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Application of Conceptual Design for Modeling and Analysis of Leaf Jig

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Abstract*— Jigs are production-work holding devices used to manufacture duplicate parts accurately. Mass production aim at high productivity to reduce unit cost and interchangeability to facilitate easy assembly. Jig is used for locating, holding and guiding cutting tool during machining operation. Jigs are usually fitted with hardened steel bushing for guiding drills or other cutting tool. As a rule small jigs are not fastened to the drill press table. Jig reduces the operation time, increase productivity and high quality product can be produced. Jig can reduce non productive time during manufacturing process. Aim of this project is to design model and analysis of a leaf jig which is used for drilling purpose CAD model prepared using AUTOCAD and AUTO DESK INVENTOR. FEM analysis also carried out in AUTO DESK INVENTOR.

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***Index Terms*—Jig, Cad, Auto Desk Inventor, Productivity.**

I. INTRODUCTION

Mass production always pointing towards increasing quality and productivity. Generally jigs always increase repeatability avoiding marking, punching and checking in individual workpieces.Jigs are used to hold, locate the work piece and also guide cutting tool in correct position.

Aim of a jig is to increase the productivity in manufacturing. Jigs are provided with tool guiding elements such as drill bushes .These directs the tool to the correct position on the work piece. Jigs are rarely clamped on the machine table because it is necessary to move the jig on the table to align the various bushes in the jig with the machine table. Jigs mainly consist locating element clamping element and tool guiding devices. Locating element accurately maintains dimensional and positional relationship between the work piece and cutting tool. Locator is the device which is used for that purpose. Clamping devices are used to securely hold the position of the part against the locator throughout the machining cycle.

Various solid modeling packages are available in order is to easy model the Jig. Auto Desk inventor is a basic level software package available. 2D and 3D design of the milling fixture make easy understand for various functions of each components of a fixture.

The structural analysis was carried out in AUTODESKINVENTOR whose result helps to examine the design.

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II. METHODOLOGY

Methodology is the most important element to be considered to make sure the fluent of the project and get expected result. In other words methodology can be described as a frame work where it contains elements of work based on objectives and scope of the project. A good frame work can get overall view of the project and get the data easily. This includes literature survey 3D modeling of jig analysis and application of flow process chart.

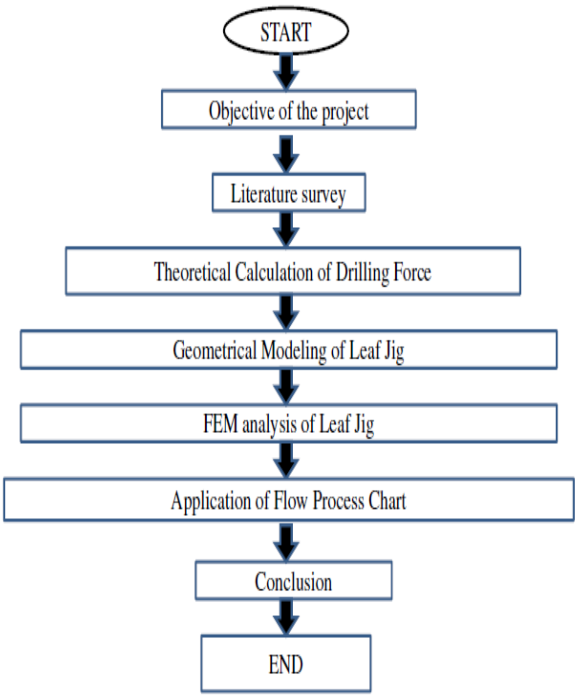

Fig: 1 Methodology

III. LITERATURE REVIEW

A. Main Parts of Jig

Tool Guiding Elements: Tool guiding elements help in guiding the tools in correct position with respect to the work piece. Drill bushes guide the drills accurately to the work piece.

Locating element: Locating element is used to locate the work piece correct relationship with cutting tool.

Clamping element: Clamps are used to hold the work piece against locating surface and prevent all disturbing forces.

Fool proofing element: Fool proofing element prevent work being loaded wrongly in the fixture.

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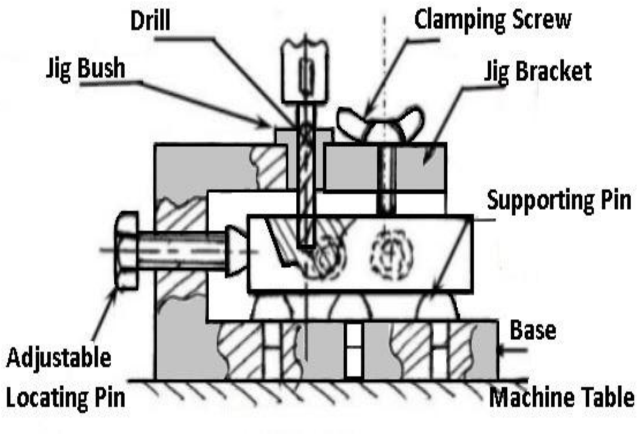

Fig: 2 Part of Jig

B. Principles of Location

1. Location has to meet dimensional requirements of the work piece stated on the component drawing.
2. Location should be done on the most accurate surface of the work piece
3. Location should prevent linear and rotary motion of the work piece along and around the three major axes X ,Y and Z
4. Location should facilitate easy and quick loading of the work piece in the fixture.
5. Redundant or duplicate location should be avoided
6. The location should positively prevent wrong loading of the piece in a fixture by fool proofing.

C. Principles of clamping

1. Clamp should be position to direct the clamping force on strong part of the work piece.
2. Clamping system does not obstruct the path of loading and unloading the work piece.
3. Clamp should not obstruct the path of cutting tool.
4. Clamping system should be capable of holding the work piece securely against the force developed during operation.
5. Clamping force does not bend or damage the work piece with excessive pressure.
6. Clamp can be tightened or loosened manually without using spanner.
7. Clamps are operated from front of operator
8. Consider operator fatigue.
9. Simple clamps are always preferred than complicated clamps
10. When cam or wedge clamp are used the designed in such a way that clamp should tightened due to vibration.

D. 3-2-1 Principle

An unrestricted object is free to move in any of twelve possible direction as shown in figure .An object is free to revolve around or move parallel to any axis in either direction.

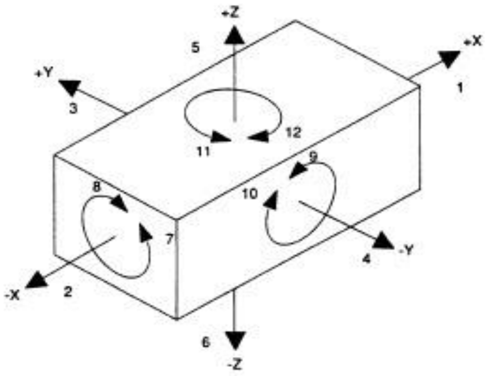

Fig: 3 Twelve degree of freedom

To accurately locate a part in a fixture movement must be restricted. This is done locators and clamp. By placing the part on a three –pin base, five direction of movement (9, 10, 8, 7 and 6) are restricted.

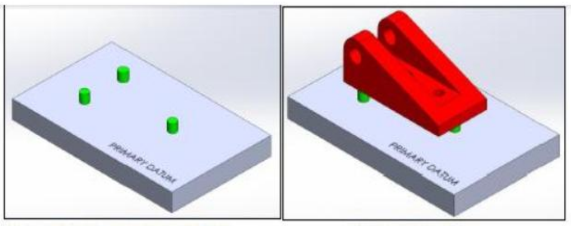

Fig: 4 Primary Locations

To restrict the movement of the part around the z-z-axis and in direction (11 and 12) and direction along three two more pin are located as shown in figure

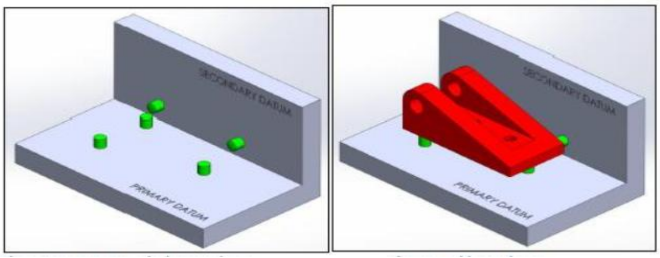

Fig: 5 Secondary Locations

To restrict direction two a single pin locator is used as shown below

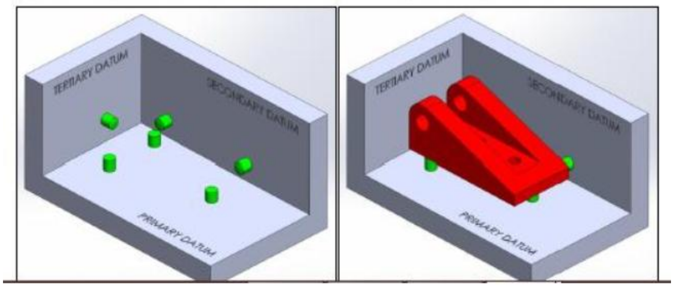

Fig: 6 Tertiary Locations

The remaining five one and four are restricted by a clamping device.

E. Types of locator

***1.* Flat Locator:** Flat locators are used for location of flat machined surfaces of the component.

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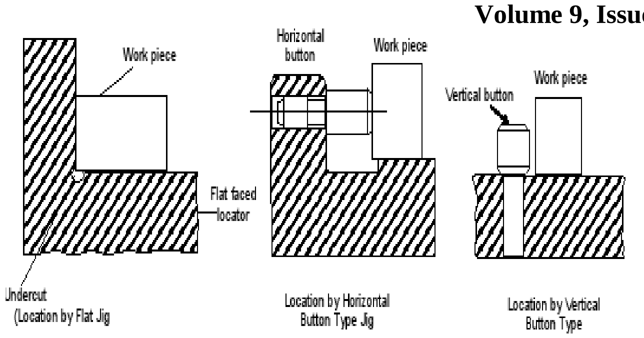

Fig: 7 Flat locator

2. Cylindrical Locators: A cylindrical locator is is used for locating components having drilled hole.

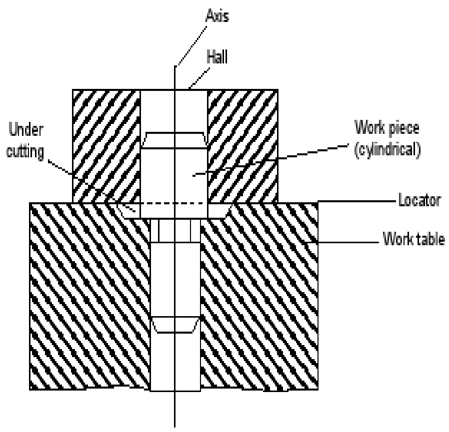

Fig: 8 Cylindrical Locator

3. Conical Locator: This is used for locating the work pieces having cylindrical hole in the work piece. The work piece is found located by supporting it over the conical locator inserted into the drilled hole of the work piece. A conical locator is considered as superior as it has a capacity to

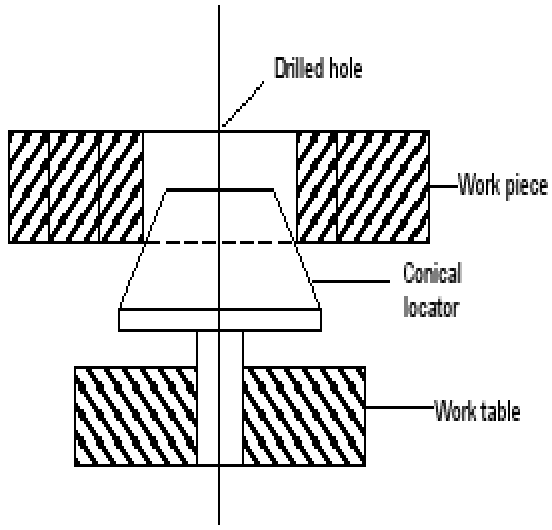

Fig: 9 Conical locator

4. Jack Pin Locator: Jack pin locator is used for supporting rough work pieces from the button. Height of the jack pin is adjustable to accommodate the work pieces having variation in their surface texture. So this is a suitable method to accommodate the components which are rough and un-machined.

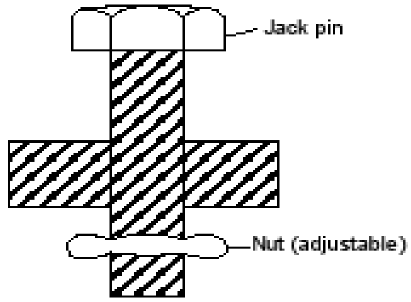

Fig: 10 Jack pin locator

5. V Locators: This is quick and effective method of locating the work piece with desired level of accuracy. This is used for locating the circular and semi-circular type of work pieces.

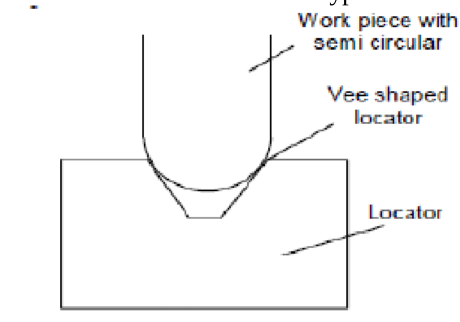

Fig: 11 V locator

F. Types of Clamps

1. Strap Clamp: They are made of rectangular plate and act like lever. The clamp is tightened by rotating a hexagonal nut on a clamping screw.

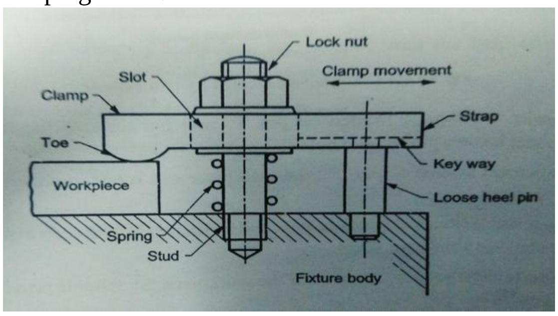

Fig: 12 Strap Clamp

2. Screw Clamp: It is also known as clamp screw. This clamping applies pressure directly on the side faces of the work piece. The clamping pressure largely depends on the work piece. it varies from one work piece to other. It is more time consuming and more efforts are required.

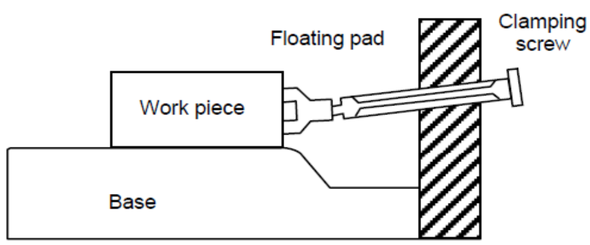

Fig: 13 Screw Clamp

3. Latch clamps are used to clamp the work piece; the clamping system is normally locked with the help of a latch provided. To unload the work piece the tail end of the latch is

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pushed that causes the leaf to swung open, so releasing the work piece. Here time consumed in loading and unloading is very less as no screw is tightened but clamping pressure is not so high as in other clamping devices

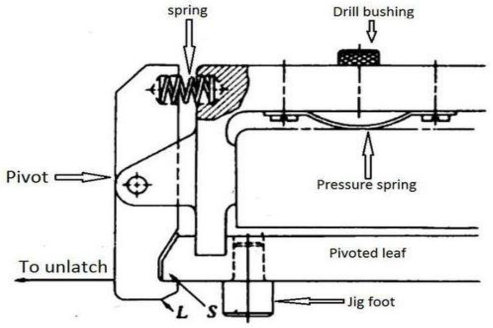

Fig: 14 Latch Clamp

4. Equalizing Clamps: It is recommended to apply equal pressure on the two faces of the work. The pressure applied can be varied by tightened or loosening the screw provided for the purpose.

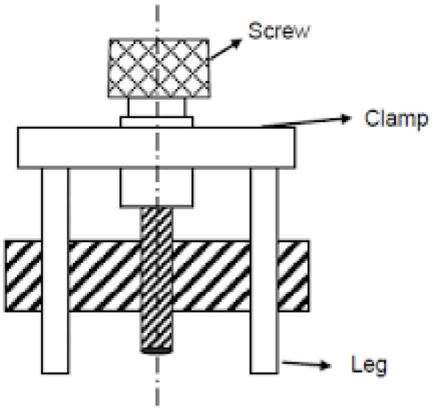

Fig: 15 Equalizing Clamp

G. Jig design consideration

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

(b) Frames should be built from simple sections so that frames can be fastened with screws or welded, whenever necessary. Those parts of the frame that remain intact with the jig may be welded. The parts needing frequent changing may be held with the screws. Where the body of jig or 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 work piece. (g) All locators, 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 jig.

(j) Work piece should be stable when it is placed in jig. 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 work piece

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

(m) Support points and other parts are designed in such a way that they can be easily replaced on failure.

H. Material Used in Jig

a) High speed steel:

- These are used mainly for cutting tools such as drill, reamer and high milling cutters.
- These can be oil or air hardened to 66 RC. 18% tungsten to 22% tungsten. HSS also contains 4.3% chromium, 1.6% vanadium and less quantities of carbon, molybdenum.

b) Die Steel :

- These are used mostly for dies for hot or cold working. Cold die steels are used for press tools
- Cold die steels are used for press tools.
- Hot die steels are used for extrusion, forging and die-casting dies which are subjected to high temperature due to hot working.

c) Carbon Steel :

- These can be used for standard cutting tools.
- This steels can used for drill bushes, locators and other parts which are subjected to wear and need to be hardened.

d) Collet steels :

- These are spring steels which contain 1% carbon, 0.5% manganese and less quantity of silicon, collet steels can be oil/ water hardened to 47 RC

e) Non- shrinking tool steels :

- These steels are used widely for fine, intricate press tools.
- This is also called as high carbon 1 to 2 % of carbon or high chromium (4 to 12 %) steel.
- These steels distort little during heat treatment.

f) Nickel chrome steel :

- Used mainly for gears these steels contain 3 to 4% nickel, 0.6 to 1.1% chromium and less quantities of carbon, silicon and manganese.

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- These can be case hardened to 61 to 63 RC. Alloy steels En 36 falls under this category.

g) High tensile steels:

- Used for mainly fasteners such as high tensile screws, these contain 0.4 to 0.6% manganese.
- These can be oil hardened to 45 to 50 RC steels En 9 is high tensile steel.

h) Mild Steel :

- Used for most of the parts in fixtures, mild steels contain less than 0.3% carbon and 0.1 to 0.8% manganese steels.
- Generally all the parts which require no hardening are made of mild steel because it is the cheapest material available among steel

i) Cast Iron :

- Used for add shapes to some machining and laborious fabrication, CI usage require a pattern for casting.
- It can withstand vibration well and very suitable base bodies of milling fixtures.
- Self-lubricating properties of cast iron make it suitable for machine slide and guide way.

J) **Phosphor Bronze:**

- When screw operated clamps are worn out the screw as well as the nuts need to be replaced.
- Generally screw are longer and costlier then nuts.. So nuts are made of phosphor bronze which has high tensile strength.

IV. IMPLEMENTATION

Conceptual design through geometrical modeling, design and analysis, CAD/CAE tools, drafting through 2D and 3D software. Documentation and storage through data base management.

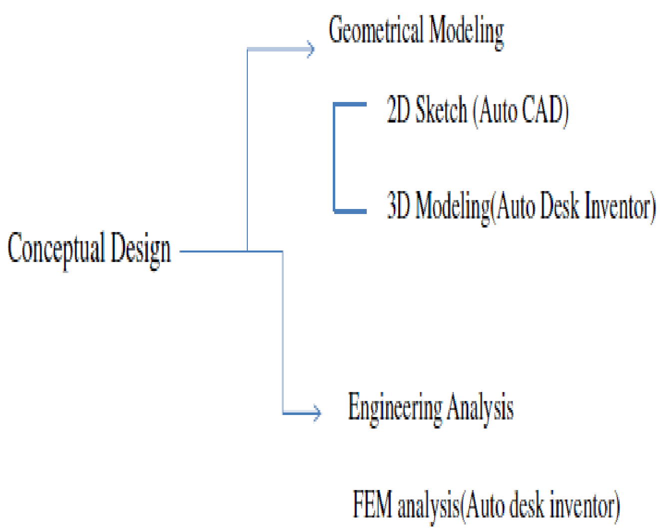

Fig: 17 Conceptual design

- ***Component Drawing***

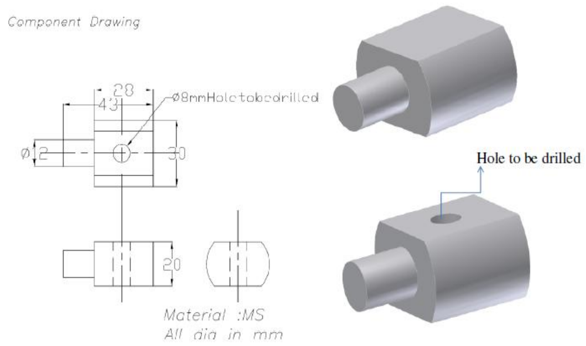

Fig: 16 Components Drawing

- ***Theoretical Calculation of Drilling Force***

Cutting speed

Cutting Speed $V = \frac{\pi d N}{1000}$

d diameter of drill=8mm

N Rpm=800 rev/min

$V = \frac{3.14 x 8 x 800}{1000} = \underline{20.09 m/minute}$

Power at the spindle= $\frac{1.25 x D^2 x K x N x (0.056+1.5s)}{100000}$

K= material factor=1.07

D=Dia of drill=8mm

N =Rpm=800rev/Min

$= \frac{1.25x8x8x1.07x500x(0.056+1.5x0.5)}{100000}$

$= \underline{0.344 KW}$

Transmission efficiency=80%

Power of motor = Power at spindle/Transmission efficiency

= 0.344/0.8

= 0.43KW

Torque = (975xP)/N

= (975x0.43) /800=$\underline{5.13 Nm}$

Thrust =$1.16 x K x D x (100 x S)^{0.85}$

S=Feed=0.5 mm/rev

$=1.16x1.07x8x(100x0.5)^{0.85} = \underline{120N}$

- ***Geometrical Modeling of Leaf Jig***

Wire Frame Modeling

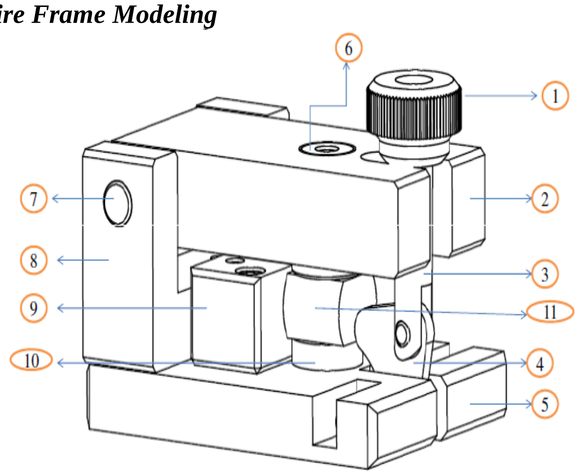

Fig: 19 Wire Frame Modeling of Leaf Jig

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Table 1: Bill of Material

Bill of Material

Sl No	Description	Qty	Material	Size	Remark
1	Locking Nut	1	MS	φ45X25	
2	Jig Plate	1	MS	30X70X145	
3	Cam Actuating Rod	1	MS	φ16X81	
4	Cam	1	C40	6X36X40	40-45HRC
5	Bottom Plate	1	MS	20X110X145	
6	Jig Bush	1	HcHcr	φ30x38	60-62HRC
7	Dowel Pin	1	STD	φ14X90	
8	Support Plate	1	MS	35X66X110	
9	Locating Plate	1	EN24	30X30X70	40-45HRC
10	Support Bush	1	C40	φ30X28	40-45HRC
11	Component	1	MS	φ30X43	
12	SHCS	2	STD	M6X35	
13	SHCS	2	STD	M8X25	
14	Dowel Pin	2	STD	Φ8x43	

Wire Frame Modeling (Orthographic)

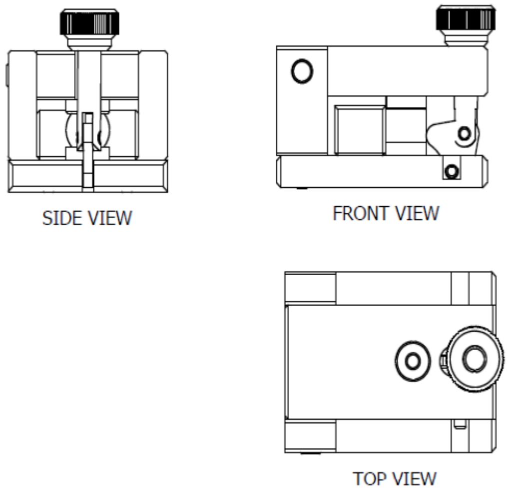

Fig 17: Wire Frame Modeling (Orthographic)

Solid Modeling of Leaf Jig - Isometric View

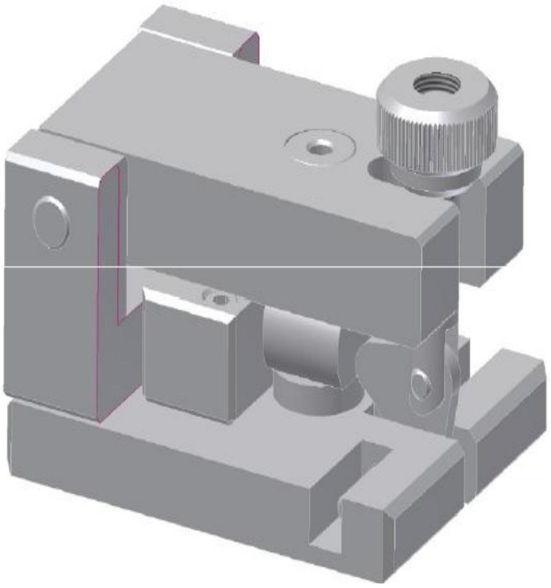

Fig 18: Solid Modeling of Leaf Jig

Solid Modeling of Leaf Jig –Ortho Graphic View

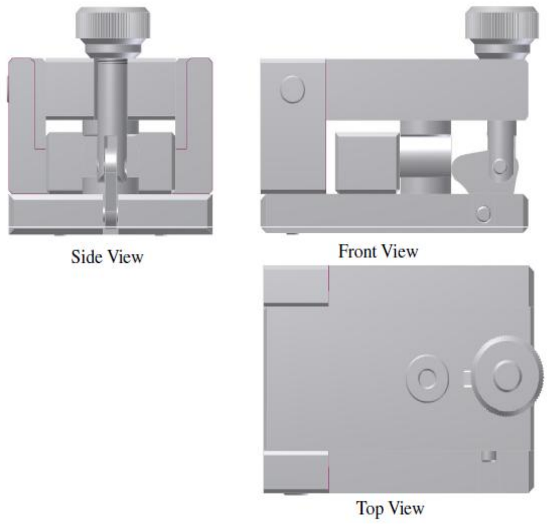

Fig 19: Solid Modeling of Leaf Jig-Ortho Graphic

Solid Modeling of Leaf Jig –Leaf Open

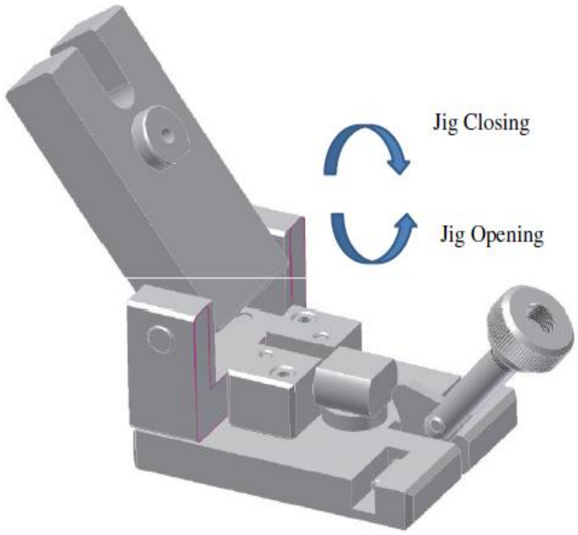

Fig 20: Solid Modeling of Leaf Jig-Leaf Open

Solid Modeling of Leaf Jig –Exploded View

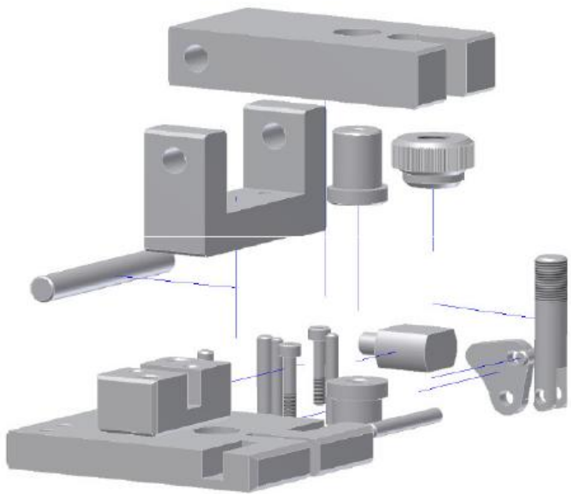

Fig 21: Solid Modeling of Leaf Jig-Exploded View

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Part Drawing

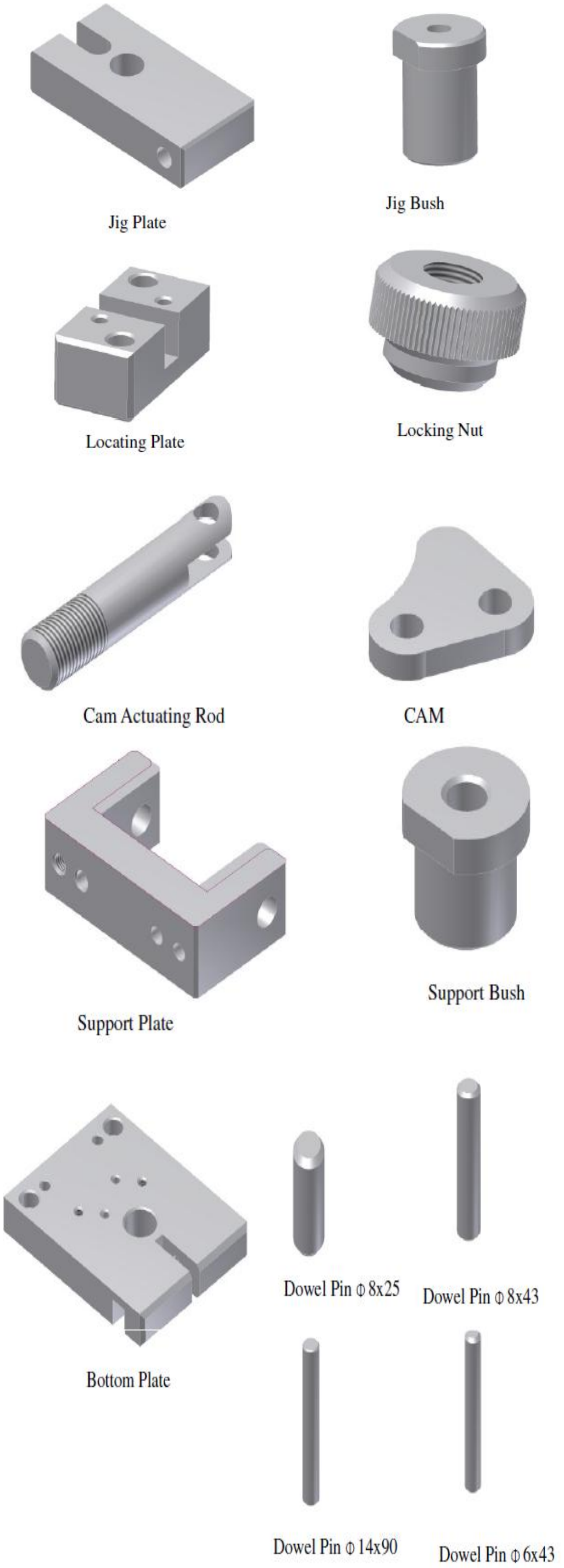

Fig 22: Solid Modeling of Leaf Jig-Parts of Jig

- ***Design Consideration***

Locating Principle

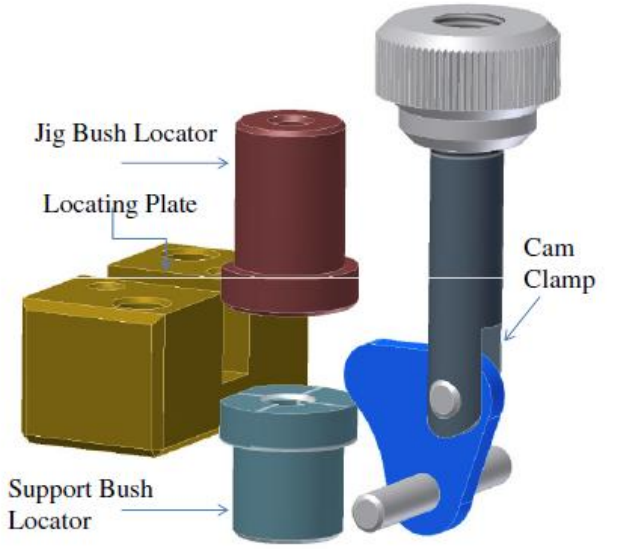

Fig 23: Locator and Clamp

Application: 3-2-1 Principle

Arrest 12 degree of freedom of a work piece

Step 1: Using Locating plate and Support Bush

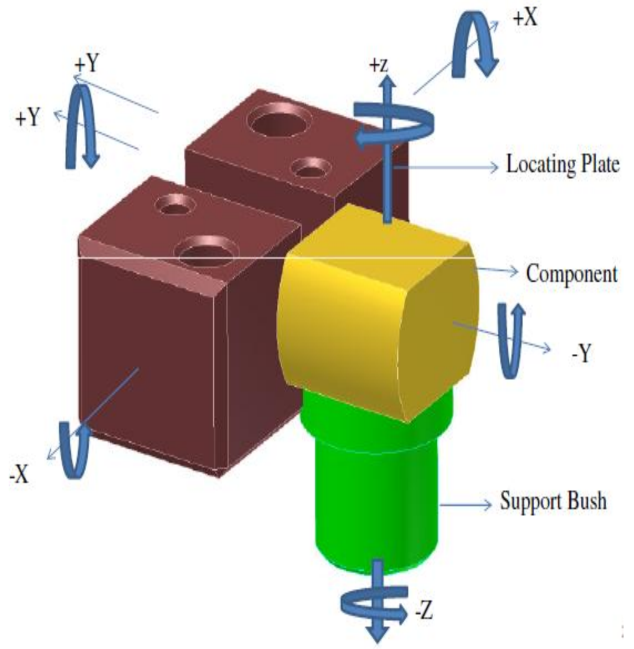

Fig 24: 3-2-1 Principle Stage One

Total Degree of freedom arrested=10

Rotation around Y axis =2(Clock wise and Anti clock wise)

Linear movement along –z direction=1

Linear movement along +Y axis=1

Rotation around Z axis =2(Clock wise and Anti clock wise)

Linear movement along X axis=2(Both positive and negative direction)

Rotation around X axis =2(Clock wise and Anti clock wise)

Step 2: Using Guide bush

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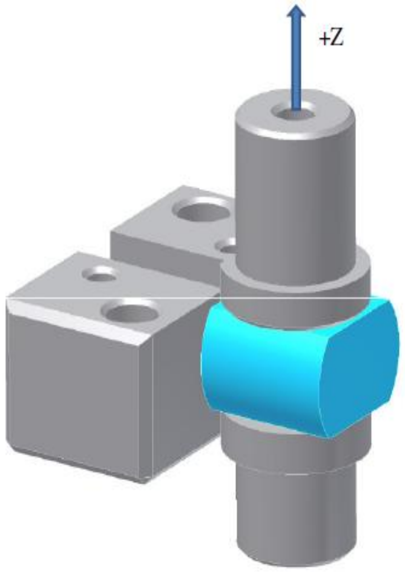

Fig 25: 3-2-1 Principle Stage Two

Total degree of freedom arrested=1
Movement along positive z axis
Step 3: Using Cam Clamp.

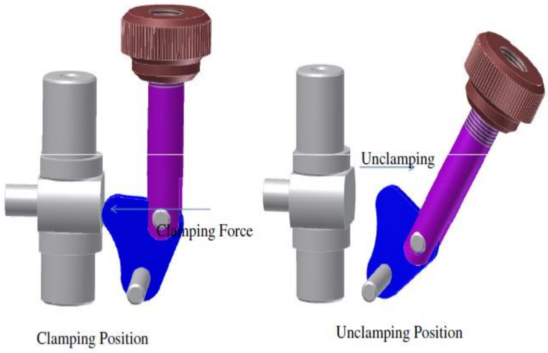

Fig 26: 3-2-1 Principle Stage Two

Fool Proofing Method

In order to ensure the part will fit in to tool only in its correct position. Locating surface also act as a fool proofing device

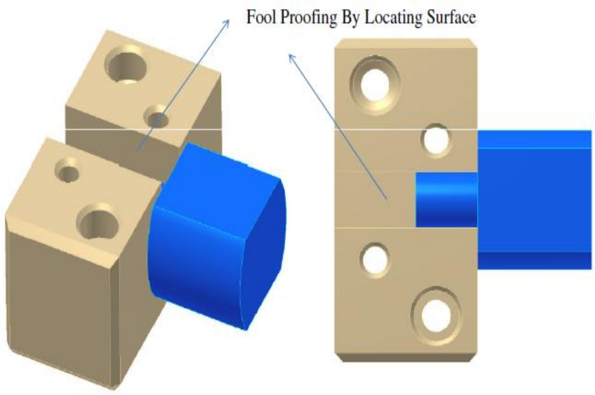

Fig 27: Fool Proofing

➢ ***Structural Analysis of Leaf Jig***

FEM analysis using Auto Desk Inventor

Analysis of Jig bush

Analysis against drill torque 5.13Nm

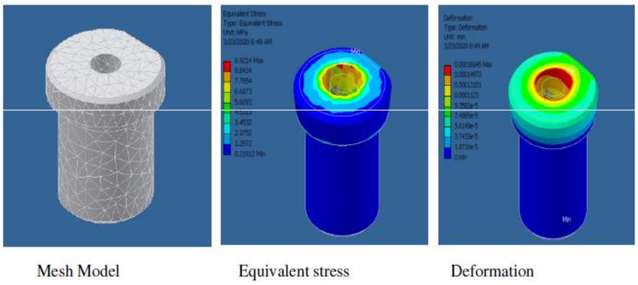

Fig 28: Analysis of Jig Bush

Equivalent stress Max: 9.9214Mpa

Deformation Max: 0.00016845 mm

Analysis of component locating element and cam clamp

Analysis against axial thrust 120N

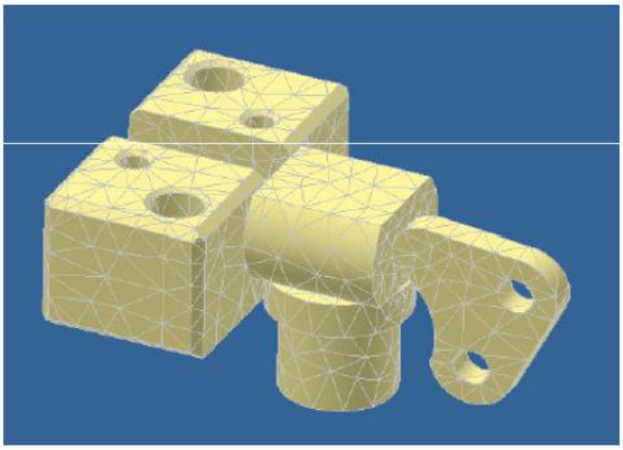

Fig 29: Mesh Model

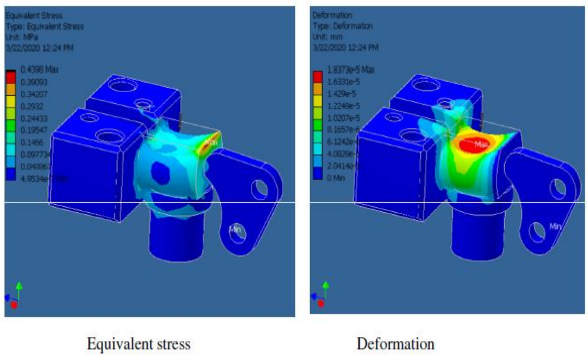

Fig 30: Equivalent Stress and Deformation

Equivalent stress Max: 0.4398Mpa

Deformation Max: 1.8373e-5 mm

➢ ***Application of Flow Process Chart***

Flow process chart gives the sequence of flow work of a component. The events are recorded in the flow chart using appropriate symbols. Material type process chart record what happen to material.

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Fig 31: Before and after Drilling Operation

Table 2: Flow Process chart without Jig

Flow Process Chart with out Jig

CHART NO:SHEET NO:1	SUMMARY	PRESENT	REPOSE	SAVING
ACTIVITY: Drilling without Jig	OPERATION ○	5		
LOCATION:	TRANSPORTATION ⇨	4		
PREPARED DATE:	INSPECTION □	2		
APPROVED DATE:	DELAY D	0		
OPERATOR:	STORAGE ▽	0		
SUPERVISOR:	DISTANCE			

DISTANCE	TIME	SYMBOL	DISCRIPTION
	1minute	●	Work Piece Receiving
	1minute	⇨	Move to Inspection
	2minute	■	Inspection
	1minute	⇨	Move to Marking and Punching
	5minute	●	Marking and Punching
	1minute	⇨	Move to drilling machine
	5minute	●	Locating and clamping
	3minute	●	Drilling Operation
	2minute	●	Releasing Part
	1minute	⇨	Move to Inspection
	5minute	■	Final Inspection
	27 minute	5 4 2 0 0	

Table 3: Flow Process chart with Jig

Flow process Chart with Jig

CHART NO:SHEET NO:1	SUMMARY	PRESENT	REPOSE	SAVING
ACTIVITY: Drilling with Jig	OPERATION ○	4		
LOCATION:	TRANSPORTATION ⇨	3		
PREPARED DATE:	INSPECTION □	2		
APPROVED DATE:	DELAY D	0		
OPERATOR:	STORAGE ▽	0		
SUPERVISOR:	DISTANCE			

DISTANCE	TIME	SYMBOL	DISCRIPTION
		●	Work Piece Receiving
		⇨	Move to Inspection
		■	Inspection
		⇨	Move to Drilling Machine
		●	Setting Work Piece in Jig
		●	Drilling Operation
		●	Releasing Part
		⇨	Move to Inspection
		■	Final Inspection
		4 3 2 0 0	

V.CONCLUSION

Since time has become precious today industrial enviroment.It is necessary to save valuable time by all possible way. By using Jig data from flow process chart for drilling holes without jig total activity will be 11 and with jig it is reduced to 9. Process time will be reduced and productivity increased.

VI.FUTURE WORK

After developing leaf jig time study can be conduct there by determine increase in productivity. Also can develop man type process flow chart record the activities of an operator related to particular drilling operation.

REFERENCES

[1] Ali, M. and Mahalle, G. (2013). Design and analysis of weight lever drilling jig. International Journal of Pure and Applied Research in Engineering and. Technology 1(8): 177-186.

[2] Midhun.R, Vignesh.A,Design and Fabrication of Jigs and Fixtures for Drilling Operation, International Journal for Scientific Research & Development| Vol. 3, Issue 12, 2016 | ISSN (online): 2321-0613

[3] Guohua Qin, Weihong, Zhang Min Wan "Analysis and Optimal Design of Fixture Clamping Sequence ASME for publication in the JOURNAL OF MANUFACTURING SCIENCE AND ENGINEERING, 2006.

[4] P H Joshi, "Jigs and fixtures" Tata McGraw-Hill Education, 2010 Edward Hoffman "Technology & Engineering" Cengage Learning, 21-Aug-2003

[5] Cyril Donaldson, V. C. Goold Machine-tools -Tata McGraw-Hill Education, 1976

[6] Tool Engineering and Design by G R Nagpal. Dhanpathrai Publications, 2006.

[7] Jigs and Fixture non- standard clamping devices by Hiram E. Grant. TMH, 2008.

[8] Jigs and Fixture Design by Hamad Mohammed Abouhenidi proposed on international journal of scientific and engineering research, volume5, issue2, February 2014: ISSN2229-5518.

[9] The Design and Need for jigs and fixtures in manufacturing by Charles chkiwendu okpala, Ezeanyim okechukwu c.. Science research. Vol3, No.4, 2015, pp-213-219.doi: 10.11648/j.sr.20150304.19.

[10] Design and analysis of work holding fixture by Shivaji popat Mengawade, Vaibhav banker, Pratik p.. IJSRD, vol.4, issue 06, 2016.ISSN:2321-0613.

[11] Multipurpose Jig & Fixture by Prof. Mr. Sangale Prabhakar S, Mr. Bidgar Ganesh Shivaji, Mr. Sangale Nagesh Mahadev, Mr. Ahire Swapnil Suresh, Mr. Lad Atul Ajinath. IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 12, 2017 | ISSN (online): 2321-0613

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