STRUCTURAL ANALYSIS AND OPTIMIZATION OF EDM TABLE TOP

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ABSTRACT

The Machine Tool industry objective for high precision and repeatability when it is in operation. The quality of the machine tool is determined on this count. The structural components in the machine tool play a vital role in helping to achieve consistent performance. The damping for the vibrations, load-bearing capacity for the over-hung members, the stable alignment between the mating parts forming links and for the components experiencing dynamic rotation movement in the given pair. The model of this Electric Discharge Machine under review is now undergoing changes to the structure. The new design needs to be reviewed in the light of structural strength while subjecting the components sub-assembly to Analysis using CAE. The geometry of the machine frame or structure is amenable to the use of 3D modeling. The design of the structure would necessitate knowledge of the fundamentals for Machine Design. The information like weight of the structure and the relative position to with respect oth er elements of the machine tool can be readily offered by the three dimensional CAD interface.

Keyword : - *EDM , CAE, CAD, 3-D MODELING.*

1. INTRODUCTION

1.1. Preamble

This project has been sponsored by the Company as it seeks to assist its client for introducing an improved design over the existing. For this reason, it has considered to sponsor PG students in the assignment that peculiarly manifests `Product Design' with respect to the geometry and material properties & `Analysis' for assessing the strength of the machine tool structure while sufficing its function.

The Machine Tool industry aims for high precision and repeatability while it is in operation. The quality of the machine tool, in fact, is determined on this count. The structural components in the mac hine tool play a vital role in helping to achieve consistent performance. The damping for the vibrations, load-bearing capacity for the over-hung members, the stable alignment between the mating parts forming links and for the components experiencing dynamic rotation movement in the given pair.

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Fig 1: EDM Machine in Working Process

Although the physical design can be done using the facilities or the faculties above, the assessment of the geometry for conformance to the conditions specified (test conditions) could be done through the utilization of a suitable tool – software for analysis in the domain of structural analysis. With the past experience of the sponsoring company in this field, 'ANSYS' appears to be a competent tool to pursue analysis for this project work.

1.2. Design Model of Electric Discharge Machine

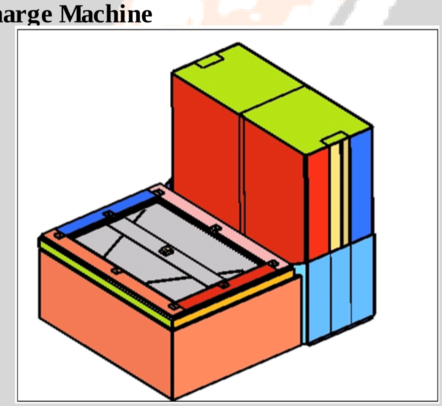

Fig 2: Existing Structure of Machine Tool EDM

1.3. Theory of Discharge Machining (EDM)

Electrical discharge machining (EDM) is a non-conventional manufacturing process based on removing material from a part by means of a series of repeated electrical discharges that created by electric pulse generators at short intervals between a tool called electrode and the part being machined in the existence of a dielectric fluid. At the current situation, EDM is an extensive technique used in industry for high accuracy machining of all types of conductive materials such as metals, metallic alloys, graphite and even some ceramic materials. The selection of manufacturing conditions is one of the most important aspects to take into consideration in the die plummeting electrical discharge machining of conductive steel, as these conditions are the ones that are to determine such important characteristics such as surface roughness, electrode wear and material removal rate. In this project, a study will be performing on the frame work load sustaining the sliding head.

1.4 EDM Types

a) Die-Sink EDM- B. R. Lazarenko and N. I. Lazarenko, were tasked in 1943 to investigate ways of preventing the erosion of tungsten electrical contacts due to sparking. They failed in this task but found that the erosion was more precisely controlled if the electrodes were immersed in a dielectric fluid. This led them to invent an EDM machine used for working difficult to machine materials such as tungsten.

b) Wire-cut EDM -The wire-cut type of machine arose in the 1960s for the purpose of making tools from hardened steel. The earliest numerical controlled machines were conversions of punched-tape vertical milling machines.

2. LITERATURE REVIEW

J.R. Bakera and K.E.Rouch [1] have studied that any structural modification that enhances chatter resistance for a cutting process characterized by the model in would likely also enhance the chatter resistance for the structural system if the cutting process model were somewhat different. A different cutting model could easily be used with the structural matrices in the stability analysis, as long as the force components are based on linear combinations of terms involving the relative tool work piece motion normal to the cutting surface. Future verification work on this method of stability analysis is desirable. This could be performed by developing a suitable FE model of an existing machine tool structure, estimating the cutting parameters necessary for representation of the cutting process using the cutting force equations in, or some other similar dynamic cutting process model, and predicting the stability borderline curve. The predicted borderline curve could be compared to experimental results found by varying widths of cut until chatter is induced across a range of spindle speeds.

RafalKicinger and Tomasz Arciszewski [2] have studied the newly developed concept of geometric analysis to structural vibration problems. After reviewing some fundamentals of isogeometric analysis, application is made to several structural models; including rods, thin beams, membranes, and thin plates. Rotation less beam and plate models is utilized as well as three-dimensional solid models. The concept of k-refinement is explored and shown to produce more accurate and robust results than corresponding finite elements. He introduced the concept of isogeometric analysis, which may be viewed as a logical extension of finite element analysis. The objectives of the isogeometric approach were to develop an analysis framework based on functions employed in computer aided design (CAD) systems, capable of representing many engineering geometries exactly to employ one and only one geometric description for all meshes and all orders of approximation and to vastly simplify mesh refinement procedures. The method is used by author that of NURBS-based isogeometric analysis on-uniform rational B-Splines (NURBS) are a standard tool for describing and modeling curves and surfaces in computer aided design.

Milos, et al [3] has described mechanism's structure, modeling approach and the development of vertical milling machine experimental prototype. The developed and preliminary investigated vertical milling machine experimental prototype indicates that such commercial machines may be superior to the comparable serial and parallel machine designs, both in respect of the price and the dynamics and accuracy, which justifies further research in this direction. The development of the 5-axis hybrid parallel-serial milling machine with added 2-DOF serial mechanism is also under way. It has several advantages such as: rather regular shape of the workspace similar to serial machines, greater stiffness by nature of strut arrangement and good force and speed ratio through the entire machine's workspace.

Anatoly Panin and Wolfgang Biel [4] studied EM forces on main plug components have been calculated and main integral mechanical moments are represented. Two external contracts on independent global EM models were launched and are being successfully benchmarked against the FZJ model. In support of the CXRS design its components are structurally analyzed under EM loading. Four different approaches to calculate EM loads for detailed structural models have been used and are described. One of them, called an "express" analysis, allows a prompt choice between different design solutions. They were concluded that the "express" approach has been used for a rather detailed EM stress analysis of the fast shutter. The shutter design changes were proposed and implemented. The "air" elements, which should fill gaps between assembled conducting parts in the electromagnetic FE models, are neglected in this approach. This may save up to 90% of time for building and calculating complex EM models.

Sung KyumCho [5] studied small machine tools have the inevitable drawback of low structural stiffness caused by a low load-carrying capacity of bearing components. Therefore, mass reduction of the components is advantageous tonsure high performance of the machine tools. In this study, a small table-top machine tool structure was designed and fabricated by using carbon or epoxy composites and resin concrete to reduce the weight of the structure, and enhance the structural stiffness and damping capacity. The types of composites and stacking sequences for fibrous composites were determined by finite element analyses with respect to structural stiffness and damping capacity. The newly fabricated hybrid structure showed a 36.8% weight reduction and the structural stiffness was increased by up to 16% based on our modal analysis results with higher damping capacity.

4. Experimental Observations

For each load case the three readings are to be observed. The three readings are respective to the three axis of rosette namely ε. For getting the three axis readings lead wires of the respective directions are to be connected in the circuit to the1111111 rear panel of 10 Channel Switching Unit along with strain indicator. The reading shown by the strain indicator is in Microstrains. The two sets of readings are recorded for two strain gauge rosette. Finally, the principal strains and principal stresses of respective point of interest where rosettes are mounted can be calculated by analytical or graphical approach.

Table -1 Strain Readings of Structure

Load Kg	Pressure N/mm2	Strain	Deformation mm	σ N/mm2
100	0.2513	30	0.006	2.12
1000	2.5130	141	0.080	18.92
1500	3.7696	212	0.101	28.53
2000	5.0261	303	0.128	42.05
2500	6.2826	375	0.156	53.00
3000	7.892	438	0.185	68.25
3724	9.216	523	0.2	86.00

Also there is possibility of some sort of error in the readings due to many reasons like voltage fluctuations, change in atmospheric temperature, mounting method etc. Compressive load of 3724 kg applied on structure. Then deformation produced in structure which easily read on computer.

5. COMPARISON AND DISCUSSION

The analysis of EDM structure by changing the cross-section and reducing thickness by 5 is done by analytically and for validation standard value is taken from sponsored company. Comparison which shown in fig.4

Table -2 Comparison of existing model on stress and deformation.

Parameter	Existing Model	Modified Model for Frame Cross-section	Modified Model for 5 mm Thickness	Experimental Analysis (For Thickness)	Percentage Variation in Result
Min Stress	11.123	10.764	10.067	-	
Max Stress	88.978	96.817	90.588	86.0	-5.1%
Min Deformation	0.09702	0.14078	0.020	-	-
Max Deformation	0.13614	0.25314	0.184	0.2	+8.7%

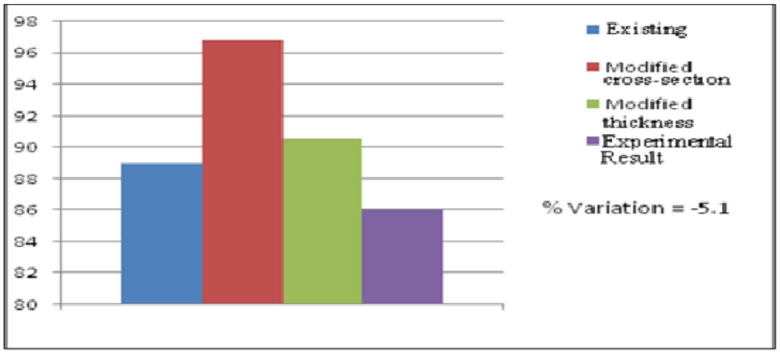

Fig 4: Variation between Stresses Produced in Structure

Stress produced in first modified method is less as compare with experimental method.
Maximum deformation is produced in first modified method as compare with experimental method.

6. CONCLUSION

The experimental method carried out by considering the two highly affected parameters i.e. Stress, deformation & material utilization. In the previous model the stress was less thus deformation in the material body is also less but this indicates the excess material consumption for manufacturing the frame structure which reflects the increased amount of various costs. Also, the experimentation carried out for the model also reflects the nearer result. Thus in the view of cost reduction a new model is designed, according to the calculation carried over the process it observed that the stress concentration as well as deformation increases beyond the permissible limit this means the stress may reflects hazardous effect on the structure. Now the final model is designed by calculation such that it gives the optimum results in all aspects viz. reduced stress concentration& deflection.

7. REFERENCES

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