Automated Manufacturing Fixture Design and Analysis to Support the Automobile Industry

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ABSTRACT: In machining fixtures, minimizing work-piece deformation due to clamping and cutting forces is essential to maintain the machining accuracy. The various methodology used for clamping operation used in different application by various authors are reviewed in this paper. Fixture is required in various industries as per their application. This can be achieved by selecting the optimal location of fixturing elements such as locators and clamps. The fixture set up for component is done manually. For that more cycle time required for loading and unloading the material. So, there is need to develop system which can help in improving productivity and time. Fixtures reduce operation time and increases productivity and high quality of operation is possible. This paper introduces the new techniques to achieve the complicated operations done with the help of fixtures. The complex structures like obtaining the cylindrical shape from a rectangular workpiece. This type of operations generally performed on the 5-axes or 6-axes machine. This fixture can provide the more advanced features by which it can facilitate the complex operations. There are various complex shapes that can be obtained on the 3-axes machine with the help of this fixture. There will be no need of 5-axes or 6-axes machine to perform such kind of operations. The production cost can be minimized relatively the selling cost of the product will be competitive in the market. The computer-aided structural analysis and simulations have been performed to study the stress and deformation of mechanical components in assembly process. The design of the fixture is done on the Cero 2.0. The validation of the design is done on the ANSYS workbench 16.0. There are various stresses acting on the fixture in different directions. The factor of safety kept as high as possible. The model analysis is carried out to keep the vibrational stresses in control and this is achieved by selecting proper material which will have the good damping capacity.The computer-aided simulation demonstrates close results that present the feasibility and reliability of this newly designed and developed mechanical system for Automobile Industry.

***Keywords*: -** *Computational Simulation, CAD model, Structural analysis, Cost-Effective, High Speed Manufacturing.*

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1.INTRODUCTION

Fixture are the workpiece holding & locating devices mounted on a machine. Fixture forms important part of machining for increasing production capacity of a machine. It is important to maintain the dimensional accuracy while enhancing production using the fixtures [2]. The accuracy of machining while using the fixture depends on rigidity of fixture and the vibration cause at the time of machining[2].Frequent checking, positioning, individual marking, and non-uniform quality in manufacturing process is eliminated by fixture. This increase productivity and reduce operation time. Fixture is widely used in the industry practical production because of feature and advantages.Computer aided engineering design can quickly model the automated manufacturing systems and speed design and development cycle. Computer aided manufacturing can improve engineering integral processes of product design, development, engineering analysis, and production [1]. In this paper, I have discussed about the new techniques of Computer Aided Design (CAD) and Computer Aided Engineering (CAE) for designing and manufacturing a fixture. The automated and high speed production systems can reduce human involvement for reduced labor cost, improved manufacturing accuracy, and increased production rates [3]. Automationis not only significantly increasing the production speed but also, more accurately controlling product quality. Automated mechanical system can maintain consistent quality, shorten lead time, simplify material handling, optimize work flow, and meet the product demand for flexibility and convertibility in production [5]. I have reviewed the best methods and steps for manufacturing a fixture. The design of a fixture relies on the system itself related to manufacturing.The system allows fixtures to be designed based on geometric features of workpiece, process planning and machining information [6]. Therefore, it is always a challenge to design fixture according to the need. The fixture should have good damping capacity and almost zero vibration for smooth profile without seam [2]. The modal and structural analysis is done to carry out the closer results.

2.METHODLOGY

To design a fixture, we need to calculate the cutting force which is acting on the fixture by milling tool. This force is determined from the machine date book [4]. To achieve the lowest possible vibration, the required material should possess good damping coefficient. The Gray Cast Iron material is selected for the fixture [4]. The rotary table mechanism is modified to achieve the required operation. The fixture consists of two expandable jaws. Those jaws can be expanded with the help of pneumatic pressure or mechanical linkage. The indexing is mounted on each side of the fixture to acquire therequired angle. The workpiece can be fastened by the jaws and can be rotated about its axis with the help of rotary table mechanism. The compactness of the assembly is required to facilitate the handling while keeping the lowest vibration constraint in consideration. The cutting force and the workpiece weight is acting on the jaws. The bending moment and shear force calculations made easy to control the diameter of jaws which acts as a cantilever beam. The factor safety is 3. The yield strength of the material is 280 N/mm^2. The good damping coefficient condition is satisfied. The base plate is designed such that it should minimize all the vibrations. The material is widely used for the fixture as it has the good damping capacity against the vibration which is necessary to manufacture seamless products with high end finish. The designed parts are shown in figures 1-4.

Fig.1. The Expandable Jaws

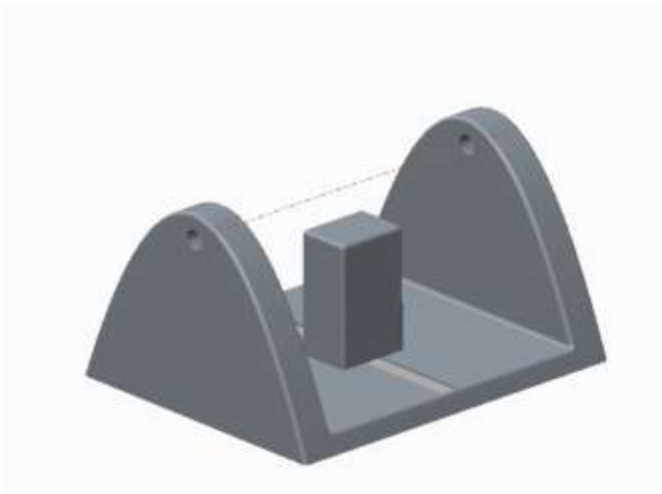

Fig.2. The Base Plate

Fig.3. Workpiece

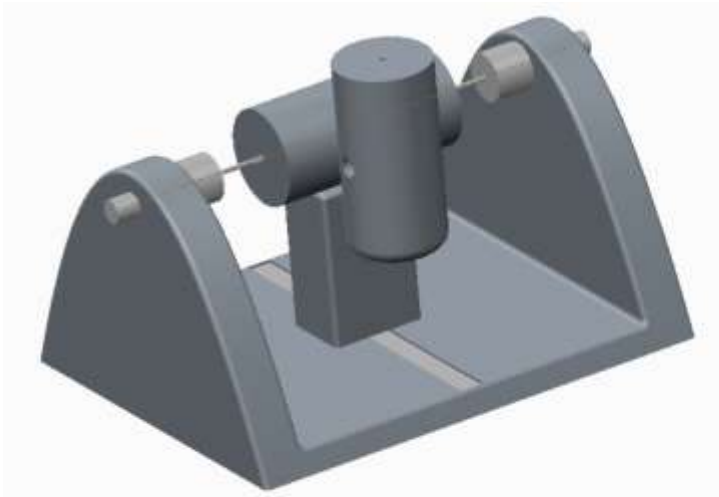

Fig.4. Assembly

To reduce the time and cost, the CAE analysis is done. To reduce the vibration during operation first we must check what is the natural frequency of the fixture. This is done with the help of modal analysis.

3.ANALYSIS

The modal analysis shows the maximum vibration at certain high frequency which cannot be attained by the machine at any speed and load. This confirms that the fixture will not have any resonance effect and the vibration will be in control. This is shown in figure.5. The structural analysis is carried out by taking vertically downward force of 45N. at the tip of the cutting tool. The total force acing will have the workpiece weight also, hence the total force will be 1845N. The deformation and maximum stress is calculated. This is shown in the figures 6-9. To calculate the cutting force which is acting on the cutting tool equation (i) and (ii) is used.

$$F_n = \frac{25 \times Q'w}{V_s} \qquad \text{(i)}$$

Where,
$F_n =$ Normal force;

$Q'w =$ Relative metal removal rate

$V_s =$ Spindle speed

$$Q'w = \frac{\pi \times d_w \times V_f}{60} \qquad \text{(ii)}$$

Where,

d_w = diameter of wheel

V_f = Feed speed mm/min

(Assume V_f = 1 mm/min)

Calculating with the data we get,

$$F_n = 45\text{ N.}$$

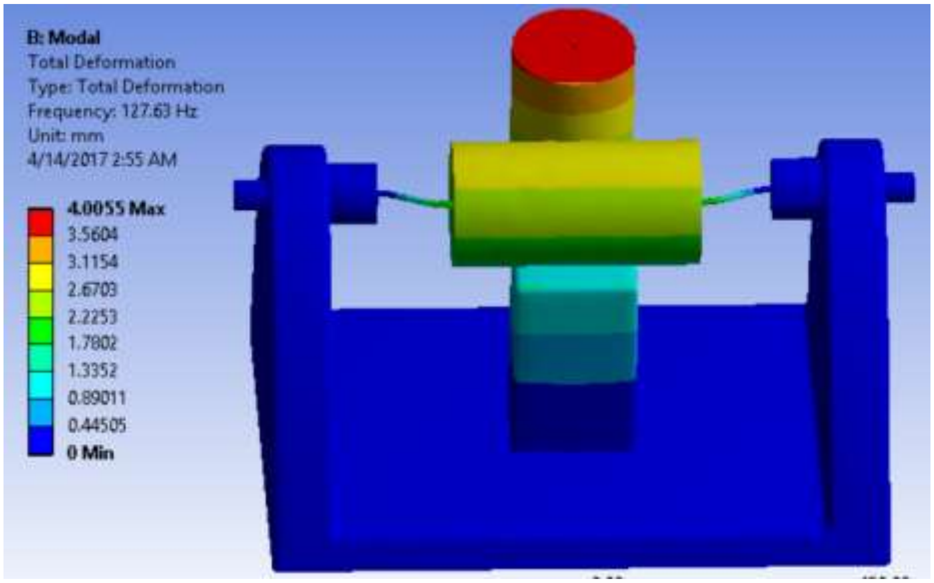

Fig.5. Modal Analysis Shows the

Minimum Frequency of Vibration (127.63Hz)

Table 1. Modes of Frequency

Mode	Frequency [Hz]
1.	127.63
2.	176.56
3.	302.81
4.	321.19
5.	339.45
6.	553.83

The frequency of vibration is kept as low as possible and the good damping is provided by the material properties.

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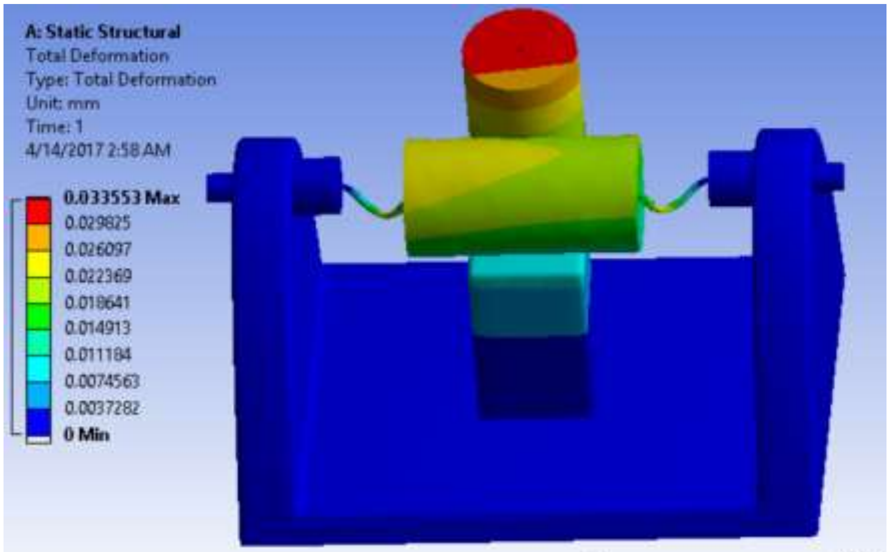

Fig.6. Total Deformation of Model

for 1845N Force (0.033mm)

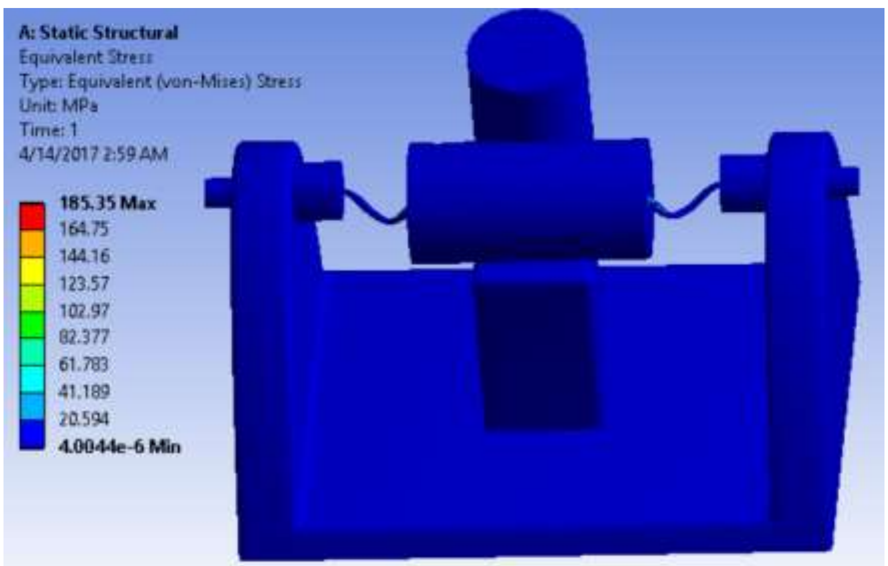

Fig.7. Equivalent Stress Shows the

Maximum Stress Acting

on Jaws (185.35Mpa)

Table.2. Maximum Stress Result

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	4.0044e-006	185.35

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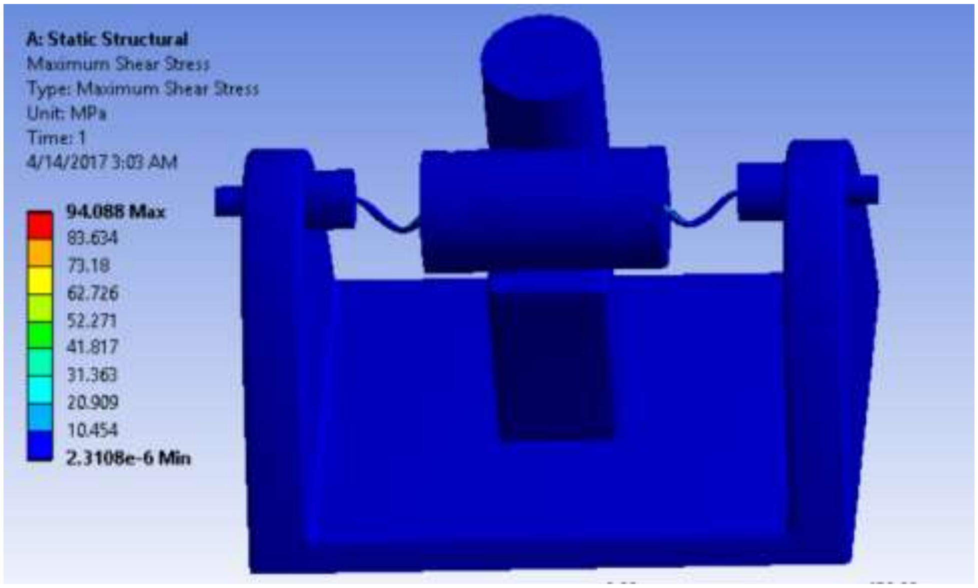

Fig.8. Maximum Shear Stress

on the Jaws (94.08Mpa)

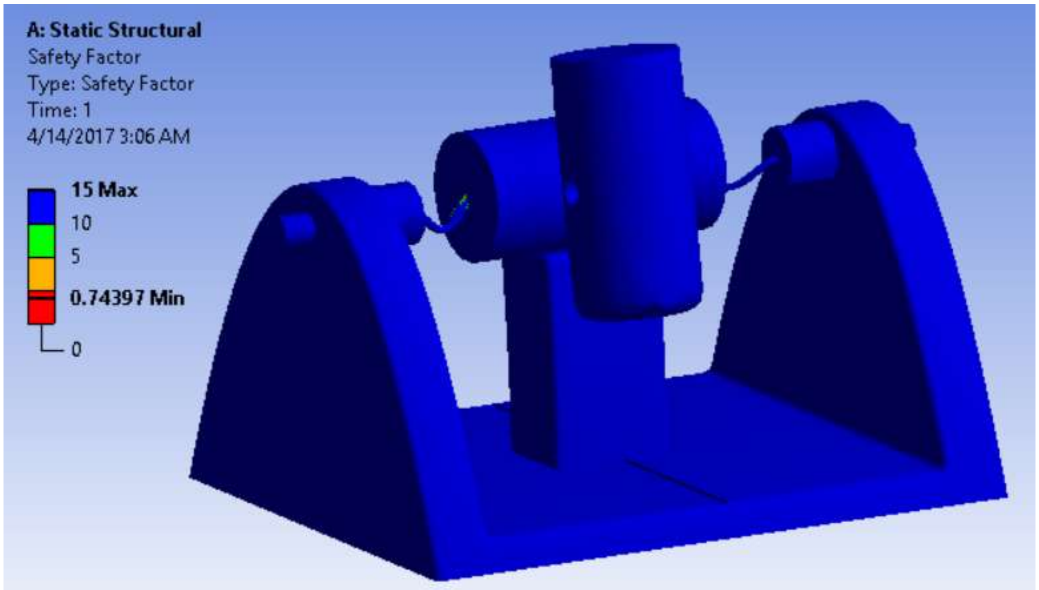

Fig.9. Safety Factor (0.74)

To reduce the vibration, we should compare the frequency of vibration of other machine components and we should keep their frequency of vibration lower as compare to the natural frequency of vibration of a fixture. The stress should not exceed the yield strength limit of the material. The analysis is done and verified.

4.CONCLUSION

The complex automobile parts can be manufactured on 3-axes machine with the help of proper fixture. The cost of the part can be lowered. Accurate and long lasting components represent a crucial ingredient of a well-functioning, reliable fixture. This may prove the importance, complexity, and purposefulness secrecy ofpresented process. Use of a 3D CAD system allows the engineer freedom of experimentation with several design alterations before arriving to optimal solution. Minimum vibration and smooth profile without seam. No need of skilled operator.

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