Influence of Cutting speed on Surface Roughness and Cutting Forces for Steel Materials by using Carbide Insert Tool Bit in Turning Operation

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Abstract

In turning many key factors like, type of tool bit and its setting angle, machining conditions, type of material to be machined, spindle speed, cutting speed and feed rate etc., plays an important role. Out of all tool bit and cutting speed plays vital role. In this study, on lathe Machine Turning operation has been carried out for different Steel materials such as Mild Steel, EN-8, EN-31 and OHNS by maintaining constant depth of cut and feed by using DNMG 110404 carbide insert tool bit and then with High speed steel (HSS) tool bit at various cutting speeds 400, 800, 1200, 1600 rpm respectively. The surface roughness values have been compared for both the tool bits and the cutting force values have been analyzed for carbide insert tool bit. From the study the effectiveness of carbide insert tool bit has been noticed for steel materials at various cutting speeds in turning operation.
Keywords: Surface Roughness, Surface Finish, Cutting Speed, Feed, Depth of Cut

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I. INTRODUCTION

Turning is a machining process in which cylindrical shapes are generated for the material parts by a single point cutting tool on lathes. The tool is fed in linear direction either in parallel or perpendicular to the axis of rotation of the work piece, or along a specified path to produce complex rotational shapes. In turning, the type of tool bit plays a vital role in perfect machining for getting accuracy in surface finish and also most desirable finish. Tool Setting angle [1] and machining conditions also plays an important role for getting smoother surface finish. Cutting speed is the speed of the work piece surface relative to the edge of the cutting tool during a cut. The Surface of an object is the boundary which separates that object from another substance. Its shape and extent are usually defined by drawing or descriptive specifications. Roughness is defined as closely spaced, irregular deviations on surface, which is measured in micro meters (μm). In turning process surface layer (chip) of the work piece material is removed by relative motion i.e., the work piece material is rotated and the cutting tool will travel towards the work piece, producing three cutting forces components. The thrust force (F_Y), which acts on the cutting speed direction, the feed force (F_X), which acts on the feed direction and the cutting force (F_Z) [2] which acts on the direction normal to the cutting speed. In this study cutting speed has been taken as key factor and for different steel materials by varying the cutting speed, the roughness values have been taken for both Carbide and HSS tool bits. Cutting force values have been analyzed for carbide insert at various cutting speeds.

II. LITERATURE REVIEW

Surface roughness and Cutting forces in turning mainly affected by following factors such as Machine variables which includes Cutting speed, Feed, Depth of cut and Tool Geometry which includes Nose radius, Rake angle Side cutting edge angle, Cutting Edge. Also the Work piece &tool material combination & their mechanical Properties, Quality of machine tool used, Auxiliary tooling and lubrication used. Cutting tool angle plays a vital role in surface finish and also to get most desirable finish, we should match the centre of work piece and tool bit i.e. to keep them concentric [1]. Carbide tool requires slightly greater cutting angle because of the brittleness of the material and Side-Cutting-Edge angle of 5 to 20 degrees are recommended [3].

III. STEEL MATERIALS & TOOL BIT

Table – 1
Steel materials composition

Material	*Carbon %*	*Manganese %*	*Silicon %*	*Sulphur %*	*Phosphors%*	*Chromium %*	*Vanadium %*
Mild steel	*0.18*	*0.90*	-	*0.040*	*0.040*	-	-
EN-8	*0.45*	*1.00*	*0.35*	-	*0.50*	-	-
EN-31	*0.90*	*0.75*	*0.35*	*0.040*	*0.040*	*1.60*	-
OHNS	*0.95*	*1.15*	-	-	-	*0.5*	*0.2*

EN-8: European standard Number 8 (Medium Carbon Steel)
EN-31: European standard Number 31: (High Carbon Steel)
OHNS: Oil Hardened Non-shrinking Steel / Oil hardened Nickel Steel (High Carbon Steel)

Fig. 1: Steel Materials

A. DNMG 110404 Carbide Insert Tool Bit

D –Turning Insert Shape (Diamond)
N – Turning Insert Clearance angle
M – Turning Insert Tolerance
G – Insert Type

11 - Turning Insert size (mm)
04 – Turning Insert Thickness (mm)
04 – Turning Insert Nose Radius (mm)

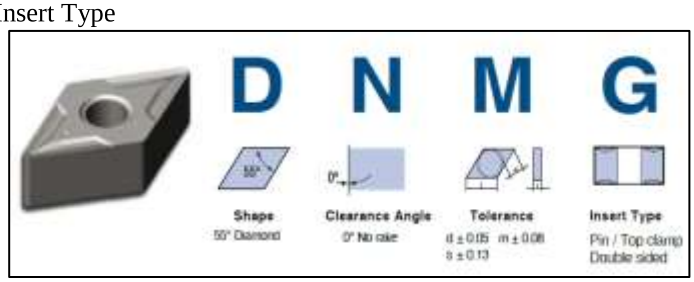

Fig. 2: Insert Nomenclature

Fig. 3: Insert with Tool holder

IV. EXPERIMENTAL PROCEDURE

Before doing the turning operation, perfect machining conditions are maintained on automatic gear controlled lathe machine. Cutting force measuring machine has been arranged on bed. Firstly by keeping the tool bit and Mild steel material in concentric position, turning operation has been carried out with constant feed – 0.103mm & depth of cut – 0.2mm and by varying the cutting speeds such as 400, 800, 1200, 1600 rpm respectively by using both HSS and DNMG 110404 tool bits. Same procedure has been carried out for EN-8, EN-31and OHNS materials. During the machining, cutting force graphs along F_X, F_Y and F_Z directions have been taken with KISTLER dynamometer setup as shown in figure. The mean and maximum values along the three directions have been tabulated. After that the surface roughness values has been taken for each material for all the cutting speeds by using Portable stylus – type profilometer, Talysurf as shown in figure. Roughness measurements, in the transverse direction, on the machined work pieces have been repeated three times and average of three measurements of surface roughness parameters have been recorded.

Fig. 4: KISTLER dynamometer

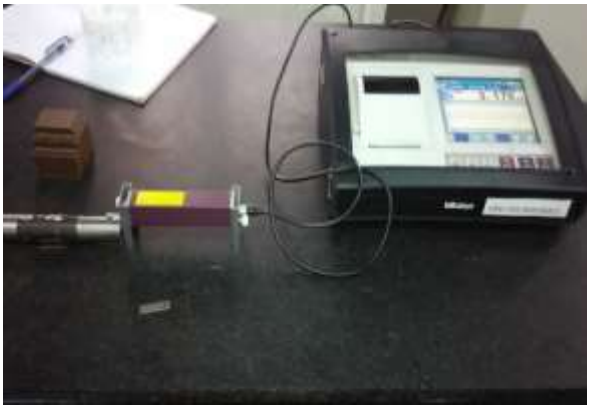
Fig. 5: Talysurf

V. EXPERIMENTAL RESULTS AND DISCUSSIONS

Table – 2
Surface Roughness Values

S. No	Material	Cutting Speed (rpm)	Surface Roughness Values for DNMG 110404 (R_a)-µm				Surface Roughness Values for HSS (R_a)-µm			
			Trial (1)	Trial (2)	Trail (3)	Avg	Trial (1)	Trial (2)	Trail (3)	Avg
1	Mild Steel	400	3.548	3.767	3.179	3.498	4.672	4.761	4.521	4.651
		800	3.578	3.646	3.621	3.615	4.896	4.921	4.976	4.931
		1200	3.544	3.945	3.875	3.788	4.882	4.963	4.972	4.939
		1600	5.273	4.516	4.437	4.742	5.721	5.231	5.034	5.328
2	EN-8	400	3.268	2.826	2.899	2.994	4.213	3.921	4.002	4.045
		800	3.765	3.640	3.559	3.654	4.721	4.520	4.411	4.550
		1200	3.813	3.055	4.069	3.779	4.968	4.763	4.961	4.897
		1600	5.307	4.931	5.524	5.254	5.431	5.442	5.417	5.430
3	EN-31	400	4.689	4.332	4.991	4.667	4.891	4.877	4.801	4.873
		800	3.472	3.176	3.339	3.349	4.621	4.631	4.624	4.625
		1200	3.072	3.243	3.146	3.153	4.721	4.786	4.790	4.738
		1600	3.851	3.854	3.876	3.860	5.332	5.375	5.345	5.350
4	OHNS	400	4.191	3.359	4.330	3.960	5.789	5.676	5.891	5.785
		800	3.172	3.445	3.607	3.408	5.564	5.641	5.462	5.555
		1200	3.267	2.991	3.927	3.395	5.899	5.901	5.878	5.892
		1600	4.321	4.108	3.784	4.041	6.012	6.076	6.065	6.051

A. *Surface Roughness Comparison Graphs for Both the Tool bits*

By taking cutting speed in RPM (rotation per minute) on X- axis and roughness R_a in µm (micro meters) values on Y – axis (from above table- 2) for each steel material the roughness graphs have been plotted for DNMG 110404 carbide insert and HSS tool bits.

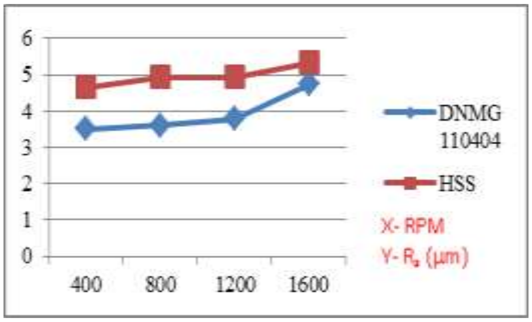

Fig. 6: Mild steel

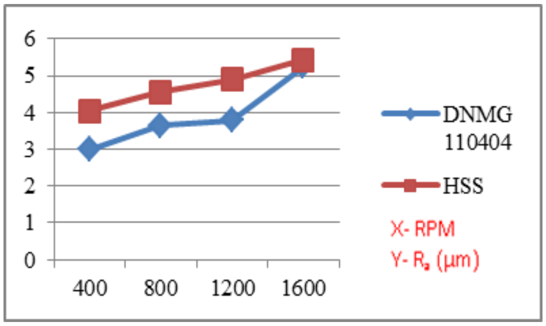

Fig. 7: En-8

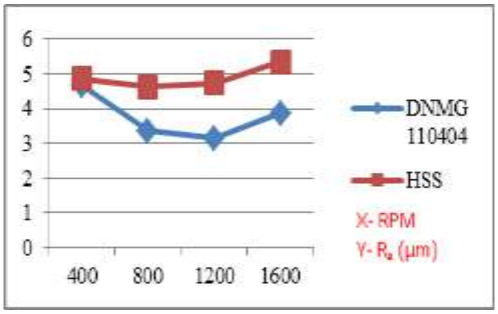

Fig. 8: EN - 31

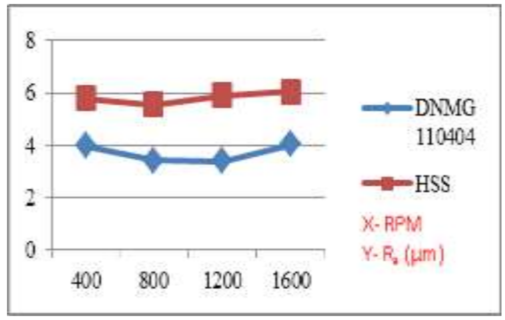

Fig. 9: OHNS

For Mild steel material as the cutting speed increases the roughness values increases for both tool bits (Fig- 6). For EN-8 steel material like mild steel material roughness value goes up as cutting speed increases for both the tool bits (Fig -7). For EN-31 steel material at 400rpm & 1600rpm the roughness values were higher than at 800rpm & 1200rpm for both tool bits (Fig -8). For OHNS steel material the roughness values at 400rpm & 1600rpm were almost same with little variance but lower than 800rpm & 1200rpm roughness values which having little variance (Fig-9). The surface roughness comparison graphs gives the evidence that, for carbide insert tool bit roughness values were low in comparison with HSS tool bit at each cutting speed.

B. Cutting force Graphs for DNMG 110404 Carbide insert

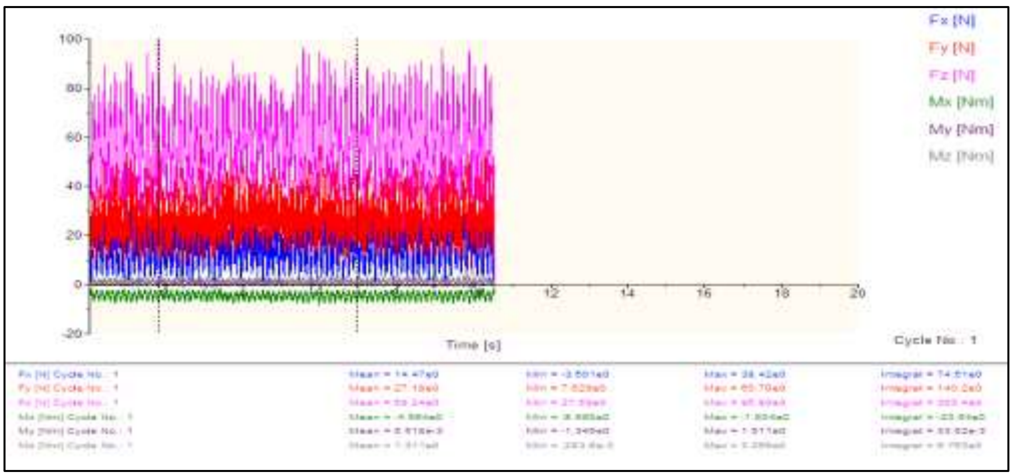

Fig. 10: Mild steel at 400rpm

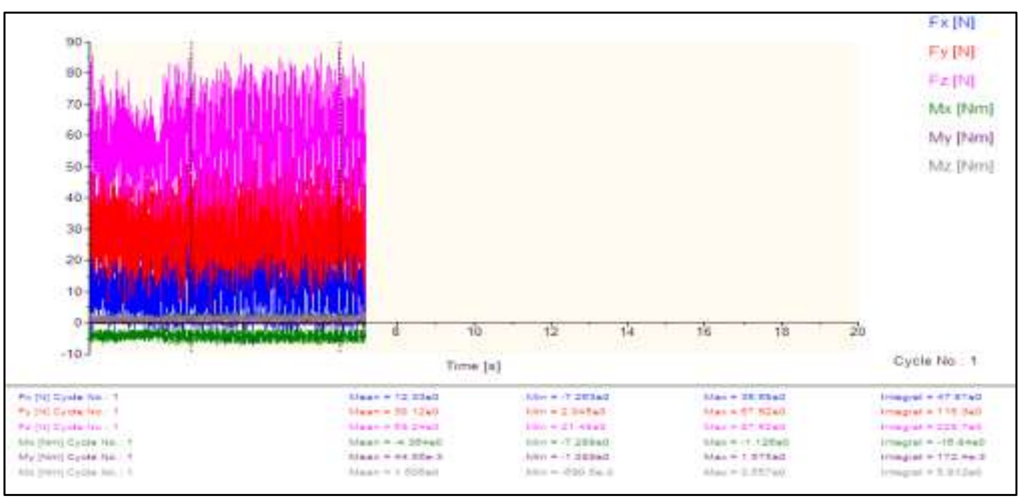

Fig. 11: Mild steel at 800rpm

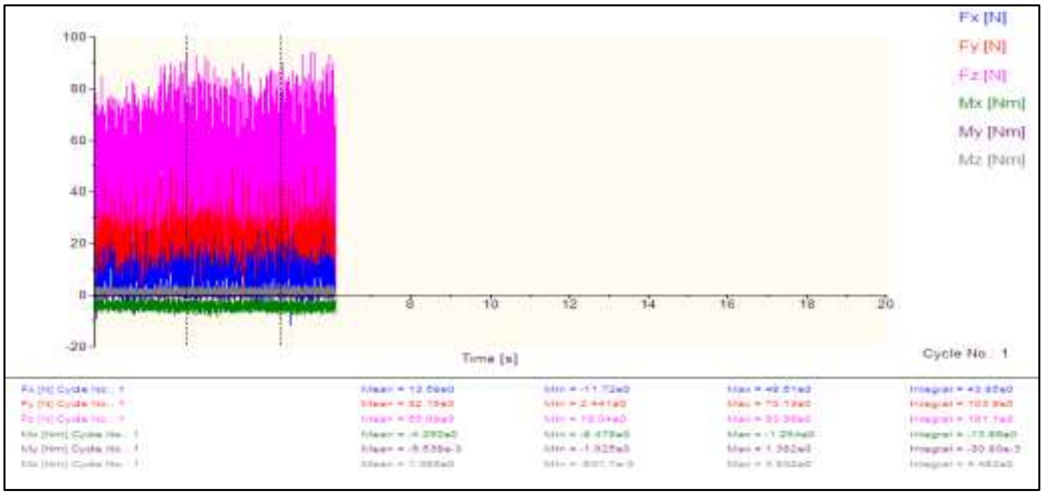

Fig. 11: Mild steel at 1200rpm

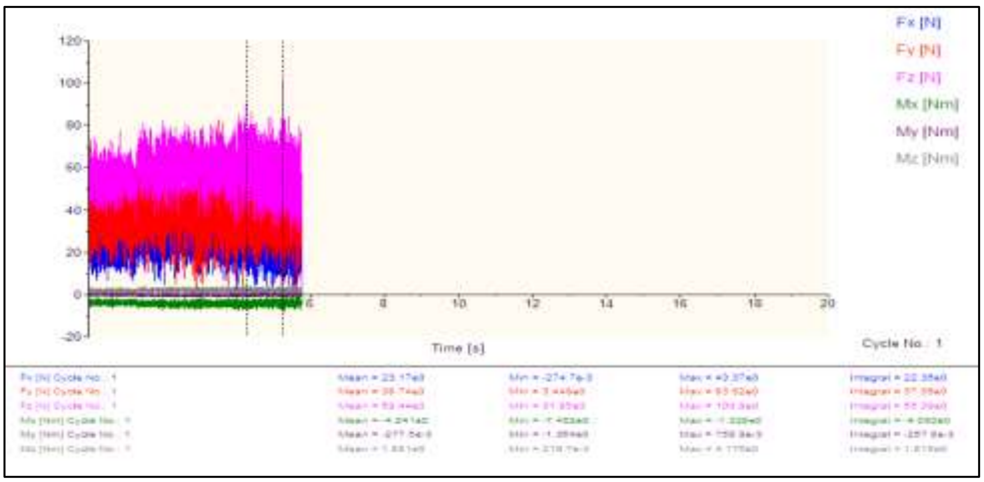

Fig. 12: Mild steel at 1600rpm

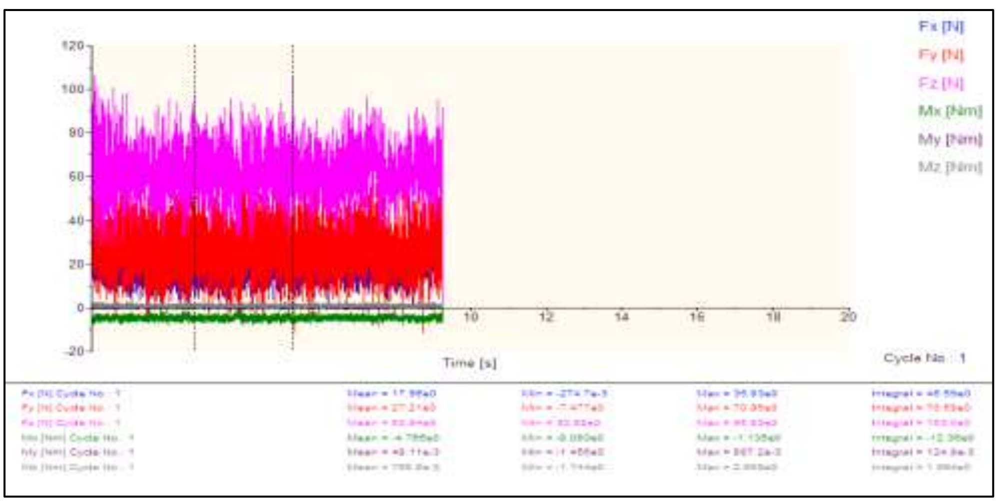

Fig. 13: EN 8 steel at 400rpm

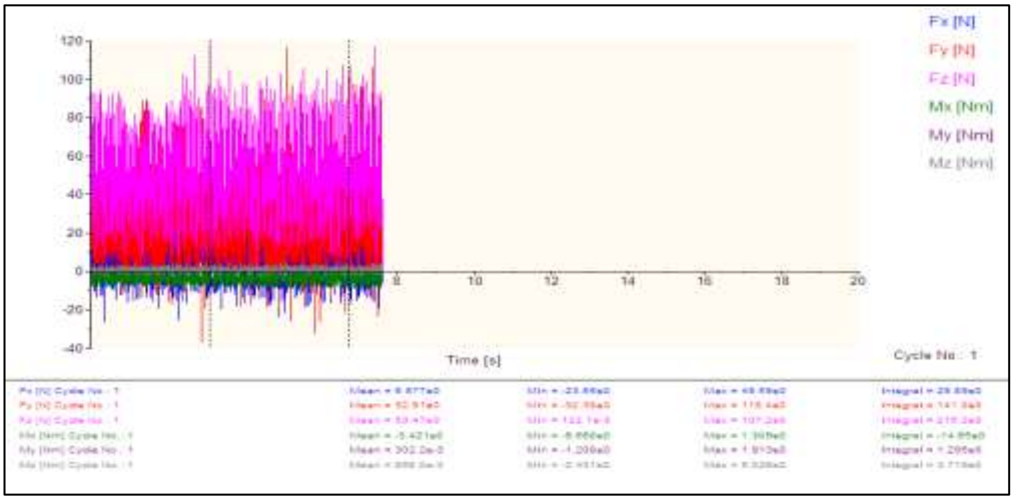

Fig. 14: EN 8 steel at 800rpm

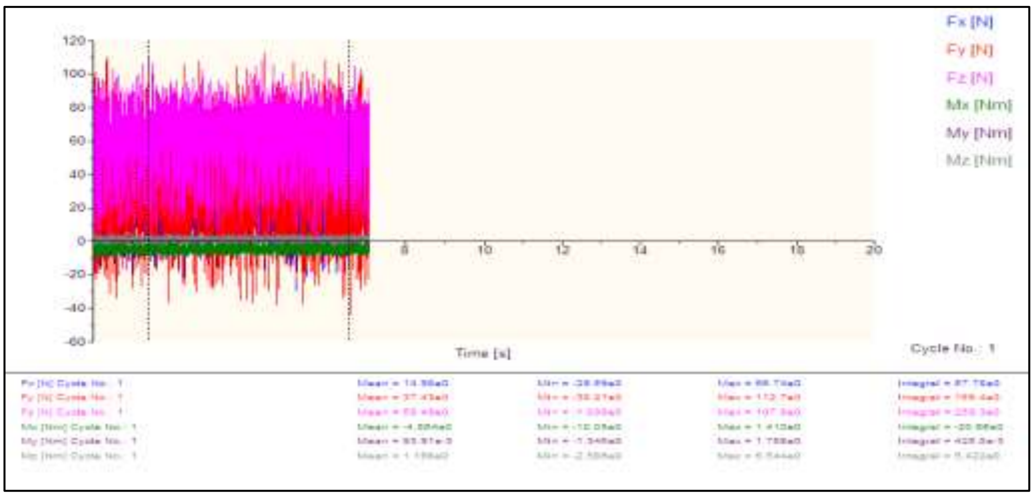

Fig. 15: EN 8 steel at 1200rpm

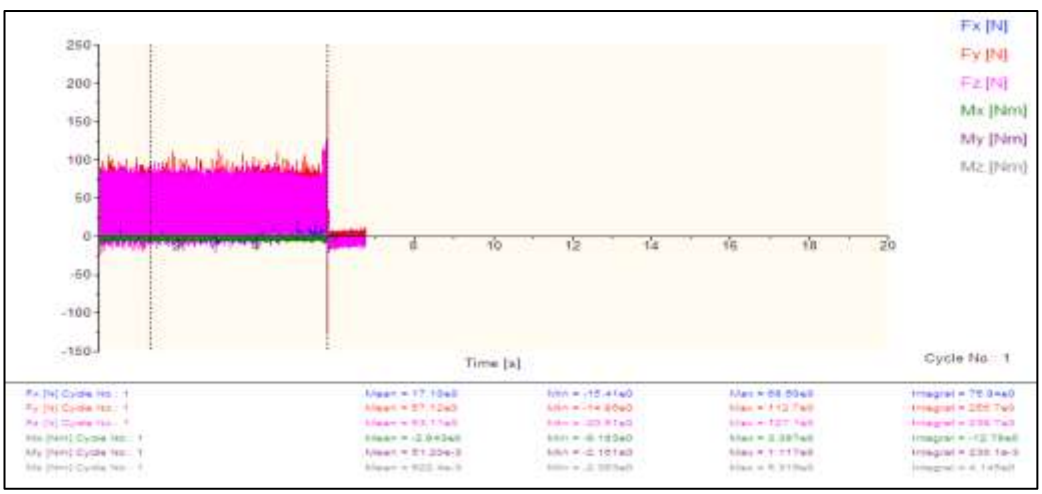

Fig. 16: EN 8 steel at 1600rpm

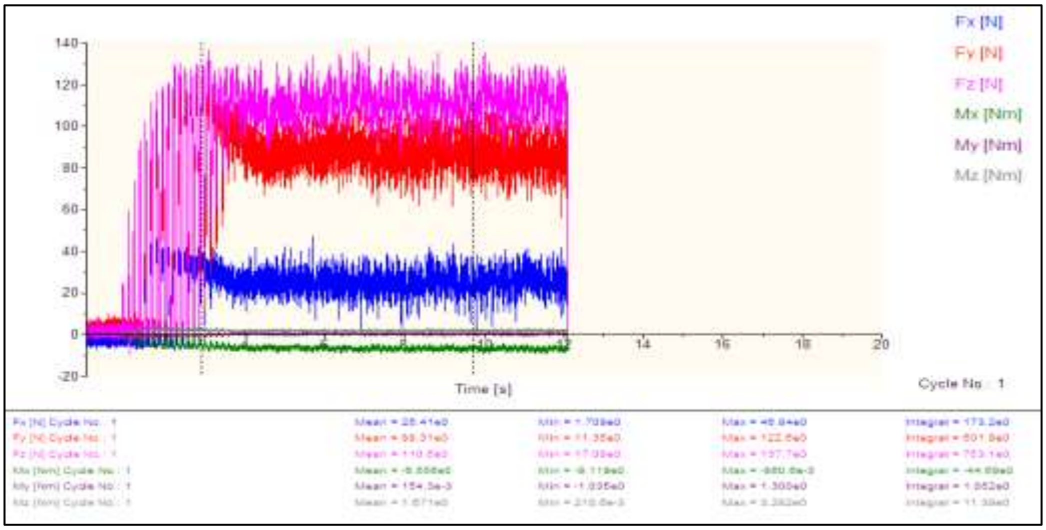

Fig. 17: EN 31 steel at 400rpm

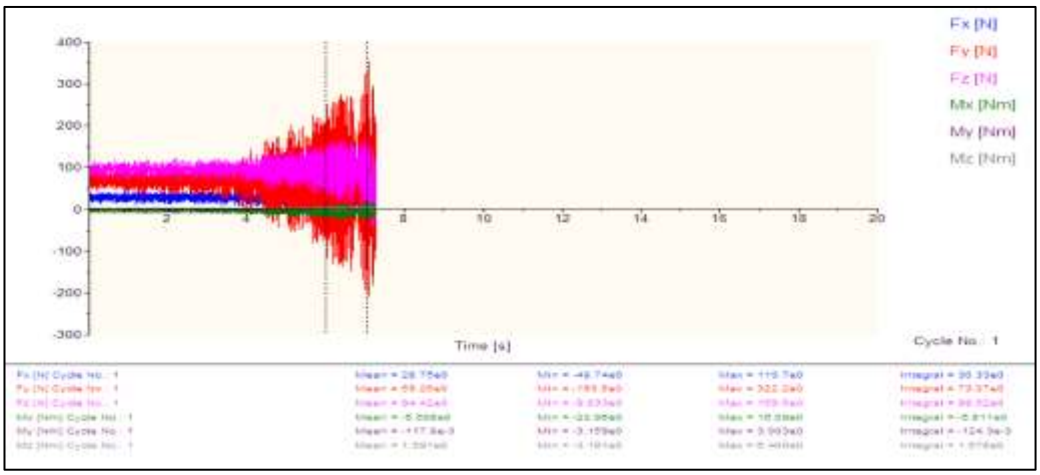

Fig. 18: EN 31 steel at 800rpm

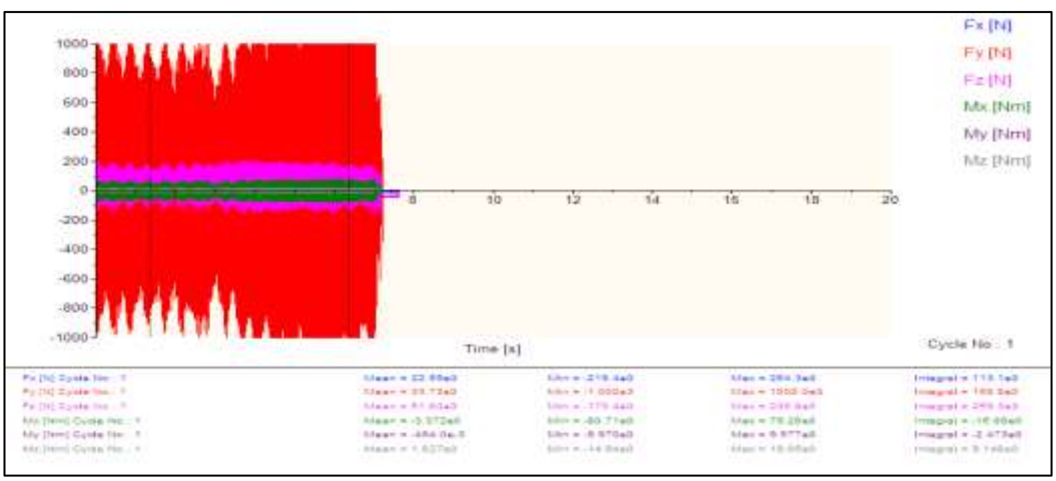

Fig. 19: EN 31 steel at 1200rpm

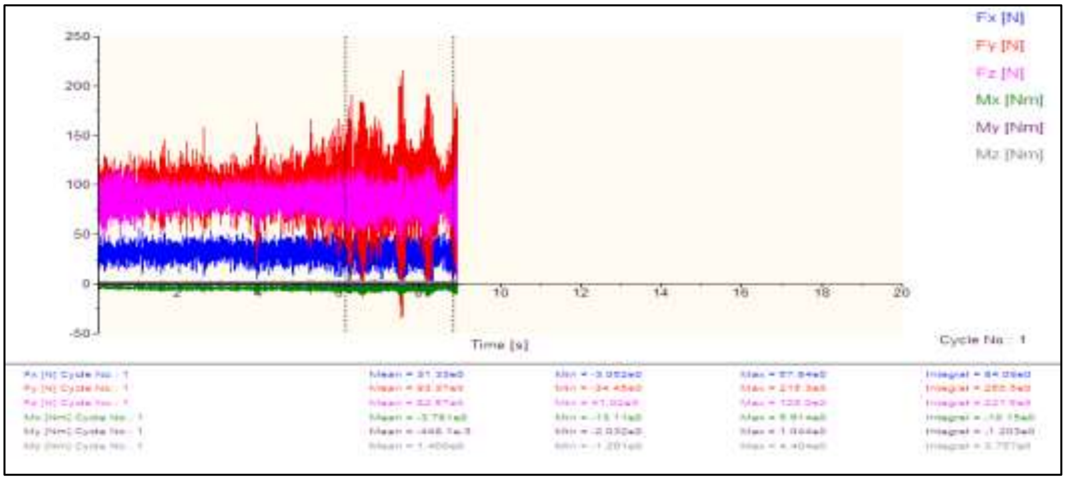

Fig. 20: EN 31 steel at 1600rpm

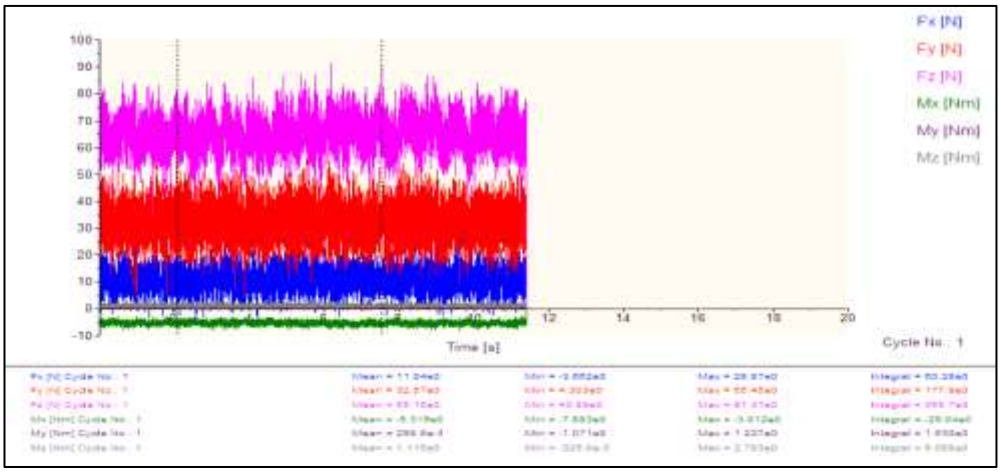

Fig. 21: OHNS steel at 400rpm

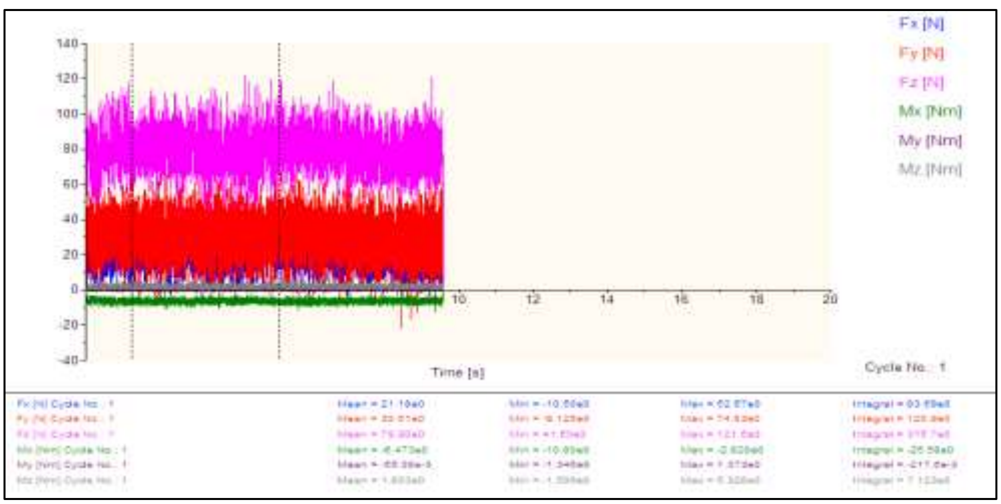

Fig. 22: OHNS steel at 800rpm

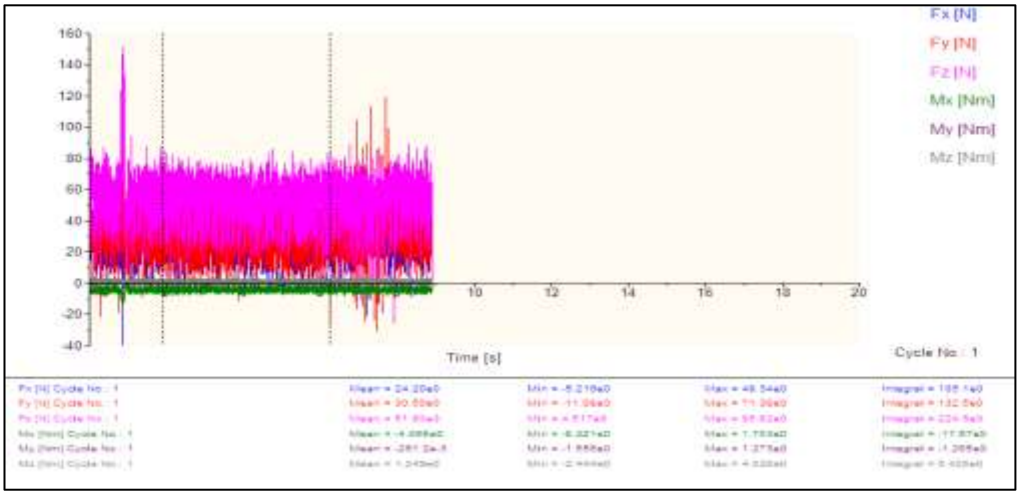

Fig. 23: OHNS steel at 1200rpm

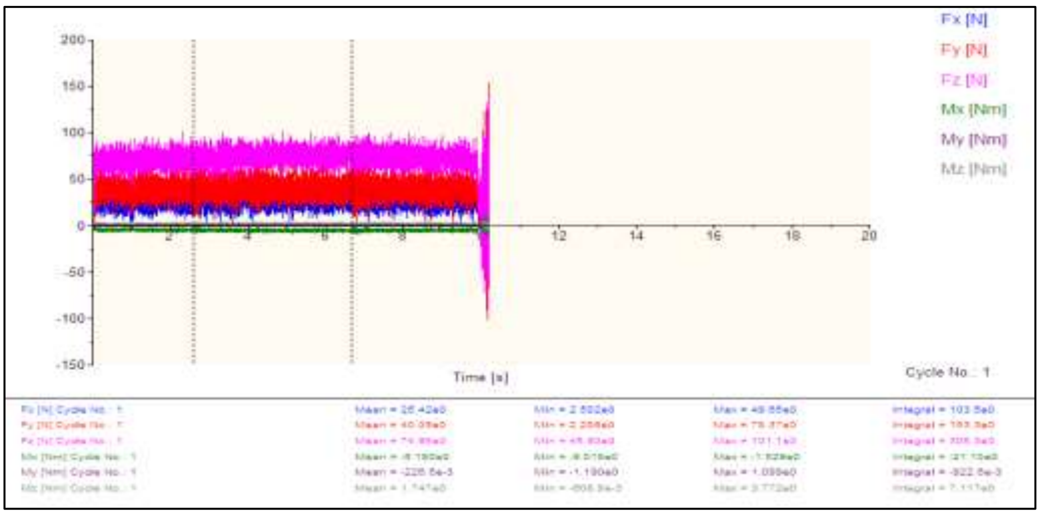

Fig. 24: OHNS steel at 1600rpm

Table – 3
Cutting Force Values for DNMG 110404 Tool Bit (From above cutting force Graphs)

S. No	*Material*	*Cutting Speed (Rpm)*	*Cutting Forces For DNMG 110404*					
			F_X (Feed force)		*F_Y (Tangential force)*		*F_Z (Radial force)*	
			MEAN	*MAX*	*MEAN*	*MAX*	*MEAN*	*MAX*
1	*Mild Steel*	*400*	*14.47*	*38.42*	*27.18*	*60.70*	*58.24*	*96.80*
		800	*12.33*	*35.68*	*30.12*	*57.92*	*59.24*	*87.52*
		1200	*13.58*	*48.61*	*32.16*	*70.13*	*56.08*	*93.99*
		1600	*23.17*	*43.37*	*38.74*	*83.62*	*58.44*	*100.80*
2	*EN-8*	*400*	*17.96*	*35.83*	*27.21*	*70.86*	*62.84*	*95.83*
		800	*16.97*	*46.59*	*32.91*	*116.40*	*50.47*	*107.20*
		1200	*14.98*	*66.74*	*37.43*	*112.7*	*59.49*	*107.90*
		1600	*17.10*	*68.60*	*57.12*	*112.70*	*53.11*	*127.10*
3	*EN-31*	*400*	*25.41*	*46.84*	*88.31*	*122.60*	*110.50*	*137.70*
		800	*28.75*	*110.70*	*69.26*	*322.20*	*94.42*	*169.60*
		1200	*22.59*	*264.30*	*33.73*	*180.00*	*51.80*	*206.80*
		1600	*31.33*	*67.84*	*93.37*	*215.30*	*82.57*	*126.00*
4	*OHNS*	*400*	*11.04*	*28.87*	*32.57*	*55.45*	*65.15*	*91.31*
		800	*21.18*	*52.67*	*30.61*	*74.83*	*79.90*	*121.50*
		1200	*24.20*	*48.34*	*30.50*	*71.38*	*51.80*	*85.82*
		1600	*25.42*	*49.65*	*40.09*	*78.37*	*74.98*	*101.10*

C. *Cutting Force Comparision Graphs for DNMG 110404 Carbide Insert*

By taking various cutting speeds such as 400rpm, 800rpm,1200rpm and 1600rpm, on X –axis and cutting forces (Newtons) on Y-axis (from above table-3), the graphs have been drawn along three cutting force directions i.e., thrust force (F_Y), feed force (F_X) and cutting force (F_Z) for four steel materials MS, EN 8, EN 31 & OHNS

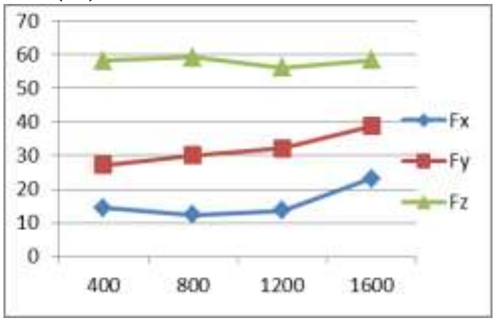

Fig. 25: Mild steel

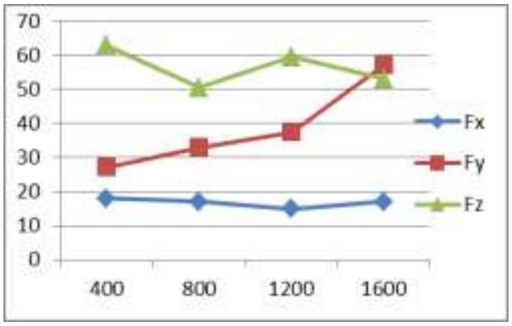

Fig. 26: EN 8

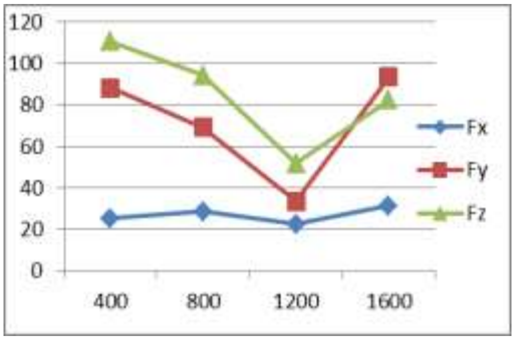

Fig. 27: EN 31

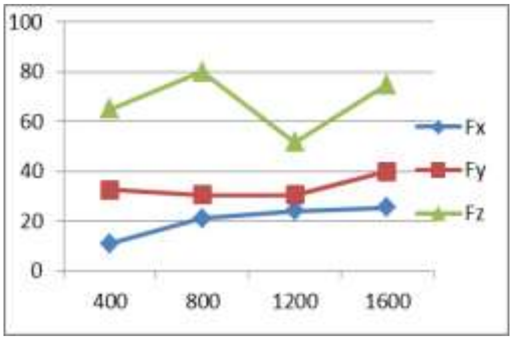

Fig. 28: OHNS

For Mild steel material (fig-25) the cutting force values were increases gradually as increasing cutting speed along the three directions. For EN 8 steel material (fig-26) along F_X the force values are almost same, along F_Y the force values increases rapidly as increasing speed. But along F_Z the force values were fluctuating, at 400rpm maximum force and at 800rpm minimum force has been observed. For EN 31 steel material (fig-27) along F_X the force values are almost same for all the speeds, little higher at 1600rpm, along F_Y & F_Z directions maximum value occurs at 400rpm and lower forces occurs at 800rpm & 1200rpm and then the value increases at 1600rpm but lower than 400rpm. For OHNS steel material along F_X & F_Y the forces varies with slight variation, along F_Z the force values were fluctuating, at 400rpm & 1200rpm lower values were observed and at 800rpm & 1600rpm higher values were observed (Fig-28).

VI. CONCLUSION

The present investigation made an attempt to have the lower roughness values in turning operation of different steel materials with preferred cutting speed by using DNMG 110404 carbide insert tool bit. A lower roughness value indicates the better surface finish. From the above experiment it is found that, with DNMG 110404 tool bit lower roughness values have been generated. Hence for different steel materials at different cutting speeds, DNMG 110404 carbide insert is preferred tool bit in comparison with HSS tool bit. Present investigation also made an attempt to analyze the cutting forces, which are developed during the turning of different steel materials with various cutting speeds by using carbide insert too bit.

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