Design and Development of Jig and Fixture for Tacho Bracket

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Abstract - *A fixture is a work holding device or supporting device used in manufacturing industry. Using jigs and fixtures improves the economy of production by allowing smooth operation and quick transition from part to part, reducing the requirement of skilled labor. In conventional method, to carry out different operations like milling, drilling, boring, etc, on Tacho Bracket component, the component is needed to move from five different setups of five different machines such as VMC, RDM, VMC, RDM and HMC respectively which takes more loading unloading time. So, in this paper we are aiming to combine these operations and carry out the process within two setups of two different HMCs by designing a new fixture which will reduce the cycle time by considerable amount.*

***Key Words*: Fixture, Loading unloading time, VMC, RDM, HMC, Cycle time, Tacho Bracket.**

1. INTRODUCTION

The successful running of any mass production depends upon the interchangeability to facilitate easy assembly and reduction of unit cost. Mass production methods demand fast and easy methods of positioning work for accurate operations on it. Jigs and fixtures are production tools used to accurately manufacture duplicate and interchangeable parts. Jigs and fixtures are specially designed so that large numbers of components can be machined or assembled identically and ensure interchangeability.

1.1 TACHO BRACKET

Figure-1.1 Front & Rear Side of Component

Tacho bracket is the vertically symmetric component & is used in the automobile sector. It is used in the assembly of rear leaf spring of heavy duty vehicles.

The material used for Tacho bracket is SG (Spheroidal Graphite) Iron. It is a type of cast iron that has been treated while molten with an element such as Magnesium or Cerium to induce the formation of free graphite as nodules.

The dimensions of the component are 730.00 x 593.50 x 431.50 (in mm). The component weights 61.163 kg. The operations to be carried out on this component are milling, boring, grooving, drilling, etc.

1.2 STUDY OF PROCESS

The operations on the casting component are carried out mainly on 5 different machines. The details are as shown below:

1.2.1 VMC Setup:

In this first setup, component is rested on the bore part and is clamped to the fixture by using manual swing clamps. Here, milling is done on the central bore and on the horizontal B-section. After this operation, boring is carried out which is followed by profile turning and grooving.

1.2.2 RDM Setup:

Here, the component is rested on rear side by using the bore part as a locator. On this machine, counters drills are done on horizontal B-section. The number of counter drills is 20, i-e, 10 on each side.

1.2.3 VMC Setup:

Once the counter drills are done, the front side is rested and fixture used is hydraulic fixture in this VMC. Here, miiling is done on rear side of horizontal B-section and bore.

1.2.4 RDM Setup:

The counter drilled part on B-section now drilled completely on RDM setup.

1.2.5 HMC Setup:

In this setup, the extended flange on back side of component and also C-section present in the base of component need to be machined. For this, component is rested again on bore using bore locator in HMC and then the section undergoes milling operation on flange and C-section. This is followed by drilling 6holes in flange and the throughout hole in C-section.

1.3 PROCESS SHEET (OLD)

This whole process can be studied with time required for each operation in following process sheet:

TABLE-1.3 Process Sheet (Old)

SR NO.	MACHINE	PARAMETER	RAW MTRL. SIZE	FINISHED SIZE (MM)	NO. OF CUTS (MM)	DEPTH OF CUT	RPM	TOOL MTRL	IDLE TIME (S)	PROC. TIME (S)
1	VMC	Milling(front)	14.8,226.8	14.4,226.4	2	0.2	1200	HSS	120	355
		OD turning	20.46	20.0	1	0.46	250	HSS		51
		Boring	128.0,118.0	127.8, 117.8	2	0.1	700	Carbide		372
		Grooving	222.0	221.0	2	0.5	1800	HSS		308
2	RDM	Head counters	12	11	2	5	1800	HSS	120	120
3	VMC	Milling(back)	14.4,226.4	14.0,226.0	2	0.2	1200	HSS	120	355
4	RDM	Drilling	-	-	1	8.5	1800	Carbide	180	416
5	HMC	Milling	22.4	22.0	2	0.2	700	HSS	120	190
		End Milling	23.4	23.0	2	0.2	600	HSS		78
		Drilling(flange)	-	-	2	7.5	1800	Carbide		89
		Drilling(C-shape)	-	-	-	10.5	1500	Carbide		147
										TOTAL TIME=47.71(Min)

The total time required for single component to undergo required machining process is 47min 7sec. With this time, in one shift 28 such components are machined. This process sheet shows that more time is consumed in loading and unloading of component.

1.4 SCOPE TO REDUCE CYCLE TIME

1) The maximum surface area of the component to be machined should be available.
2) Loading and unloading of component should be effortless but accurate.
3) Pneumatic or Hydraulic clamping can avoid spanners and reduce operator fatigue.
4) Parallel locators can be preferred for easy loading unloading.

2. CAD DESIGN OF NEW FIXTURE

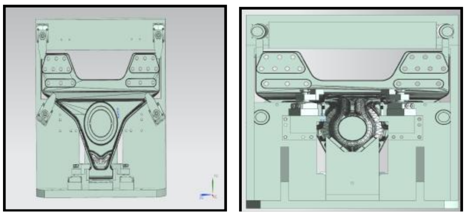


Figure-2.1 Front View & Rear View

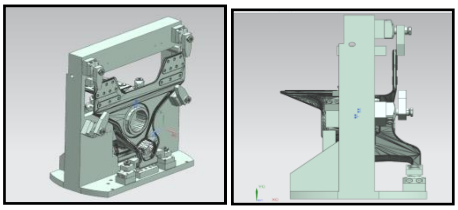


Figure-2.2 Isometric View & Lhs View

The newly designed fixture is for HMC & 3D model is drawn in UG NX12.

The main components of fixture are base plate, angle plate, V-block, resting pad along with the hydraulic clamping system.

By considering this new design, maximum area of component on which machining is to be done is available. The base plate is fixed to turntable of HMC. The angle plate is welded on this base plate. V-block gives sturdy support from back side to cylindrical bore part of the component. Use of hydraulic clamping system reduces time and fatigue of workers.

3. OLD SETUP VS NEW SETUP

TABLE-3 Old Vs New Setup

OLD SETUP	NEW SETUP
• 5 Sets of machines required • Multiple operations cannot be conducted in single setup • Manual loading-unloading • Clamping force might not be equal • Cost of machining is much more • Huge space required for large production line • Total cycle time is more	• 2 Sets of machines required • Multiple operations can be conducted in single setup • Hydraulic loading unloading • w/p is held securely with equal clamping force • Cost is one time investment • It will reduce space required for production line • Total cycle time can be reduced to considerable amount.

4. ANALYTICAL CALCULATION & FE ANALYSIS

In this machining, 3 operational forces, i-e, Milling & Drilling forces are required to calculate using the specifications which are given below

4.1 MILLING OPERATION

TABLE-4.1 Milling Cutter Details

Component Material	HSS
RPM Of Cutter	1200rpm
Depth Of Cut	0.2mm
Feed Per Revolution	1.33mm/rev
Cutter Diameter	80mm

Cutting Speed (m/min)

V $= \frac{\pi \text{ Dn}}{1000}$

= 301.59 m/min

Power at Spindle (Kw)

N = $1.25\text{x}D^2\text{x } k \text{ x } n \text{ x}\frac{(0.056+1.5s)}{10^5}$

= 1.88Kw

Torque at spindle (kgfm)

Ts = 975 x $\frac{\text{N}}{n}$

=3.07kgf

Tangential Cutting Force (N)

Pz = 6120 x $\frac{\text{N}}{v}$

= 375.74N

≈ 376 N

The cutting force for milling operation is 376N.

4.2 DRILLING OPERATION

TABLE-2.2 Drilling Cutter Details

Component Material	Carbide
RPM Of Cutter	1800rpm
Depth Of Cut	8.5mm
Feed Per Revolution	0.3mm/rev
Cutter Diameter	17mm

Cutting Speed (V)

V $= \frac{\pi \text{ Dn}}{1000}$

= 96.13m/min

Power at Spindle (Kw)

N = $1.25\text{x}D^2\text{x } k \text{ x } n \text{ x}\frac{(0.056+1.5s)}{10^5}$

= 5.13Kw

Torque at spindle (kgfm)

Ts = 975 x $\frac{\text{N}}{n}$

=2.777kgfm

Tangential Cutting Force (N)

Pz = 1.6 x k x D x $(100s)^{0.85}$

= 1044.90N

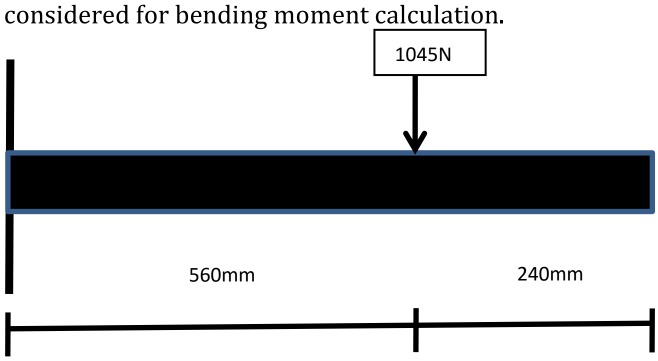
≈ **1045 N**

The cutting force for milling operation is 1045N.

4.3 ANALYTICAL CALCULATIONS FOR ANGLE PLATE

Angle plate is the critical part in the fixture. Its thickness can be calculated by finding stress and deformation occurring onto that plate.

Maximum force occurs by Drilling. So, drilling force is considered for bending moment calculation.



Bending Moment (N)

M= Force x Distance

= 1045 x 560

= 585200 N

TABLE-4.3 Calculations Of Y & Area

Y(mm)	Area(mm^2)
Y_1=17.5mm	A_1= 28.25 x 35 = 988.75mm^2
Y_2=72.5mm	A_2= 75 x 30 = 2250mm^2

$$Y = \frac{A_1 Y_1 + A_2 Y_2}{A_1 + A_2}$$

$= 55.71$mm

Bending Stress (N/mm^2)

$$\sigma_b = \frac{Syt}{FOS}$$

$= 173.33$ N/mm^2

Also,

$$\sigma_b = \frac{MY}{I}$$

$\therefore I = 1856.745 \times 10^3\ mm^4$

Moment Of Inertia (mm^4)

$$I = \frac{bd^3}{12}$$

$\therefore$b = 16.74mm

$\approx$ 17mm.

$\therefore$ Minimum thickness of angle plate should be 17mm.

4.4 STRESS ANALYSIS OF FIXTURE ASSEMBLY

Fixture assembly is designed in Unigraphics NX12 CAD software and it has been imported to ANSYS workbench 18.2 for analysis. Base plate is been fixed and load of 1045N has applied on angle plate. Boundary conditions and load location in the angle plate assembly are applied.

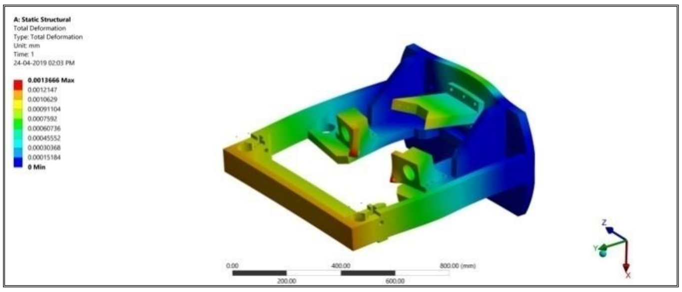


FIGURE-3.4.1 Deformation Of Angle Plate

Static analysis is carried out to calculate the maximum deformation of fixture. The maximum stress and deflection is seen to be $1.9074e^{-9}$MPa and 0.0013666mm respectively, which can be recorded as safe values for fixture and also for machining processes.

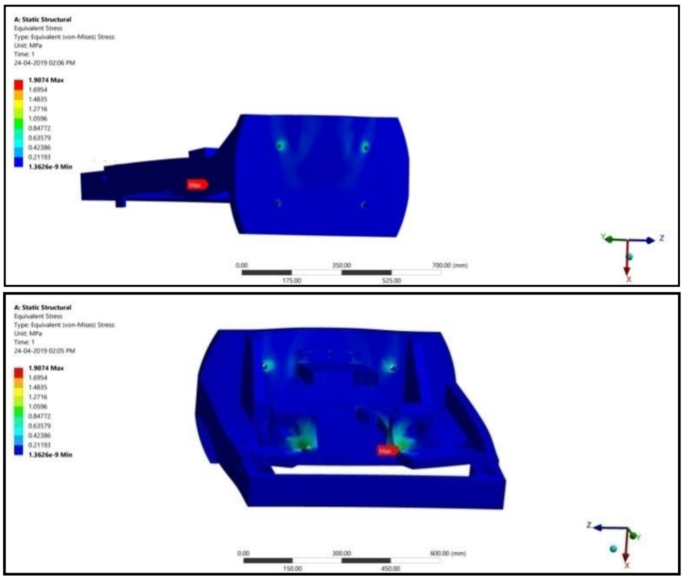


FIGURE-4.4.2 Stress Distribution

The fig.5 shows the stress distribution on fixture under cutting load and clamping load conditions. The maximum stress is observed at base plate and RH, LH blocks of clamps at the back side of angle plate. The table 5 shows ANSYS result of maximum stress and maximum deflection in fixture.

TABLE-4.4.1 Maximum Stress & Deflection Calculations

	Stress	Deflection
Minimum Value	$1.3626e^{-9}$MPa	0 mm
Maximum Value	$1.9074e^{-9}$MPa	0.0013666mm
Minimum Occurs On	Angle plate	Base plate
Maximum Occurs On	RH & LH block of clamps	

So, with this design consideration, the new process sheet for the machining of Tacho Bracket will become as follows:

TABLE-4.4.2 Process Sheet (New)

SR NO.	MACHINE	PARAMETER	RAW MTRL. SIZE	FINISHED SIZE (MM)	NO. OF CUTS (MM)	DEPTH OF CUT	RPM OF M/C	TOOL MTRL	IDLE TIME (S)	PROC. TIME (S)
1	HMC	Milling(front)	14.8,226.8	14.4,226.4	2	0.2	1200	HSS		
		Drilling	-	-	1	8.5	1800	Carbide		
		OD turning	20.46	20.0	1	0.46	250	HSS		
		Boring	128.0,118.0	127.8, 117.8	2	0.1	700	Carbide		
		Grooving	222.0	221.0	2	0.5	1800	HSS		
		Milling(back)	14.4,226.4	14.0,226.0	2	0.2	1200	HSS		
2	HMC	Milling(flange)	22.4	22.0	2	0.2	700	HSS		
		End Milling	23.4	23.0	2	0.2	600	HSS		
		Drilling(flange)	-	-	2	7.5	1800	Carbide		
		Drilling(C-shape)	-	-	-	10.5	1500	Carbide		
								TOTAL TIME=		

5. CONCLUSIONS

In this paper, design requirements of fixture were studied and cutting forces were calculated. The dimensions of critical component which means angle plate thickness was calculated analytically and verified by analysis using ANSYS workbench. The findings of the work can be illustrated as

1. The stress values obtained in analysis are far within the allowable values.
2. The proposed new design of fixture is stable and capable.
3. This fixture combines 4 operational setups into single setup, hence reduces need of 4 different machines.
4. Worker's fatigue and manpower is reduced.
5. The cycle time is reduced noticeably.

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