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Weight Optimization of Bed for Heavy Duty CNC Lathe Machine MGX200 using FEM

Haresh Modhavadiya, Rakesh Prajapati, Bhupesh Goyal

Abstract: In this paper, MGX200 CNC Lathe bed selected for the complete static and vibration analysis. The examination work completed to lessen the heaviness of bed without break its basic inflexibility and the precision of the machine instrument by expelling material.In this work, 3D CAD model done by using Autodesk Inventor Professional 2018 Software and analysis carried out in ANSYS 16.2 Software. The outcomes appeared with the assistance of qualities break down the impact of weight decrease on the basic trustworthiness of the machine bed when the weight decrease then decisions about the enhanced structure.

Keywords: Optimization, CNC Bed, FEM

I. INTRODUCTION

A CNC machine used for remove the material and give the desire shape and size as we required.

CNC Machine Mainly two types HMC and VMC Machine. HMC have a rotating workpiece and fix tool. And VMC have a rotating tool and workpiece is fix. In HMC Machine mostly round shape workpiece is place. In CNC Machine main operation like Facing, Groove, threading, drilling, knurling etc…

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* Correspondence Author

Haresh Modhavadiya*, M.Tech.(CAD/CAM) Mechanical Engineering, Parul Institute of Technology, Parul University, Vadodara, India.E-mail: modhavadiyah22@gmail.com

Rakesh Prajapati, Mechanical engineering, Parul Institute of Technology, Parul University, Vadodara, India. E-mail: rakeshkumar.prajapati@paruluniversity.ac.in

Bhupesh Goyal, Mechanical engineering, Parul Institute of Technology, Parul University, Vadodara, India. E-mail: bhupesh.goyal@paruluniversity.ac.in

II. WORKING PRINCIPLE

CNC Machine works under close circle framework which implies when CNC read the Program and execute and criticism returning to the CNC Framework**.** By controlling the relative movements between the tool and work piece geometrical shapes are machined. Control the relative movements through coded letter numbers is known as numerical control of machine apparatuses.

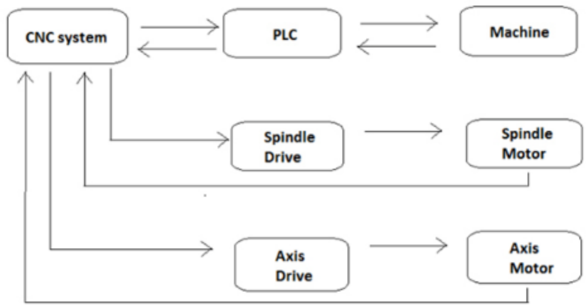

Fig.1 CNC Machine Working Principle

III. LITERATURE REVIEW

The review papers are mainly referring to reducing the weight of CNC Lathe bed with gray cast iron material and majority of the published work applies to them. At el. B.MALESWARA SWAMI[1]: In this paper the 3D model can be done by using CATIA software. For Analysis HYPERMESH software used.. Here material used CAST IRON G15, CAST IRON G40 AND CAST IRON G70. From the above material, the G15 chose as the best material because of low stress and high natural frequencies, At el. SUJIT GANESH KORE[2]: In this paper, a machine bed chose for the total analysis for static loads. The exploration work completed to decrease the heaviness of the machine bed, reduced the stress induced in the lathe bed and to lessen the relocation. In this work 3D model done by using SOLID EDGE V20 software. Analysis done by ANSYS 13 software. Material used CAST IRON, ST-STEEL and AL-ALLOY. The weight optimization of machine bed accomplished (Around 15%) for all the three material, consequently the manufacturing cost additionally diminished. The von-misses stress for Upgraded model 2 and Upgraded model 3 diminished. (Approximately 19%).At el. JUTURI SAIDAIAH [3]: structural and modal analysis completed on lathe bed at maximum load conditions.

These simulation results used to decrease the heaviness of the lathe bed without breaking down its structural strength and damping limit by including ribs and expelling mass where less deformation and stresses induced. FEA analysis of modified lathe bed carried out with Gray cast iron and Epoxy-granite which is a mixture of granite and epoxy resin-hardener as an alternative material. Effectiveness of both materials compared in terms of induced stresses. Deformation and weight reduction. Lathe bed CAD models generated with CREO software. The analyses did utilizing ANSYS APDL software. The outcomes appeared as contour plots and tabulated, to analyses the impact of weight decrease on the structural integrity of the machine bed before and after the weight reduction and conclusions drawn about the optimized design. The current lathe bed weight is 105.816 Kg, after optimize the design weight of the bed has reduced to 97.992 kg. Weight decrease is equivalent to 7.4% base model weight. Also Structural and modal analyses carried out for modified lathe bed with Epoxy granite material. By changing lathe bed material bed weight has decreased to 39.469 kg weight decrease is equivalent to 62.7% base model weight.

IV. PROBLEM STATEMENT

MGX200 CNC Lathe bed weight was 1149 kg so company want to reduce the weight. This lathe bed is chosen for the complete analysis for both static and natural frequencies. At that point investigation is completed to diminish the heaviness of the machine bed without falling its structural rigidity and the accuracy of the machine tool by decreasing the material where lathe bed under goes less stress and deformation area likewise FE analysis will be done with grey cast iron material by applying on modified lathe bed.

Mgx200 Cnc Machine Specification

Table 1: MGX200 CNC Machine specification

1	Max. Turning Diameter	200mm
2	Max. Turning length	170mm
3	Swing Over bed	380mm
	SPINDLE DRIVE	
4	Spindle Motor Power	7.5HP
5	Speed Range	3000 rpm
	AXES SLIDES	
6	X Axis Strokes	350mm
7	Z Axis Strokes	200mm
8	Rapid Traverse: X&Y Axis	24m/min.
	MAIN SPINDLE	
9	Spindle Nose	A2-6
10	Bore Through Spindle	55mm
11	Bar Capacity	42mm
12	Chuck size	200mm
	ACCURACY	
13	Position Accuracy	0.015mm
14	Repeatability	±0.003mm

V. MODELING AND ANALYSIS

1. Part Drawing of CNC Lathe Bed MGX200

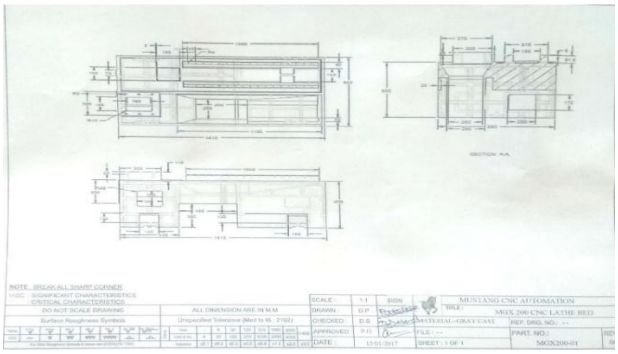

Fig.2. Detail Drawing of MGX200 CNC Lathe Bed

2. Material:

Gray Cast is amalgam of Carbon and silicon with iron. It contains 2.53 to 8 % C, 1.1-1.8% Si, 0.4-1% MN, 0.15 % P and 0.10% S. Graphite pieces possess about 10% of the metal volume.

It has high compressive strength, low tensile strength, high rigidity, high fluidity and ability to make sound casting. It has relatively low melting temperature 1130° to 1250° C. It easily machining.

Table 2: Material Property of gray cast iron

Sr. No.	Properties	Values
1	Density	7.2e-006 kg mm^{-3}
2	Coefficient of Thermal Expansion	1.1e-005 C^{-1}
3	Specific Heat	4.47e+005 mJ kg^{-1} C^{-1}
4	Thermal Conductivity	5.2e-002 W mm^{-1} C^{-1}
5	Resistivity	9.6e-005 ohm mm
6	Compressive Ultimate Strength	820 Mpa
7	Tensile Ultimate Strength	240 MPa
8	Young's Modulus	1.1e+005 MPa

3. Modeling

The CNC lathe bed created a 3D model in Autodesk Inventor Professional 2018 software.

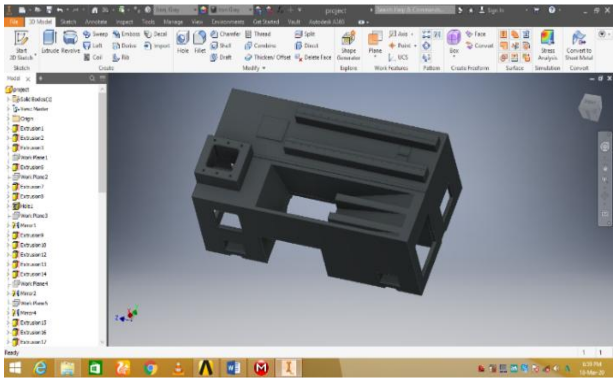

Fig.3. CNC Lathe Bed MGX200

4. ANSYS 16.0 Software:

A.MGX200 CNC Lathe Bed Import:

Here we can import MGX200 CNC Lathe bed model in ANSYS 16.0 Software

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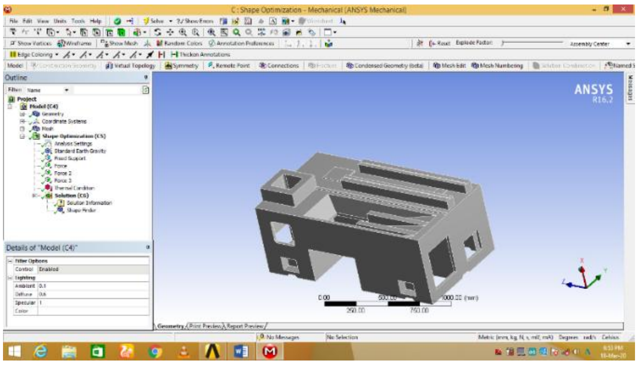


. Fig.4. CNC Lathe Bed Import in ANSYS 16.0

B. Meshing:

Here Hex Dominant method used for mesh. This meshing mostly used in the industries for the accurate mesh result. Meshing of solid model is 5.0 mm, element edge length adjusted to 2.50 mm in order to obtain a regular uniform mesh.

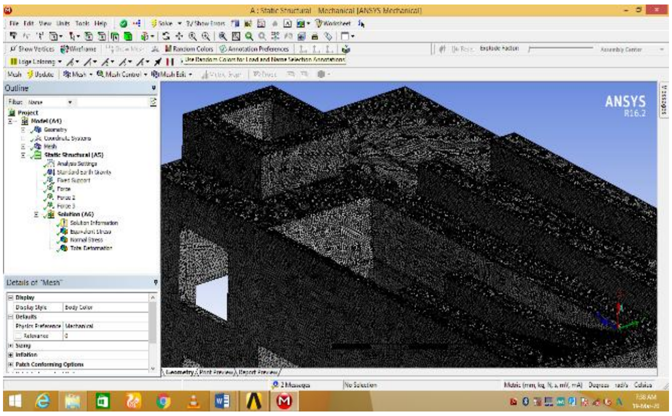


Fig.5. Applied Meshing on CNC Lathe Bed MGX200

C. Boundary Condition:

1) The determination of limit states of the CNC Machine bed base is fixed on the floor.
2) Gravitational force applied for stress distribution and deformation because of self-weight.
3) According to Industrial data 8000N force applied on Head Stock.
4) According to Industrial data 6000N force applied on Sliding portion.
5) According to Industrial data 2500N force applied on Tail Stock.

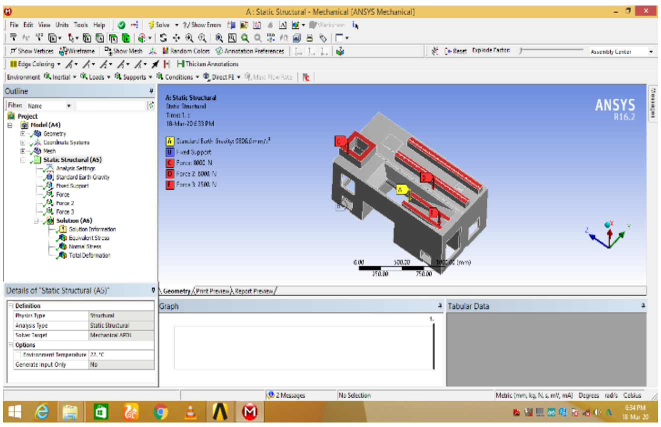


Fig.6. Applied Boundary Condition on MGX200 CNC Lathe Bed

D. Static and Vibration Analysis of Existing Bed

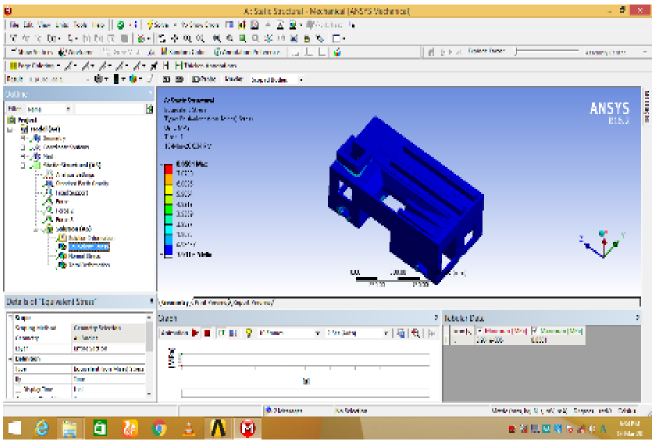


Fig.7. Equivalent Von-Mises Stress

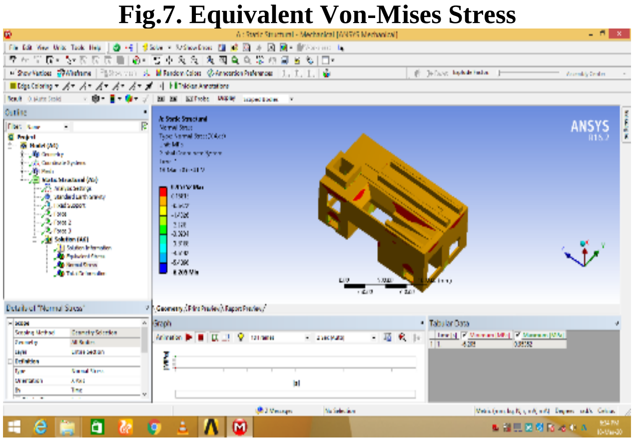


Fig.8. Normal Stress

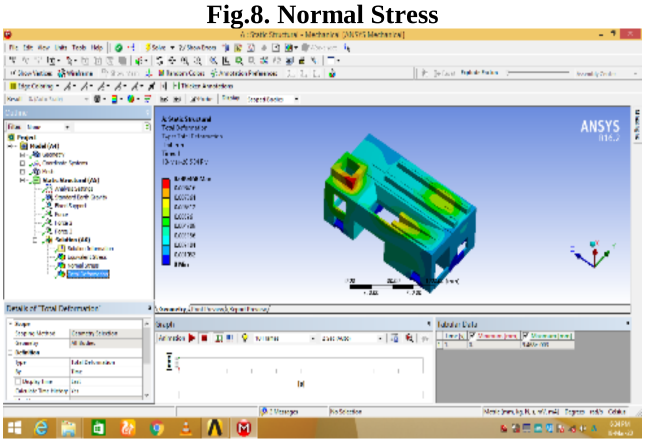


Fig.9. Total Deformation

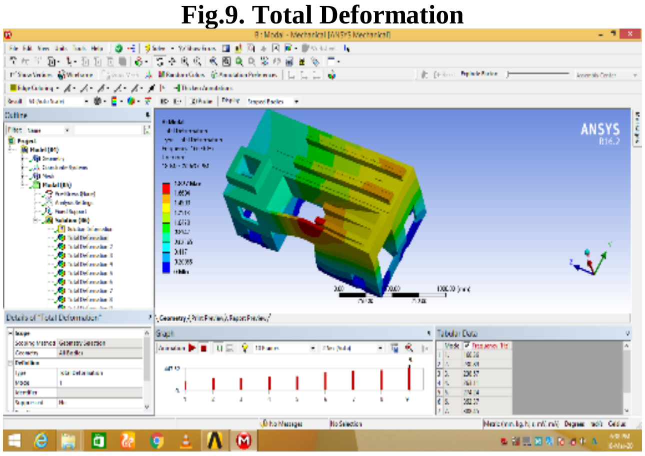


Fig.10. Natural Frequency Mode 1 Deformation

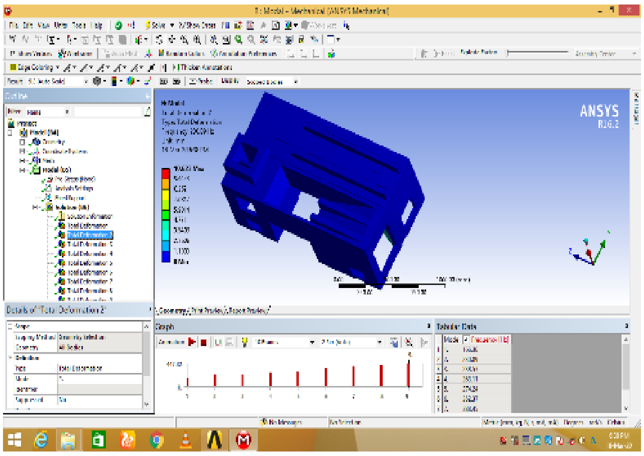


Fig.11. Natural Frequency Mode 2 Deformation

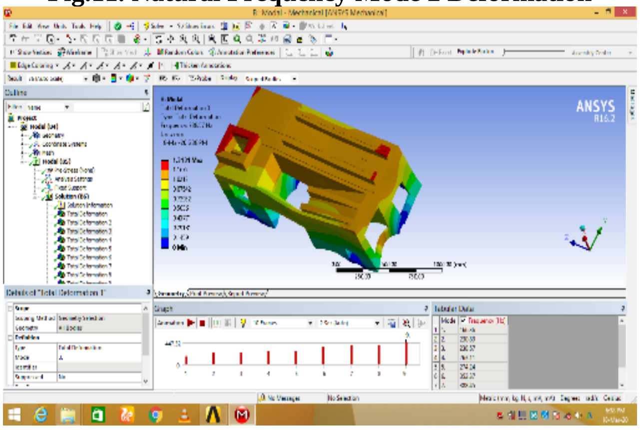


Fig.12. Natural Frequency Mode 3 Deformation

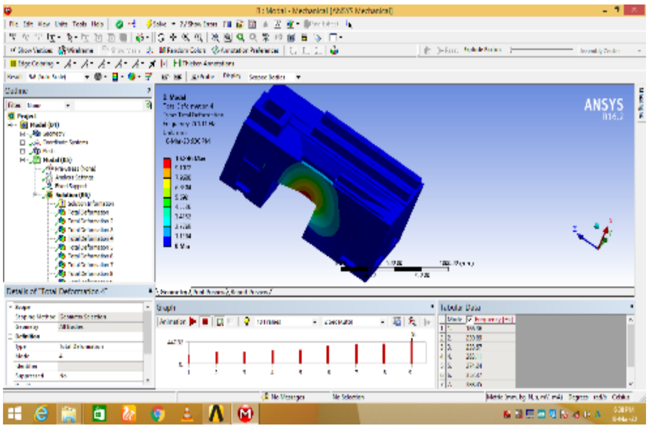


Fig.13. Natural Frequency Mode 4 Deformation

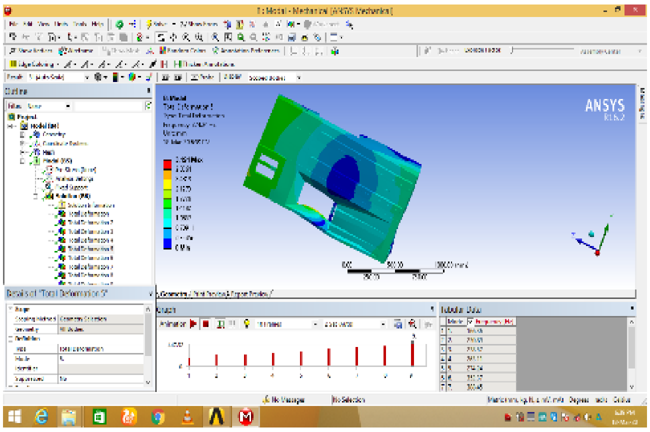


Fig.14. Natural Frequency Mode 5 Deformation

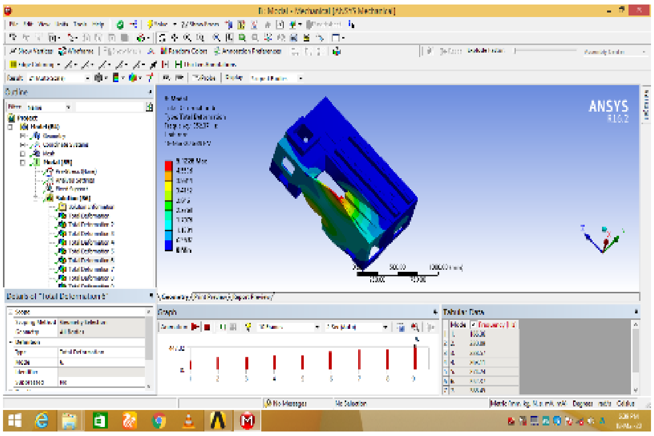


Fig.15. Natural Frequency Mode 6 Deformation

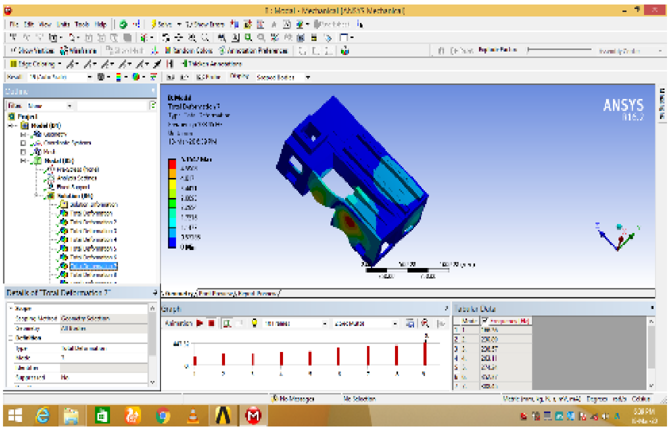


Fig.16. Natural Frequency Mode 7 Deformation

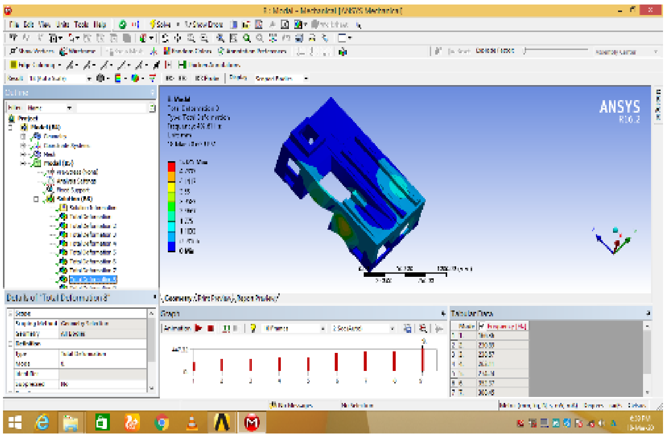


Fig.17. Natural Frequency Mode 8 Deformation

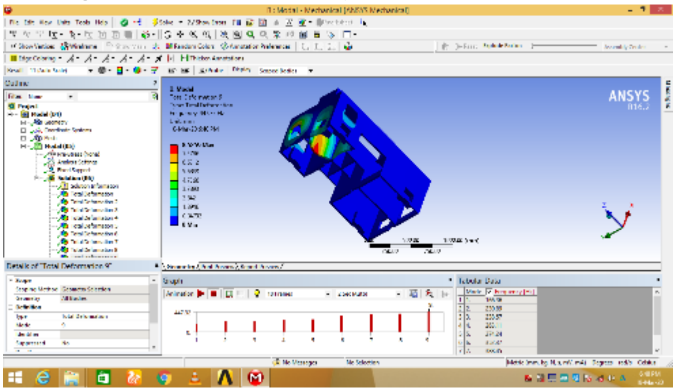


Fig.18. Natural Frequency Mode 9 Deformation

E. Static and Vibration Analysis After Modification of Bed:

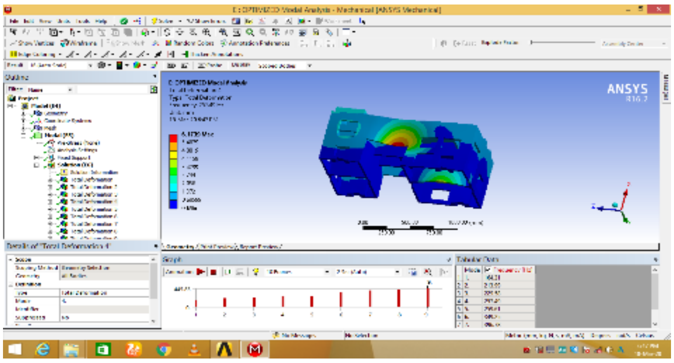


Fig.19. Equivalent Von-Mises stress

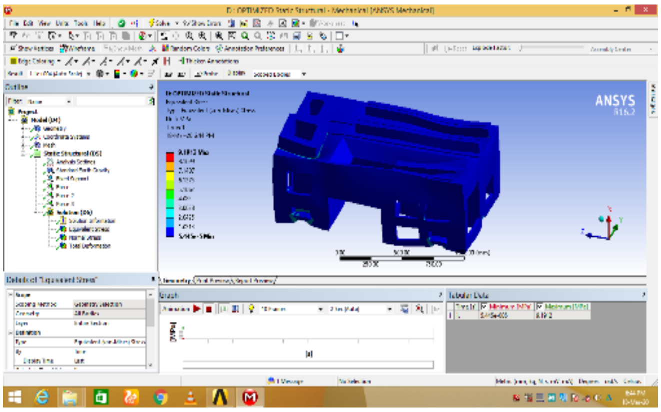


Fig.20. Normal Stress

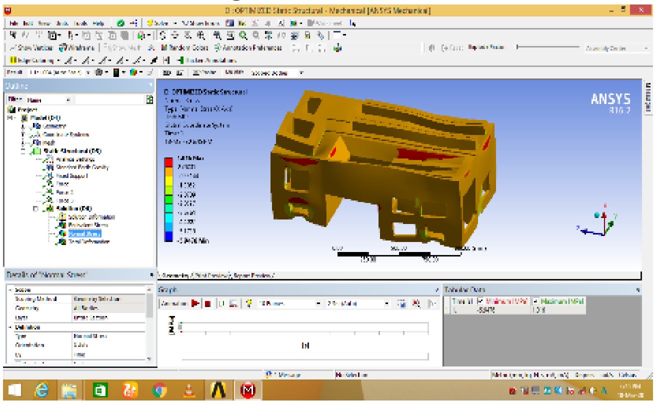


Fig.21. Total Deformation

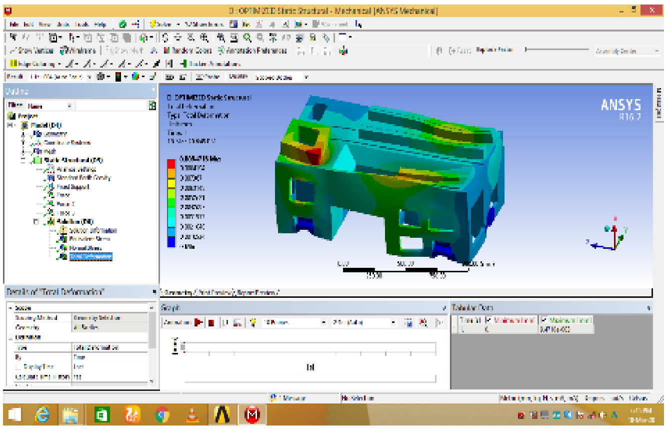


Fig.22. Natural Frequency Mode 1 Deformation

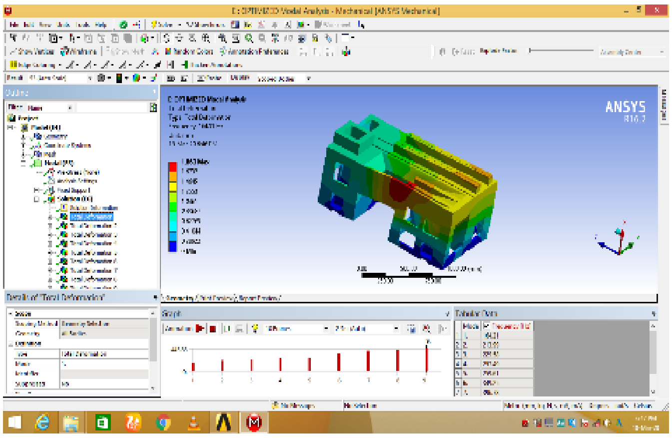


Fig. 23. Natural Frequency Mode 2 Deformation

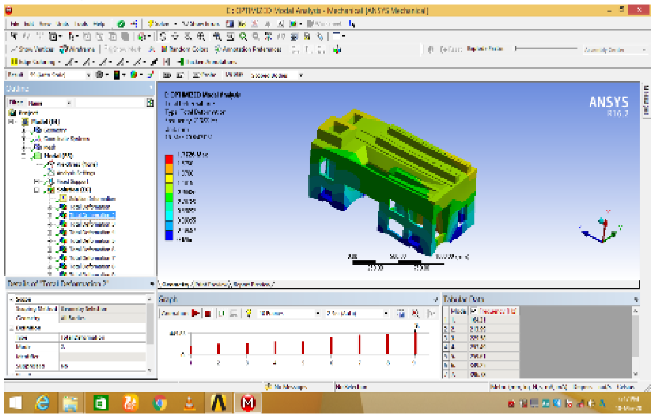


Fig.24. Natural Frequency Mode 3 Deformation

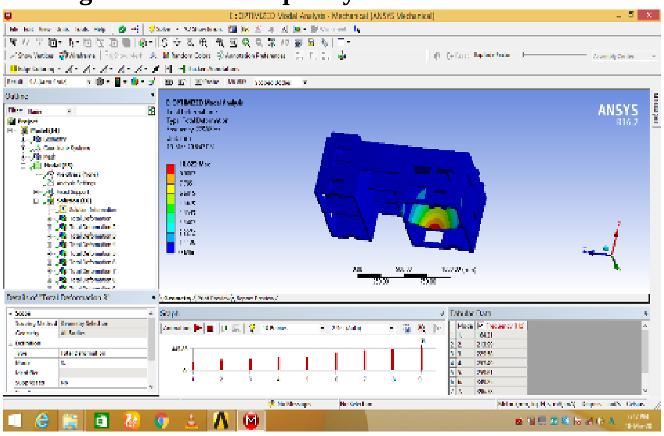


Fig.25. Natural Frequency Mode 4 Deformation

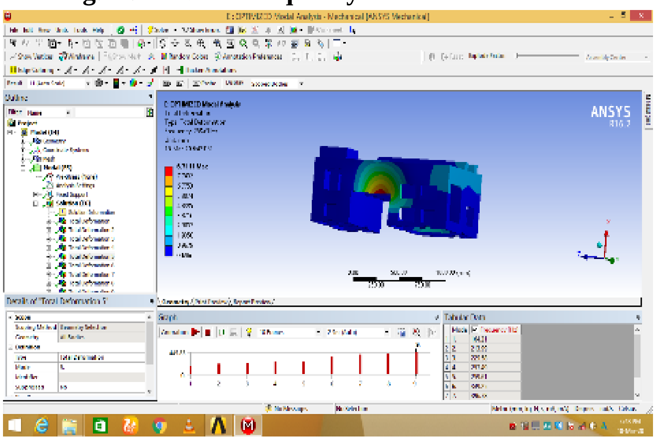


Fig.26. Natural Frequency Mode 5 Deformation

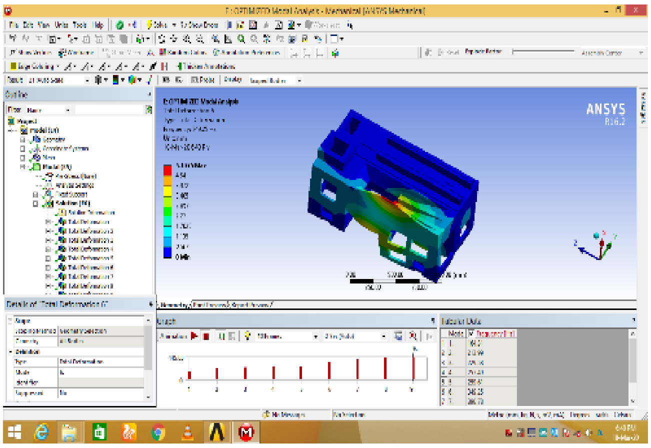
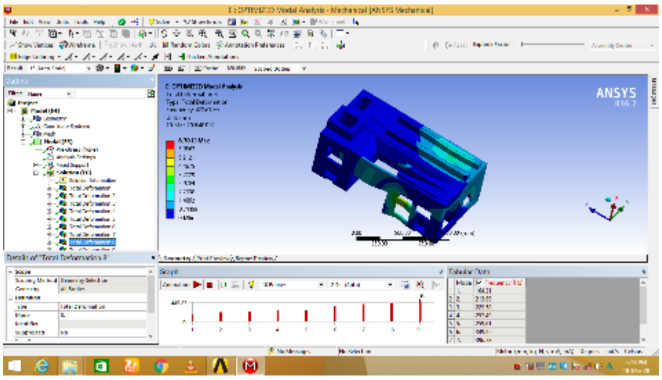


Fig. 27. Natural Frequency Mode 6 Deformation

Fig.28. Natural Frequency Mode 7 Deformation



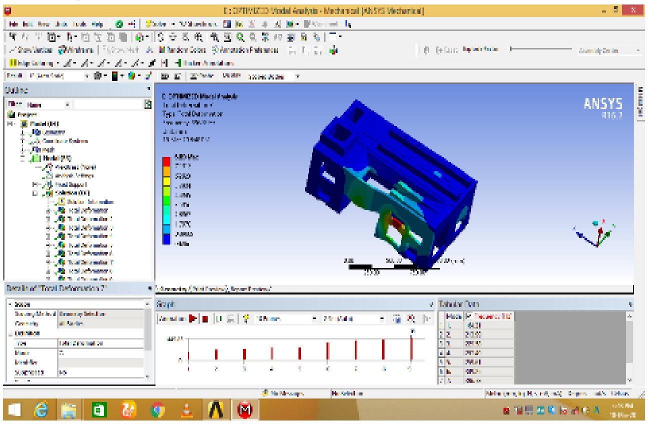


Fig.29. Natural Frequency Mode 8 Deformation

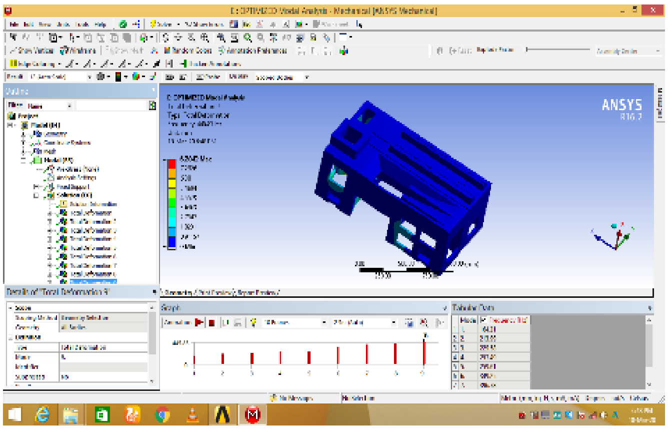


Fig.30. Natural Frequency Mode 9 Deformation

F. Result and Discussion:

TABLE 3: Comparison of Structural Analysis

Parameter	CNC Lathe Bed (Industrial Data	Existing CNC Lathe Bed ANSYS Software Data	Modified CNC Lathe Bed ANSYS Software Data	Modified CNC Lathe Bed With Gray Cast Iron Grade 40 ANSYS Software Data	Modified CNC Lathe Bed (Industrial Data
Normal Stress(X-Direction) (Mpa)	0.9838	0.95352	1.016	1.0558	1.104
Equivalent(Von-Mises) Stress (Mpa)	8.9851	8.8581	9.1912	9.1124	9.1536
Total Deformation (Mm)	0.0091529	0.009468	0.0094718	0.0089526	0.0095241

TABLE 4: Comparison of Vibration Analysis

Parameter		Existing CNC Lathe	Modified CNC Lathe Bed	Modified CNC Lathe Bed With Gray Cast Iron Grade 40
Mode 1	Frequency(Hz)	166.36	164.31	169.35
Mode 2	Frequency(Hz)	230.89	213.99	220.65
Mode 3	Frequency(Hz)	238.57	229.58	236.99
Mode 4	Frequency(Hz)	263.11	257.49	265.55
Mode 5	Frequency(Hz)	274.24	259.61	267.83

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Mode 6	Frequency(Hz)	352.37	349.78	360.31
Mode 7	Frequency(Hz)	388.45	396.78	409.39
Mode 8	Frequency(Hz)	402.61	422.61	435.87
Mode 9	Frequency(Hz)	447.32	445.83	460.42

- The result of the Static Structure parameter is almost the same as an existing and modified bed.
- We tried to change the material grade but Static Structure and Vibration Parameter is almost the same as an existing material.

VI. CONCLUSION

- The weight of the CNC lathe bed before modification is 1149 Kg, Subsequent to changing the design weight of the bed has decreased to 1115 kg. This weight decrease is equivalent to 2.95% base model weight.
- We get practically same natural frequencies in case of modified model.

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AUTHORS PROFILE

Haresh Modhavadiya, I did Bachelor of Engineering in Mechanical Engineering from V.V.P. ENGG. College, Rajkot. Under Gujarat Technical University. M.Tech. CAD/CAM is pursuing in Parul University.

Prof. Rakesh Prajapati is currently working as an Assistant professor at Parul Institute of Technology, Parul University. He did his mechanical engineering M. Tech CAD/CAM from Charusat University, Changa. His research area is CNC Machine, CNT, Composite, Additive Manufacturing.

Prof. Bhupesh Goyal is currently working as an Assistant professor at Parul Institute of Technology, Parul University. He did his mechanical engineering M. Tech CAD/CAM from M. S. University. His research area is CNC Machine, 3D Printing, Metal Forming, Composite.