Designing Fixture To Optimize The Manufacturing Process Plan Of Timer Used In War Missiles

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Abstract - The price of scheming and manufacturing fixtures can cost up to 10±20% of the total production system costs. To reduce manufacturing costs, an accessory system aims to be competent in fixturing as many work pieces as possible. In mass production, it can be accomplished by fixturing a large quantity of the same kind of work pieces. In low-to-medium scale production, improvement of the flexibility of fixture systems becomes a favourable way to reduce the unit cost of the product. The timer is a tiny component used in war missiles. When the war missile is triggered the timer sets the bullet, and then the bullet is released from the target missile. Timer plays a significant role in the target missile, so this component should be manufactured with dimensional accuracy. The timer is modelled by considering tolerances if specified using NX-CAD. Manufacturing process plan will be developed in CAM system using the NX-CAM software. Process optimization was also carried out by using the fixture for a job holding to reduce damage to the component while manufacturing and reduces rejection and rework rate by maintaining dimensional accuracy as well as designed fixture reduces manufacturing time. The designed fixture is validated using finite element analysis whether it suits for manufacturing timer component. The dynamic analysis shall be performed on the fixture component and from the analysis results mode shapes and frequencies are documented by using FEA software. Finite element analysis of fixture component will be done using Ansys software.

Keywords - Fixture Designing, Triggering, Ansys, NX-CAM, Missile Timer

I. INTRODUCTION

FIXTURE AND TIMER

FIXTURE: A fixture is termed as an element for holding, locating and maintaining a workpiece at the time of manufacturing. Fixtures are all-important components of producing as those are essential in almost all the automated manufacturing, assembly, and inspection operations

Central parts of the Fixture are:

- Locators
- Clamps
- Supports
- Fixture Body

TIME: The applications of this word time as a remark about it and familiar to all. One typical practice is the automatic home washer. A clock-type motor drives a shaft, which turns discs that operate electric contacts. These contacts close control circuits that operate hot- and cold-water valves, start and stop the water pump, change the washer speed, spin the clothes dry, and finally shut off the power. Each operation runs for a specified time interval. This kind of timer can be used for certain missile control services.

TIMER: Timer plays a significant role in the target missile, so this component should be manufactured with dimensional accuracy mainly the holes on the part because they are assembled with gears. Manufacturing timer is a critical task due to its size, the maximum diameter of the timer is 4.2 cm, and it is missile part, and it requires dimensional accuracy, so this component demands fixture for manufacturing.

Timer control units alter substantially in physical attributes and operations. All these categories require an initial triggering, pulse. Since all the timers in a system are not entirely triggered at a time, each must have its trigger installed. This refers an electrical signal conventionally. It may be fed to a solenoid which mechanically triggers the timing device.

Another triggering method involves the application of an electrical signal to a heater coil which heats a bimetal strip and causes it to bend, thus opening or closing electrical contacts. This method is maybe more familiar when you contemplate the operation of a typical thermostat like the one found in the home.

II. LITERATURE SURVEY ON FIXTURES

Owen B. Toon and James B. Pollack, 1976 [1] Fixture is a work piece locating and holding device used for machine tools, inspection, welding and assembly; it does not control the position of the tool or instrument which is being used. Elements of the Jig or Fixture must also be present which Support the work and elements, called locators, which Position the work **o**nce located and positioned, the work is Clamped so that it will not move off the supports or locators.

Burley and Corbett, 1998 [2] A Jig is defined as a manufacturing aid that either holds a part or is itself located on the part and is suited for devices to guide a cutting tool confirming the correct location of the machining path relative to the part. A Fixture is defined as a manufacturing aid for holding and locating parts during machining or assembly operations, which do not provide definitive guidance on the cutting tools**.** Tooling is used as the generic name for jigs and fixtures and also the tools set from the master gauges for calibrating jigs and fixtures**.** Hence, Jig-less Assembly is assembly without the use of jigs; it requires that parts are manufactured to sufficient accuracy to ensure correct assembly; it is not necessarily fixtureless [or tool less] assembly.

J. C. Trappey and C. R. Liu 1990 [3] Fixture design can be classified as a part of process planning. The wise task description of process planning explicitly states that "'fixture design for each work piece set-up" is an integrated planning function. However, the automation of fixture design has been overlooked in most research into automated process planning.

1. Fixture configuration - determining the types of fixture elements required, and selecting locating points on the selected elements according to the specified process information.
2. Fixture assembly - constructing and assembling the modular fixture components. The orientation of each element on the base plate is determined according to the work piece set-up. Consequently, the assembly sequence of the fixture components is planned for automatic assembly by a robot hand.
3. Fixture verification - proving the validity of the fixture configuration with consideration of some operating factors, such as the cutting directions, the acting forces and the machining sequence.

III. MODELING OF TIMER

3.1 TIMER 2D DRAWING

A 2D drawing is used to design a 3D model for our component using Unigraphics NX 7.5 CAD software. Below image shows the 2D drawings of the time with all the required dimensions for manufacturing the component without any errors.

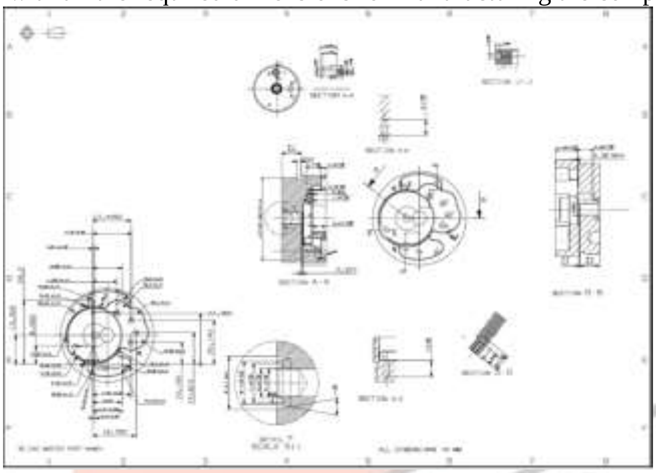


Fig.1: Timer 2D drawing

3.2 STEPS INVOLVED IN 3D MODELLING OF TIMER:

3D model is designed by using NX cad software.

Sketching:

Below is the sketch required to obtain the 3D model of the timer from the above 2D drawing. Below image shows the sketch and revolving of the timer

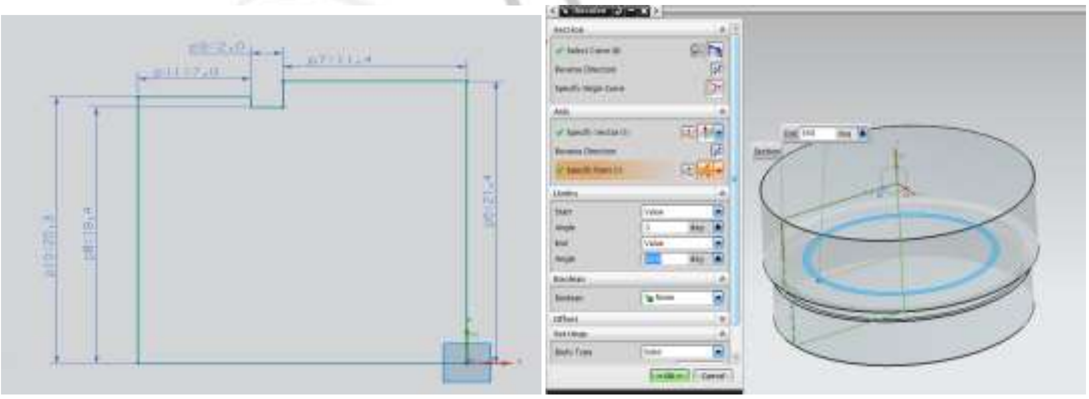


Fig.2 : sketches and revolve of the timer

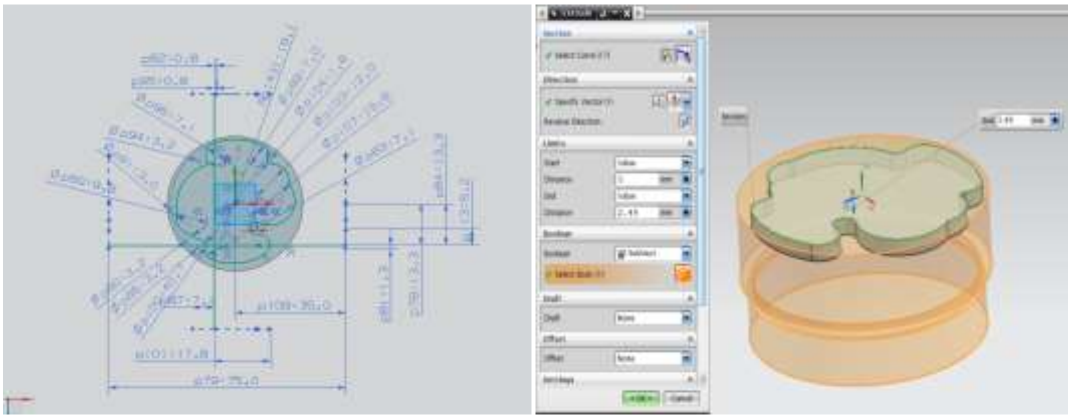


Fig.3 : sketches and extrude of the timer

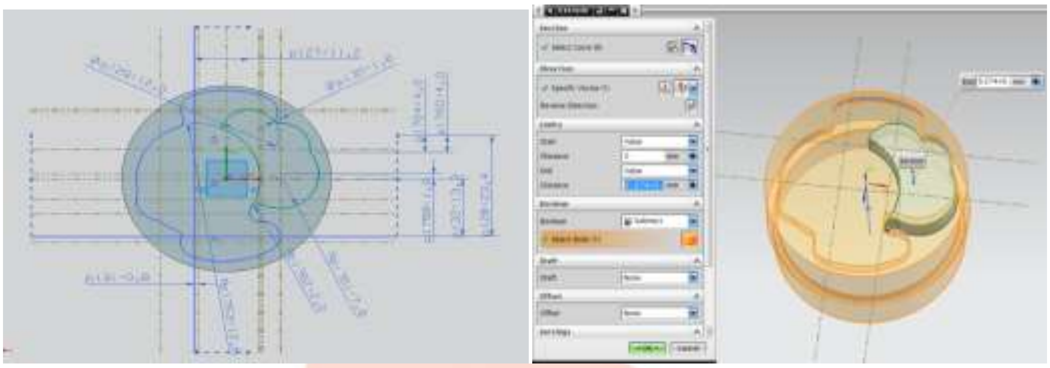


Fig.4: sketches and extrude of the timer

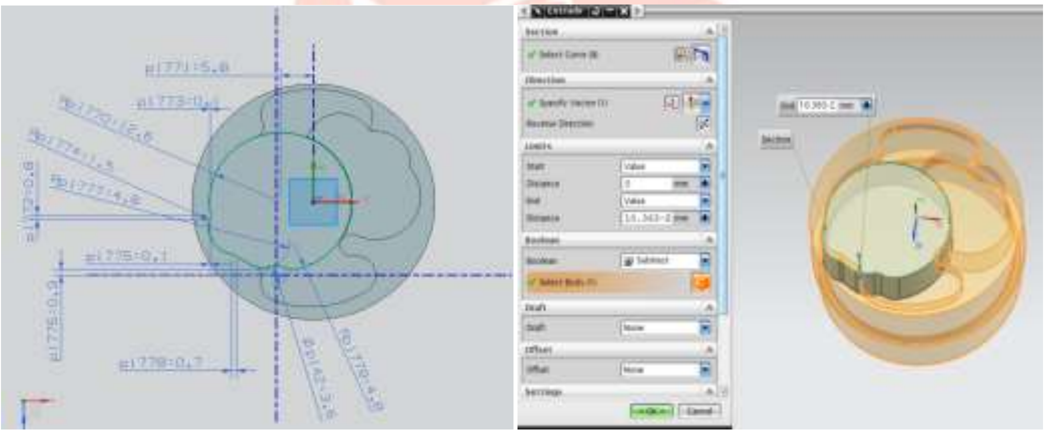


Fig.5: sketch and extrude of the timer

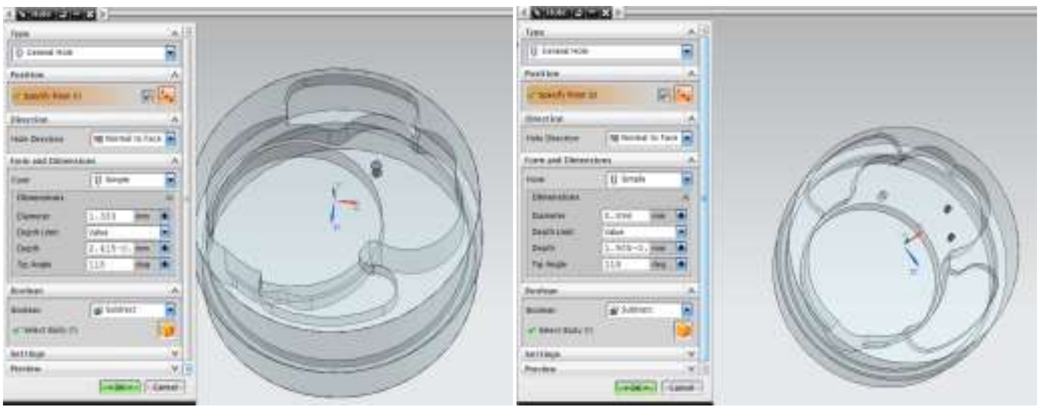


Fig.6: creating holes in the extrude

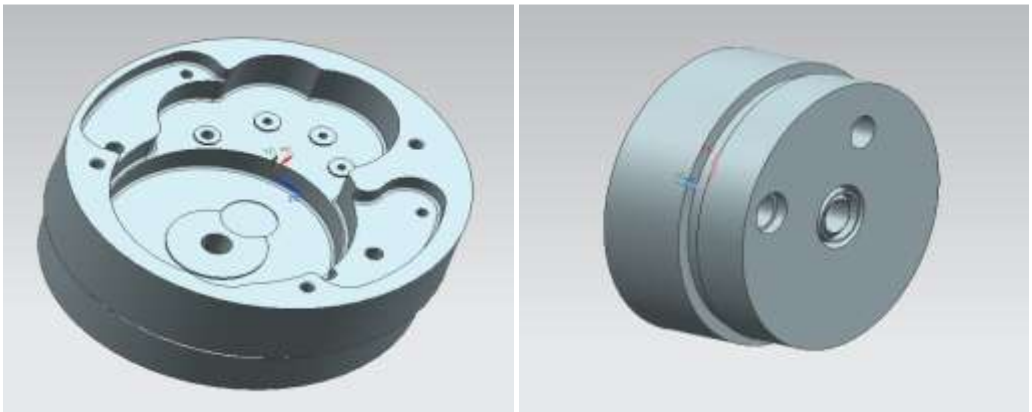


Fig.7: final 3D model of the timer

IV. COMPUTER AIDED MANUFACTURING OF THE TIMER

After creating the 3D model of Timer tool path is generated using NX-cam software. Timer material is Brass. The methodology used in the manufacturing of Timer is as mentioned below:

- Identifying suitable machine.
- Selecting suitable tools for manufacturing component.
- Designing fixture/fixture to support Timer component for milling operations.
- Listing down the sequence of operations performed on Timer component.
- Generating tool path at specified cutting speed.
- Generating NC program using the NX-CAM software.
- Specify coordinate machine system

Fig.8: machines coordinate system

4.1 STEPS INVOLVED IN GENERATION OF TOOL PATH

The material of timer is brass. Brass is a metal alloy made of copper and zinc.
Start manufacturing: Go to start→ manufacturing
Below image shows part and raw material

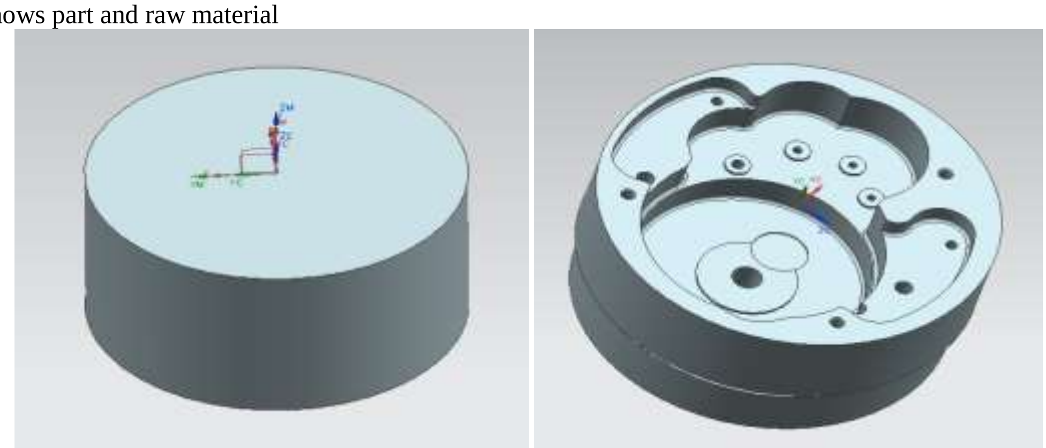


Fig.9: Part and raw material

Below image shows face mill operation and verification

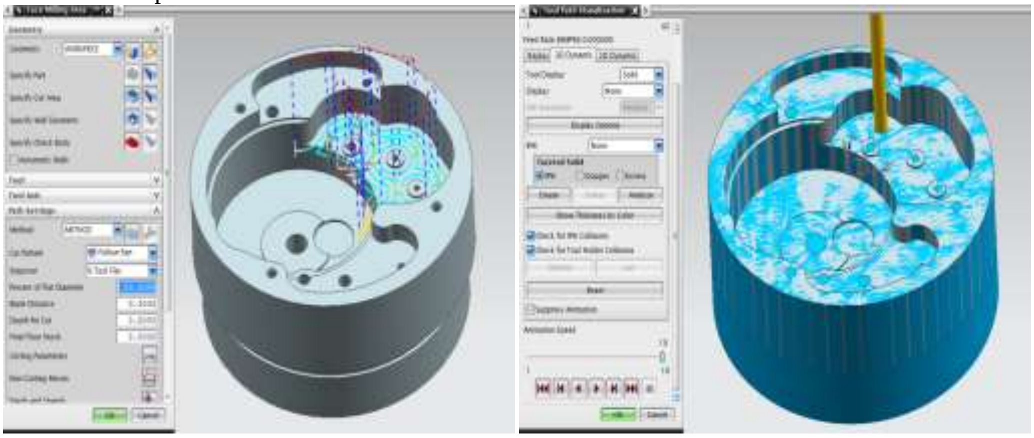


Fig.10: Face mill operation and verification

Below image shows planar mill operation and verification

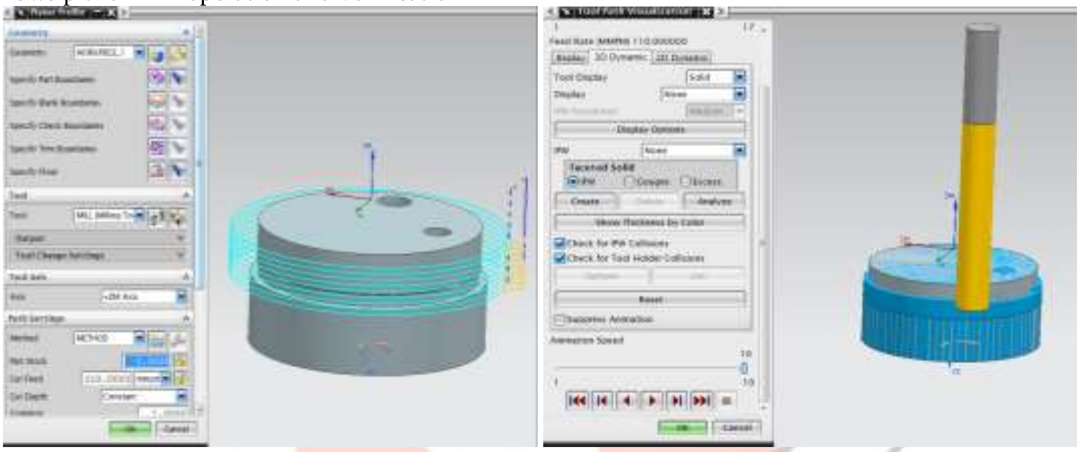


Fig.11: Planar mill operation and verification

Below image shows drilling operation and verification

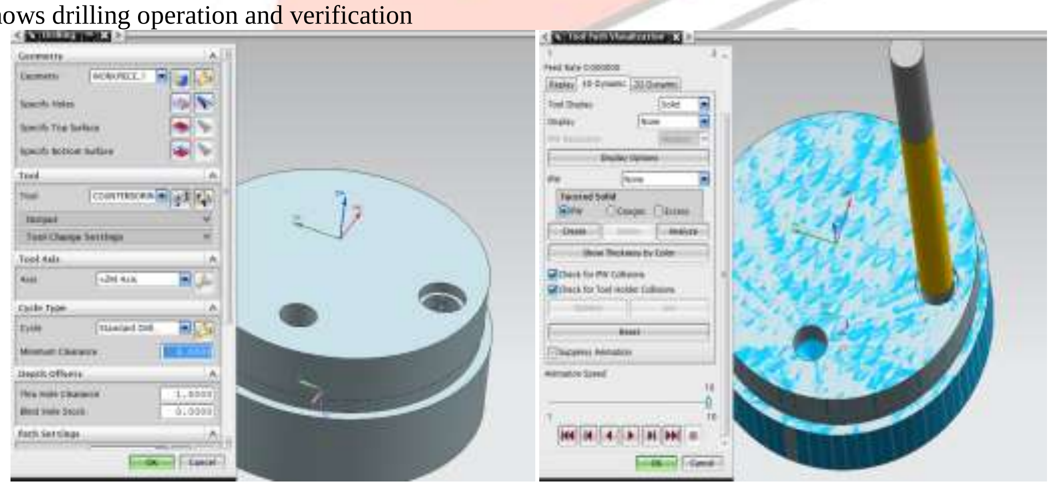


Fig.12: Drilling operation and verification

V. DEVELOPMENT OF FIXTURE FOR TIMER

Fixtures accurately locate and secure a part portion during machining operations such that the part portion can be manufactured to design specifications. The reduction of design cost is associated with fixturing, various Computer-Aided Fixture Design (CAFD) methods have been flourished throughout the years to assist the fixture designer. Fixture layout design is a major concern in the development of automated fixture design systems. The task of fixture layout design is to lay out a set of locating & clamping points on workpiece surfaces such that the work piece is accurately located & completely restrained during manufacturing operations.

5.1 MODELING OF TIMER FIXTURE

Below image shows 2D drawing of fixture

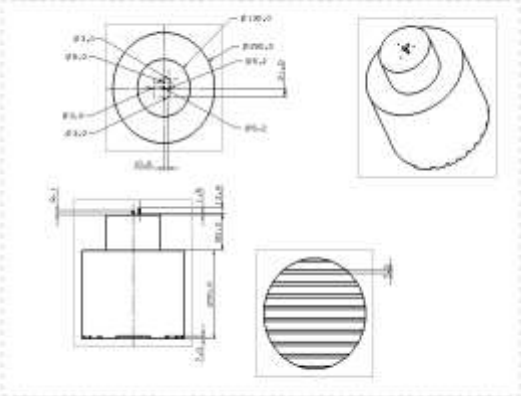


Fig.13: 2D drawing of fixture

Below image shows final 3D model of fixture

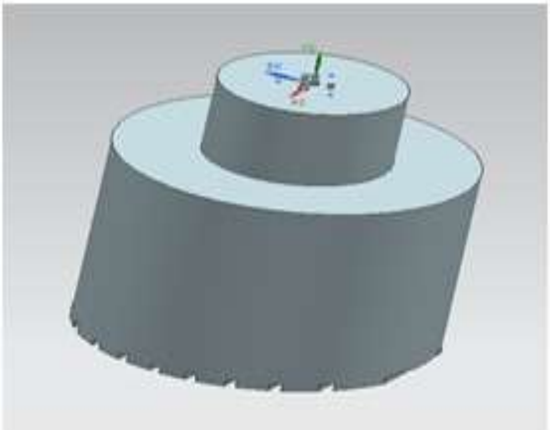


Fig.14: final 3D model of fixture

Below image shows assembly of part and fixture

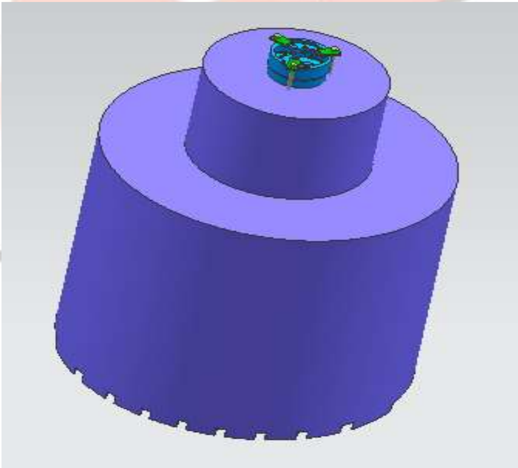


Fig.15: assembly of part and fixture

VI. DYNAMIC ANALYSIS OF FIXTURE AND TIMER

6.1 MODAL ANALYSIS

Modal analysis is used to determine the vibration characteristics which include natural frequencies and mode shapes, of a structure or a machine component while it is designed. It also serves as a starting point for another, a harmonic response analysis, more detailed, dynamic analysis, such as a transient dynamic analysis, or a Spectrum analysis. The objective of my analysis is to compare natural frequencies of mandrel and timer.

Element Types used:

Name of the Element: SOLID 92

Number of Nodes: 10

DOF: UX, UY & UZ

The Parasolid file is imported into ANSYS and is meshed with ten nodes solid92 element type. In the structure, some nodes and input summary of the element is given below.

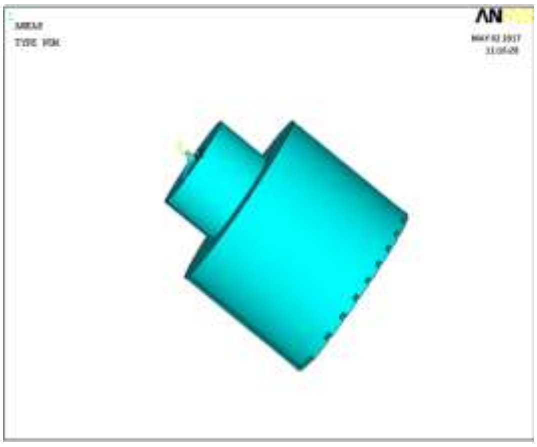


Fig.16: shows the geometric model of the Fixture

Results –Mode10 @ 9606 Hz

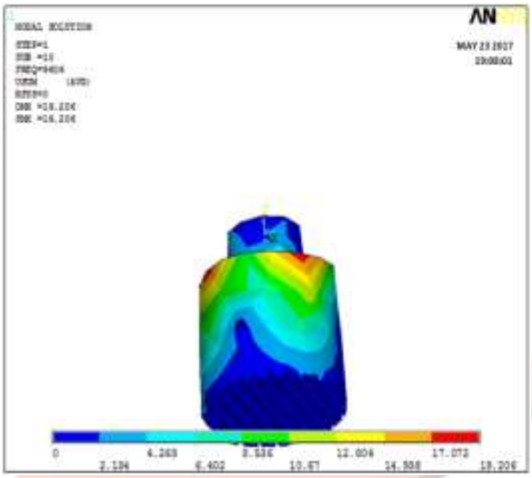


Fig.17: Shows Mode shape 10@9606Hz for Fixture

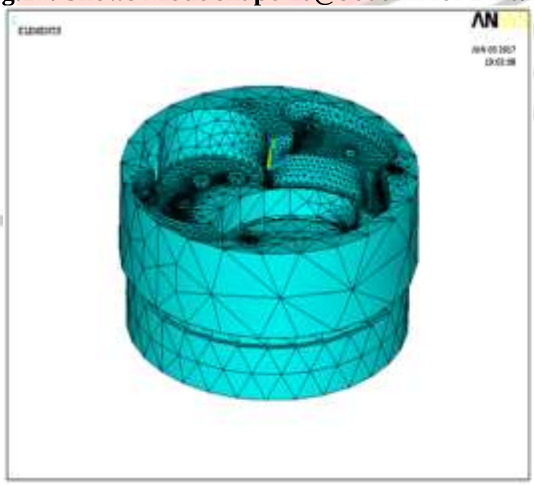


Fig.18: shows the finite element model of the Timer

Results –Mode6 @ 36,797 Hz

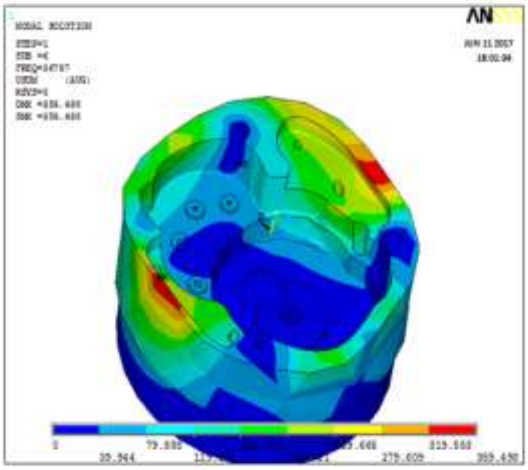


Fig.19: Shows Mode shape 6@ 36,797Hz for Timer

Results –Mode9 @44,877 Hz

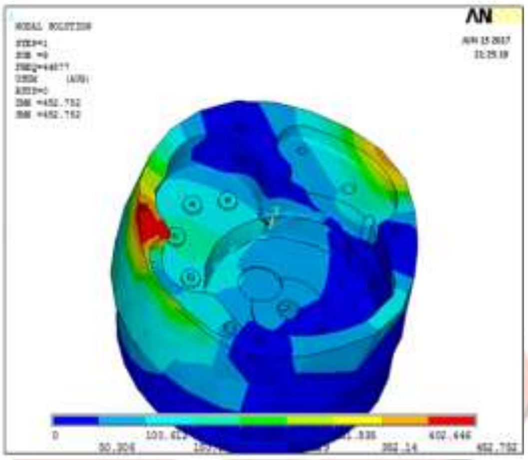


Fig.20: Shows Mode shape 9@44,877 Hz for Timer

6.2 Analysis results:

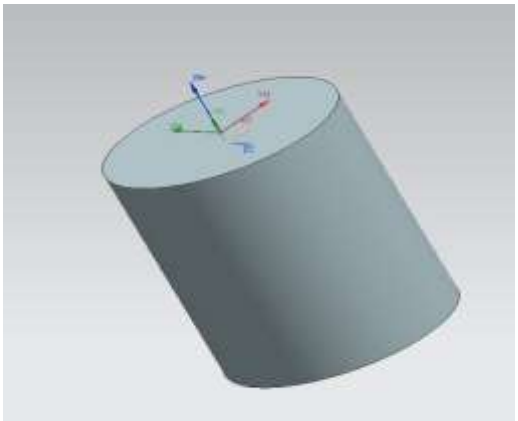
From the modal analysis of Fixture and Timer following conclusion can be drawn:

Both the frequencies of Fixture and Timer are far away from each other which will avoid resonance vibration between two components.

Also, during working conditions that are for operating spindle speeds up to 4000 rpm corresponding to frequency 41 Hz, there will be no resonance with the Fixture which is having primary frequency 2176.6Hz s.

VII. MANUFACTURING OF FIXTURE

Below image shows raw material and part of the fixture. The material of fixture is aluminium.



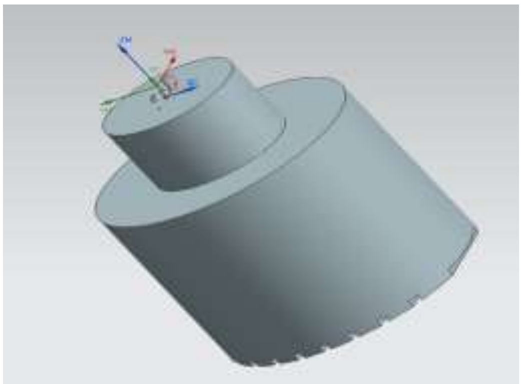


Fig.21: raw material and part of fixture

Below image shows planar mill operation and verification

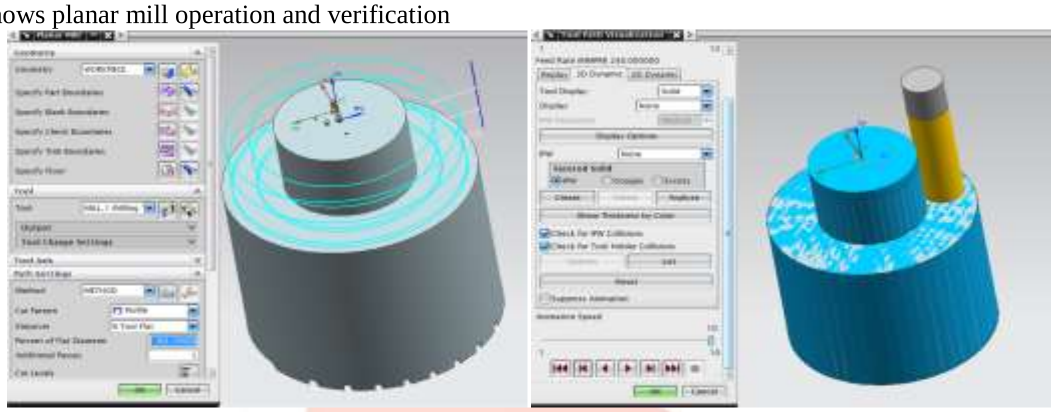


Fig.22: planar mill operation and verification

Below image shows face mill operation and verification

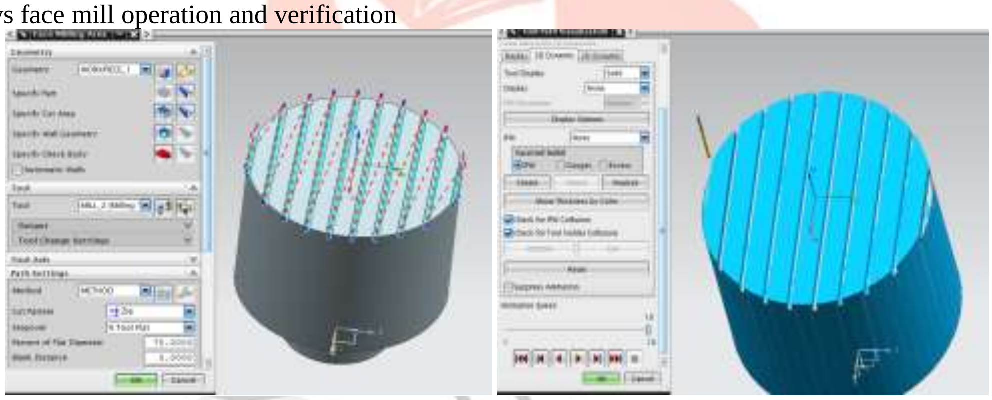


Fig.23: face mill operation and verification

VIII. RESULTS

8.1 Manufacturing of Timer with 3jaw chuck:

Time is taken to manufacture a single component with3jaw chuck on CNC machine = 33min 31sec=34min
If the time in seconds is above 30 then it is taken as 1min, if it is below 30 then it is exception
Manufacturing cost of CNC machine per hour = 1200rs/hr
Manufacturing cost of single Timer = (1200/60)*34= 680rs
Direct Labour Cost = Tm * Man Hour Rate Rs.
Man Hour Rate = 96 Rs.
Tm= machining time
Tm =(34/60) hrs= 0.56hrs
Direct Labour Cost = 0.56*96= 54 Rs.

Machining type	Time required to machining	Machine cost/hr	Raw material cost- R	Labour Cost - L	Manufacturing Cost -M	Total cost of part (R+L+M)
Milling machine	34 min	1200	150	54	680	884

Total cost of part =raw material cost + labour cost +manufacturing cost = 150+54+680= 884rs

8.2 Manufacturing of Timer with designed fixture:

Time is taken to manufacture a single component with fixture on CNC machine = 22min 22sec=22min

If the time in seconds is above 30 then it is taken as 1min, if it is below 30 then it is exception

Manufacturing cost of CNC machine per hour = 1200rs

Machining cost per piece (machining cost per min x machining time in min) = (1200/60)*22=440 rs

Manufacturing cost of single Timer= 440rs

Direct Labour Cost = Tm * Man Hour Rate Rs.

Man Hour Rate = 96 Rs.

Tm= machining time

Tm = (22/60) hrs= 0.36hrs

Direct Labour Cost = 0.36*96= 35 Rs.

Machining type	Time required to machining	Machine cost/hr	Raw material cost	Labour cost	Manufacturing Cost	Total cost of part
Milling machine	22min	1200	150	35	440	625

Total cost of part =raw material cost + labour cost +manufacturing cost = 150+35+440= 625rs

Graphical representation of machining cost, labour cost, and machining time

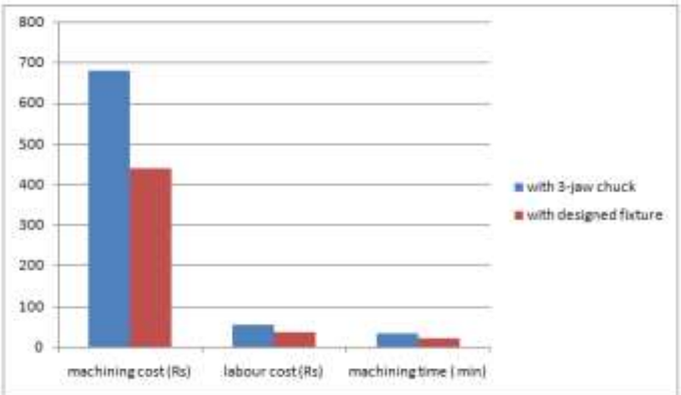


Fig: graphical representation of cost estimation

Graphs represent there is the reduction in machining cost, labour cost, machining time by using designed fixture compared to 3jaw chuck.

IX. CONCLUSION

The outer diameter of the timer is 4cm which is hard to manufacture by using machine vice or chuck. Trail operations are done on three parts to check whether manufacturing is possible using chuck as the fixture by maintaining low speed and feed. But all the three parts are rejected; to overcome from the rejection rate new fixture is developed by considering part dimensions. Using 3-2-1 concept fixture is developed 3points for specifying plane it indicates the fixture surface should be flat and parallel, next 2 points for the location to stop rotation of part. The fixture has three pins to stop the rotation of a part and finally clamped using clamping bolts to stop vertical movement. Dynamic analysis has been done on the fixture to validate, and mode shapes are plotted in the report. Manufacturing time, labor cost, manufacturing cost was reduced Using designed fixture. Inspection charts are shown in the report. Graphical representation of reduction of time and cost is shown in results.

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