Finite Element Analysis of CNC Slanted Bed

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Abstract— In the field of Engineering we come across many complex problems, the solution of which extremely tedious and usually not possible by analytical methods. In such case we have to resort to the use of Numerical Techniques. "Finite Element Analysis" is an extremely powerful Numerical Technique for the solution of complex problems. In this project, the investigation is carried out to reduce the weight of the machine bed without deteriorating its structural rigidity and the accuracy of the machine tool by adding ribs at the suitable locations. In this work, the 3D CAD model for the base line and the optimized design has been created by using commercial 3D modelling software CREO. The objective of this project is to carry out analysis (IN ANSYS) and to validate the actual load carrying capacity of the original design of machine.

Key words: Weight, Slanted Bed, 3D modelling software CREO, Ansys, Finite Element Analysis

I. INTRODUCTION

A. Finite Element Analysis

Finite element modelling (FEM) and analysis (FEA) are two of the most popular mechanical engineering application offered by existing CAD/CAM systems. This is attributed to the fact that the finite element method is perhaps the most popular numerical technique for solving e0ngineering problems. The method is general enough to handle any complex shape or geometry, any material properties, any boundary condition, and any loading condition. The generality of the finite element method fits the analysis requirements of today's complex engineering systems and designs where closed-form solution of governing equilibrium equations are usually not available. In addition, it is an efficient design tool by which designers can perform parametric design studies by considering various design cases (different shapes, materials, loads, etc.), analyzing them, and choosing the optimum design. The finite element method is a numerical analysis technique for obtaining approximate solution to a wide variety of engineering problems. Let us takes an example of a Stress Analysis problem of a body under certain loading conditions. The normal analytical procedure would involve taking an extremely small box element of dimensions (dx , dy , dz).Each tending to zero and then writing down the equations of equilibrium and compatibility for this element. Then we would try to obtain a solution for the Stress Distribution in the body under the specified boundary conditions using the techniques of Integration over the entire body.

II. LITERATURE SURVEY

A. Malleswara Swami1et al. "Design And Structural Analysis Of CNC Vertical Milling Machine Bed", Dec-2012.

In this paper, then investigation is carried out to reduce the weight of the machine bed without deteriorating its structural rigidity and the accuracy of the machine tool by adding ribs at the suitable locations. In this work, the 3D CAD model for the base line and the optimized design has been created by using commercial 3D modeling software CATIA.

B. S. Syath ABUTHAKEER, et al. "Structural Redesigning Of A Cnc Lathe Bed To Improve Its Static And Dynamic Characteristics", year -2011.

These study's aims to provide various form designs of machine tool structure with the help of structural modifications made in CNC machine tool bed. After the lightening effect was verified by finite element simulation, scale-down models of an original bed and vertical ribs with hollow bed models were fabricated using rapid prototyping method and tested.

C. N. Ashwin Kumar, Et Al. "Optimization And Enhancement Of Load Carrying Capacity Of Cnc Coordinate Drilling Machine Using Finite Element Method" , AUG-2013.

The objective of this project is to carry out analysis and to validate the actual load carrying capacity of the original design of machine bed and the new design proposed by the company, using finite element analysis.

D. B.V. Subrahmanyam Et Al. "Static And Dynamic Analysis Of Machine Tool Structures", Nov 2013- Apri L 2014.

In this paper an attempt has been made to analyze both statically and dynamically the three machine tool structures milling, shaping, and lathe. In all machines, the stresses are high along x-direction, is a direction transverse to the longitudinal axis.

E. S.S. Abuthakee et al., "Static And Dynamic Performance Improvement Of Conventional Computer Numerical Control Machine Tool Bed With Hybrid Welded Steel" , Year -2011.

The objective of this study is to improve the stiffness, natural frequency and damping capability of machine tool bed using a composite material containing welded steel and polymer concrete.

III. FINITE ELEMENT ANALYSIS OF SLANT BED

A. Dynamic Analysis

First of drawing of slant bed taken from Macpower industries then according to drawing part of slant bed are created in pro-engineer. For analysis purpose we have

modify actual slant bed such that it does not affect more on the result so that we can reduce the computational time.

1) Types of Analysis:

- Dynamic
- We have done dynamic analysis of slant bed.

2) Constraint:

- Bottom surface of slant bed is fixed.

In pro-mechanica we have to define six degree of freedom. Three translators and three rotational movements. Slant bed is fixed with base of CNC machine so we have define all the six degree of freedom is fixed for base surface of slant bed.

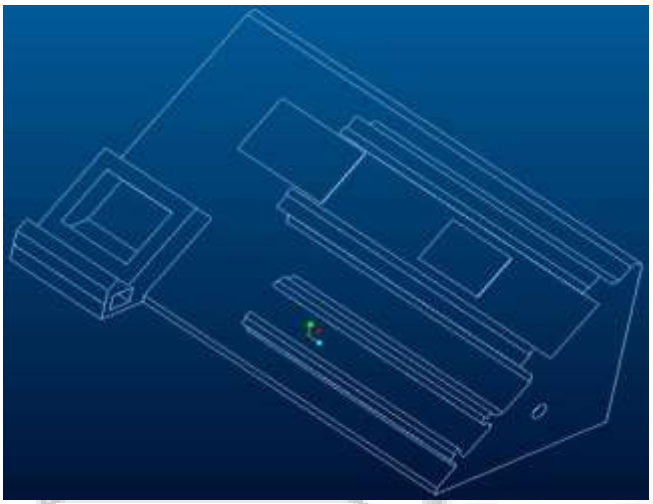

Fig. 3.1 Slant bed drawn in pro-engineer

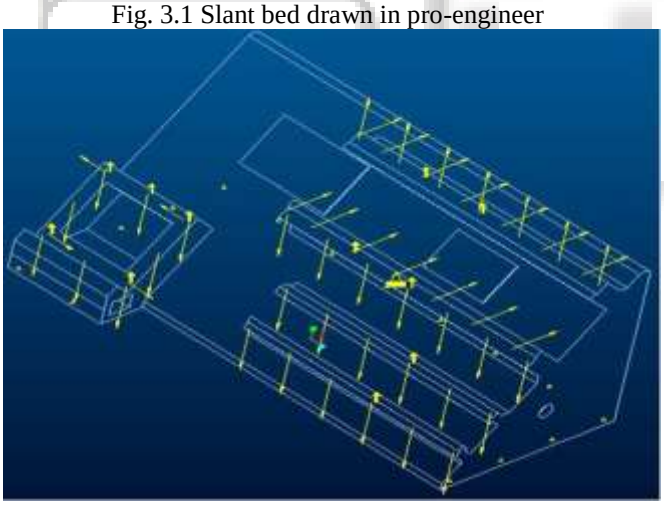

Fig. 3.2 Slant bed with Forces and constraint

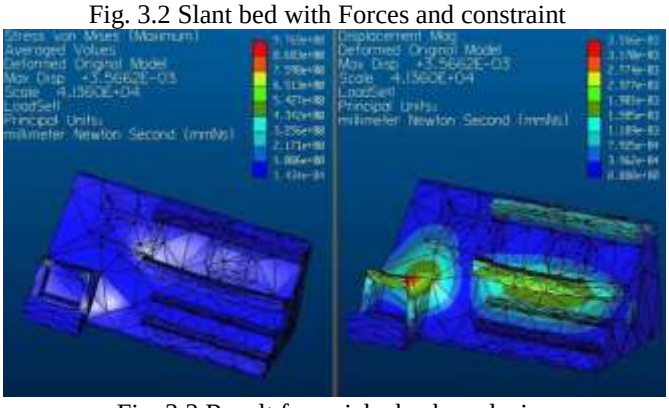

Fig. 3.3 Result for quick check analysis

Here, Max. Von Mises stress = 9.769 N/ mm^2
Max. Displacement = 35.66e-003 mm

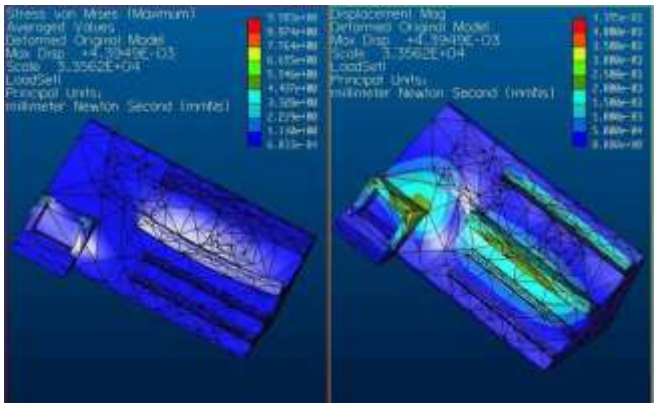

Fig. 3.4 Result for multi-pass adaptive analysis

Here, Max. Von Mises stress = 9.983 N/ mm^2
Max. Displacement = 4.395-003 mm

From result of quick check and multi-pass, Max Von Mises stress and Max Displacement is within the permissible limit so design of slant bed is safe.

3) Quick Check:

This is not a convergence method since the model is run only for a single fixed (low, usually3) polynomial order. The result of a Quick Check should never be trusted. What a Quick Check is for is to quickly run the model through the solver in order to pick up any errors that may have been made.

4) Multi-Pass Adaptive:

The ultimate in convergence analysis. Multiple "p-l oop" passes are made through the solver, with edge orders of "problem elements" being increased with each pass. This iterative approach continues until either the solution converges to a specified accuracy or the maximum specified edge order (default 6, maximum9) is reached. As we are increase polynomial order accuracy of analysis is increased but computational time of computer is increased so we have to compromise between accuracy and time of analysis.[3]

5) Summary for Quick Check Analysis:

Pro/MECHANICA STRUCTURE Version 23.3(320)
Summary for Design Study "quick"
Run Settings
Memory allocation for block solver: 48.0
Checking the model before creating elements...
These checks take into account the fact that Auto GEM will Automatically create elements in volumes with material Properties, on surfaces with shell properties, and on curves With beam section properties.
Generate elements automatically.
Checking the model after creating elements...
Excluded elements may be required near one or more Loads due to concentrated stresses.
No errors were found in the model.

6) Analysis "quick" Completed (03:44:24)

Memory and Disk Usage:
Machine Type: Windows NT/x86
RAM Allocation for Solver (megabytes): 48.0
Total Elapsed Time (seconds): 565.01
Total CPU Time (seconds): 258.29
Maximum Memory Usage (kilobytes): 186875
Working Directory Disk Usage (kilobytes): 200704
Run Completed

7) Summary for Multi-pass adaptive Analysis:
Pro/MECHANICA STRUCTURE Version 23.3(320)
Summary for Design Study "multipass_1"Run Settings
Memory allocation for block solver: 48.0
Checking the model before creating elements...
These checks take into account the fact that Auto GEM will Automatically create elements in volumes with material properties, on surfaces with shell properties, and on curves with beam section properties.
Generate elements automatically.
Checking the model after creating elements...
Excluded elements may be required near one or more Loads due to concentrated stresses.
No errors were found in the model.
8) Analysis "multipass_1" Completed
Memory and Disk Usage:
Machine Type: Windows NT/x86
RAM Allocation for Solver (megabytes): 48.0
Total Elapsed Time (seconds): 2155.22
Total CPU Time (seconds): 747.73
Maximum Memory Usage (kilobytes): 230599
Working Directory Disk Usage (kilobytes): 526336
Run Completed

IV. DIFFERENCE BETWEEN QUICK-CHECK AND MULTI-PASS

In Quick Check time of analysis required is less compare to multi-pass but the accuracy obtained in case of multi-pass analysis is more compare to Quick Check so we have to compromise between analysis time and accuracy.
In Quick Check analysis maximum polynomial order is taken as 3 where as n case of multi-pass analysis we have defined maximum polynomial order as 5.
In Quick Check analysis no. of solid element generated is 3697 where as in case of multi-pass analysis no. of solid element generated is 3709
In Quick Check analysis total no. of equations produced in pass-1 is 63903 where as in case of multi-pass analysis total no. of equations produced in pass-1 is 3438, in pass-2 is 21120, in pass-3 is 62298, in pass-4 is 130053.
In Quick Check analysis total elapsed time required is 565.01sec. where as in case of multi-pass analysis total elapsed time required is 2155.22sec.

V. CONCLUSION

After conducting the analysis we can conclude that.

- Pro mechenica analysis of CNC slant bed gives much accurate results compare to experimental work.
- Reduced weight of 2% gives same result with load constraints and hence cost is also reduced with same accuracy.

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