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A Static Analysis of A Machine Base of Sheet Polishing Machine for A Structural Strength and Weight Optimization

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Abstract— In current competitive market it is required to develop a good quality and cost reduced machine tools with optimum usage of material. In today's world an aesthetic view of a product will give better look to the product. Every product of metal is required to be finished. A polishing is a process of giving a better look or to give a better finish on the surface of a product. In present work a conceptual design of sheet polishing machine is developed for polishing a metal sheet and analysis of the components are carried out using ANSYS. Also machine base is optimized for the weight and cost reduction. A maximum stress and deflection produced in machine base are find out and a machine base is then optimized with the help of solid thinking inspire optimization software package for maximized stiffness and weight reduction up to 30%. A new machine base is designed from a C-channel and analysed for the maximum stress and deflection.

Keywords— *Sheet Polishing, Weight optimization, ANSYS, Maximum stress, Deflection.*

I. INTRODUCTION

Over the centuries, as new machines and tools were developed, it becomes possible for humans to produce better quality products faster and thereby improve their standard of living. Due to technologies and customer preferences are evolved the demand for polishing machines are on peak. The technological capability of producing machine tool is limited in most of the developing countries. Since from many years the large improvements are done in field of high speed machining, however manual polishing operations are still necessary to achieve high quality surfaces in prosthetic parts. In today's scenario the demand for polishing of product is much important for the areas like automobiles, aerospace, medical, home appliances, pharmaceutical and dairy/food processing equipment.

Polishing is a surface finishing process used to obtain a smooth and lustrous surface on a part. The purpose of polishing is to remove tool marks, scratches, and surface irregularities from the surface of the work piece produce by casting, forging, and other machining processes. [1]

II. CONCEPTUAL DESIGN OF SHEET POLISHING MACHINE

A new machine has been designed for polishing a sheet having a 600mm width. This machine tool contains various components like machine base, Roller conveyor, Main spindle, housing, worm gear screw jack and many more. Fig.1 shows the conceptual design of a sheet polishing machine. Machine components is designed based on the various data and as per specifications required by customer.

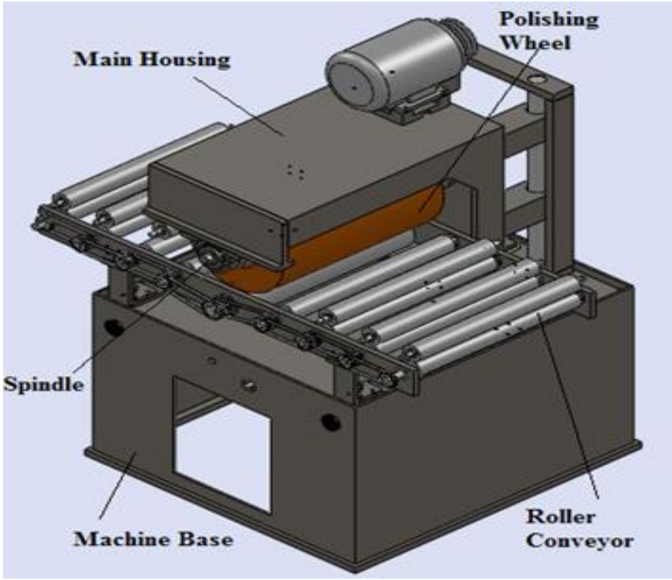

Figure 1: conceptual design of sheet polishing machine

III. FORCES DEVELOPED IN MACHINE TOOL

The forces developed on machine tools are cutting forces, vibrational forces, frictional forces and weight of individual assemblies which are mounted on a machine base. The forces developed are mainly moment on spindle, tangential cutting force during operation, normal reaction force and the weight of a polishing wheels which act on spindle.

The various types of forces are calculated as below:

1. Moment on spindle
2. Tangential cutting force
3. Normal force
4. Weight of polishing wheels
5. Resultant load on spindle

IV. STATIC ANALYSIS OF MACHINE TOOL

A static analysis calculates the effect of steady loading condition on a structure, while damping effects, such as those caused by time varying loads. The main objective of this study is to determine stresses and total deformation produce on machine base under the static loading condition.

A. Material Properties

Table 1: Material Properties

Name	Mild Steel
Model Type	Linear Elastic Isotropic
Yield Strength	250N/mm^2
Tensile Strength	400N/mm^2
Elastic Modulus	2.10E+005N/mm^2

Poisson's Ratio	0.26
Mass density	7850kg/m^3
Shear Modulus	7.93E+004N/mm^2

B. Loading Condition

Design and analysis of Machine Base for weight optimization and material saving and time varying load that can be approximated as static equivalent loads. Select element and apply material properties. Static analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

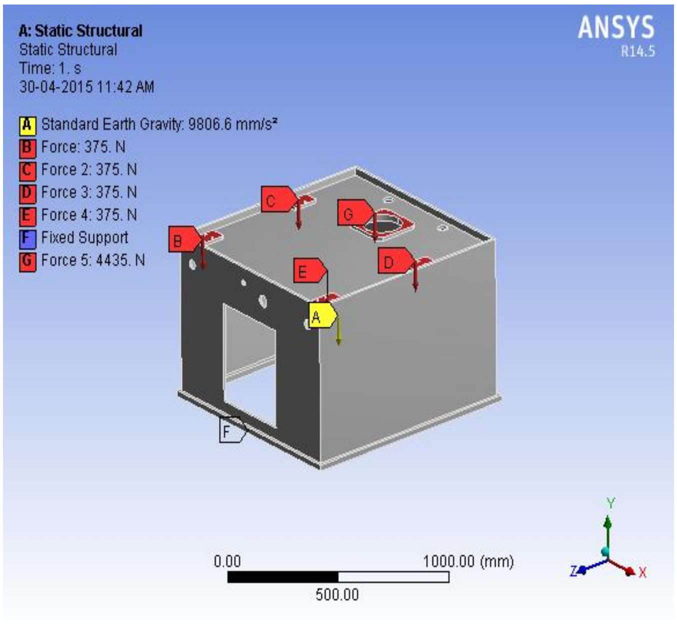

Figure 2: Loading Condition on Machine Base

C. Meshing Information

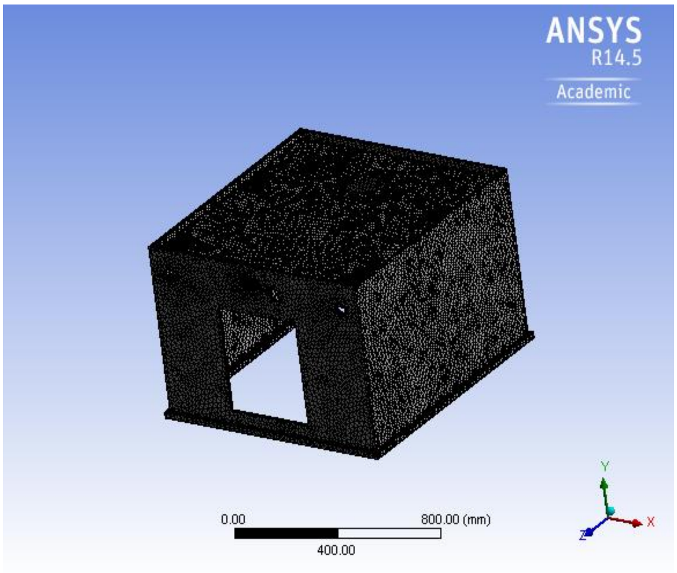

Figure 3: Meshing of Machine Base

Table 2: Meshing data of Machine Base

Mesh Type	Solid Mesh
Mesher used	Standard Mesh
Jacobian points	4 points
Element Size	5.3765 mm
Tolerance	0.265899 mm
Mesh Quality	High
Total Nodes	90834
Total Elements	105668
Maximum Aspect Ratio	3.5894

D. Study Results

Fig. 4 shows equivalent von misses stress generated in machine base, 31.347 MPa. Whereas Fig. 5 shows total deformation produced in machine base is 0.5658 mm.

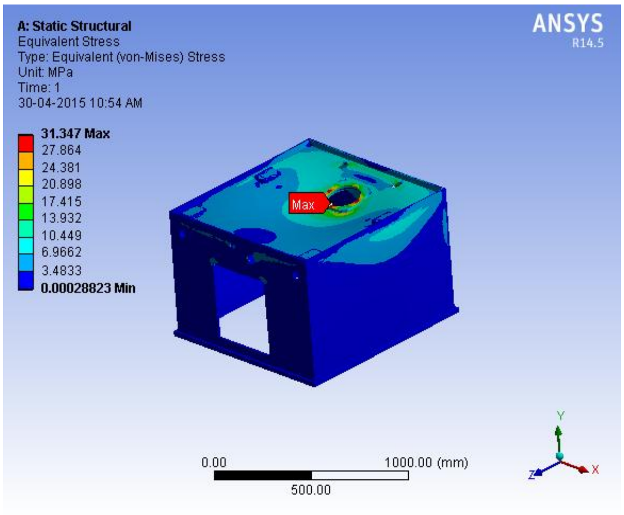

Figure 4: Equivalent Stress in Machine Base

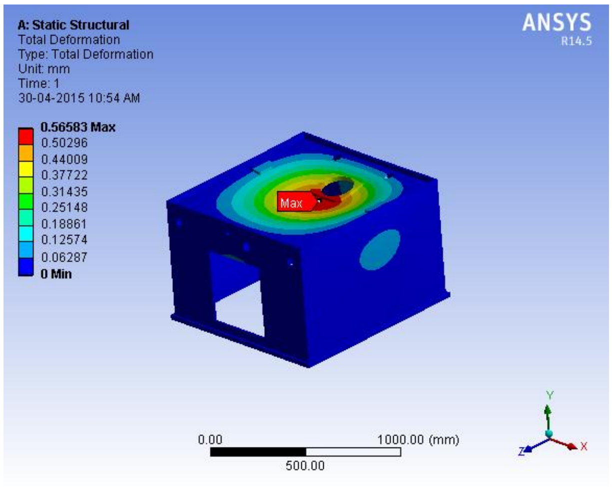

Figure 5: Total Deformation in Machine Base

V. OPTIMIZATION OF STRUCTURE

As factor of safety for machine base is very high, so there is a possibility optimize a structure and weight and material used in manufacturing can be reduced. An optimization is to be carried out with the help of solid thinking topology optimization tools.

A. Optimization Parameters

For optimization various parameters are defined for the objective function like for maximize stiffness and minimize mass. In this simulation objective is taken as to maximize the stiffness with up to 30% mass reduction constraints.

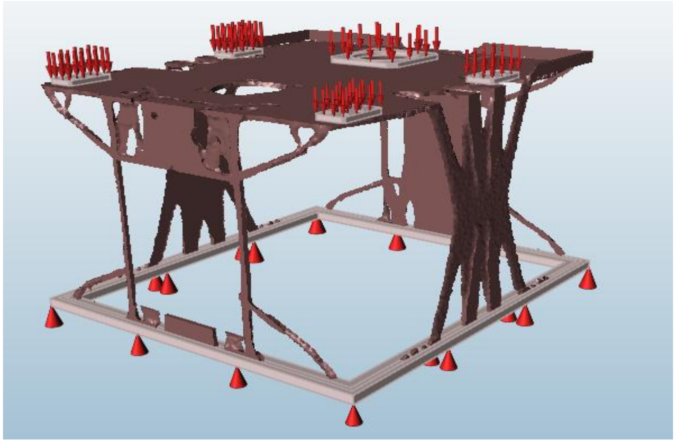

Figure 6: Front View of Optimized Machine Tool

From the result of optimization, it is observed that the structure can be optimized by removing solid plate. A conceptual model obtained from the topology optimization, a new machine base is designed with standard structural steel components as shown in Fig 7.

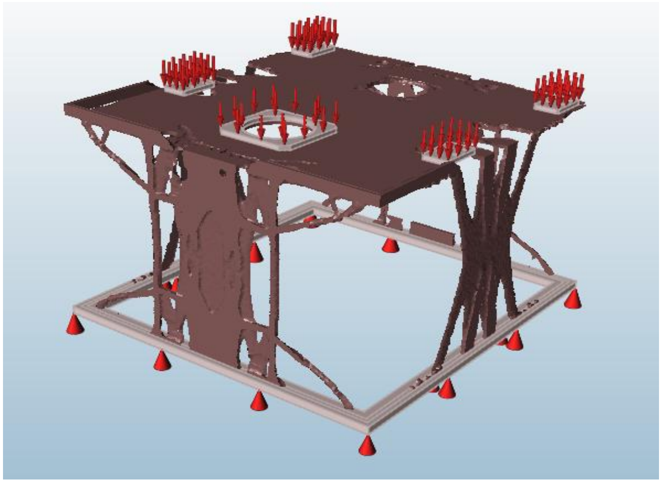

Figure 7: Back View of Optimized Machine Tool

VI. REDESIGN OF MACHINE BASE

A machine base is a heavy and sturdy component on which a various components and assemblies are mounted. The main objective is to reduce and optimize the weight of existing machine base which is fabricated from 12 mm plate. A new machine base is to be designed which also a box type structure is made from number of standard C-channels and plates. Fig.8 shows the new optimized machine base design.

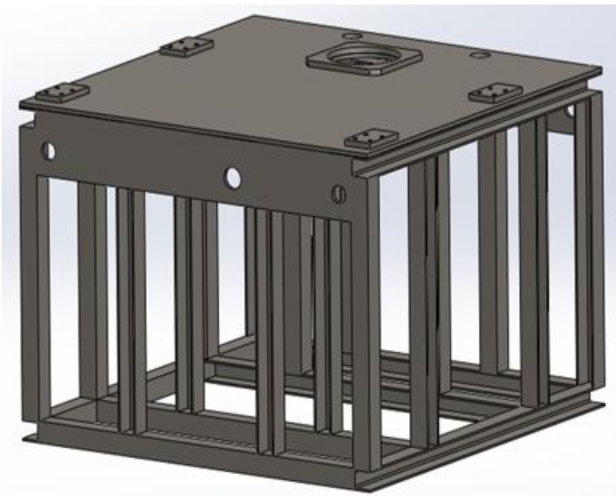

Figure 8: New Design of Machine Base

A. Static Analysis of New Machine base

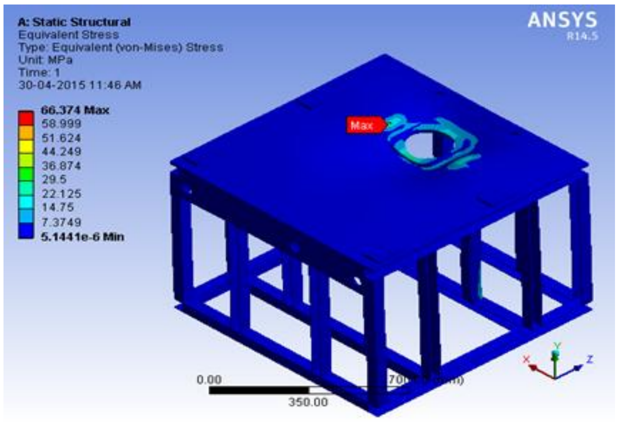

Figure 9: Equivalent Stress in Modified machine Base

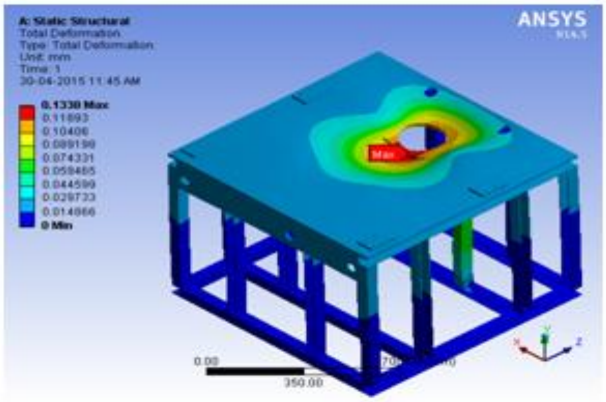

Figure 10: Total Deformation in Modified machine Base

VII. RESULT COMPARISON

Table 3: Stress Analysis before and after optimization

Design	Max. Deformation(mm)	Max. Stress(N/mm^2)
Existing	0.5658	31.34
Optimized	0.1338	66.37

Table 4: Weight Reduction Due to Optimization

Design	Weight (kg)	% Material required compared to existing design	%Material save compared to existing design
Existing	368.67	100	-------
Optimized	214.47	58.18	41.82

CONCLUISON

1. As shown in Table 3 stress value is increases in optimized structure but it is within the permissible limit.
2. Table 4 shows that 154.2 kg weight is reduced in optimized structure as compared to existing machine base design.
3. Table 4 also indicates that percentage of material required compared to existing is 58.18%. So a 41.82% reduction in material requirement is achieved. This will also reduce the overall cost of a machine tool.

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