Design and Optimization of Drill Jig

Mr. Premodh Leonarld[1], Mr. G.Jerome Nithin Gladson[2], Mr. Sunil Kumar A S
[1](Assistant Professor, Department of Mechanical Engineering, CSI College of Engineering, Ketti, The Nilgiris)
[2, 3] (Department of Mechanical Engineering, CSI College of Engineering, Ketti, The Nilgiris)

ABSTRACT

Tool design is the process of designing and developing the tools, methods, and techniques necessary to improve manufacturing efficiency and productivity. The main objectives of tool design are to lower the manufacturing cost while maintaining the quality and increased production by cutting down time between machining operations. Various parameters that forms the main criterion in the tool design are providing simple, easy-to-operate tools for maximum efficiency, reduction of manufacturing expenses by producing parts at the lowest possible cost, design of tools which consistently produce parts of high quality, increasing the rate of production with existing machine tools, design of tool to make it fool proof and prevent improper use, selection of materials that will give adequate tool life Tooling refers to the hardware necessary to produce a particular component. Tooling consists of a vast array of cutting devices, jigs, fixtures, dies and gauges used in normal production. A special attempt has been made to develop an adjustable type of drill bush, which can enhance for the holding of work piece with variable dimension.

***Keywords**: Tool Design, Adjustable drill bush, jig and fixture.*

I. INTRODUCTION

The Over the past century, manufacturing has made considerable progress. New machine tools, high-performance cutting tools, and modern manufacturing processes enable today's industries to make parts faster and better than ever before. Although work holding methods have also advanced considerably, the basic principles of clamping and locating are still the same. Jigs and fixtures form an important category of equipment that goes a long way in achieving productivity. A jig, however, guides the cutting tool. A fixture references the cutting tool. The differentiation between these types of work holders is in their relation to the cutting tool. As shown in Figure 1, jigs use drill bushings to support and guide the tool. Fixtures, Figure 1, use set blocks and thickness, or feeler, gages to locate the tool relative to the work piece.

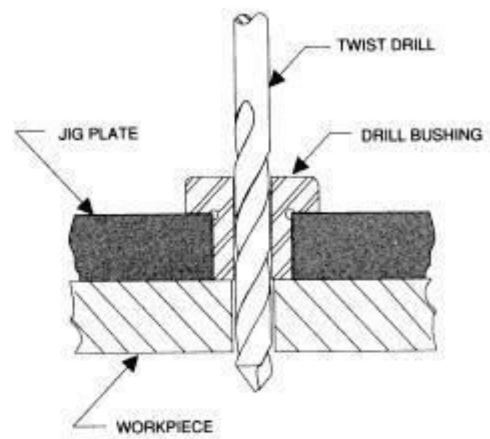


Fig 1: A Jig guides the cutting tool, in this case with a bushing

In the shop, drill jigs are the most-widely used form of jig. Drill jigs are used for drilling, tapping, reaming, chamfering, counter boring, countersinking, and similar operations. Jigs are further identified by their basic construction. The two common forms of jigs 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. The most-common open jigs are template jigs, plate jigs, table jigs, sandwich jigs, and angle plate jigs. Typical examples of closed jigs include box jigs, channel jigs, and leaf jigs.

II. DESIGN CONSIDERATIONS

The principal considerations when choosing among work holder varieties fall into three general categories: tooling cost, tooling details, and tooling operation.
The points that are taken into consideration for designing a product are as following:
a) Jig must be so strong that the deflection in the jig should be as less as possible. The deflection that is mentioned includes the forces of cutting, clamping of work piece to the machine table. The frame of the fixture should have sufficient mass to prevent vibrations during the machining of the job.

b) Another important design consideration is the clamping which should be fast enough and require less amount of effort.
c) Arrangement of clamps should be such that they are easily available. They should also have the arrangement for easy removal as well.
d) Is swinging of clamp system is provided for removal of work piece the clamp should swing as far as possible for unclamping the device.
e) There should also be provision for easy removal of chip. This will prevent the interference of the chip with the operation on the work piece i.e. cutting operation.
f) The clamps and support points which are to be adjusted in due course of time should be preferred of same size. It will be better if the clamps and adjustable support points can be operated from the front of the fixture.
g) If the surface area of clamping is more it damages the work piece. This can be avoided by making the surface area of clamping as small as possible.
h) As it is difficult to get spare parts during the operation so it is designed in such a way that they can be easily replaced on failure.
i) The study of the design should be done thoroughly before fabricating. It should always be ensured that the work is done in proper sequence. This will ensure zero loss of material. It should always be preferred that there is maximum operation in a single setting of the work piece.
j) The movement of the work piece is restricted i.e. there is zero degree of freedom of the work piece after clamping the work piece. Sharp corners and redundant locators must be avoided. One should try to maintain at least one datum surface.
k) The design must possess enough rigidity and robustness to prevent vibration else it may lead to undesired movement of the work piece and tools.

III. ESSENTIAL FEATURES OF JIGS AND FIXTURES

The jigs and fixture must satisfy the following conditions:
(i)Reduction of Idle Time:
The design of jigs and fixtures should be such that the process of loading and unloading the component takes the minimum possible time and enables on easy loading and clamping should be such that idle time is reduce to minimum.
(ii)Provision for Coolant:
The jigs and fixtures must have adequate arrangement for the cutting edges of the tools so that the tool is cooled and at the same time the chips produced are washed away, so that the operator does not have to waste time in adjusting the coolant flows and cleaning of the chips.
(iii)Hardened Surfaces:
All locating and supporting surfaces such as faces of locating pins should be hardened materials as far as conditions permit, so that they are not quickly worn out and their accuracy is retained for a longer time.
(iv)Safety:
The design of jigs and fixtures should be such that it should not constitute a danger to operator.
(v)Fool Proof:
Since the use of jigs and fixtures allows for the employment of unskilled workmen, the design of such equipment should be such that it would not permit the work piece or the tool to be inserted in any position other than the correct one.
(vi)Indexing Type of Jig:
These types of jigs are used to drill a series of holes in a circle, on the face of a work piece. The work piece is indexed and the next place the hole is to be drilled, comes under the jig bush, with the component clamp in one position of the jig, after each hole has been drilled there the single bush, etc. The work is indexed there 60 degree and the previously drilled hole located by the angular pin.

IV. CATIA MODEL

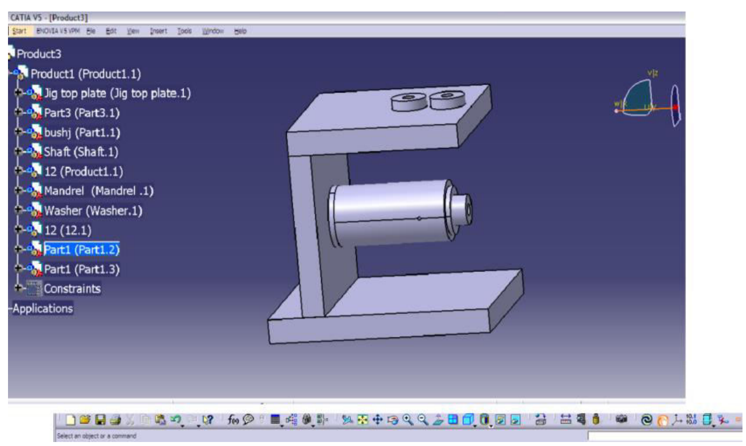


Fig 2: CATIA V5R20 Model of Assembled Drill Jig

V. CALCULATIONS

1) $Efficiency,\ \eta = \frac{Output\ power}{Input\ power}$

Where, Input Power = 1.5 kW
$\eta = 0.75$

i.e., Output power = 1.5 * 0.75

Output Power = 1.125 kW

2) *Output Power = Force × Velocity*

We know, Velocity, v = s × n

Where s = Feed in mm

n = Speed in rpm

Also, output power = 1.125 kW

Feed = 0.315 mm

Speed = 2700 rpm

i.e., $1.125 = F \times (0.315 \times 10^{-3}) \times (2700 / 60)$

1.125= F (0.0142)

Force, F = 777.2 N

F = 79.22 × 9.81

3) $Cutting\ Force = Ksc \times \frac{D \times s}{4}$

Where, Ksc = Specific Cutting Force, Assumed as 150 N

D = Diameter of the Mandrel equals to 10 mm

s = Maximum feed in mm

i.e., $C.F = 150 \times \frac{(10 \times 0.315)}{4}$

C.F= 118.125 N

4) *Torque = Force(cutting) × Distance*

Where, Cutting Force = 118.125 N

i.e., τ =118.125× 5

τ = 590.65 N

5) $Factor\ of\ Safety = \frac{Clamping\ Force}{Cutting\ Force}$

$= \frac{777.2}{118.2}$

= 6.57 ~ 6

F.O.S = 6.

VI. ANALYSIS OF DRILL JIG ASSEMBLY- MANDREL

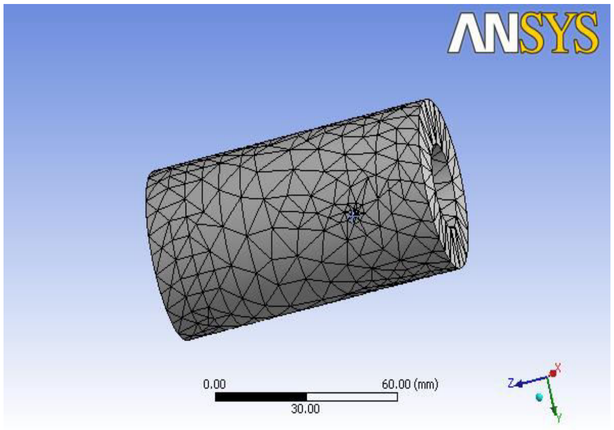


Fig 3: Drill jig component (Mandrel) - Meshed

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.

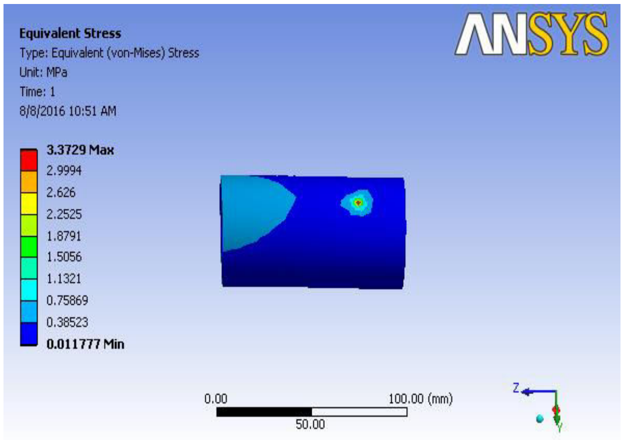


Fig 4: Drill jig component (Mandrel) – Equivalent Stress

Model > Static Structural > Solution > Results

Object Name	*Equivalent Stress*	*Total Deformation*
State	Solved	
Scope		
Geometry	All Bodies	
Definition		
Type	Equivalent (von-Mises) Stress	Total Deformation
Display Time	End Time	
Results		
Minimum	1.1777e-002 MPa	0. mm
Maximum	3.3729 MPa	4.9304e-004 mm

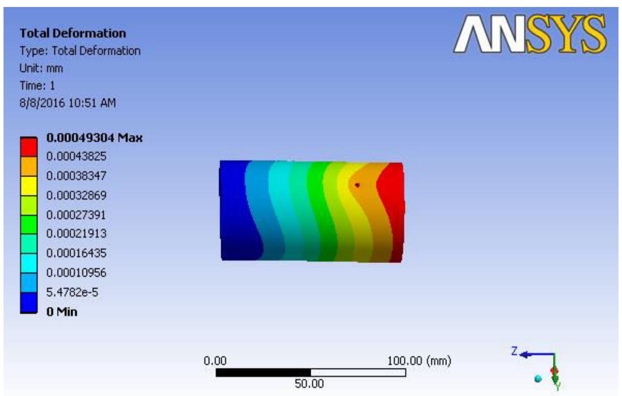


Fig.5 Drill jig component (Mandrel) –Total Deformation

Model > Static Structural > Solution > Probes

Object Name	*Force Reaction*
State	Solved
Definition	
Type	Force Reaction
Location Method	Boundary Condition
Boundary Condition	Fixed Support 2
Orientation	Global Coordinate System
Options	
Result	All

The Structural properties of the Mild Steels are listed below:

Structural Steel > Constants

Structural	
Young's Modulus	2.e+005 MPa
Poisson's Ratio	0.3
Density	7.85e-006 kg/mm³
Thermal Expansion	1.2e-005 1/°C
Tensile Yield Strength	250. MPa
Compressive Yield Strength	250. MPa
Tensile Ultimate Strength	460. MPa
Compressive Ultimate Strength	0. MPa
Thermal	
Thermal Conductivity	6.05e-002 W/mm·°C
Specific Heat	434. J/kg·°C
Electromagnetics	
Relative Permeability	10000
Resistivity	1.7e-004 Ohm mm

VII. DEFORMATION AND STRESS ANALYSIS OF MANDREL IN CATIA V5 R20

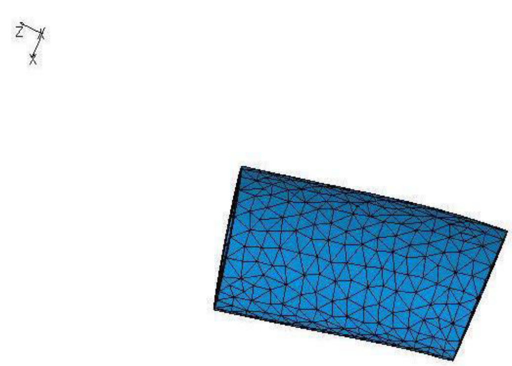
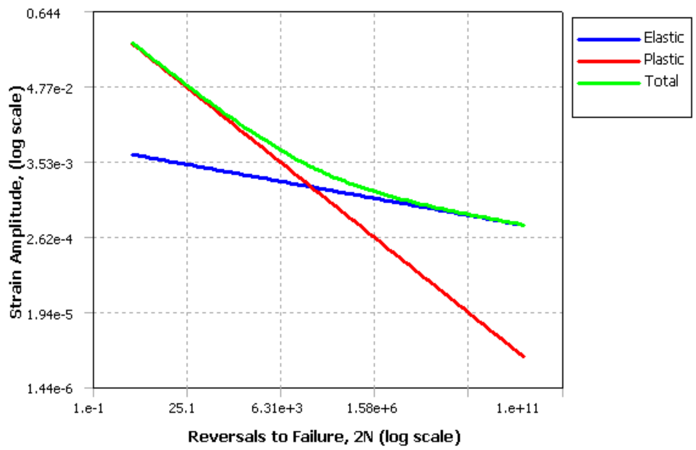


Fig 5: Deformation and Stress analysis of Mandrel in Catia V5 R20

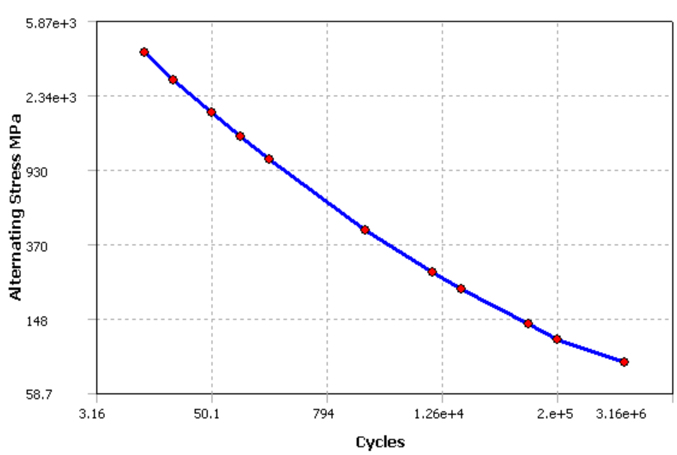
VIII. STRAIN-LIFE PARAMETER OF THE MANDREL



Structural Steel > Strain-Life Parameters > Strain-Life Parameters

Strength Coefficient MPa	920.
Strength Exponent	-0.106
Ductility Coefficient	0.213
Ductility Exponent	-0.47
Cyclic Strength Coefficient MPa	1000.
Cyclic Strain Hardening Exponent	0.2

IX. ALTERNATING STRESS CYCLE BEHAVIOUR OF MANDREL



Structural Steel > Alternating Stress > Alternating Stress vs. Cycles

Cycles	Alternating Stress MPa
10.	3999.
20.	2827.
50.	1896.
100.	1413.
200.	1069.
2000.	441.
10000	262.
20000	214.
1.e+005	138.
2.e+005	114.
1.e+006	86.2

From the above table, it can be clearly understood that 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 Stresses in the Nodal Solution indicate that the component as well as the assembly is reliable and safe under working conditions.

X. CONCLUSION

This report deals with the design and fabrication of drill jig and the detailed drawing of the component and assembly. The project carried out by us made an impressing task in drilling works. It is very useful industries for mass production of identical parts. Jigs are used to hold and locate the work piece that positions and guides or controls the cutting tool. In jigs, drill bush is used to guide the tool. In conventional jigs we can't change the diameter of drill bush. Main objective of this project is to vary the diameter of the drill bush based upon the application. Drill jig is used to ensure a hole to be drilled, tapped or reamed in the work piece at proper place. Jigs are generally used for mass production. Jig reduces operators fatigue and increases productivity. Jig consists of locating, clamping and tool guiding elements.

REFERENCES

[1] M. Donoldson.C and Others, "*Tool Design*", Tata McGraw Hill, 1978
[2] Kempster, "*Introduction to Tool Design and Jigs and Fixtures*", ELBS
[3] ASTME, *"Hand book of Fixture design"*
[4] Korsakov, *"Fundamental of Fixture Design"*, MIR Publication, Moscow
[5] Goroshkin.A.K., "*Jigs and Fixtures Handbook*", MIR Publication
[6] Colvin, F. H.; Haas, L. L. *Jigs and Fixtures: A Reference Book.* New York and London: McGraw-Hill Book Company.
[7] NBV Lakshmi Kumari, G.Prsasnna Kumar, "Design and Analysis of Indexing Type of Drill Jig",*IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 2 Ver. I (Mar - Apr. 2015)*
[8] P H Joshi, *"Jigs and fixtures"* Tata McGraw-Hill Education, 2010
[9] P. Stephen Antony Predeep , S. Sivason raja, C.Rammurugan, R.Senthil Kumar, "Optimizing the Method of Work Holding Device- Drill Jig with Adjustable Drill Bush", *IJIRSET, and ISSN (Online): 2319 – 8753, ISSN (Print): 2347 – 6710,Vol. 4, Special Issue 6, and May 2015.*
[10] Bralla, J. G, *Design for manufacturability handbook.* New York: McGraw-Hill, pg.4-56. ISBN 978-0-07-007139-1.