REPLACING THE COLUMN OF A VERTICAL MILLING MACHINE

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ABSTRACT

For many years, up to a decade, the machine tools have not been updated since their initial debut. The goal of this study is to make a workable suggestion for modifying the vertical milling machine that is currently in production. Redistributing the material can change the material that was used to cast the column of the vertical milling machine. The same amount of material will be moulded into a honeycomb-like structure rather than the current hollow form.
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INTRODUCTION

Vertical milling machine tools are under pressure globally due to market competition and considerable improvements in the production of traditional machine tools. Therefore, it is essential to update and alter the tools for vertical milling machines.

In the study and application of vibration, modal analysis, static and kinematic analyses of machine tool structures, and gearboxes, references from the web application are employed. By shifting the weight of the machine column and using some of this material as honeycomb-shaped ribs, the milling machine's structure is changed in this study. The milling machine's primary and feed gearboxes were also examined and modified.

DISCUSSION

The following parameters are used in a case study to illustrate the results in this article: feed rate s=152.46 (mm/min), tool diameter d=100 (mm), number of teeth nt = 8, width of cut b=67.35 (mm), depth of cut a=4.06 mm, and cutting speed V=30480 (mm/min).

Table 1 displays the predicted power and cutting force for steel alloy, carbon steel, and light alloy.

Table (1) The Power & Cutting Fore Estimated By Different Methods.

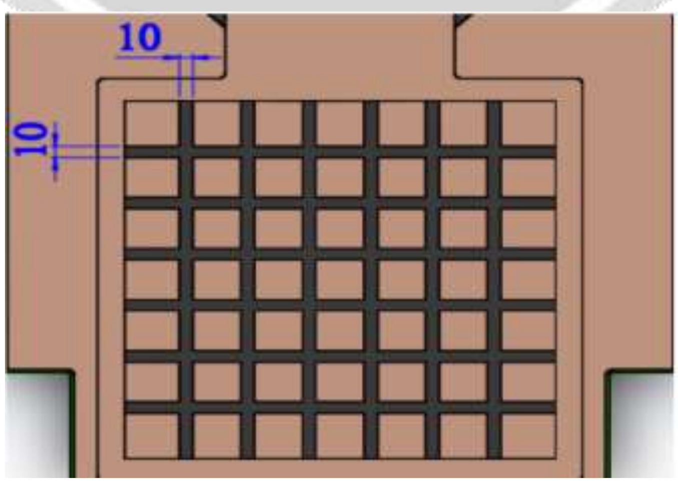
	Power (kw)		
	steel alloy	carbon steel	light alloy
Manual Nomogram (hard copy)	3.8	2.2	1
Nomogram Software (VB)	3.8	2.3	1
Equation Software (VB)	3.8	2.2	1
	Cutting force (N)		
	steel alloy	carbon steel	light alloy
Manual Nomogram (hard copy)	7480	4331	1969
Nomogram Software	7480	4331	1969
Equation Software	7480	4331	1969

STRUCTURE MODIFICATION

The milling machine's structure is modified in this study with the goal of improving performance. These changes may improve the reduction of damaging vibration. The milling process is negatively impacted by harmful vibration. The mass of the milling machine column is 1175 kg. 165 kg is subtracted from the base of the column and added again in the form of honeycomb form to be as reinforcement ribs added to the core of the machine column. The redistribution and the reshaping of the column are shown in Figure.

The current height of the machine base is 130 mm. This height reduced to 80 mm through the suggested four modifications. Figure (5) summarizes the suggested 6 matrix of×modification scenarios. Which is adding a 6 ribs with the same thickness equals to (10 mm)

The surface area of the base and column before adding ribs is 5.43 m2. The surface area is 9.33 m2 for modification. This means that the increase in surface area is 1.72 times higher than the original one. This increase in the surface area could play an important role in structural heat transfer.



STATIC ANALYSIS

From a static, dynamic, and practical standpoint, machine tool structures with a higher degree of stiffness, higher natural frequencies, and lighter weight are the best. When designing the milling machine's column, these objectives must be taken into account. The degree to which a structure resists deforming in response to an applied force is referred to as stiffness. The ratio of applied force to deflection is known as the stiffness. The young's modulus is the most crucial factor to take into account when choosing a material since the stiffness of a structure is extremely significant in machine tool structures. A high elastic modulus is advised because deformation in machine tool constructions is undesired. Increased rigidity reduces the deformation of the milling machine. The outcomes demonstrate that the spindle head experiences the most deflection. The spindle head can therefore be identified as the static behaviour characteristic's weakest position.

The static deformation obtained is given in Table (2). The percentage change is calculated from the following form:

Rate of Improvement (%) = [Modified value - Current value] / Current Value x 100.

Table (2) The Maximum Deformations at Spindle Head.

Current	Deformation (µm)	Reduction in Deformation (%)
Current Machine	145.1	-
Modification	102.9	29

From table (2) it is clear that the maximum static deformation is reduced from 145.1µm for the present machine tool structure to 102.9µm for the modification. lesser the deformation higher the stiffness. The maximum deformation at spindle head for modifications decreases by 29% lower than the original one. This means that modification reduced the milling machine structure’s deformation.

MODAL ANALYSIS

Modal analysis is the study of the dynamic characteristics of systems in the frequency domain, including "mode forms, natural frequency, and damping." The overall mass and stiffness of the milling machine structure are used in structural modal analysis to determine the modal parameters.

In the case of machine tool structures, modal analysis is especially crucial because the engineer should make an effort to separate the exciting natural frequencies from the frequencies of the machine tool structure and its constituent parts.

Table (3) The Maximum Deflection (µm): Frequency, Location & direction.

	Location of Max. Deformation	Maximum Deflection (µm)	FRF Direction
Present Machine	Spindle head	22.87 (@ 73.8 Hz)	X-direction
	Table	0.262 (@ 247 Hz)	Y-direction
	Spindle head	6.16 (@ 121Hz)	Z-direction
Modif.	Spindle head	1.91 (@170 Hz)	X-direction
	Column	0.447 (@ 442 Hz)	Y-direction
	Column	0.287 (@ 442Hz)	Z-direction

From Tables (2) and (3), the dynamic deflection values of the milling machine are smaller than the static deflections.

From Table (3), it is clear that all modifications have lower dynamic deformations. Table (3) shows the maximum deflection (µm): frequency, location, and direction. The detailed study of such parameters is essential to understand the milling machine column dynamic behavior. As can be seen in Table (4), the natural frequencies of all ten first modes of all modifications are higher than those of the original structure. The first mode natural frequencies of the original structure and modification are 73.8 Hz respectively. The improvement is by increasing the fundamental natural frequency of the proposed scenarios by 50.6 % higher than those of the original structure.

Table (4) The Natural Frequencies of the Original & the Modified Machine Columns.

	Current	Modi.	%
1	73.8	111.2	50.6
2	97.2	145.2	49.3
3	120.8	170	40.7
4	134.4	217.7	61.9
5	156.4	243.6	55.7
6	245.1	340.8	39
7	259.5	369.2	42.2
8	281.5	426.9	51.6
9	317.4	442	39.2
10	336.33	478.6	42.3

SUMMARY

Repeating and/or changing a design element multiple times enables designers to cover all design-related bases. Managers can overcome the issue of a lack of funding for tests and instrumentation thanks to the virtual design. It shields designers from the risks they encounter when doing some lab tests on the original or updated prototype. The designer is permitted to regulate the design's inputs, alter the various design parameters, and track changes in the outcomes without risk. It facilitates collaboration and interaction between designers and production engineers, as well as between designers. It offers manufacturing institutions significant financial savings additionally, it saves the designers' time and effort because they don't have to move about the plant as much.

RESULT

Machine designers must rethink their design strategies in light of the rising need for gadgets and machines with higher productivity, more rapid design cycles, and lower machine costs. Machine tool design successfully makes use of an integrated set of software. This machine design guide covers the design strategies used by successful machine manufacturers to raise productivity while lowering costs and risks associated with their products. One can reach the following conclusion:

1. The perception of design tools has changed as a result of the requirement to create machine tools that are faster and more effective. Tools based on finite element technology are used by mechanical engineers to study strain and deformation as a machine is in operation. Engineers can integrate various design tools with this new method to quickly see how design changes impact overall performance. They can then construct prototypes to modify, update, and validate the overall design rather than to test the performance.
2. The milling machine column's modification surface area is increased by its shape. Surface area has increased to 1.72 times that of the initial value. This rise in surface area might be significant for structural heat transfer.
3. Higher stiffness is indicative of less deformation. The maximal static deformations at the modified spindle head result in a lower deformation than the initial one (145.1 m). This indicates that the milling machine's structure was improved via alteration.
4. For all modified constructions, the reshaping of the milling machine column raises all-natural frequencies. All 10 first modes of every change have greater natural frequencies than the original structure did. Both the original structure and the alteration have natural frequencies of 73.8 Hz. The natural have been improved by 50.6% above those of the original construction.

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