Analysis and Modelling of Single Point Cutting Tool with help of ANSYS for Optimization of Vibration Parameter

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Abstract—Machining is process where material is removed from the workpiece and is often accompanied by Self-excited vibration generated by the cutting process or by friction. These vibrations are undesired and have to minimised. Here, a single point cutting tool (20x20x40) made of molybdenum High Speed steel (UNST11302) is used for turning operation. It experiences forces due rotation of spindle, feed rate and depth of cut (2000 N, 1100 N, 1000 N) which produces vibration in tool as stated above. This is responsible for high wear and tear of tool. The tool is modeled in ANSYS Workbench. Modal analysis is done to determine the natural frequency of the work piece. With the range of frequency obtained from modal analysis, harmonic analysis is done to study the vibrational effect. To minimise this, optimization is done to find dimension of tool for which it experiences minimum vibration and minimum stresses so that it may work for longer period of time or its life may be enhanced. The tool having cross sectional dimension of (19.8x 18.7) and (21.8 x 20.45) and have minimum vibrational effect and minimum vibrational effect and equivalent stress both respectively.

Key words: ANSYS, Vibration Parameter

I. INTRODUCTION

Mechanical material removal processes are the backbone of industrial manufacturing practice. These processes provide a great deal of flexibility, since the shape and the kinematics of the tool and work piece define the geometry of the part. The material removal mechanism is a very important aspect of removing processes. There are four types of material removal mechanisms

– Mechanical - the mechanical stresses induced by a tool surpass the strength of the material
– Thermal - thermal energy provided by a heat source melts and/or vaporizes the volume of the material to be removed
– Electrochemical - electrochemical reactions induced by an electrical field destroy the atomic bonds of the material to be removed
– Chemical - chemical reactions destroy the atomic bonds of the material to be removed.

II. MACHINE TOOL VIBRATION

Machining and vibration measuring are invariably accompanied by relative vibration between work piece and tool. These vibrations are due to one or more of the following causes:

– In homogeneities in the work piece material
– Variation of chip cross section
– Disturbances in the work piece or tool drivers
– Dynamic load generated by acceleration of massive moving components
– Vibration transmitted from the environment

Self-excited vibration generated by the cutting process or by friction (machine-tool chatter).

The tolerable level of relative vibration tool and work piece, the maximum amplitude and to some extent the frequency is determined by the required surface finish and machining accuracy as well as by detrimental effects of the vibration on tool life and by the noise which is frequently generated.

III. PROBLEM FORMULATION

Properties of HSS Tool:
Modulus of Elasticity: 210 GPa.
Density: 8160 kg/m^3
Melting Point = 460 °C
Poison's Ratio = 0.3
Rockwell Hardness = 62 to 65
Compressive Yield strength = 3250MPa
Abrasion = 25.8 to 77.7
Izod Impact Unmatched = 67 J

Back Rack angle	12degree
Side Rack angle	12degree
End relief angle	10degree
End cutting angle	30degree
Side cutting Edge angle	15degree
Nose Radius	0.8mm

Table 1: Properties

IV. SINGLE POINT CUTTING TOOL

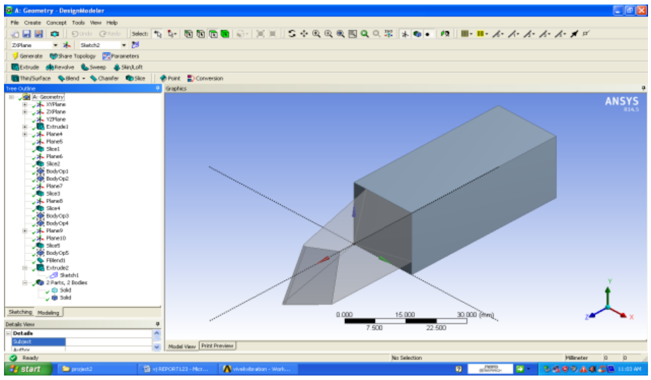


Table 2: Single Point Cutting Tool

Properties of Outline Row 3: molybdenum High speed steel(UNST11302)

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	8.16E-06	kg mm^-3		
3	Isotropic Elasticity				
4	Derive from	Young's...			
5	Young's Modulus	2.1E+05	MPa		
6	Poisson's Ratio	0.3			
7	Bulk Modulus	1.75E+05	MPa		
8	Shear Modulus	80769	MPa		

Table 3: Determination of frequency range by model analysis

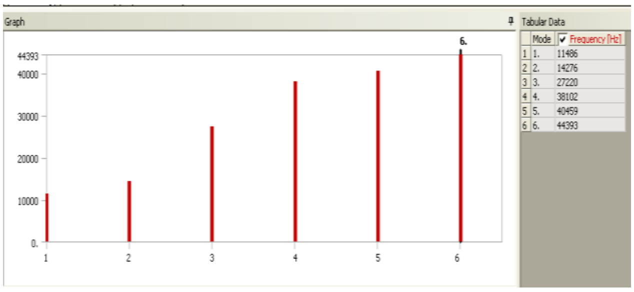
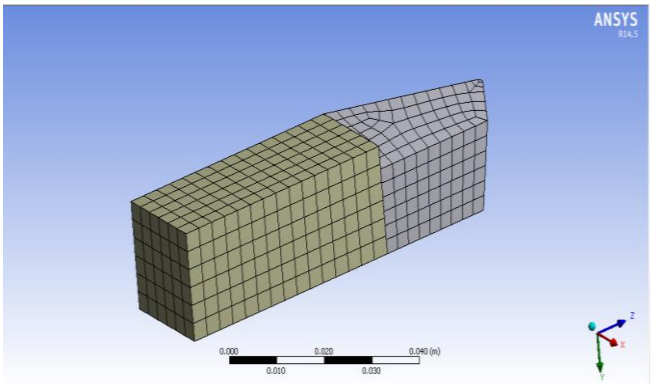


Fig. 1: Graph

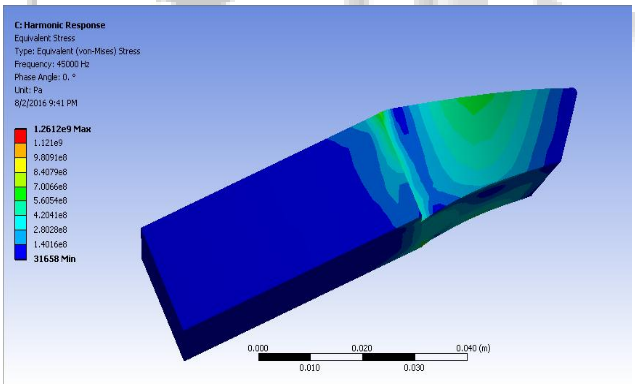
A. Harmonic Analysis

Harmonic analyses are used to determine the steady-state response of a linear structure to loads that vary sinusoidally (harmonically) with time, thus enabling you to verify whether or not your designs will successfully overcome resonance, fatigue, and other harmful effects of forced vibrations.

B. Meshing of Single Point Cutting Tool



C. Result Plotting



	Frequency [Hz]	Amplitude [m]	Phase Angle [°]
1	4500.	5.2466e-006	180.
2	9000.	1.2234e-005	180.
3	13500	2.6447e-005	0.
4	18000	1.4525e-006	180.
5	22500	1.9556e-006	180.
6	27000	1.084e-004	180.
7	31500	3.7194e-007	0.
8	36000	2.7475e-006	180.
9	40500	1.268e-006	0.
10	45000	1.828e-005	180.

Table 4: Variation of amplitude and phase with the given range of natural frequency

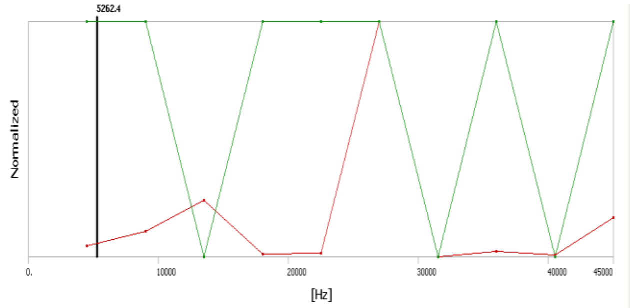


Fig. 2: Graphical representation of variation of amplitude and phase with the given range of natural frequency

V. OPTIMIZATION

Machining is very important process in which tools are used to remove metal from the work piece. In process of removing material from the work piece, it experiences several forces. The machine tool starts vibrating with different amplitudes and in different phases when it experiences different forces in different direction. This vibration is unwanted in the machining process which has to be minimised.

Here we are concerned with the dimension of tool for which it experiences minimum vibration and minimum stresses so that it may work for longer period of time or its life may be enhanced.

Table of Schematic D2: Optimization

	A	B	C	D	E
1	Name	P1 - XYPlane .H1	P2 - XY... .V2	P3 - Frequency Response Frequency (Hz)	P4 - Equivalent Stress Maximum (Pa)
2	1	18.2	18.2	13500	4.9079E+08
3	2	18.6	20.2	45000	4.174E+09
4	3	19	19.2	27000	8.782E+08
5	4	19.4	21.2	13500	4.5864E+08
6	5	19.8	18.7	13500	8.3229E+08
7	6	20.2	20.7	27000	4.9946E+08
8	7	20.6	19.7	45000	3.1357E+09
9	8	21	21.7	27000	2.6845E+08
10	9	21.4	18.45	13500	1.5283E+09
11	10	21.8	20.45	13500	3.4383E+08

Table 5: Raw Optimization Data

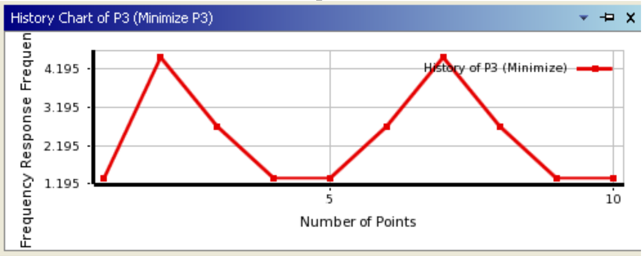


Fig. 3: Graph 1 Optimization Frequency And Equivalent Stress

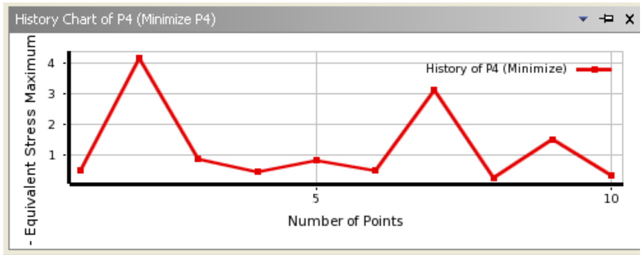


Fig. 4: Graph 2 Graphical Representation of Variation Of Frequency

Table of Schematic E2: Optimization , Candidate Points

	A	B	C	D	E	F	G
1	Reference	Name	P1 - XYPlane .H1	P2 - XYPlane .V2	P3 - Frequency Response Frequency (Hz)		P4 - Equivalent Stress Maximum (Pa)
2					Parameter Value	Variation from Reference	
3	○	Candidate Point 1	18.2	18.2	★★ 13500	0.00 %	4.9079E+08
4	○	Candidate Point 2	19.4	21.2	★★ 13500	0.00 %	4.5864E+08
5	◉	Candidate Point 3	19.8	18.7	★★ 13500	0.00 %	8.3229E+08
6	○	Candidate Point 4	21.4	18.45	★★ 13500	0.00 %	1.5283E+09
7	○	Candidate Point 5	21.8	20.45	★★ 13500	0.00 %	3.4383E+08

Table 6 Result of Optimization of Frequency

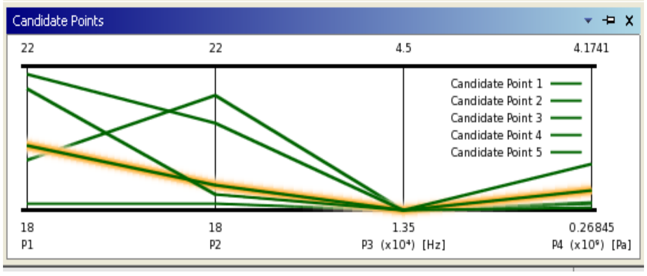


Fig. 5: Graph 3

VI. Conclusion

The following conclusions are drawn from the modelling, modal analysis, harmonic response analysis and optimization of single point cutting tool. The modal analysis of single point cutting tool which is modelled in ANSYS and is made of molybdenum High speed steel (UNST11302) is done to determine the natural frequency of the tool. The frequency range was found to be 11486Hz to 44393Hz. Figure 4.9 shows this frequency range. The Harmonic analysis of above mentioned single point cutting tool is done to determine the variation of vibration when this tool is subjected to different forces which acts on it while machining operation is done. Figure 1 shows the variation of amplitude and phase within the above mentioned natural frequency range. To minimize the vibrational effect optimization is done with various raw optimization data. The horizontal and vertical cross It is also concluded that the tool with optimised dimension will have least Equivalent stresses and vibrational effects. This will enhanced the tool life.

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