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Design and Fabrication of Drill Jig for Flange Coupling PCD Holes

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ABSTRACT
The Employment of jigs and fixtures is an important aspect of Workshop Engineering for the Production of Articles in large quantities with a High Degree of Accuracy and Interchangeability at a Competitive Cost. The purpose of jigs and fixtures is to maintain Low Manufacturing Costs and to Increase Industrial Efficiency. Thus, the jigs and fixtures are mainly used to Reduce Costs and Ensure Interchangeability which allows for rapid assembly. Its purpose is also to speed up machining times by eliminating time of handling and setting of the Component parts. Further jigs and fixtures are taking the place of the skilled man in the production factory and making it possible to employ unskilled or semiskilled operators. The primary objective of the use of jigs and fixtures is to facilitate the holding and supporting of the component by using fixtures, to position it properly and guide the cutters so that every component will be uniform. It is also employed to accommodate several components at one setting and thus taking advantage of multiple machining. It is particularly very suitable where correct positioning of various holes at various exact places is important and which otherwise would consume lot of time in marking etc.
Keywords: *Material; Jigs; Fixtures; Machining Cost; Parts Designs; Parts Assembly.*

NOMENCLATURE

V	Speed of Drilling (m/sec)
N	Spindle Revolution per Minute
Ft	Tensile Stress
Fs	Shear Stress
P	Power required for Clamping
Subscript	
T	Torque
F	Force which exerts Torque
P	Power required for Clamping

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I. INTRODUCTION

Tool design is concerned with design and development of machines and special tooling, methods and techniques required by today's high speed mass manufacture at high efficiency and productivity. Its main objective is to produce Flange Coupling component at a competitive price, maintaining quality and increased production. All this calls for selection of best tool materials for adequate tool life, providing compact and easy to operate even unskilled operator tools for high efficiency, design of tools to be full proof with no possibility of wrong operation, quality consciousness at all levels. The employment of JIGS and FIXTURES is an important aspect of workshop engineering for the production of different sizes Flange coupling with accurate PCD holes articles in large quantities with a high degree of accuracy and interchangeability at a competitive cost. The primary objective of the use of jigs and fixtures is to facilitate the holding and supporting of the component by using fixtures, position it properly and guide the cutters so that every component will be uniform. It is also employed to accommodate several sizes coupling components at one setting and thus taking advantage of multiple machining. It is particularly very suitable where correct positioning two joining shafts with flange couplings to align the shafts accurately is important and which otherwise would consume lot of time in marking etc.

II. MATERIALS AND METHODS

The material used in jig and fixture manufacture cover the whole range as features in modern engineering practice. The choice of material can only be made when the operating conditions are known as a designer must study the economics of the proposed layout. Following points must be taken in to account while deciding the material of jig and fixture:

1. The case with which the material can be purchased in the required size and shape. The often governs the method of manufacturing e.g., Casting, Welding or Bolting wrought metal section together.
2. Heat treatment and the size of the available furnace in relation to dimension of the largest part to be hardened,
3. The ability of the material to withstand the stresses to be expected when the equipment is placed in service.
4. The ability to retain both size and shape over a long period under the required service conditions. There should be little tendency for the article, when placed in use to distort, shrink or grow in size.
5. The article should be able to withstand unexpected impact loading and mal-treatment that many jigs and fixtures are subjected to when in the shop.
6. The resistance to wear in the various forms, so that accuracy over a long period.
7. Possess when required, the ability to clamp down vibrational stresses as maybe created by a no. of machining operations.
8. When a jig or fixture is to be handled frequently, the possibility of introducing one of the like metals should have careful attention.
9. The value of the material when regarded as crap, normally this point has to be scarified to those given above. The commonly used to jigs and fixtures are:
10.

2.1 Design Of Components

2.2 Calculation Of Machining Time

Component Material	=	M.S	
Recommended drilling speed for steel	=	24 – 45 m/min	(Ref. No.1)
Feed per revolution	=	0.1422 mm	
Drilled hole diameter	=	7/16 inches	(Ref. No. 2)

Speed for drilling 7/16 inches S i.e 0.4375 inches or 11.112 mm

We know that,

V = πDN/100 Choosing V = 35 m/min (Ref. No. 2)

N = 1000 x 35 / (π x 11.112)

= 1002.595

= 1003 rpm

Machining Time:

Time/hole = L(feed x rpm)

= (L1 + L2 + L3 + L4) / (feed x rpm) (Ref. No. 2)

= (15 + 3 + 3.224 + 6) / (0.14224 x 1003)

= 0.1908 min

= 11.449 Sec.

Therefore, for six holes

Total time for six holes = 6 x 11.449

= 68.69 sec.

L = Total drill travel.

L1 = total length of the whole drilled in work piece.

L2 = Clearance between drill bit and work piece.

L3 = Length of drill bit nose.

L4 = Drill travel below work piece.

2.3 Calculation Of Various Forces on Drill:

Component Material	=	M.S
Recommended drilling speed for steel	=	24 – 49 m/min
Drill diameter	=	7/16 inches
Drill made of material	=	high speed steel

Standard sizes of twist drill:

Diameter:

Decimal Equivalent = 0.04375 inches

Fractional = 7/16 inches

Length:
Short series
Overall = 512
Flute = 41/16
Long series
Overall = 71/4
Flute = 45/8
Therefore, selecting cutting speed = 35 m/min
We know that,

$V = \pi DN/100$ Choosing V = 35 m/min

$N = 1000 \times 35 / (\pi \times 11.112)$
$= 1002.595$
$= 1003$ rpm

To calculate torque (T):

$T = C\ Fm\ Dn$

Where, F = drill forward inches / rev
D = diameter of drill inches
m & n = Constant (m = 0.75, n = 1/8)
C = Constant depending on material (i.e 1800)

Diameter		**feed**
¼ to ½ inches	=	0.004 to 0.007 inches / rev
Choosing F	=	0.0056 inches / rev
Where F	=	Feed

Therefore,

Torque (T) = 1800 (0.0056) 0.75 x (0.4375) 1/8 (ref.no.3)
= 8.32 Ib.I
= 1.152 kg.m

Therefore T = Force x D/20

Force which exerted torque

$F = T/(D/2)$
$= 1.152 / (11.112 \times 2/1000)$
$= 207.1$ kg.

Therefore

Power required $P = 2\pi NT / 33000$
$= 2 \times \pi \times 1003 \times 8.32/33000$
$= 1.588$ HP

Comparing with standard value taken for practice

HP = 0.166 x 1003/100
= 1.664

Therefore, calculated HP within limit.

Drilling force required = 85 DS0.7

Where,

D = Diameter of drill in mm
S = feed of drill mm/rev
= 85 x (11.112)(0.1422)0.7
= 241.34 kg.

2.4 Actual Design

1. Design of power Screw:

Power is an important part of the drill jig which holds the indexing plate assembly rigidly during drilling operation, through jaws on nuts. Nuts slides on screw with help of L. H. and R.H. square threads on screw.

Let,

F - be the torsion force of the drill acting on each jaw.
F - 2071 N
Dc - be the diameter of screw.

ft & fs - be the tensile and shear stresses since similar pull cuts on each jaw in opposite direction the total tensile pull acting on threaded screw is

$W = 2F$

= 2 x 2071

= 4142 N

Let us check whether the induced stresses safe or not

W = $\pi/4$ (dc)2 x ft

From design data book we have

Permissible tensile stress (ft) = 100 N/mm2

And Permissible shear stress (fs) = 50 N/mm2

4142 = $\pi/4$ (20)2 x ft

Ft = $\frac{4 \times 4142}{\pi \times (20)2}$

= 13.18 N/mm2

Included stresses are less than permissible i.e. tensile stress value.

Hence the design is safe and we get

dc = 20mm

Now,

Outer dia. Of threads

(d0) = $\frac{dc}{0.8}$ = $\frac{20}{0.8}$ = 25m

Mean dia.= $\frac{d0+dc}{2}$ = $\frac{25+20}{2}$

= 22.5mm

Pitch (p)= d0 – dc

= 25 -20

= 5 mm

The screw also subjected to twisting moment, when we rotate screw by lever.

So, let us check the dimension for shear failure due to torsion.

Let,

T = be torque applied on screw for holding Indexing plate rigidly

α = helix angle of thread

ϕ = friction Angle

μ = Coefficient of friction, between screw and nut.

μ = 0.15

We have,

T = W tan (α + ϕ) d/2

Tanα = $\frac{P}{\pi\, d}$ = $\frac{5}{\pi \times 22.5}$ = 0.07

α = tan-1(0.07)

= 4

And μ = tanϕ

= tan-1μ

= tan-1(0.15)

= 8.53

T = W tan (α + ϕ) d/2

T = 4142 tan (4 + 8.53) x $\frac{22.5}{2}$

T = 10356 N-mm

Shear stress in the screw due to torque,

Fs = $\frac{T \times 16}{\pi \times (dc)2}$

= $\frac{10356 \times 16}{\pi \times (20)2}$

= 6.59 N/mm2

The induced shear stress is less than the given value. Therefore, the dimensions are safe i.e. design is safe.

2. Design Of Sliding Nut:

Nuts works as two movable jaws it has internal square thread and slider

Slider over sliding screw which has external square threads.

Threads are subjected to bearing pressure

Let, Pb - be the bearing pressure between screw and nut

n - be the no. of threads in contact

d0 - outer dia. Of threads

dc - core dia. Of nut threads

F - be torsional force of drill

W - be total load act on screw

$$Pb = \frac{W}{\pi/4(d02 - dc2)n}$$

$$= \frac{2F}{\pi/4(d02 - dc2)n}$$

$$15 = \frac{2 \times 2071}{\pi/4[(25)2-(20)2]\times 15}$$

$$= 1.56$$

For the stability of assembly use hence to take no. of threads in contact on minimum6

Then we can find the length of nut (L)

L = n x p

= 6 x 5

= 30 mm

Where,

p - pitch of thread = 5 mm

3. Design Of Base Plate:

Base plate supports all other parts and this base plate is supported by two supporting plates and forms a simply supported beam like structure.

The base plate subjected to two vertically downward loads.

Weight of the components mounted on it & including its self weight. Acting at the centre of the base plate.

Let, it be - W1

W1 - 15kg =150N

Drilling force acting at a distance of 50 mm from the centre of the base plate.

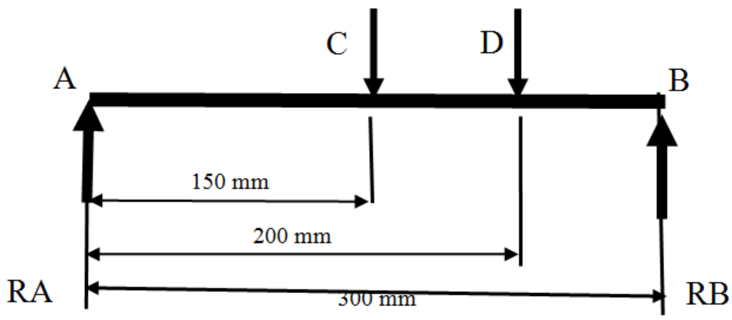
Let, it be - W2

W2 = 241.34 kg

= 2413.4 N

We have permissible tensile stress for M.S. = 300 N/mm2

Let the plate fail at Max B.M. point. The max B.M. occurs at the point of max load.



From above Figure,

We have,

RA + RB = 150 + 2413.4

= 2563.4 N

By taking moment about A

RB x 300 = 150 x 150 + 2413.4 x 200

RB x 300 = 505180

RB = 505180 / 300

= 1683.93

RB = 879.47 N

Then calculate the B.M.

The B.M. at A & B = 0

B.M. at C = RA x 150

B.M. at D = RB x 100

= 1683.93 N-mm

B.M. at C and B.M. at D shows that the B.M. is max at D.

Therefore,

Max. B.M. (M) = 168393 N-mm

Then,

We know,

fb = M/2

Where,

fb = Bending stress

M = be the max. B.M.

Z = section modulus

$= \frac{b \times t^2}{6}$

Where,

b = Breadth of plate

= 250 – 40= 210 mm

&t = Thickness of plate

Take t = 10 mm

Then we have,

fb = $\frac{168393}{[210\, x\, (10)^2]/6}$

fb = 48.112 N / mm2

fb is equal to the ft and we have ft is 300 N/mm2 which is greater than calculated value, therefore our design is safe.

4. Design Of Clamping Bolt:

Bolts are generally subjected to tension therefore for bolts M.S. is used. The permissible tensile stress value for M.S. is given 300 N/mm2.

Here, in drill jig clamping bolt is subjected to only initial tightening for holding rigidly the indexing plate assembly.

For general joint the internal tightening load is – 1420 x d

Where,

d - mean dia. Of bolt

do = 10 mm

dc = 0.8 x do

= 0.8 x 10

= 8 mm

d = $\frac{do+dc}{2}$

= $\frac{10+8}{2}$

= 9 mm

Initial tightening load = 1420 x 9

= 12780 N

Then Initial tightening load = π/4(8)2 x ft

12870 = π/4(8)2 x ft

ft = $\frac{12870 \times 4}{\pi \times (8)^2}$

= 254.25 N/mm2

The permissible tensile stress is 300 N/mm2 . Therefore our design is safe.

III. RESULTS AND DISCUSSION

1. The jigs and fixtures may be defined as device used in the manufacturing of the duplicate Flange coupling and to make possible interchangeable work at reduced cost, as compared with the cost of production each coupling detail individually.
2. To achieve the dimensional accuracies, interchangeability, high rate of production, eliminates marking of dimension on the work piece, less fatigue to the operator.
3. Widen the process capabilities of the machine.
4. Use of unskilled labor.
5. Less Rejection and lower cost per piece.
6. To drill the holes 2, 3,4,6,8 etc. on flange couplings at exact location with the help of indexing plate.

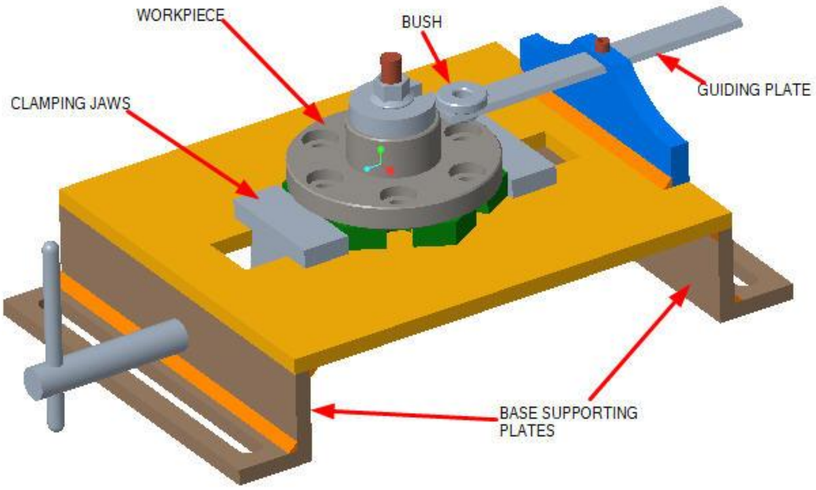


Figure 1: Drill Jig Assembly

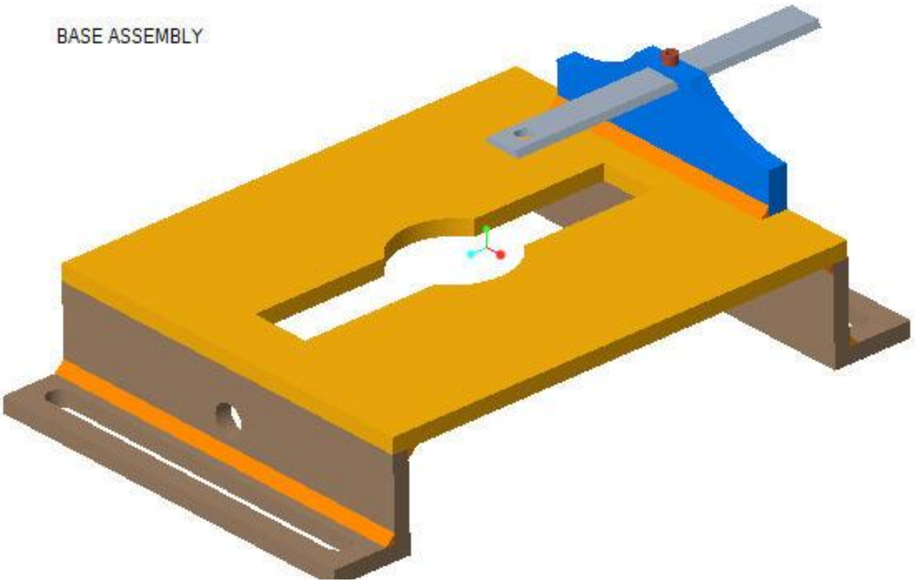


Figure 2: Base Plate Weldment Assembly

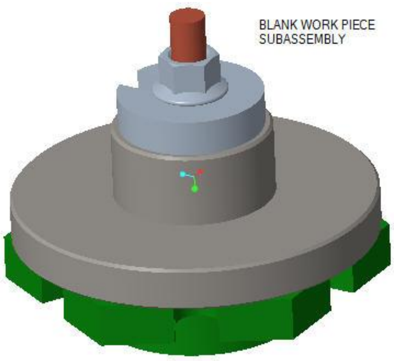


Figure 3: Blank Workpiece Subassembly

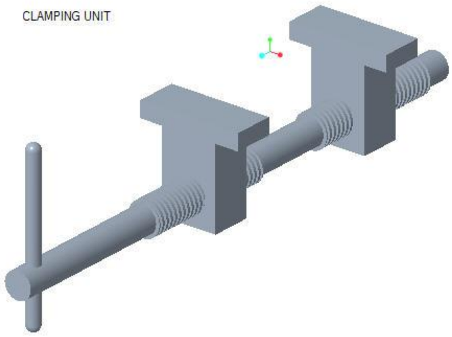


Figure 4: Clamping Unit Subassembly

Table 1: Accuracy of aerodynamic independent variables

Independent Variables	Accuracy
Position Of the holes on PCD	$\pm 1\%$
Angular velocity of Drill(ω)	$\pm 2\%$

IV. CONCLUSIONS

1. This is to conclude that during the test, the drill jig was able to drill holes at different PCD and number of holes 2, 3, 4, & 6 on work piece and it was found to be working properly.
2. No vibration effect due to the present of jig foot. Also Clamp screw and locating pin was served as support that hold the work piece to its proper position during drilling operations.
3. However, present of bushing enable the drill jig to maintain its life and also helps for proper positioning of the work piece.
4. In this project, we have made the jig of drilling machine of mild steel to provide proper support to work piece and ease the work handling.
5. By manufacturing of these jigs, we can reduce the setup time of raw material on machine.
6. By using this Drill jig we can reduce labor cost as unskilled or semiskilled person can work with this drill jig.

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Place any acknowledgements here.

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