1})

$$P_c = \frac{(680 * 0.3 * 94.24)}{8000}$$

=>Cutting Power=19.224KW

The above result can be summarized in the table given below which allows us to easily compare and observe the required forces during the drilling process by the designed setup that is known as Indexing drill jig.

Table 3: Summary of calculated values

PARAMETERS	CALCULATED VALUES
TORQUE	10.20 N-mm
POWER OF CUT	19.244 KW
DRILL THRUST	1020 N
CLAMPING FORCE	1500 N

From the above table it can be clearly understood that the clamping force is more than drilling forces therefore the design is safe for machining. Hence the design made satisfies the interchangeable part concept, and the design is fool proof and the design is validated.

The results obtained after drilling like bore, surface finish etc are found to be within the limit.The advantage of our Indexing jig model can well define by the table given below

Table 4 :Comparison

S.NO.	EXISTING SOLUTION (INDUSTRY DATA)	PROPOSED SOLUTION (USING JIG)
1	OPERATION TIME=245 SECONDS (MARKING+SETTING+DRILLING)	OPEARTION TIME=60 SECONDS (LOADING+DRILLING +UNLOADING)
2	NUMBER OF WORKERS REQUIRED=2	NUMBER OF WORKERS REQUIRED=1
3	RATE OF PRODUCTION=116 JOBS/DAY (WHEN WORKING HOUR = 8H)	RATE OF PRODUCTION=480 JOBS/DAY (WHEN WORKING HOUR = 8H)
4	LABOUR COST=Rs 2.4/-	LABOUR COST=Rs 0.30/-

V. CONCLUSION

1. Dimension of type of indexing drill jig that involved in designing is 100x100 mm.
2. Mild steel is component material.
3. The clamping force is greater than the drilling forces (calculated).
4. The assembly of the indexing type of drill Jig is found satisfactory.
5. The results obtained after drilling like bore, surface finish etc.are found to be within the limit.

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