Optimization of CNC Lathe Saddle

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Keywords : CNC Lathe saddle, Topology, OptiStruct, OSSmooth, Compliance

Abstract

A machine tool structure has great influence on the precision of machine tool's operations. The present work involves the optimization of CNC Lathe saddle for minimum overall compliance and weight. The CNC Lathe sub-assembly is modeled, static analyzed using OptiStruct and optimized the saddle for more stiffened and light weight structure.

Introduction

Optimization process of the saddle of CNC Lathe is the part of the design process for the project of developing the CNC Lathe at college workshop. After the conceptual design process of machine tool structure for CNC Lathe, the structural optimization requires various techniques viz. topology, topography, shape and size optimization. Topology optimization is a mathematical process that optimizes material layout within a given design space, for a given set of loads and boundary conditions such that the resulting layout meets performance targets. Using topology optimization, the best conceptual design can be found that meets the design requirements.

Process Methodology

Finite element meshed model of the sub-assembly is prepared using HyperMesh with OptiStruct profile. The components of the model which are fastened with bolts are realized with bolt connectors and sliding contacts between parts are realized with sliding contact interfaces. The maximum loads possible at heavy cutting conditions are applied at the cutting tool tip and the appropriate constraints of boundary conditions are applied to the assembly model.
Topology Optimization:
Present work adopts topology optimization, which includes Design Packing space as a design variable.

It is performed by following steps.

1. Defining designable and non-designable space in the model
2. Creating the responses required to define global objective and constraints.
3. Defining design objective: Minimization of the Compliance (The compliance is the strain energy of structure and can be considered as reciprocal measure for the stiffness of the structure.)
4. Constraints: Target Upper Bound of Volume Fraction of designed space is taken as 0.7 (30% reduction of material)
5. Manufacturing constraints: As this is single die cast component, the draw direction is defined with draw constraints of non-designing space. The symmetry about two Centre planes is also provided.

Results of Topology optimization:
The density plot of saddle obtained from analysis by reducing the 30% volume of the designed space of the saddle. The blue color region in the plot shows least density required in that region of component, that indicates the material in that area can be completely removed. The red color region indicates the material essentially required in the component.
Identifying the resultant geometry after optimization:
OSSmooth option is used which facilitates the recovery of a modified geometry resulting from a structural optimization. Figure shows the resultant model generated by OSSmooth.

**Figure 2**: Density Contour Plot

**Figure 3**: Iso Value Plot (Above 0.7)

**Figure 4**: After OSSmooth

**Figure 5**: Determined Geometry
Results & Discussions

The present work illustrates how the topology optimization tools can be used in the structural design of machine tool components. The technological tools are very efficient and productive in the product design process and provides strength and stability to the components. By the application of the topology optimization, optimum material layout for maximum stiffness with reduction of 30% weight of the CNC Lathe saddle is generated.

Benefits Summary

Benefits of the HyperWorks software are:

1. The complete design process of any component can be reduced both in terms of time and cost.
2. There will be a reduction in the number of prototype to be built and testing cost.

Challenges

As the saddle is sliding during the process over the lathe bed, the load transfer pattern through the saddle during the cutting process is varying by its position. So, optimization should be done either with Dynamic analysis or by providing the load cases at different positions of sliding saddle, but to provide same load cases at the different positions the loading pattern at the sliding runner blocks must be directly provided to that particular positions of load cases.

Conclusions

The use of Altair OptiStruct in phase of design optimization process has helped in defining material layout for the lightweight and stiffened structure for the CNC Lathe saddle. It also saved a lot of time when compared to that of traditional design process.

ACKNOWLEDGEMENTS

I would like to thank Altair Engineering for giving an opportunity to present the paper and would like to thank them all for their technical support.

REFERENCES