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Design and development of seeker base component by optimizing the manufacturing process

T. Anil Kumar, Y. Venu Babu

Abstract
Computer Aided Manufacturing is commonly linked to Computer Aided Design (CAD) systems. The resulting integrated CAD/CAM system then takes the computer-generated design, and feeds it directly into the manufacturing system; the design is then converted into multiple computer-controlled processes, such as drilling or turning. Seeker Base is a single target offensive spell cast by the Terrain Raven. Upon casting, a projectile with normal speed is created and travels towards the assigned target. When the missile is within 2 range of its target it accelerates, becoming impossible to escape from. Upon reaching its target, it explodes and causes area effect damage. Seeker Missile becomes less effective against skilled players, as they are able to better position units to mitigate damage. Despite this, Seeker Missiles grow increasing powerful as the game progresses, due to splash against larger army sizes and its constant 100 damage the dynamic characteristics analysis of Seeker Base is mainly involved in the calculation about vibrations on model. The objective to calculate the vibrations and resonances of Seeker Base is modulating those frequencies and avoiding resonance, thus the vibrations.

Keywords: Design, development of seeker, manufacturing process, CAD/CAM system.

1. Introduction
Today's developments of technology in the field of manufacturing sector and the complexity of the aerospace components demanded the new methodologies in the production practices and management of the production activities. Global business drivers such as competition, consumer's desires, and government regulations continue to influence the manufacturing applications for product and process development, which leads to reduction in cost and improvement in quality and productivity by reducing scrap and effective utilization of man and machines.

2. Computer Aided Design (CAD)
The CAD system provides generally the following design activities:
- Geometric modeling,
- Engineering analysis,
- Design review and evaluation,
- Computer drafting.

2.1 Background of CAD development
From 1980, rapid developments of computer equipment lead to more powerful computers hardware and computer systems. Workstations and personal computers became widely available at reasonable prices [3, 5]. This development enabled the introduction of CAD on a wider scale. Knowledge based engineering system for design was introduce in the mid-eighties. These systems employ artificial intelligence technology for representing expert design and manufacturing knowledge. The advantage of these systems is that similar designs with different specifications and geometry can be generated much faster. However, the realization of truly intelligent CAD systems still is an academic research issue. After 1970, the meaningful step was development of graphical terminals that make possible to work interactively [5]. However, the available hardware was very expensive and therefore the using was restricted to a limited number of companies and people. Accordingly the CAD

applications occurred in small amount. The CAD system provides generally the following design activities:

- Geometric modeling
- Engineering analysis
- Design review and evaluation
- Computer drafting

2.2 Different types of CAD Software's:

- Autocad
- Proe
- Solidworks
- Solidedge
- Ideas
- Catia
- Unigraphics NX

3. Unigraphics Introduction

NX is one of the world's most advanced and tightly integrated CAD/CAM/CAE product development solutions. Spanning the entire range of product development, NX delivers immense value to enterprises of all sizes. It simplifies complex product designs, thus speeding up the process of introducing products to the market [3]. The NX software integrates knowledge-based principles, industrial design, geometric modeling, advanced analysis, graphic simulation, and concurrent engineering. The software has powerful hybrid modeling capabilities by integrating constraint-based feature modeling and explicit geometric modeling. In addition to modeling standard geometry parts, it allows the user to design complex free-form shapes such as airfoils and manifolds. It also merges solid and surface modeling techniques into one powerful tool set. Our previous efforts to prepare the NX self-guiding tutorial were funded by the

4. Commonly used basic GD&T symbols

SYMBOL	GEOMETRIC CHARACTERISTIC	TYPE OF TOLERANCE	PRIMARY CONTROL
⏥	FLATNESS	Form No relation between features	Controls form (shape) of size and non-size features. Datum reference is not allowed
—	STRAIGHTNESS		
⌭	CYLINDRICITY		Controls form (shape) of size features Datum reference is not allowed
○	CIRCULARITY (ROUNDNESS)		
⊥	PERPENDICULARITY	Orientation No relation between features	Controls orientation (tilt) of surfaces, axes, or median planes for size and non-size features Datum reference required *Optional: Angularity symbol may be used for all orientation controls*
//	PARALLELISM		
∠	ANGULARITY		
⌖	POSITION	Location	Locates center points, axes and median planes for size features. Can also control orientation.
⌓	PROFILE OF A SURFACE		Locates surfaces Can also be used to control size, form, and orientation of surfaces based on datum reference
⌒	PROFILE OF A LINE		
⌰	TOTAL RUNOUT	Runout	Controls surface coaxiality Can also control form and orientation of surfaces.
↗	CIRCULAR RUNOUT		
◎	CONCENTRICITY	Location of derived median points.	Locates derived median points of a feature *Not common, consider position, runout, or profile.*
⌯	SYMMETRY		

5. National Science Foundation's advanced

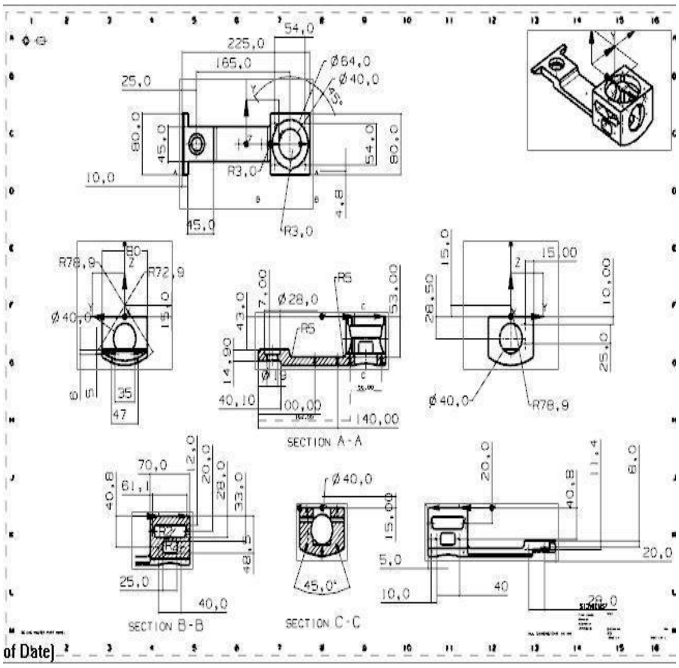
Technological Education Program and by the Partners of the Advancement of Collaborative Engineering Education (PACE) program.

NX is a premier 3D computer aided design suite [3]. It allows you to model solid components and assemblies, to perform engineering analyses such as mechanism simulation and stress analysis, to create tool paths for computer-based manufacturing processes and to perform numerous other engineering design activities in a single software environment. Software suites like NX are referred to as product lifecycle management (PLM).

6. Input for the project

6.1 Piston 2D Drawing

A 2D drawing is used to design a 3D model for our component using Unigraphics NX 7.5 CAD software. Below shows the 2D drawings of the Seeker Base with all the required dimensions and GD&T representations the suits the best for manufacturing the component without any errors.



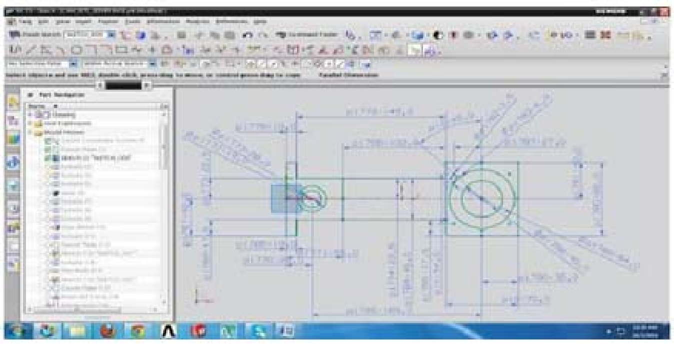
7. Steps involved in 3D

7.1 Modeling of piston

3D model is designed by using NX cad software.

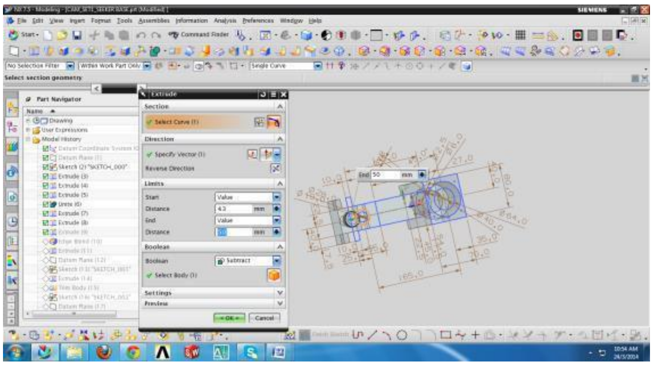
7.2 Sketching

Below is the sketch required to obtain the 3D model of the piston from the above 2D drawing? Below image shows the SKETCH of the Seeker Base.



Procedure to draw the above sketch →
Insert → sketch in task environment → select plane ok.
Insert → curve → profile.

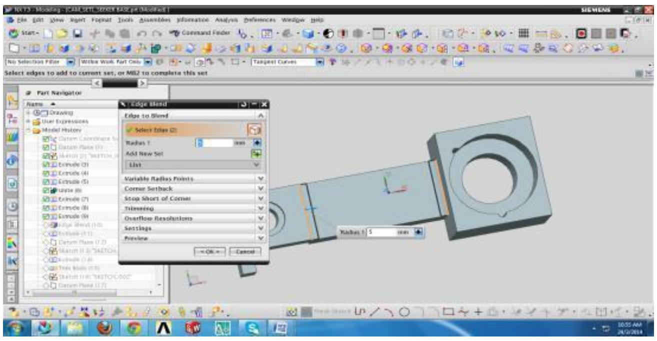
By using profile curve we will get the 2D design of seeker base wall cross-section below images shows extrude option.



7.3 Extrude

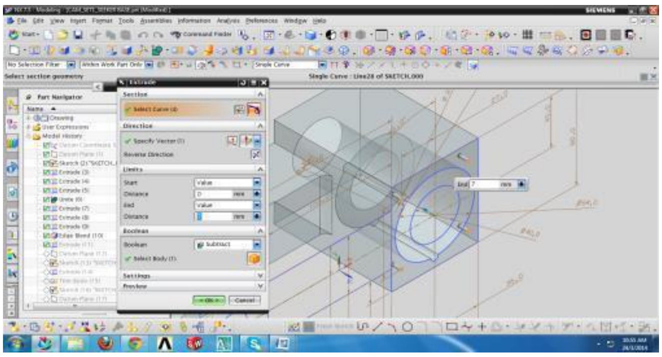
➢ Extrude command is used to create a body by sweeping a 2D or 3D section of curves, Edges, sketches in a specified Direction.

Insert → design features → extrude.
Select curve → specify vector → Boolean operation (None) → ok.
Below images shows Edge blend option.



7.4 Edge blend

Insert → detail features → edge blend. Select edge specify radius → ok. Below image shows Extrude option.

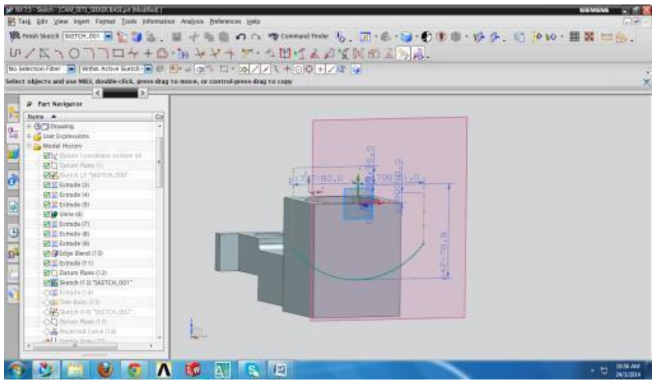


7.5 Extrude

Extrude command is used to create a body by sweeping a 2D or 3D section of curves, Edges, sketches in a specified Direction.
Insert → design features → extrude.

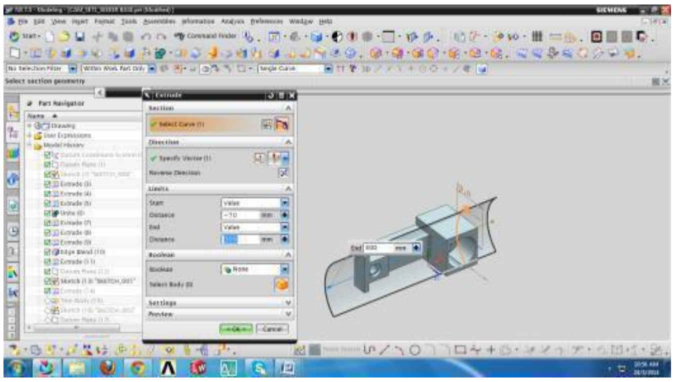
Select curve → specify vector →
Boolean operation (None) ok

Below image shows the SKETCH of the Seeker Base



Procedure to draw the above sketch
Insert → sketch in task → environment → select plane ok. →
Insert → curve → profile.

By using profile curve we will get the 2D design of seeker base wall cross-section below image shows EXTRUDE option.



7.6 EXTRUDE

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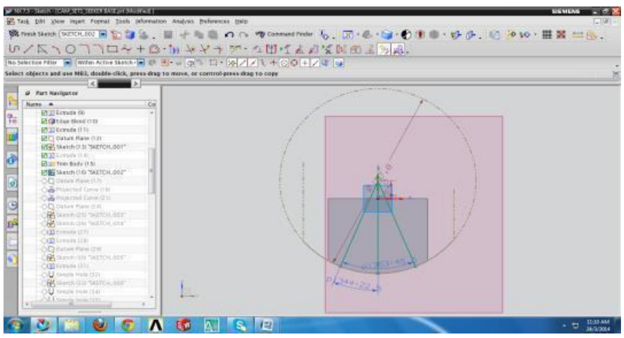
Insert → design features → extrude.
Select curve → specify vector → Boolean operation (None) → ok

Below image shows the SKETCH of the Seeker Base



8. CNC machine used in our project:

8.1 Types of CNC machine used in this project:

DMG 5-axis milling machine is used for manufacturing seeker base component. In DMG 5-axis milling machine X, Y, Z, B, C are 5 vectors, X & Y are tool movement and Z is for table upwards movement, B for spindle movement, C for table rotation [4].

High rigidity with Integrated Spindle up to 12000 rpm, Spindle is directly coupled with motor [8]. Vertical Operations, Integrated rotary table of 1200 mm X 700 mm with rotary dia 700 mm. Horizontal Operations, With head tilting at 90 deg. Angular and 5-axes simultaneous machining, Capable of machining from +30 deg to -120 deg head tilting. Machine accuracies, Positional Accuracy +/-0.005 mm, Repeatability +/- 0.003 mm

9. Rotary table 5-axis CNC vertical milling machine

9.1 National Science Foundation's advanced

Technological Education Program and by the Partners of the Advancement of Collaborative Engineering Education (PACE) program.

10. Selection of tool

Selection of tools plays an important role in manufacturing any component. Proper tools must be selected otherwise in manufacturing process improper tools results in damage of work piece or damage to the tools, tool holders.

10.1 Slab mill

10.2 HSS slab mill

Slab mills are used either by themselves or in gang milling operations on manual horizontal or universal milling machines to machine large broad surfaces quickly. They have been superseded by the use of carbide-tipped face mills which are then used in vertical mills or machining centres.

10.3 Side-and-face cutter

10.4 Side and face cutter

The side-and-face cutter is designed with cutting teeth on its side as well as its circumference. They are made in varying diameters and widths depending on the application. The teeth on the side allow the cutter to make unbalanced cuts (cutting on one side only) without deflecting the cutter as would happen with a slitting saw or slot cutter (no side teeth).

Cutters of this form factor were the earliest milling cutters developed. From the 1810s to at least the 1880s, they were the most common form of milling cutter, whereas today that distinction probably goes to end mills.

10.5 Involute gear cutter

There are 8 cutters (excluding the rare half sizes) that will cut gears from 12 teeth through to a rack (infinite diameter).

10.6 Hob

Aluminum Chromium Titanium Nitride (AlCrTiN) coated Hob using Cathodic arc deposition technique

10.7 End Mill

End mills (middle row in image) are those tools which have cutting teeth at one end, as well as on the sides. The words *END MILL* is generally used to refer to flat bottomed cutters, but also include rounded cutters (referred to as *BALL NOSED*) and radiuses cutters (referred to as *BULL NOSE* or *TORUS*). They are usually made from high speed steel (HSS) or carbide, and have one or more flutes. They are the most common tool used in a vertical mill.

10.8 Involute gear cutter

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Aluminum Chromium Titanium Nitride (AlCrTiN) coated Hob using Cathodic arc deposition technique

10.10 End Mill

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10.11 Face Mill

A face mill consists of a cutter body (with the appropriate machine taper) that is designed to hold multiple disposable carbide or ceramic tips or inserts, often golden in color. The tips are not designed to be re sharpened and are selected from a range of types that may be determined by various criteria, some of which may be: tip shape, cutting action required, and material being cut. When the tips are blunt, they may be removed, rotated (indexed) and replaced to present a fresh, sharp face to the work piece. This increases the life of the tip and thus its economical cutting life.

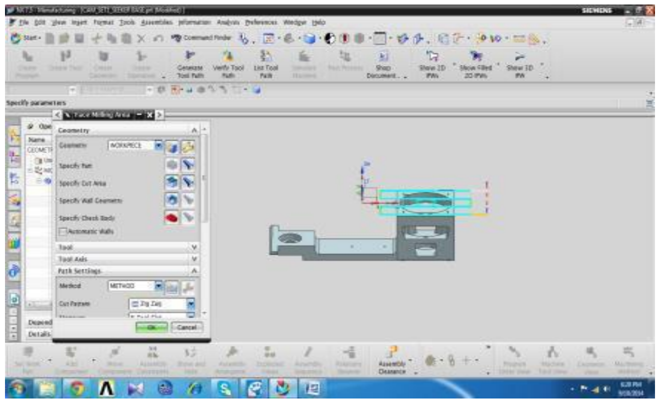
10.12 Drill Bits

10.13 Setup tooling list

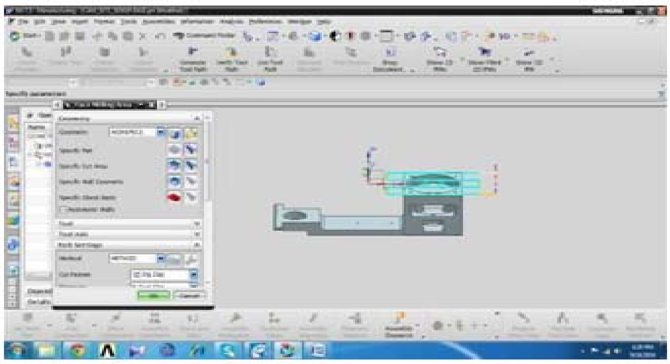
We need to select/create a tool for each of the Machining operations. In the Project Manager, you can create and automatically assign new tools to tool stations in the Tools view. You can also create tools from the Machining menu.

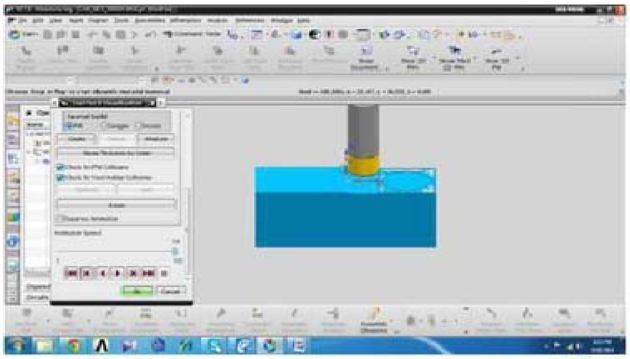
11. Simulation of the manufacturing process in cam:

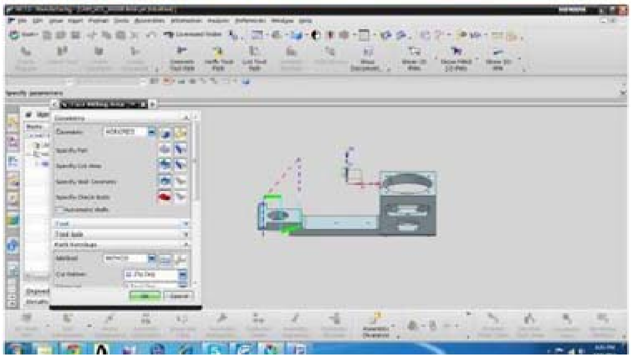
Below Image shows blank (raw material) and part of the seeker base.

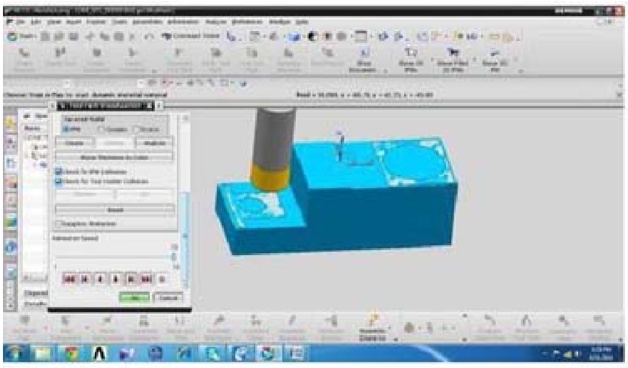


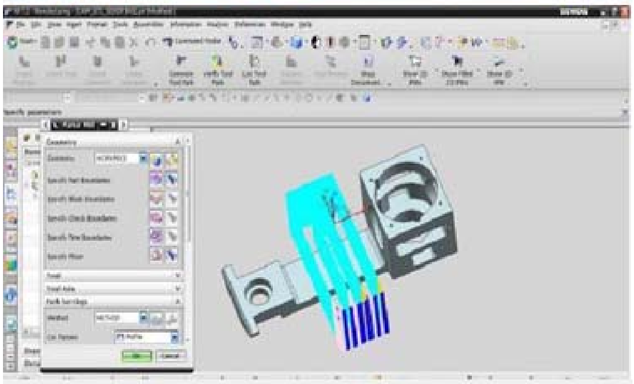
Below Image shows face mill area operations

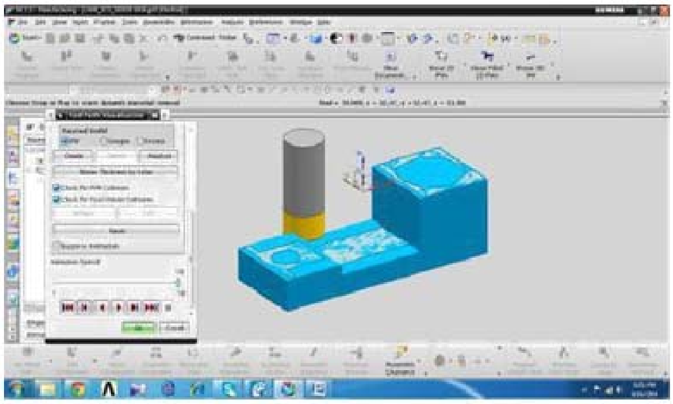


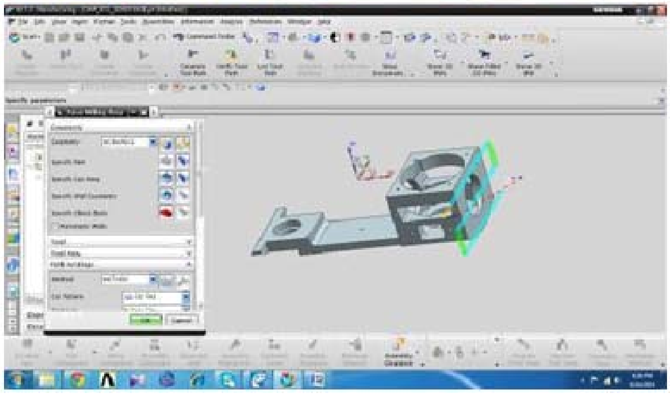












12. Fundamental Natural Frequency

The fundamental frequency, often referred to simply as the fundamental, is defined as the lowest frequency of a periodic waveform. In terms of a superposition of sinusoids (e.g. Fourier series), the fundamental frequency lowest frequency sinusoidal in the sum.

13. Resonance

In physics, resonance is the tendency of a system to oscillate with greater amplitude at some frequencies than at Frequencies at which the response amplitude is a relative maximum are known as the system's resonant frequencies, or resonance frequencies. At these frequencies, even small periodic driving forces can produce large amplitude oscillations, because system stores vibration energy.

14. Mode Shapes [7]

For every natural frequency there is a corresponding vibration mode shape. Most mode shapes can generally be described as being an axial mode, torsional mode, bending mode, or general modes. Like stress analysis models, probably the most challenging part of getting accurate finite element natural frequencies and mode shapes is to get the type and locations of the restraints correct. A crude mesh will give accurate frequency values, but not accurate stress values.

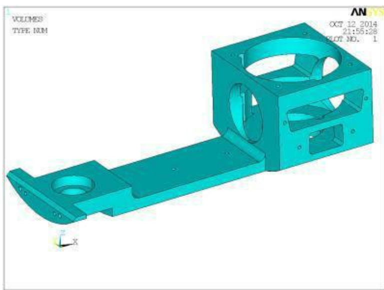


Fig: Shows geometric model of Seeker base for modal analysis

15. Material properties:

All the components of the Seeker base are made using Steel, High Strength Alloy ASTM A-514. All the components of the Seeker base are assigned as per the below material properties.

Steel, High Strength Alloy ASTM A-514Mechanical Properties:

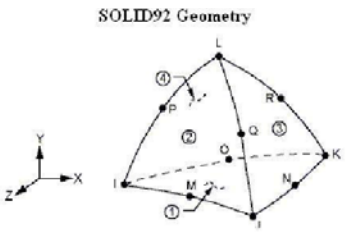
Young's modulus = 200Gpa
Yield Strength = 690 Mpa
Tensile Strength = 760 Mpa
Density = $7850 kg/m^2$

Element Type Used:

Solid 92
Number of Nodes: 10

16. SOLID 92 Element Description

SOLID92 has a quadratic displacement behavior and is well suited to model irregular meshes (such as produced from various CAD/CAM systems) [7]. The element is defined by ten nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element also has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities.



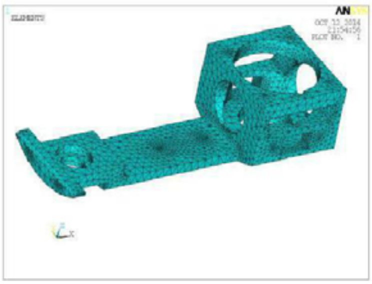


Fig 9: Shows meshed model of Seeker base for modal analysis

The Seeker base was studied to understand the natural frequencies between 0-500Hz. The Boundary condition used for modal analysis is shown in below figure [7].

17. Boundary conditions:

Seeker base is fixed in all Dof at connecting locations.

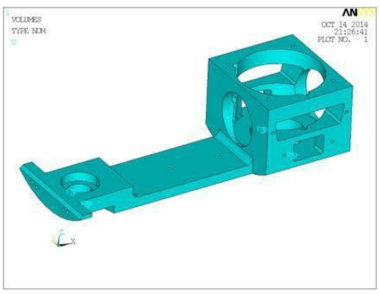


Fig: Shows Boundary conditions applied on the Seeker base for modal analysis.

From the modal analysis, a total of 5 natural frequencies are observed in the frequency range of 0-500 Hz. The mass participation of each of these 5 frequencies are listed in the below table. The mode shapes of these frequencies are shown in the below figures.

18. Modal analysis of seeker base

Table 1: shows the Frequencies in the range of 0-500Hz.

MODE	FREQUENCY	PARTIC.FACTOR			EFFECTIVE MASS		
		X	Y	Z	X	Y	Z
1	307.718	0.01	1E-03	0.016	1E-03	1E-07	2E-03
2	344.738	-3E-03	0.019	1E-04	1E-06	3E-03	3E-07
3	352.25	0.016	3E-04	-9E-02	2E-07	1E-06	8E-04
4	377.846	2E-04	2E-05	-7E-04	3E-07	4E-09	5E-08
5	477.704	7E-06	1E-04	-2E-02	6E-10	3E-07	6E-05

The mode shapes for the above natural frequencies are plotted below:

Results –Mode1 @ 307 Hz

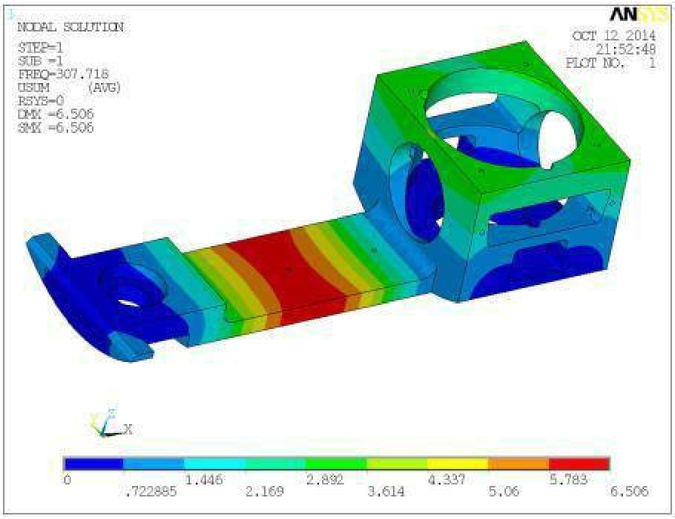


Fig: Shows Mode shape 1@307Hz for seeker base

Results –Mode2 @344Hz

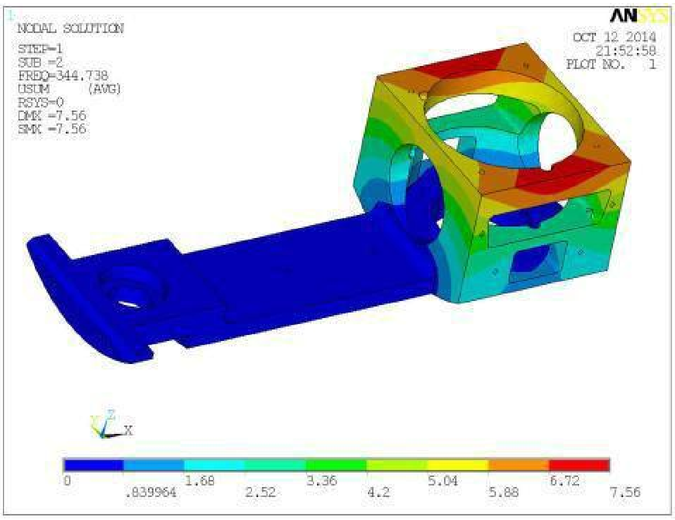


Fig 10: Shows Mode shapes 2@ 344 Hz for seeker base

Results –Mode3@352Hz

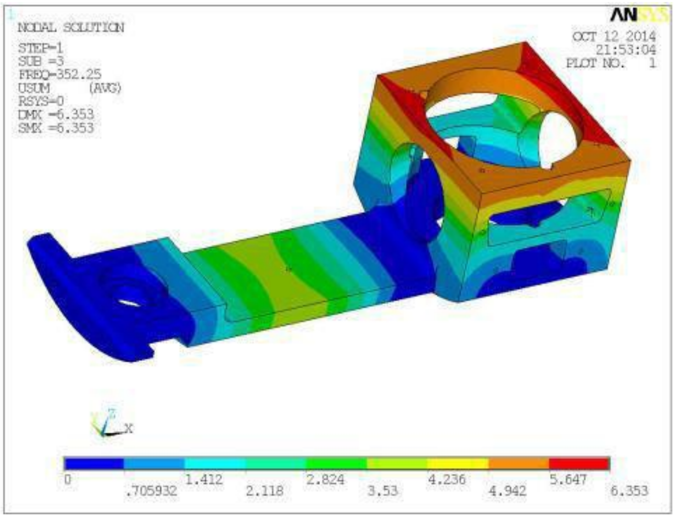


Fig: Shows Mode shape 4@377 Hz for seeker base

Results –Mode5 @477Hz

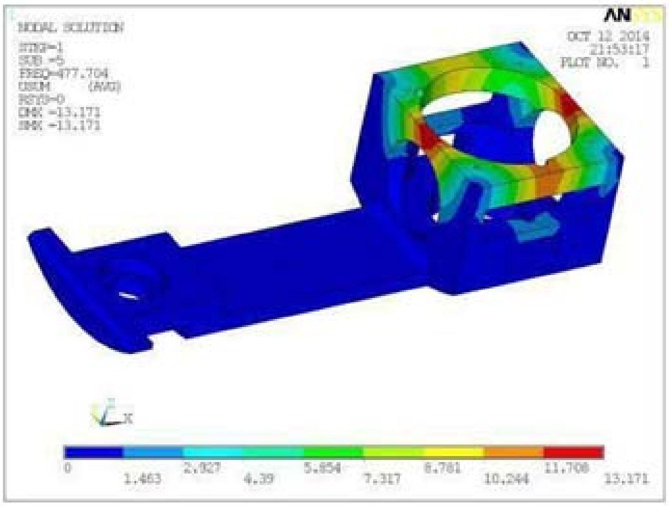


Fig: Shows Mode shape 5@ 477 Hz for seeker base

From the above modal analysis results it is observed that only 5 natural frequencies exists in the operating range of 0-500 Hz. From the modal analysis, the total weight of the seeker base is 0.015 Tone.

- It is observed that the maximum mass participation of 0.001 Tone in X-dir for the frequency of 307Hz.
- It is observed that the maximum mass participation of 0.003 Tone in Y-dir for the frequency of 344 Hz.
- It is observed that the maximum mass participation of 0.002 Tone in Y-dir for the frequency of 307Hz.

However RSA analysis has been carried out to check the structure behavior for random vibrations in the frequency range of 0-500Hz.

19. RSA analysis of seeker base response spectrum Analysis (RSA):

A Response spectrum is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency, that are forced into motion by the same base vibration or shock [9]. The resulting plot can then be used to pick off the response of any linear system, given its natural frequency of oscillation. One such use is in assessing the peak response of buildings to earthquakes. The seeker base is subjected to a base excitation of 0.2 mm in X, Y and Z directions. Response spectrum analysis has been carried out on the seeker base to check the effect of mode combination of the existing natural frequencies. SRSS mode combination is used for the analysis. The boundary conditions used for the RSA are shown in below figures.

20. Boundary conditions

Seeker base is fixed in all Dof at connector location.

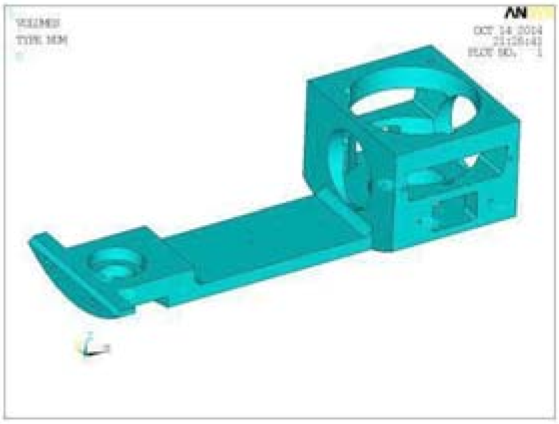


Fig: Boundary conditions applied on the Seeker base for RSA analysis

RSA analysis along X- direction

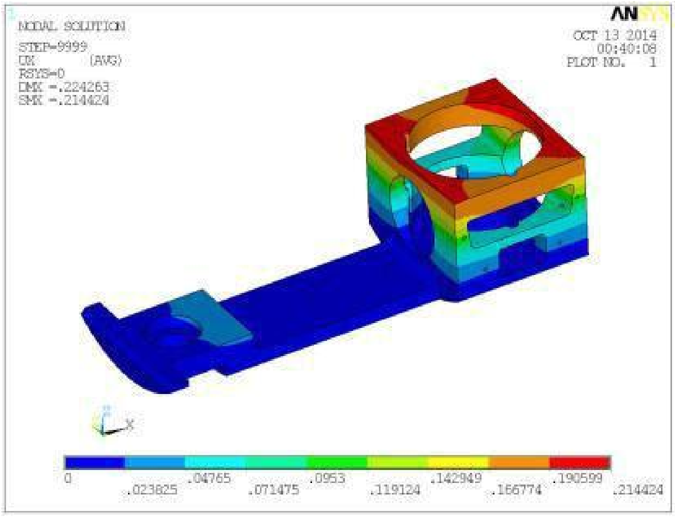


Fig: Deflections in X - Direction of Seeker base for RSA analysis in X-Dir

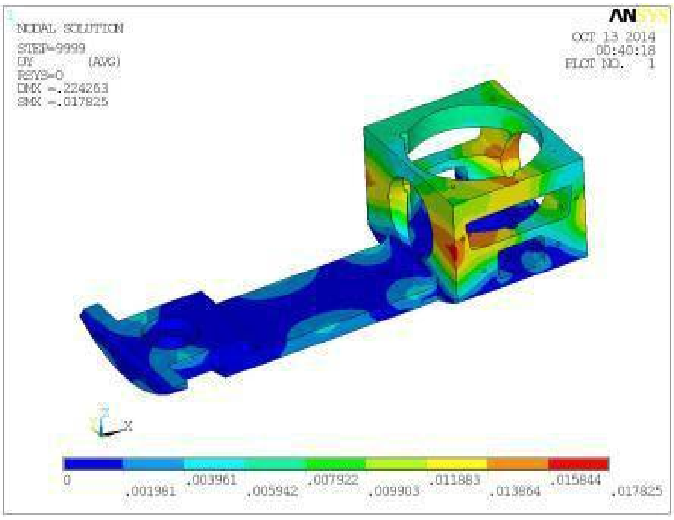


Fig: Deflections in Y - Direction of Seeker base for RSA analysis in X-Dir

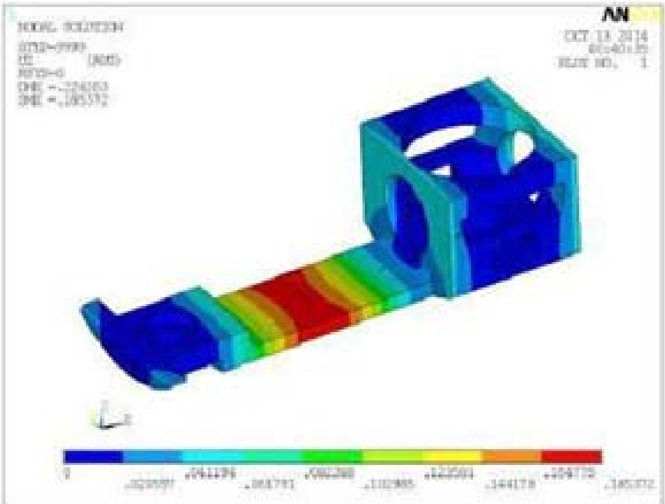


Fig: Deflections in Z - Direction of Seeker base for RSA analysis in X-Dir

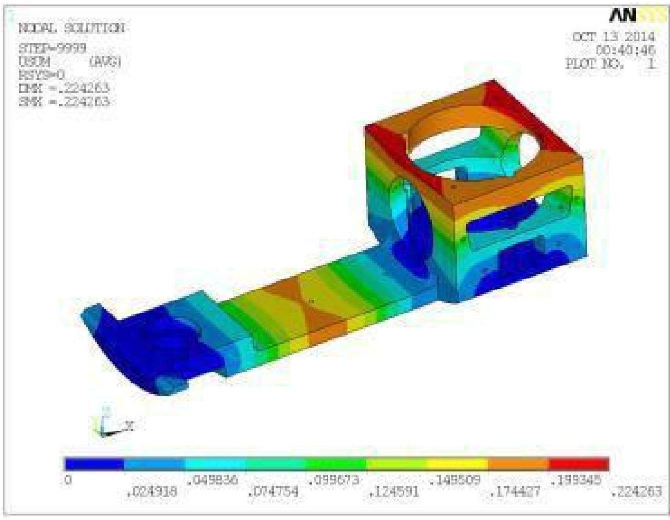


Fig: Max. Deflections of Seeker base for RSA analysis in X-Dir

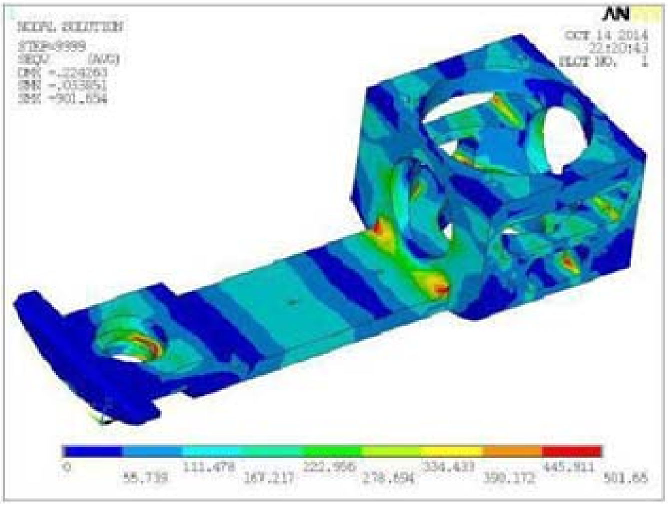


Fig: Von Mises stress of Seeker base for RSA analysis in X-Dir

Table 2: Deflection and Von Mises stress of Seeker base for RSA analysis in X-Dir

S.NO.	DEFLECTION(mm)	VONMISES STRESS (MPa)
1	0.22	601

RSA analysis:
From the RSA analysis in X - Dir,

Table 2: Deflection and Von Mises stress of Seeker base for RSA analysis in X-Dir

S.NO.	DEFLECTION(mm)	VONMISES STRESS (MPa)
1	0.22	601

Results-RSA analysis along Y-direction

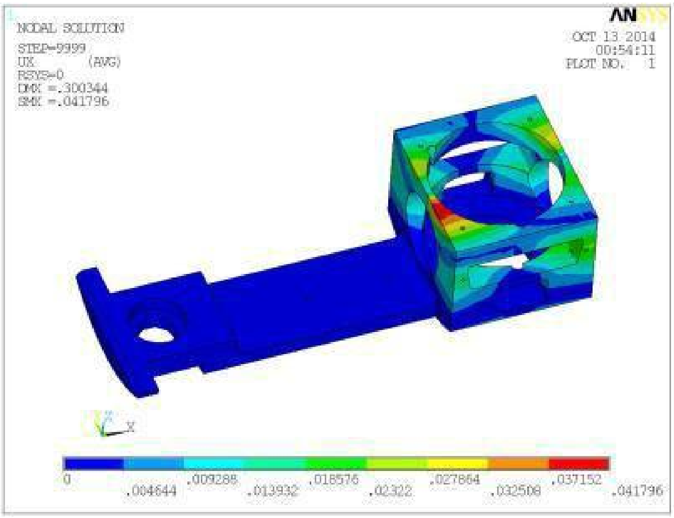


Fig: Deflections in X - Direction of Seeker base for RSA analysis in Y-Dir

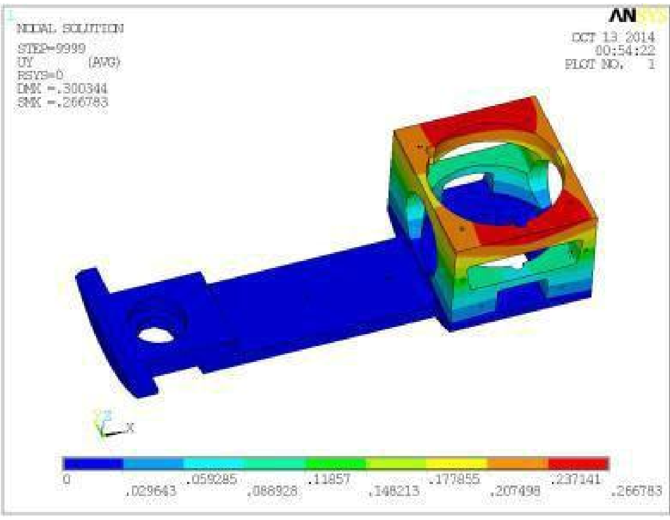


Fig: Deflections in Y - Direction of Seeker base for RSA analysis in Y-Dir

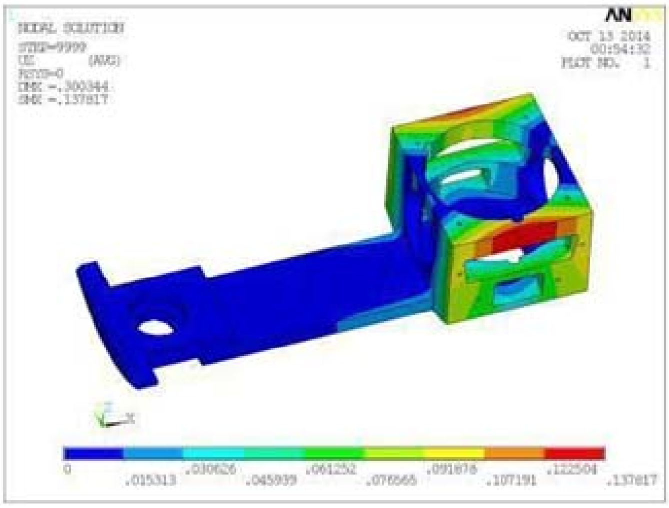


Fig: Deflections in Z - Direction of Seeker base for RSA analysis in Y-Dir

21. RSA ANALYSIS:

22.1 From the RSA analysis in X - Dir,

Table 2: Deflection and Von Mises stress of Seeker base for RSA analysis in X-Dir

S. NO.	Deflection (mm)	Von Mises stress (MPa)
1	**0.22**	**601**

22.2 From the RSA spectrum analysis in Y - Dir,

Table 3: deflection and Von Mises stress of Seeker base for RSA analysis in Y-Dir

S. NO.	Deflection (mm)	Von Mises stress (MPa)
1	0.30	545

From the RSA spectrum analysis in Z - Dir,

Table 4: deflection and stress of Seeker base for RSA analysis in Z-Dir

S. NO.	Deflection (mm)	Von Mises stress (MPa)
1	0.228	549

From the above RSA results observed Von Mises stress 501MPa, 545MPa and 549MPa are less than the yield strength of material used Modified Seeker base. The yield strength of the material used for Seeker base is 690MPa.According to the Von Mises Stress Theory, the Von Mises stress of Seeker base is less than the yield strength of the material.

23. Cam Results

1. We have developed 3D design using 'UGNX-7.5' which is CAD software.
2. Tool path generation for "SEEKER BASE" component using CAM software ('UGNX-7.5' CAM software used to generate part program by designing and feeding the geometry of the component).
3. Defining the proper tool path and thus transferring the generated part program to the required CNC machine with the help of DNC lines.
4. Reduction in number of fixtures in manufacturing seeker base by using 5-axis machine obtained in Tthe spectrum analysis are also under the design limits of the material. Therefore it concluded that the Seeker base is safe under the random loading conditions.

24. Acknowledgment

This paper is based on m. tech. project carried out by the student of Chirala Engineering College, Chirala studying M.TECH (CAD/CAM) the project had been completed by Mr. T. Anil Kumar, bearing h.t.no.: 12E91D0401 under the guidance of Ms Y .Venu Babu, M.tech, M.I.S.T.E. R

25. Conclusion

In the present project The Seeker base has been designed and analyzed for Dynamic behaviour and Tool path is generated.
Tool path generation for "SEEKER BASE" component using CAM software ('UGNX-7.5' CAM software used to generate part program by designing and feeding the geometry of the component).
Reduction in B number of fixtures in manufacturing seeker base by using 5-axis machine.
From the above analysis it is concluded that the Seeker base has stresses and deflections with in the design limits of the material used. The deflections and stresses obtained in the spectrum analysis are also under the design limits of the material. Therefore it concluded that the Seeker base is safe under the random loading conditions.

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