Design of Machining Fixture for Support Bracket

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Abstract: This Project presents the Design of Machining Fixture for Support Bracket for Machining on VTC (Vertical Turning Centre). Fixture Design consists of High product rate, low manufacturing operation cost. The fixture should be designed in such-a-way that part/product change overtime is very less. The report consists of study of input data from customers like Part drawing and Assembly drawing. The fixture design begins with part modeling, Machining and Analysis of various parts in the fixture assembly using AutoCAD and Solid works, for a analysis ANSYS Software package is used. The actual design begins with study details of project proposal summary from customer. After that machining fixture concept is done. Locating and clamping points are decided. This also includes accessibility, loading and unloading sequence of parts, required material for this fixture is selected, and Fixture is designed at HMT MACHINE TOOL, KALAMASSERY using Industrial application standards. Locating accuracy and machined part quality tested and found that the fixture is as good as any dedicated fixture in production.

Keywords: Fixture design, vertical turning centre, solidwork, ansys. Accuracy and production.

1. INTRODUCTION

This project is intended to design and develop a machining fixture for the support bracket. Machining fixture requires systematic design to clamp, hold the work-piece during machining process. Using the design data and geometry of the component fixture is designed to hold the part with less time for loading and unloading the part

In HMT plant manufacturing of the support bracket is done on four machines like Centre lathe, Radial drilling machine, Horizontal milling machine and Slotting machine. In this project we replace the four machines into one VTC machine. Thus it will increase production rate about 50% and reduce the labour cost and power consumption rate. By this method we maximize profit of company.

1.1 Elements of Fixtures:

Five considerations are important, of which the first two are common to both jigs and fixtures, the third applies to jigs only, and the last two only to fixtures.

a) Location b) Clamping c) Guidance d) Setting of cutters e) Securing to the machine table

1.2 Advantages of jigs and fixtures:

a) Productivity: Jigs & Fixtures eliminate individual marking, positioning and frequent checking. This reduces operation time and increase productivity.

b) Interchangeabilit**y:** Jigs & Fixtures facilitate uniform quality in manufacture. There is no need for selective assembly. Any part of the machine would fit properly in assembly and all similar components are interchangeable.

c) Skill Reduction: Jigs & Fixtures simplify locating and clamping of the work pieces. Tool guiding elements ensure correct positioning of the tools with respect to the work pieces. There is no need of skillful setting of the work piece or

tool. Any average person can be trained to use Jigs & Fixtures. The replacement of a skilled workman with unskilled labor can effect substantial saving in labor cost.

d) Cost Reduction: Higher production, reduction in scrap, easy assembly and savings in labor costs results in substantial reduction in the cost of work pieces produced with Jigs & Fixtures.

1.3 Material used:

Jigs and fixtures are made from a variety of materials some of them can be hardened to resist wear. It is sometimes necessary to use non-ferrous metals like Phosphor Bronze or Brass to reduce wear of mating parts or Nylons or Fiber to prevent damage to the work piece.

Mild steel: It is the cheapest and most widely used material in Jigs & Fixtures. It contains less than 0.3%C. Steel En 2 falls in this category. This steel can be case hardened to 56 HRC. It is used to make parts which are not subjected to wear and not highly stressed. .

High Tensile Steels: These can be classified into medium carbon steels with 0.45-0.65%C (En 8, En 9) and alloy steels like En 24 (40Ni2Cr1Mo28).The tensile strength can be increased up to 125 kg/mm2 by tempering.

Case Hardening Steels: These can be carburized and case hardened to provide 0.6-1.5 mm thick, hard exterior (58-62 HRC). 17Mn1Cr95 steels with 1%Mn and 0.95%Cr is widely used for locating pins, Rest pads etc. These steels are suitable for parts which require only local hardness on small wearing surfaces.(Ex: En 353, En 36).

Cast Iron: It contains 2-2.5%C. As it can withstand vibrations well, it is used widely in milling fixtures. The ingenious shaping of a casting and the pattern can save a lot of machining time. Nodular CI is as strong as MS while Meehanite castings have heat resistance, wear resistance and corrosion resistance grades.

Nylon and Fiber: These are usually used as soft lining of clamps to prevent denting or damage to work piece under high clamping pressure. Nylon or Fiber pads are screwed or stuck to mild steel clamps.

2. LITERATURE REVIEW

A literature search is performed to understand the fixture-workpiece systems. Much research has been done regarding fixture-workpiece systems. These studies give a great insight into various fixturing schemes. However, these studies lack the focus on theturning process. N.P.Maniar and D.P.Vakhariya[1] have introduced the proposes direction for future research of fixture. In his paper Basic requirements of fixture, phases of fixture design, Dedicated and modular fixtures, Flexible mechanical fixtures, locating and clamping consideration, Fixture design process and computer aided fixture design have explained very well for the Design and Development of Fixture.R.D.Makwana and N.D.Gosvami[2]have study is about the 3-2-1 principle of fixture design and the different approaches which are used in the related fixture design are explained. ShaileshS.Pachbhai and LaukikP.Raut[3] details to minimizing workpiece deformation due to clamping and cutting forces is essential to maintain the machining accuracy, different Steps of fixture design, study of Elements of Fixtures and different types of locator and clamping Tom Zacharia and M.S. Steve [4] The design requirements of the fixture were studied and cutting forces were calculated. Strap clamp which is convenient to use the fixture at different machine beds is designed and modeled. Fixture models were developed in 3D modeling softwares.

3. FIXTURE DESIGN FOR SUPPORT BRACKET

For making the machining fixture design it is required to study in detail about the component for which fixture is designed and customer requirements.

3.1 customer requirement:

a. The requirement is a machining Fixture.

b. Five components loading at a time.

c. Loading and unloading of part using hand and it shouldn't foul with either machine elements or fixture elements.

d. Fool proofing while loading component. Write-up of Interchangeable elements. Machining Accuracy should be within 50 microns.

3.2 component description:

The component is support bracket used in offset printing machine. Support bracket is correcting the position feed paper. It is made up with aluminium alloy 4055 b grade.
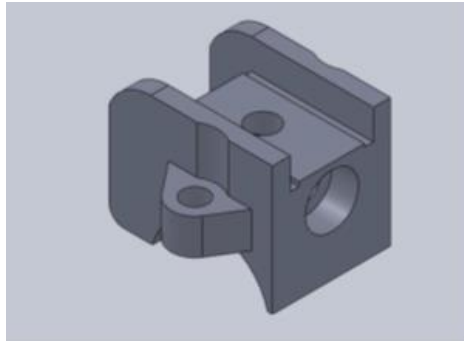
Operation are boring, drilling, milling.

Fig. 1, Support bracket using in printing machine

Table. 1: Material properties of aluminium alloy

Material	Elongation (%)	Tensile Strength (MPa)	Yield strength (MPa)	Temperature coefficient ($^oF^{-1}$)	Melting point (^oF)	Thermal conductivity (W/mk)
Al alloy	11 - 30	89.6-572.3	34.5-53.3	13.1-13.4	1190-1205	167-210

3.3 Solid Modeling:

A solid model is a digital representation of the geometry of an existing or envisioned physical object. Solid models are used in many industries, from entertainment to health care. They play a major role in the discrete-part manufacturing industries, where precise models of parts and assemblies are created using solid modeling software or more general computer-aided design (CAD) systems. The solid modeling technology is implemented in dozens of commercial solid modeling software systems, which serve a multi-billion dollar market and have significantly increased design productivity, improved product quality, and reduced manufacturing and maintenance costs (Requicha, 1988; and Rossignac, 1992). Solid modeling impacts a great variety of design and manufacturing activities. Examples include early sketches, design decisions, space allocation negotiations, detailed design, drafting, interactive visualization of assemblies, maintenance process simulation, usability studies, engineering changes, reusability of design components, and analysis of tolerances (Requicha, 1993).

Fixture Assembly:

This subassembly is made of different parts of which many are standard items used for particular application. The main parts of this assembly are as follows:
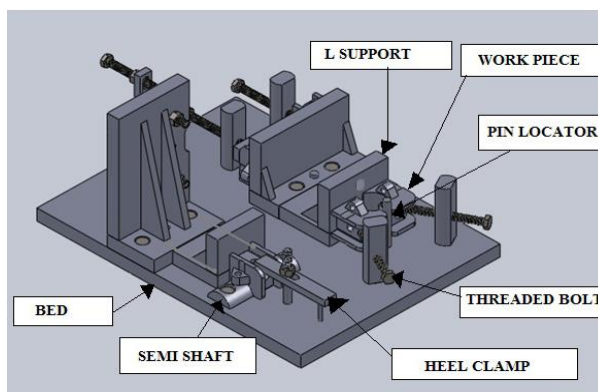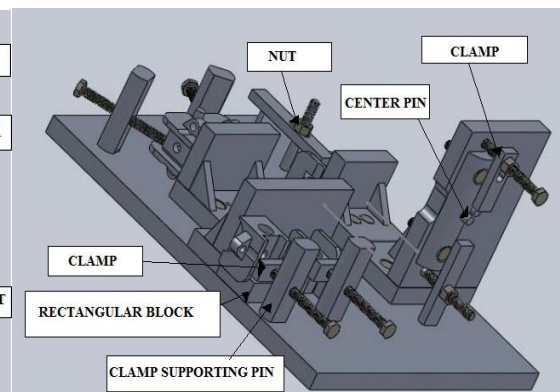

Fig. 2a Isometric view VTC Fixture   **Fig. 2b Isometric view VTC Fixture**

Main elements of fixture:

1.L support,   2.heel clamp,   3. semi shaft   4. pin locator   5.center pin   6.rectangular block

7.bed   8.Support pin,   9.Tenon,   10.nut   11.Hex soc head cap bolt.

12.clamp supporting pin

4.   CALCULATION

4.1 Boring operation:

Available Data:

Component Material: Al Alloy

Hardness = 190 – 220 BHN

BoringDia = Ø40 mm

Max Boring Depth = 40 mm

Feed rate, f = 0.2 mm

Specific cutting force, k_c= 500 N/mm^2

Spindle speed, n = 1500 rpm

D = final diameter mm

d = initial diameter mm

Cutting depth,

a_p=(D-d)/2   = (30-25)/2 = 2.5 mm

Cutting cross section

 A = a_px f x z = 2.5 x 0.2 x 1 = 0.50 mm^2

Cutting force

 F_C = A xk_c = 0.50 x 500 = 250 N

Cutting torque

M_C = F_Cx(d_m/2)

Where d_m= averagediameter in metres

 = 250 x 0.0275/2 = 3.44 Nm

Cutting power

P_C = (2 x π x n x M_c)/60s = (2 x π x 1500 x 3.44) / 60 = 540.35 N

Required clamping force = cuting force x factor of safety = 250 x 2 = 500 N

Design is safe

4.2 Drilling operation:

Available Data:

Component Material: Al Alloy

Hardness = 190 – 220 BHN

Speed (N) = 1300 rpm

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Drill Dia = Ø10 mm

Max Drill Depth = 7 mm

Feed per Revolution = 0.04 -0.06 mm/rev

Notations Used

kWs – Spindle Power, kW

TF – Thrust Force, N or kgf

Cutting Speed Calculations(V):

V = π x D x n / 1000

    = π x 2.5 x 1300 /1000 = 10.21 m/min

Material factor, k = 0.55

Spindle Power:

N = 1.25 x D^2 x k x n (0.056 + 1.5 x s) / 105   = 1.25 x $(10)^2$ x 0.55 x 1300 x (0.056 + 1.5 x 0.04) /105   = 0.1036 kW

Torque:

 T = 975 x N/ n = 975 x 0.1036/1300 = 0.0777 kgf = 0.762 N

Thrust Force:

TF = 1.16 K D $(100 \text{ x } s)^{0.85}$

    = 1.16 x 0.55 x 10 x $(100 \text{ x } 0.04)^{0.85}$ = 20.73kgf = 203.35 N

Required clamping force = cuting force x factor of safety

                        = 203.5 x 2 = 207 N

4.3 Milling operation:

Available Data:

Component Material: Al Alloy

Cutting Tool: Side and face tool

Cutting Speed, (n) = 3000 rpm

Cutter Dia, (D) = Ø100 mm

Width of Cut, (b)= 10 mm

No of Teeth, (Z) = 2

Feed(S) = 1000 mm/min

Speed Calculations (v):

V = πDn/1000 m/min = πx100x3000/1000 = 942.48 m/min

Feed/Tooth (S_z)

S_z= S/(Zx Speed) = 1000/(2x3000) = 0.17mm/tooth

Feed per minute (S_m)

S_m = S_z x Z x n = 0.17 x 2 x 3000 = 1020mm/min

Material removal rate (Q)

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$Q = b \times d \times S_m / 1000 = 10 \times 1 \times 1020/1000 = 10.2$ cm^3/min

Where b = width of cut

d = depth of cut

S_m= Feed /min.

Unit power: U = 2.4 kW / cm^3 / min

Correction factor for flank wear (Kh): = (1.10-1.25)

Correction factor for radial rake angle (Kr): = 0.87

Radial rake angle: = 20 degrees

Power at the spindle (N)

N = U x Kh x Kr x Q KW = 2.4 x 1.15 x 0.87 x 10.2= 24.5 kw

Power at the motor (Nel)

Nel = N /E = 24.5/0.8 = 30.6 kw

Tangential cutting force (Pz)

P_z = 6120 x N / V kgf = 6120 x 24.5 / 942.48 = 159.7 kgf= 1567 N

Required clamping force = cuting force x factor of safety

= 1567 x 2 = 3134 N

4.4 Drilling operation:

Available Data:

Component Material: Al Alloy

Hardness = 190 – 220 BHN

Speed (n) = 1500 rpm

Drill Dia = Ø18 mm

Max Drill Depth = 9 mm

Feed per Revolution = 0.04 mm/rev

Cutting Speed Calculations (V)

V = π x D x n/ 1000 m/min = π x 18 x 1500 /1000 = 84.82 m/min

Material factor: k = 0.55

Spindle Power

N = 1.25 x D^2 x k x n (0.056 + 1.5 x s) / 10^5 = 1.25 x (2.5) 2 x 0.55 x 1500 x (0.056 + 1.5 x 0.04) /10^5 = 0.38 kW

Torque

T = 975 x N/ n = 975 x 0.38 /1500 = 0.247 kgf = 2.42 N

Thrust Force

Tf = 1.16 K D (100 x s)$^{0.85}$kgf = 1.16 x 0.55 x 18 x (100 x 0.04)$^{0.85}$ = 37.31 kgf = 366 N

Required clamping force = cuting force x factor of safety

= 366 x 2 = 732 N

5. SIMULATION RESULTS AND DISCUSSION

Table.2, Material properties

Carburized low carbon steel	
Density	7.85e-006 kg mm^{-3}
Coefficient of Thermal Expansion	1.2e-005 C^{-1}
Specific Heat	4.34e+005 mJ kg^{-1} C^{-1}
Thermal Conductivity	6.05e-002 W mm^{-1} C^{-1}
Resistivity	1.7e-004 ohm mm
Gray cast iron	
Density	7.2e-006 kg mm^{-3}
Coefficient of Thermal Expansion	1.1e-005 C^{-1}
Specific Heat	4.47e+005 mJ kg^{-1} C^{-1}
Thermal Conductivity	5.2e-002 W mm^{-1} C^{-1}
Resistivity	9.6e-005 ohm mm

5.1 analysis of boring part of fixture:

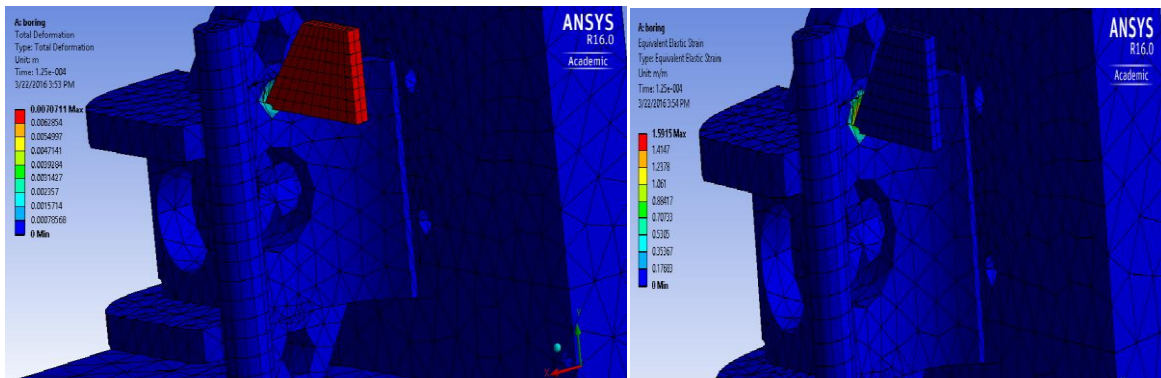Fig .3a: Displacement Plot   Fig. 3b: von mises strain plot

Fig.3a shows the variation of von mises strain. The max value of von mises strains is (1.5915) and is developed where there is maximum load. The value of von mises stress is less, where there is minimum load. Fig.3b shows the variation of resultant deformation. The max value of resultant deformation is 7.0711e-003 and is developed where there is maximum load.

5.2 analysis of drilling part of fixture:

Fig .4a: Displacement Plot   Fig. 4b: von mises stress plot
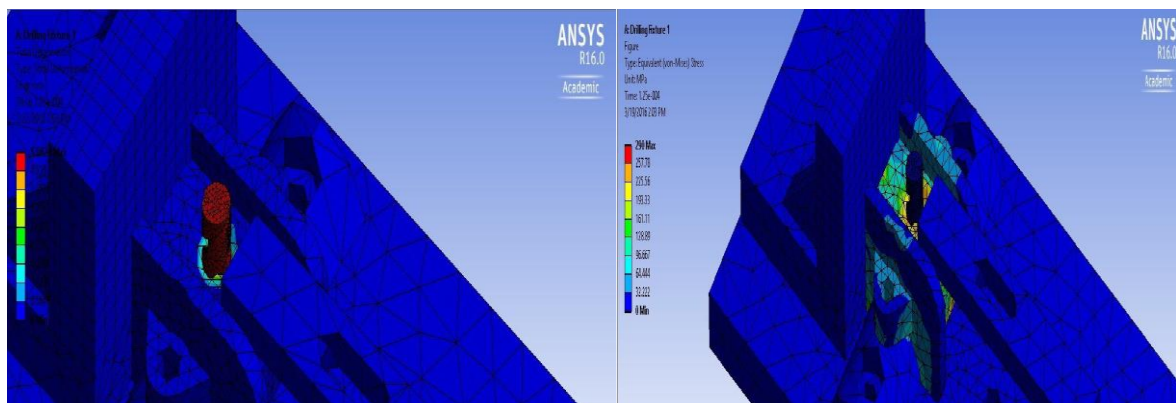
Fig.4b shows the variation of von mises stress. The max value of von mises stress is (5.5e+008) and is developed where there is maximum load. The value of von mises stress is less, where there is minimum load. Fig.4a shows the variation of

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resultant deformation. The max value of resultant deformation is 5.0828 mm and is developed where there is maximum load.

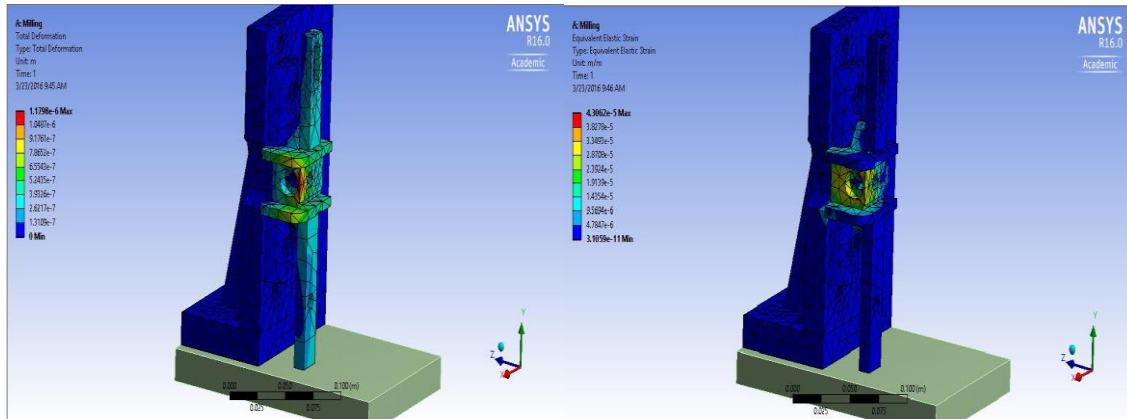### 5.3 analysis of milling part of fixture:

| Fig .5a: Displacement Plot | Fig. 5b: strain plot |

Fig. shows the variation of von mises stress. The max value of von mises stress is (8.62e+007) and is developed where there is maximum load. The value of von mises stress is less, where there is minimum load. Fig.7.12 shows the variation of resultant deformation. The max value of resultant deformation is 1.1798e-006 m and is developed where there is maximum load. The variation of equivalent strain. The max value of equivalent strain is 4.3062e-005 m/m and is developed where there is maximum load. The value of equivalent strain is less, where there is minimum load

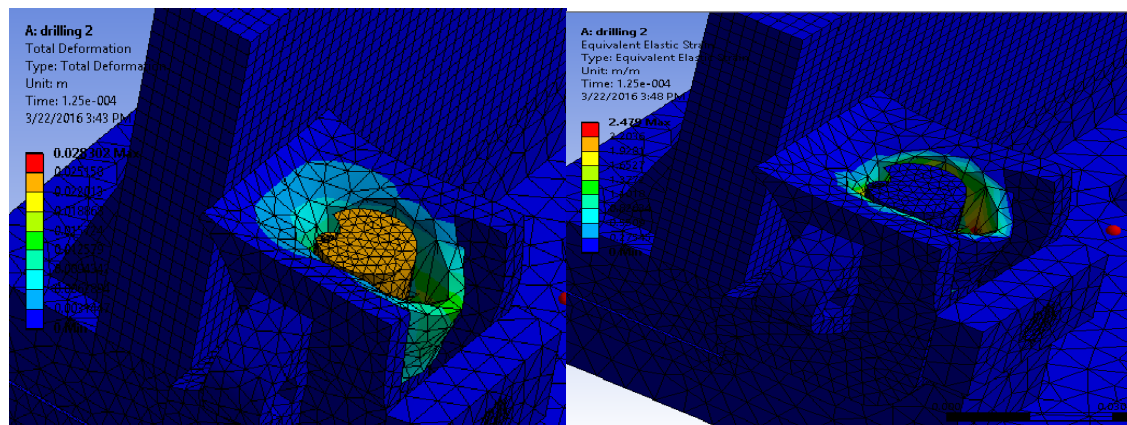### 5.4 analysis of drilling part of fixture:

| Fig .6a: Displacement Plot | Fig. 6b: strain plot |

Fig. shows the variation of von mises stress. The max value of von mises stress is (5.5 e+008) and is developed where there is maximum load. The value of von mises stress is less, where there is minimum load. Fig.7.15 shows the variation of resultant deformation. The max value of resultant deformation is 2.8302 e-002 m and is developed where there is maximum load. The variation of equivalent strain. The max value of equivalent strain is 2.479 m/m and is developed where there is maximum load. The value of equivalent strain is less, where there is minimum load.

6. CONCLUSION

The fixture is successfully designed and manufactured at HMT MACHINE TOOL LIMITED, KALAMASSERY, ERNAKULAM leading manufacturers of printing machine. The following are the results obtained while designing and from tryout of the fixture. This project proves utility of VTC in fixture design in three different ways: (i) reduces cycle time, (ii) reduces operator fatigue and increases productivity and (iii) reduces wear and tear of fixture components.

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