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Modal Analysis of CNC Lathe Cross-Slide

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Abstract

In this project an attempt has been made to analyze the cross slide of a CNC lathe machine for its natural frequencies and corresponding modes. Initially, the analysis has been taken up for the existing cross slide for its material and geometric properties. The procedure has been extended further by selecting four appropriate materials. In all the cases modeling has been done using pro-e and analysis with Ansys. The first 10 natural frequencies and corresponding mode shapes are obtained. Based on above analysis and subsequent results the most optimum material has been suggested to the manufacturer to facilitate the extension of life of the component.

1. Introduction

The modal analysis is done on the cross-slide component to obtain ten different mode shapes. Initially the analysis will be taken up for the cross-slide for its existing material and geometric properties. The procedure will be extended further by selecting four other appropriate materials. In all the cases, modeling is done using PRO-E and analysis is done by using ANSYS software. Based on analysis and subsequent results, it is intended to suggest the most optimum material to the manufacturer to facilitate the extension of life of the component.

2. CNC Lathe

The machine is controlled electronically via a computer menu style interface; the program may be modified and displayed at the machine, along with a simulated view of the process. The setter/operator needs a high level of skill to perform the process, however the knowledge base is broader compared to the older production machines where intimate knowledge of each machine was considered essential. These machines are often set and operated by the same person, where the operator will supervise a small number of machines (cell).The design of a CNC lathe has evolved yet again however the basic principles and parts are still recognizable, the turret holds the tools and indexes them as needed.

A CNC lathe does not differ from a conventional lathe and major parts of a CNC lathe and a conventional lathe are similar. However, when CNC technology is extended to conventional machines, it enables part programmers to achieve a higher productivity. As a result, most industries have replaced conventional lathe machine tools with CNC lathe machines tools. Competition has led even the small scale industry to switch over to CNC lathes. Further, R&D in the field of CNC machine tools has provided several new designs to cater to the needs of the industries. These machines are capable of manufacturing high precision components and large volumes of production.

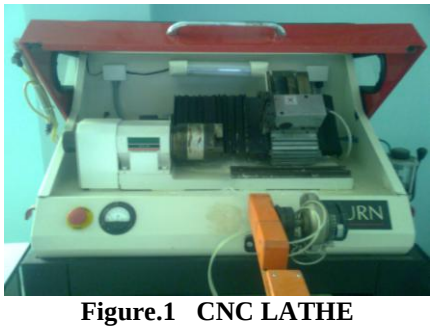

Figure.1 CNC LATHE

3. The main parts of CNC lathe are

- Bed
- Headstock
- Tailstock
- Carriage
- Turret
- Cross slide

4. Cross-Slide

The cross-slide (Figure 1.4) rides on the carriage and has a feed screw that travels perpendicular to the main spindle axis. This permits facing operations to be performed, and the depth of cut to be adjusted. This feed screw can be engaged, through a gear train, to the feed shaft provide automated 'power feed' movement to the cross-slide. On most lathes, only one direction can be engaged at a time as an interlock mechanism will shut out the second gear train.

Figure.2 CNC Lathe Cross-Slide

5. Identified Materials for the Analysis of CNC Cross-Slide

- Mild steel.
- Stainless Steel.
- Bronze.
- Aluminium.
- Cast Iron.

6. Procedural Steps for the Modeling of CNC Cross Slide using PRO-E

- The dimensions of existing cross slide of CNC Lathe are identified manually.
- Then in PRO-E, the part module for modeling of cross slide is selected.
- By the dimensions, the line drawing of the component is done using line or rectangle command.
- Using extrude command, the model is converted into solid model, and then the component is filled with material and appeared to be as solid.
- This finishes modeling of the cross slide.
- To import the model into ANSYS we have to save the file in extension of IGES.

7. Developed model of CNC Lathe Cross Slide using PRO-E

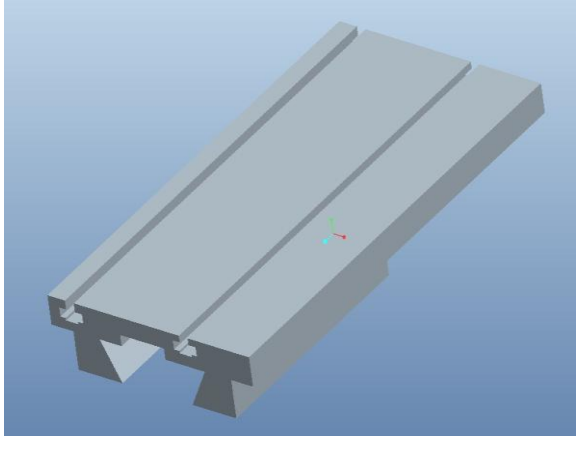

Figure.3 Solid model of CNC lathe Cross slide

8. Wire frame model of CNC Cross Slide

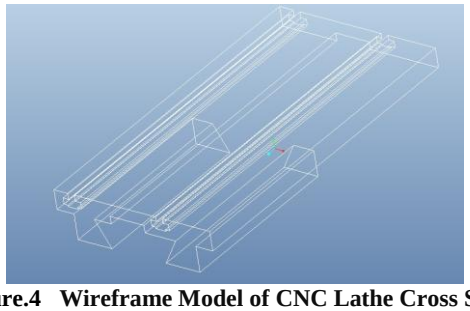

Figure.4 Wireframe Model of CNC Lathe Cross Slide

9. Procedural steps for modal analysis of CNC cross slide

- The IGES file of model developed by using PRO-E is imported into ANSYS.
- The options, Structural and h-method, are selected in preferences.
- The element solid 20node95 is chosen.
- The structural-linear-elastic-isotropic material is selected mentioning the required material properties.
- After defining the element and material properties, the model is meshed to obtain FE model.
- Constraints were applied to the model, by fixing UX and UY moment along the area required.
- By selecting frequency range and the number of modes require, modal analysis is performed.
- After solution is done for results display, the results are displayed in results viewer.
- The advantage of results viewer is we can get the each mode shape of the element with the frequency and the plot.
- The same process is repeated for the all other four selected materials by changing the properties of the material.

10. Results and Discussions

MATERIAL		MODE NUMBERS									
		1	2	3	4	5	6	7	8	9	10
Mild steel	Frequency (Hz)	25.9	52.23	84.36	94.89	141.8	152.7	186.4	218.	243.8	246.8
	DMX (mm)	1.82	3.218	1.979	4.311	3.309	4.371	3.621	3.88	2.637	2.703
Stainless steel	Frequency (Hz)	25.0	50.42	81.45	91.70	137.2	147.7	180.2	211.6	233.4	238.8
	DMX (mm)	1.81	3.187	1.955	4.267	3.271	4.338	3.603	3.867	2.454	2.664
Aluminum	Frequency (Hz)	25.6	51.60	82.59	93.40	140.4	151.4	183.7	216.0	238.5	243.8
	DMX (mm)	3.11	5.484	3.334	7.326	5.563	7.531	6.3	7.4	3.66	4.468
Bronze	Frequency (Hz)	18.7	37.50	60.64	68.49	102.8	110.6	134.7	158.3	175.2	198.2
	DMX(mm)	1.71	3.02	1.83	4.002	3.054	4.134	3.458	3.702	2.009	2.434
Cast Iron	Frequency (Hz)	23.9	49.02	78.96	88.43	130.9	141.2	171.0	202.7	226.7	229.8
	DMX(mm)	1.88	3.316	2.074	4.464	3.374	4.5	3.631	3.88	3.46	2.08

Table.1 Computed Values of Frequencies and Displacements

10.1 Mode Shapes of Cross-Slide for Mild Steel

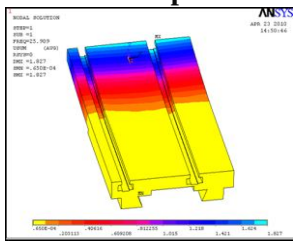

Figure.5 1st mode shape

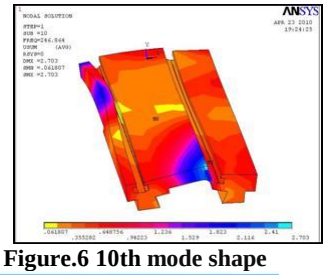

Figure.6 10th mode shape

SET,LIST Command

File

***** INDEX OF DATA SETS ON RESULTS FILE *****

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	25.909	1	1	1
2	52.239	1	2	1
3	84.361	1	3	1
4	94.896	1	4	1
5	141.80	1	5	1
6	152.71	1	6	1
7	186.43	1	7	1
8	218.81	1	8	1
9	243.86	1	9	1
10	246.86	1	10	1

Table.2 shows the mode shapes of cross-slide, for Mild Steel.

10.2 Mode Shapes of Cross-Slide for Stainless Steel

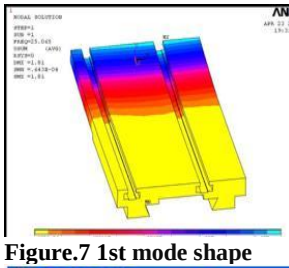

Figure.7 1st mode shape

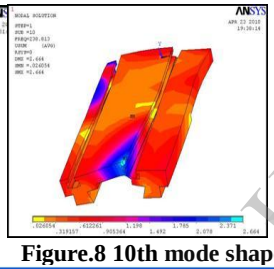

Figure.8 10th mode shape

SET,LIST Command

File

***** INDEX OF DATA SETS ON RESULTS FILE *****

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	25.065	1	1	1
2	50.421	1	2	1
3	81.453	1	3	1
4	91.706	1	4	1
5	137.20	1	5	1
6	147.73	1	6	1
7	180.24	1	7	1
8	211.60	1	8	1
9	235.46	1	9	1
10	238.81	1	10	1

Table.3 shows the mode shapes of cross-slide, for Stainless Steel.

10.3 Mode Shapes of Cross-Slide for Aluminum.

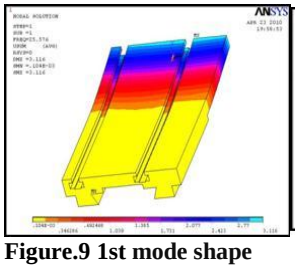

Figure.9 1st mode shape

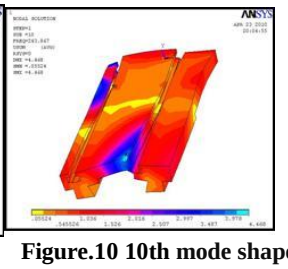

Figure.10 10th mode shape

SET,LIST Command

File

***** INDEX OF DATA SETS ON RESULTS FILE *****

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	25.576	1	1	1
2	51.167	1	2	1
3	82.726	1	3	1
4	93.369	1	4	1
5	140.10	1	5	1
6	150.77	1	6	1
7	183.64	1	7	1
8	215.75	1	8	1
9	239.05	1	9	1
10	243.87	1	10	1

Table.4 shows the mode shapes of cross-slide, for Aluminum

10.4 Mode Shapes of Cross-Slide for Bronze

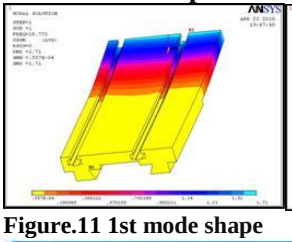

Figure.11 1st mode shape

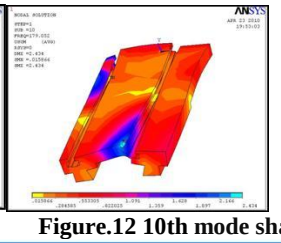

Figure.12 10th mode shape

SET,LIST Command

File

***** INDEX OF DATA SETS ON RESULTS FILE *****

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	18.772	1	1	1
2	37.503	1	2	1
3	60.647	1	3	1
4	68.498	1	4	1
5	102.85	1	5	1
6	110.67	1	6	1
7	134.74	1	7	1
8	158.33	1	8	1
9	175.22	1	9	1
10	179.05	1	10	1

Table.5 shows the mode shapes of cross-slide, for Bronze

10.5 Mode Shapes of Cross-Slide for Cast Iron

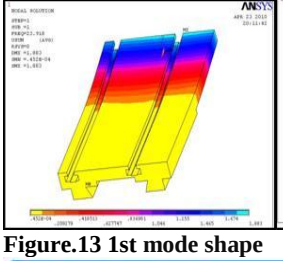

Figure.13 1st mode shape

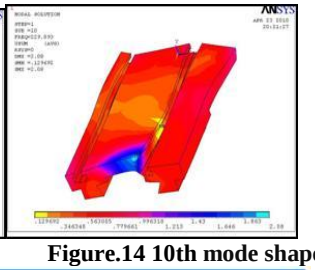

Figure.14 10th mode shape

SET,LIST Command

File

***** INDEX OF DATA SETS ON RESULTS FILE *****

SET	TIME/FREQ	LOAD STEP	SUBSTEP	CUMULATIVE
1	23.918	1	1	1
2	49.029	1	2	1
3	78.965	1	3	1
4	88.438	1	4	1
5	130.98	1	5	1
6	141.23	1	6	1
7	173.03	1	7	1
8	202.75	1	8	1
9	226.78	1	9	1
10	229.89	1	10	1

Table.6 shows the mode shapes of cross-slide, for Cast Iron

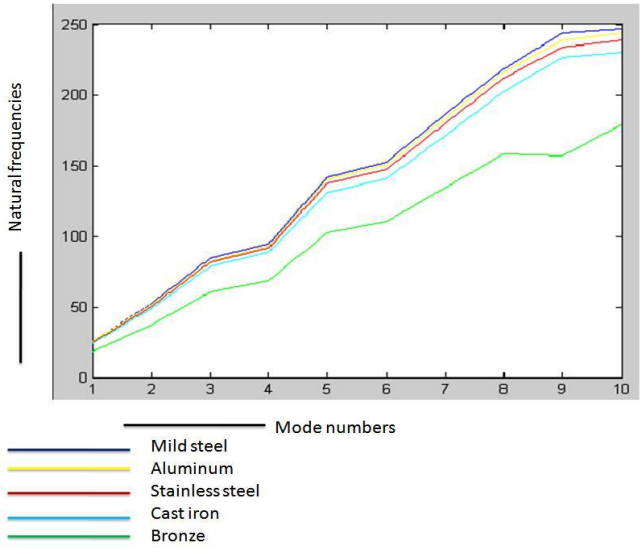

Fig.15 shows the variation of natural frequency with respect to natural modes, for the materials selected for the analysis.

The results clearly indicate that at all the ten modes of cross-slide for ten different materials selected, it is observed that there is no significant change is observed in natural frequencies and corresponding deformations, except for Bronze, which has a marginal lower frequency and deformation, during first nine modes and cast iron for its tenth mode.

11. Conclusion

In this project an attempt has been made to estimate the first ten natural frequencies and corresponding modes of an existing CNC lathe cross-slide. The modeling and analysis has been done considering the five different materials. Frequencies are computed using Sub-space and Block lancoz's Method and observed to be equal for all the materials and modes. It is concluded that if the material is of Bronze, there is an little decrease in frequencies and deflections.

12. Suggestions

It is suggested to modify the shape of the bearing surface of the cross-slide to optimize the same for its natural frequency and deflections, by selecting other appropriate cross-slide for Bronze.

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