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OPTIMIZATION AND ANALYSIS OF SLANT BED - A REVIEW

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ABSTRACT

For the Mechanical Design Engineering we have face many complex problem of structural design, the solution of that type of problems are not possible with analytical methods. In such case we have to use the Numerical Technique known as “Finite Element Analysis (FEA)”. FEA is a most powerful Numerical Technique for the solution of a very complex mechanical design problem. In present case, matter is discussed with Finite Element Analysis of slant bed of CNC-Turning center. The machine tool-bed structure has a great influence on the overall performance of a machine. With the development of high speed and high precision of CNC machine, the requirements of the static and dynamic performance of the machine tool structural components have become more significant. The two functional requirements of machine tool bed for machine tools are high structural stiffness and high damping. The previous work has been done on individual component and supporting structure by some researchers. Here, any individual component plays an important role and have a great influence on productivity and quality of product.

KEYWORDS: Finite Element Analysis, Creo, 3D Modelling, CNC Machine. Machine Tool Bed.

INTRODUCTION

A CNC turning center is one of the most popular types of metal cutting CNC machines because it is designed to perform common, yet important, types of machining operations. This type of circuit breaker has a primary and an auxiliary switch called closing resistor. This closing resistor switch used either in series with the primary switch or in parallel combination. Both switches operated with a common drive with some delay in closing time. The auxiliary switch has a spring to hold it in open position. Primary switch is directly connected with a drive mechanism. When the breaker operates the primary switch close first prior to the auxiliary switch. In order to close the auxiliary switch after the primary switch some delay mechanism used between both primary and auxiliary switch.

There are several types of CNC turning centers. While at first glance there may appear to be substantial differences among the various types, all turning centers share several commonalities. We’ll begin by describing the most popular type of CNC turning center is the universal style slant bed turning center.

Older NC lathes, and those that have been converted to numerical control with retrofit units, look like traditional engine lathes. The lathe carriage rests on the ways. The ways are in the same plane and are parallel to the floor as illustrated in fig. 1. This arrangement allows the machinist to reach all the control readily. Since the CNC lathe performs its operations automatically, this type of arrangement is not necessary. In fact, it is quite awkward since the operator will be busy with other responsibilities while the program is running and will not necessarily be there to brush the chip off the ways. In conventional lathe bed arrangement, the chips have nowhere to fall except on the ways. To overcome this problem, many CNC lathes make use of the slant bed design illustrated in fig. 2.

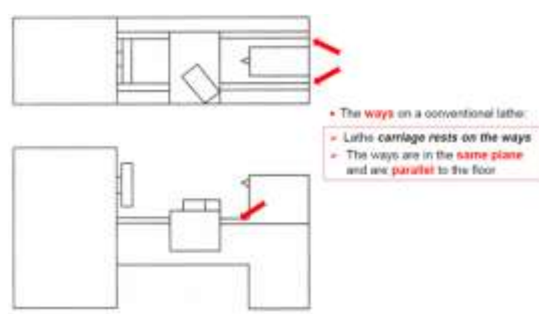

Fig. 1 Bed arrangement on a conventional lathe

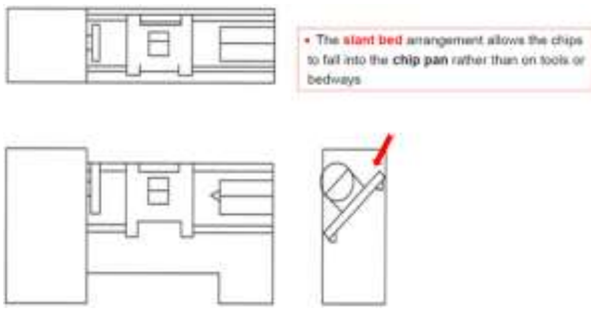

Fig. 2 Slant Bed arrangement for NC or CNC lathe

INTRODUCTION TO FEA

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centred on the "stiffness and deflection of complex structures".

FEA consists of a computer model of a material or design that is stressed and analysed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

There are generally two types of analysis that are used in industry: 2-D modelling, and 3-D modelling. While 2-D modelling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modelling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modelling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture.

FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress usually have a higher node density than those which experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object, creating many elements.

LITERATURE REVIEW

The CNC machine tool structure design includes the design of supporting structure, design of various component like head stock, guide ways, saddle, rib-stiffener structure, etc. There are few works have been done by the previous researchers for the design of machine tool bed.

So, the full system is divided into different individual components. Every individual components having functional as well as a design requirement. In this review, the research works in the area of machine tool structure and its components-parts have been presented. This may be helpful to people who are working in this area.

S.S. Abuthakeer et al. [1], discussed about the functional requirement of machine tool which are high static stiffness and damping. They suggested that the composite material of steel and polymer concrete can be used for replacement of conventional cast iron for bed structure. Experimental modal and static analysis proved that steel-polymer composite is suitable for replacement of cast iron.

B. Malleswara et al. [2], analysed the machine tool bed for static and dynamic loading. For machine tool bed, the stiffness and rigidity can be improved by better structural design. Author optimized the machine tool bed using Optistruct and analysed in ANSYS workbench. Study shows that, machine structural behaviour can be influenced by adding ribs at the suitable locations.

P. Mohanram et al. [3], presented that material distribution plays an important role in the structural strength and by utilizing proper material at required place can increase static stiffness with lower mass. They modified the existing supporting structure by adding vertical ribs and analysed both structure. Study shows that Vertical ribs in the machine tool structure can be useful in improving the static and dynamic behaviours of machine tool.

Duan Yaodong et al. [4], investigated the effect of different configuration of stiffer in machine tool bed. Three configurations (Arc shaped stiffened plate configuration, Cross-vertical stiffened plate configuration and Square mesh stiffened plate configuration) are analysed for torsional and bending stiffness. Study shows that to improve torsional stiffness of a machine structure, the material should be distributed in the surrounding to increase torsional moment of inertia section.

R. Staniek et al. [5], studied the effect of internal wall thickness in machine structure for improvement in performance. The Finite element method is used for evaluation of stress distribution in turning machine structure. Here lightening of machine tool structure is achieved by decreasing internal wall thickness without compromising the stress and deflection of machine tool.

B. V. Subrahmanyam et al. [6], studied the relation of machine tool vibration with excessive chatter and its effect on machine tool life. In machine tool structure, the dynamic behaviour is evaluated in the form of modal analysis. Modal analysis is used to determine the vibration characteristic of a structure or machine components while being designed.

N. Lenin Rakesh et al. [7], discussed about the different static and dynamic forces acting on machine structure and designed the machine structure. He analysed the effect of forces on headstock, tail stock, saddle and base. For designing the bed MATLAB programming is used.

M. Sulitka et al. [8], analysed the lightening of movable parts in machine tool for achieving better performance and lower energy consumption. They used portal crossbeam for replacing the heavy mass structure which does not influence the static stiffness and rigidity of the structure much. They also suggest that for lighting the structure, optimization also proves an important tool.

Mihai Simon et al. [9] studied the influence of increased mass of stiffness and vibration of the machine tool structure. The study shows that the high damping capacity of machine tool is a desirable functional requirement of the machine structure. The authors suggested that the concrete filled steel tube proves better than cast iron. Here test confirms that increased mass and rigidity improvement reduces vibrations considerably.

Tom Zacharia et al. [10], studied the design requirement of machining fixture for the slant bed. The modelled and analysed the fixture for static loading condition and also optimize for reducing material. Study suggests that the dead weight of fixture is also results in deformation, which influence the machining process.

Kunal Gajjar [11], presented the topology optimization technique for saddle structure. Topology optimization is a mathematical process that optimizes material layout. Author suggested that this tool proves efficient and productive and provides strength and stability to the components.

A. M. Joshi et al. [12], presented the FE analysis of machine tool head stock. A Head stock is a supporting structure for spindle bearing system and provides housing for rotating element like gears. Authors presents results for FEA of head stock at different loading condition for machining operation of drilling and turning.

Dr. S. Shivakumar et al. [13], discussed the Design and analysis of lathe spindle in which alloy steel material was used for the spindle. Two bearings were supported by spindle with different spans. They considered bearing as spring in the Ansys for the analysis and also carried out static analysis and dynamic analysis of a spindle supported by the front and rear bearing.

Chi-Wei Lin et al. [14], discussed that Development of high speed spindle technology is critical to the implementation of High speed machining. As Compared to the conventional spindles, motorized spindles are equipped with a built-in motors for good power transmission but the built in motors produces extent amount of heat into the spindle bearing system as well as extra mass to the spindle shaft, thus it affect to the dynamic behaviour of the spindle. The author presents sensitivity analysis for studying various thermomechanical dynamic spindle behaviours at high speeds.

Tobias Maier et al. [15], presented modelling of the thermo-mechanical process effects on machine tool structures. In machine tools thermally induced deviations are key issues specially when considering the actual trends of high performance and dry cutting. An author presents an approach for the atomistic modelling of process effects, it comprises process of heat, cutting forces and increased load on feed and main drives.

R. A. Gujar et al. [16], discussed on Shaft design under fatigue loading by using modified Goodman method. Here, shaft was used in an inertia dynamometer rotated. Considering the different parameters like torque acting on a shaft, uses it helps to calculate the stresses induced. With the help of FEA stress analysis carried out and the results which were obtained from FEA compared with the theoretical values.

A. M. Joshi et al. [17], discussed on The machine tool is machine that imparts the required shape to a work piece with the desired accuracy of removing metal from the work piece in the form of chips. Beds, columns, bases, head stock are called “structures” in machine tool. In machine tool 70-80% of the total weight of the machine is due to structure.

CONCLUSION

After following above research paper it is concluded that for the design of CNC machine structure, the machine capacity i.e. speed of spindle, workspace of travel of tool post etc. must be considered in design. Also the different forces imparted on machine tool member required to analyse for each member for designing. Here different loads includes cutting force, gravity loads of each member and inertia forces of moving member, which caused stress and deflection in machine tool structure. The most important functional requirements for a machine tool are static, dynamic and thermal performances of the machine tool.

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