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Development and Analysis of Zero Point System for Universal Fixturing

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ABSTRACT

This Machining is the most commonly used process in the manufacturing industries. The machine tool industry has undergone sufficient changes. Although fixturing contributes significantly 30% to 40% of overall manufacturing cost. The design and manufacturing of fixture can be time consuming and it increases the manufacturing cycle time of any product that needs machining. This study deals with universal fixture with help of zero point system. It is suitable for more than five of single turning machine components. The objectives of this study are to reduce the set-up time and to increase the accuracy and productivity of the machine component. The paper contains the analysis of the fixture component and analysis of the result that how much time & money we can save per annum. The zero point system for universal fixturing is going to compensate all the disadvantages of conventional universal fixture and it will save up to 90% of set up time.

***Keywords*— zero point system (zps), universal fixture, universal clamping, zero point clamping**

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I. INTRODUCTION

A fixture is a device for locating, holding and supporting a work-piece during a manufacturing operation. Fixtures are essential elements of production processes as they are required in most of the automated manufacturing, inspection, and assembly operations.

Fixtures must correctly locate a work-piece in a given orientation with respect to a cutting tool or measuring device, or with respect to another component, as for instance in assembly or welding. Such location must be invariant in the sense that the devices must clamp and secure the work-piece in that location for the particular processing operation.Fixtures are normally designed for a definite operation to process a specific work-piece and are designed and manufactured individually. Jigs are similar to fixtures, but they not only locate and hold the part but also guide the cutting tools in drilling and boring operations.

Manufacturing industry involves tooling intensive operations. Fixturing is an important manufacturing operation which contributes greatly to the production quality, cycle time, and cost. Mass production aims at high productivity to reduce the unit cost and interchangeability to facilitate easy assembly. This necessitates production devices to increase the rate of manufacture and inspection device to speed-up inspection procedure.The machine tool industry has undergone sufficient changes as the requirement of user engineering systems changed; first it started with the manufacture of basic general purpose machine tools. These machines though offered higher flexibility were not suitable for mass production owing to longer set up times and the tedious adjustments of machine and tools besides requiring highly skilled operators. With growing need of fast production to meet the requirements of industry, mass production machines are conceived. Hydraulic, tracer control machine tool, special purpose automatic and semi-automatic machines were introduced with the advancement of technology. These machines were highly specialized but inflexible. The use of these machines was with a success for mass production and they have considerably reduced the production costs by way of reduced machining times and labor costs. Because of inflexibility these machine tools could not however be adopted by units involved in small lot and piece production. Because of the above, great need is felt for tools that could bridge the gap between highly flexible general purpose machine tools (which are not economical for mass production) and highly specialized, but inflexible mass production machines. Numerical control machine tools with proper fixture set up have to take up this role very well.

The fixture designing and manufacturing is considered as complex process that demands the knowledge of different areas, such as geometry, tolerances, dimensions, procedures and manufacturing processes.

II. LITERATURE REVIEW

A lot's of research is going on fixture design so that time required for setting the work-piece should be decreased. To mount more than one component universal fixture is used. Still researchers are doing modification in universal fixture to make it flexible for more than 2 components. During research it became clear that fixture design is part of manufacturing system planning.

Studies in fixturing began in the 1940's [1]. The results lead to several manuals on jig and fixture. The main reason is that fixtures are designed to tight tolerances, typically 30-50% of overall work-piece tolerance. To make sure the work-piece maintains the dimensional specifications and tolerances, the external cutting forces must be resisted by the fixture so that the work-piece remains in equilibrium.

Marcel Schluessel [5] has invented Zero Point Clamping Device for clamping the work-piece. After inventing the zero point clamping device it become easy to clamp the component on the fixture. Lately lots of modifications are done on this zero point clamping device. Now the most of the large industries are using this zero point clamping device for better accuracy and for increasing the production rate. By using this zero point clamping device we can achieve zero degree of freedom of work-piece in all direction with less effort.

After inventing this device Klaus Hofmann [6] invented clamping system for fixturing the work-piece. This invention concerns a clamping system for the clamping of work-piece, wherein a clamping means can be moved by a small spacing relative to a stationary affixing block, so as to be able to clamp a work-piece independently of fastening grid pre-specified on a machine tool or to compensate for a distance change between clamping components located on the work-piece, so that a zero point previously defined on the work-piece again coincides after a renewed clamping components whose distance were changed.

III. OBJECTIVE

- To design a zero point system for universal fixture on which number of different types of components should get machined
- To select the material and this should lighter in weight and with good properties & low cost.
- To minimise the set up timeand this should very large in conventional system.
- Design should be compact and it should be easy to handle for workers.
- Analysis of designed part with the help of ANSYS software (workbench).

IV. METHODOLOGY

The whole project is based on the improving the fixturing method and make it universal type. For that purpose all literature and important issues regarding zero point system is studied. For designing the fixture parts, for 3-D drawing Solid Works software is used and for analysis purpose ANSYS (Workbench) Software is used. After getting the results, results are analysed by theoretical method. If the designed parts of fixture are safe then parts are manufactured.

The existing conventional universal fixturing system is improved by doing the modification and development. After doing this modification and development new zero point system have better efficiency than conventional one and it save set up time very largely.

V. DESIGN OF PARTS

A. *Fixture Base Plate*

By using the Roark's Formula shown in fig. 1 for plate design the base of fixture is designed. Using this formula we can calculate the thickness of the plate and stress. Also deflection at centre is calculated

Input Data Selected as:-[7]

Forced Applied = P = 2196.2628 N

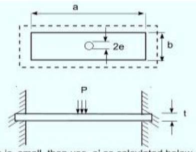
Poisson's Ratio = 0.3

Material: EN8 Steel (40Mn2S12)

Modulus of Elasticity = E = 2.1×10^5 N/mm^2

Permissible Stress σ_{per} = 700 N/mm^2

For the fixture base plate and for the supporting cylinder the material selected is same.



If e is small then use e' as calculated below

$$e' = \left(\sqrt{1{,}6e^2 + t^2}\right) - 0{,}675t \quad \text{if } e < 0{,}5t \text{ else use } e' = e$$

$$\sigma_{mc} = \frac{1{,}5P}{\pi t^2}\left((1+v)\ \ln\left(\frac{2b}{\pi e}\right) + k_3\right) \quad \text{At centre}$$

$$\sigma_m = k_2 \frac{P}{t^2} \quad \text{Middle of edge a}$$

$$y_m = k_1 \frac{Pb^2}{Et^3} \quad \text{At centre}$$

	a/b						
	1,0	1,2	1,4	1,6	1,8	2,0	3 ->
k_1	0,061	0,071	0,076	0,078	0,0786	0,0788	0,0791
k_2	0,754	0,894	0,962	0,991	1,000	1,004	1,008
k_3	-0,238	-0,0078	0,011	0,053	0,068	0,067	0,067

Fig.1Roark's Formula

So after calculating doing the calculation we get the following results:

$$\sigma_{mc} = \frac{1.5\times2196.2628}{\pi\times35^2} \times ((1+0.3)\times\ln(\frac{2\times155}{\pi\times62.5}) + 0.053)$$
$$= 0.553577 \text{ N/mm}^2$$
$$\sigma_m = 0.991\times\frac{2196.2628}{35^2}$$
$$= 1.776731 \text{ N/mm}^2$$
$$Y_m = 0.078 \times (\frac{2196.2628\times155^2}{2.1\times10^5\times35^3})$$
$$= 0.0004571 \text{ mm}$$
$$= 4.571 \times 10^{-4} \text{ mm}$$

As $\sigma_{mc} < \sigma_{per}$ design is safe.

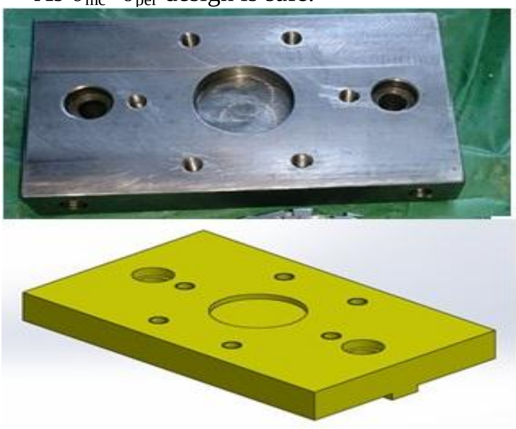


Fig. 2 Fixture Base Plate

B. *Supporting Cylinder*

For designing the supporting cylinder specific method is not available. So by using the ANSYS (workbench) Software supporting cylinder is designed.

Input Data Selected as:-[7]
Forced Applied = P = 2128.77 N
Poisson's Ratio = 0.3
Material: EN8 Steel (40Mn2S12)
Modulus of Elasticity = E = 2.1×10^5 N/mm^2
Permissible Stress σ_{per} = 700 N/mm^2

ANSYS Analysis Report:

Load is applied on the top side of the supporting cylinder. Bottom side is fixed. As per the input data all the vales are given for analysis and after solving we get the following results:

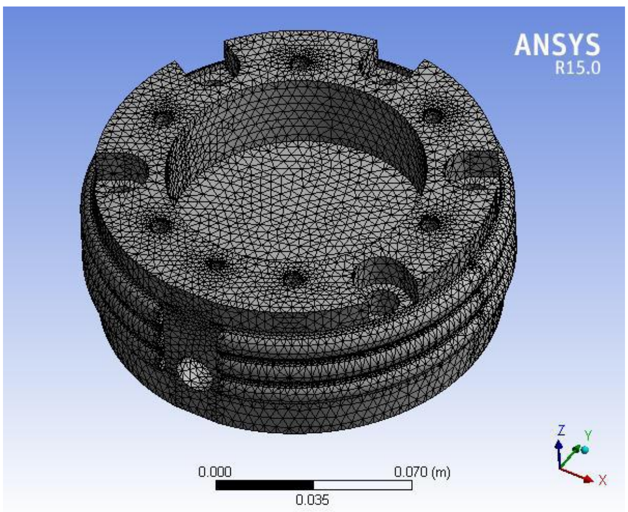


Fig.3 Meshing of the Supporting Cylinder

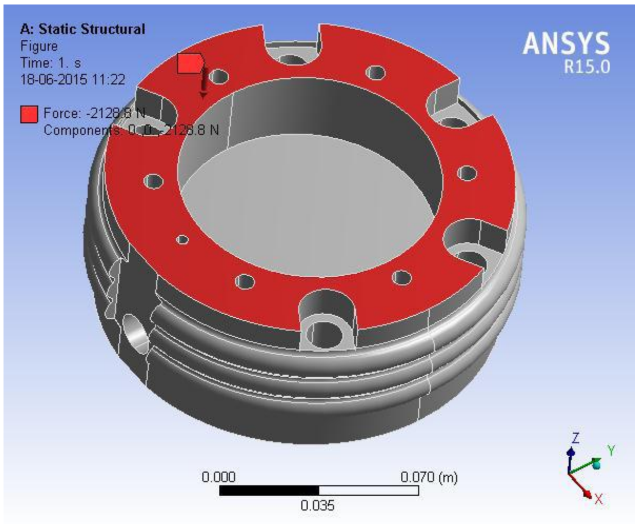


Fig. 4 Load applied on the top of cylinder

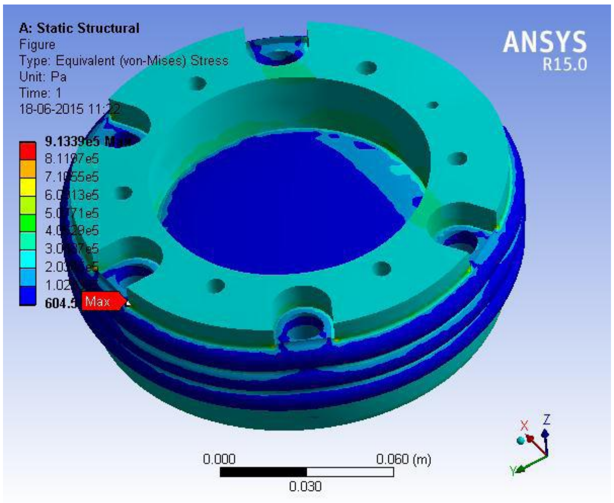


Fig. 5 Equivalent (von-mises) Stress

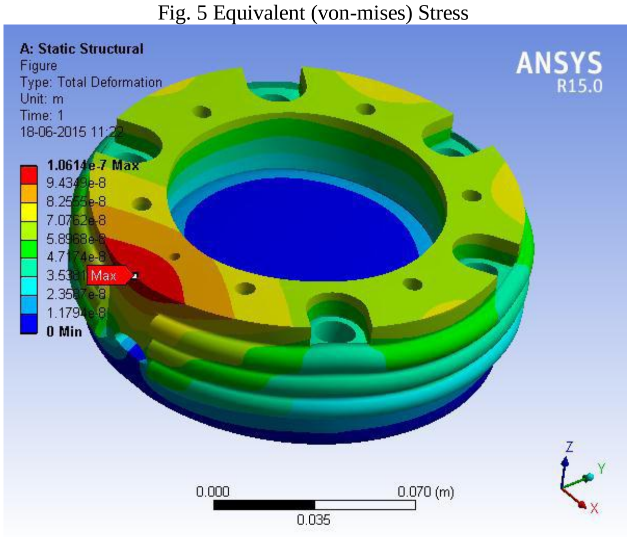


Fig. 6 Total Deformation of Supporting Cylinder

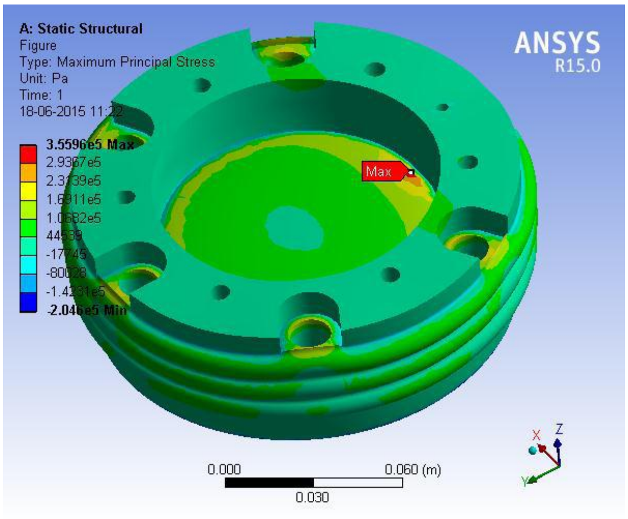


Fig. 7 Maximum Principal Stress

TABLE I
RESULT TABLE OF ANALYSIS

Object Name	Equivalent Stress	Maximum Principal Stress	Total Deformation
State	Solved		
Definition			
Type	Equivalent (von-Mises) Stress	Maximum Principal Stress	Total Deformation
Integration Point Results			
Display Option	Averaged		
Results			
Minimum	604.5 Pa	-2.046e+005 Pa	0. m
Maximum	9.1339e+005 Pa	3.5596e+005 Pa	1.0614e-007 m

As per properties of the EN8 steel material the values after the solution are within the permissible limit. Maximum deflection and von-mises stresses are within the permissible limit. So per design conditions the design of the supporting cylinder is safe.

Fig. 8 Supporting Cylinder

VI.RESULT ANALYSIS

After assembling all the parts on the pallet of the machine different types of components are mounted on the fixture. It is observed that previously for mounting the component near about 30 to 40 minutes are required but after installing the zero point system it requires only 2-3 minutes.

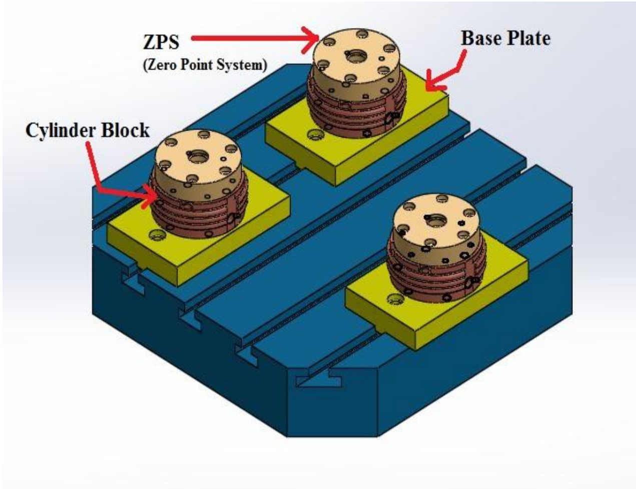


Fig. 9 Fixture Assembly

On this fixture assembly different types of machine components are mounted and machining is done. After the machining of these components flatness and perpendicularity are checked. Results are within 10-15 micron.

A sample calculation is done in the following table that shows how the time and money is saved.

TABLE III
SAMPLE CALCULATION WITH AND WITHOUT ZERO POINT SYSTEM

Procedure	Without zero point system	With zero point system
Machine Costs	Rs. 4500 /h	Rs. 4500 /h
Number of set-ups per shift (8h)	4	4
Number of set-ups in 3-shift (8h)	4 × 3 = 12	4 × 3 = 12
Set-up time per procedure	30 min	2 min
Set-up time in 3-shift	30×12=360 min	2×12=24 min
Set-up time per shift (8h)	120 min (2h)	8 min (0.13h)
Set-up costs per shift (8h)	Rs. 9000 /-	Rs. 585 /-
Set-up costs per shift each year (305 working days)	Rs. 82,35,000 /-	Rs. 5,35,275 /-

Annual Saving Per shift	Rs. 25,66,575 /-
Total Annual saving	Rs. 76,99,725 /-

VII.Conclusion

Fixtures have direct impact on product manufacturing quality, productivity and cost. So it is very important part of the design procedure. By using the zero point system we can save large amount of set up time and money also. This zero point system gives high productivity and high precision product. It also gives the accuracy within 10 to 15 micron and now this is the requirement of any component or work-piece after machining. This can be achieved by zero point system.

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