International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-3, February 2019

Comparative assessment on the machinability of EN 24 and EN 36C Steels

Vishal Mishra, Nikhil Bharat, Kalyan Chakraborty

Abstract: ***EN 24 steel is medium carbon steel of nickel-chromium-molybdenum grade generally used for manufacturing heavy-duty axles, shafts, etc., whereas EN 36C steel is low carbon, nickel- chromium case hardened steel used widely in the manufacturing of heavy-duty crane shafts, aeroplane gears, cams, rollers, etc. The paper presents the comparative analysis on machinability of two varieties of steels, i.e. EN24 and EN 36C steels. Machining experiments were done according to 3^3 factorial design. Cutting speed, feed and depth of cut are the input process parameters and chip reduction coefficient, Von Mises stress, temperature differential and tool wear are the output parameters considered in the analysis. Metal removal of the work material was done in a conventional way by using carbide tool and lathe.***

Keywords: ***Machinability, Von Mises stress, Temperature differential, Tool wear.***

I. INTRODUCTION

EN 24 steel is medium carbon steel constituting nickel-chromium- molybdenum grade. It has a good impact, shock resistance; wear as well as abrasion resistance properties in the hardened condition. EN36C steel is low carbon; nickel-chromium case hardened steel generally used in the dynamic environment due to its high strength, corrosion resistance, shock resistance and good fracture toughness properties. M.Korat et al. [1] selected TiN coated tungsten carbide tool and inserts tool holder of ISO coding ETJNL2525M16 for machining of EN24 steel and studied optimization of effects of cutting parameters on surface finish and MRR of EN24/AISI4340 work material by employing Taguchi techniques. Krishankant et al.[2] used a single point cutting tool made of high-speed steel and optimized the effects of machining parameters applying Taguchi methods to improve the quality of manufactured goods. R. Kumar et al.[3] Optimized different Machining Parameters such as speed, feed, depth of cut, nose radius, the cutting environment of En24 Alloy Steel in CNC turning was chosen as wet and dry . The results showed that speed 1500rpm, feed 0.12 mm/rev, depth of cut 1mm and nose radius 1.2mm are the appropriate best input parameters setting. E. Koorapati et al. [4] selected the cutting conditions like speed and feed rate based on the PCBN tool material specifications, and best surface finish was produced for a smaller length of cut following optimum cutting conditions. Rahul Davis et al. [5] used L9 Taguchi orthogonal design in order to study the effect of three process parameters (Spindle Speed, Feed & Depth of cut) on the tool life of EN24 steel in dry turning operations by Carbide P-30 cutting tool and the results represented that spindle speed followed by feed rate, and depth of cut were the combination of the optimal levels of factors. M. Adinarayana et al. [6] conducted an experiment for dry turning operation using PVD as tool material on a conventional lathe PSG A141 and analysed using the ANOVA technique. The result obtained for material removal rate had increasing trend, and for maximum material removal rate, the optimality conditions were: Speed: 740rpm, Feed: 0.09 mm/rev, and Depth of cut: 0.10 mm. Umesh Gupta et al.[7] studied the effects of coated tools on turned AISI 4340 alloy steel under dry cutting conditions with CVD and PVD coated inserts by using RSM methodology. The results indicated that the feed is the most important factor affecting the surface roughness and followed by cutting speed with the depth of cut to be the least one. Amit Aherwaret et al.[8] used carbon steel as the cutting tool material Based on the signal to noise (S/N) ratio using smaller is the better approach and they concluded that the best optimal cutting condition is A1B1C1, i.e. cutting speed is 100 rpm, depth of cut is 0.5 mm and feed rate is 0.1mm/rev and found that cutting speed has a maximum contribution on cutting tool vibration in both the directions. Amritpal Singh et al. [11] investigated on dry turning of EN36 steel by using KENNAMETAL grade KYON KY4400 physical vapour deposition (PVD) coated alumina-based ceramic insert ($Al2O3+TiC$) on CNC lathe. By Taguchi optimization technique analysis it was found that feed was the important parameter which minimizes the surface roughness contributing 57.13% and depth of cut is an important parameter that has the highest contribution (70.2%) in maximizing the MRR. A.Venkata Vishnu et al. [12] performed turning operation using CNC lathe, and the cutting temperature was measured by using portable digital thermometer tester. By using Taguchi methodology, it was concluded that vegetable oil + boric acid with the cutting speed of 500m/min, feed rate 0.4mm/min., depth of cut 5mm optimizes the cutting of EN36 alloy. MehulGosai et al.[13]used quenched and tempered EN36 steel as work material, CNMG4325 TN2000 as tool insert and K-type artificial thermocouple sensor(-200C to +1200C) was used for average temperature measurement during cutting operation, and they derived a mathematical model using Central Composite Design (CCD) based on Response Surface Methodology(RSM). Rahul Singh et al. [14] used heavy duty lathe for turning the work material, customized dynamometer was used to measure the cutting forces,

Manuscript published on 28 February 2019.
***** Correspondence Author (s)

Vishal Mishra*, M.Tech (Pursuing), Department of Mechanical Engineering, National Institute of Technology Silchar (Assam), India.
Nikhil Bharat, M.Tech (Pursuing), Department of Mechanical Engineering, National Institute of Technology Silchar (Assam), India.
Dr Kalyan Chakraborty, Associate Professor, Department of Mechanical Engineering, National Institute of Technology Silchar (Assam), India.

and L9 orthogonal array was selected according to the Taguchi approach. For optimum MRR, higher feed and depth of cut were required. MRR increased with the cutting speed. P. Surulimani et al. [15] studied the optimization of the turning parameters on machining with EN36B steel by using the Taguchi approach and also used L9 orthogonal array depending upon the total degree of freedom, and it was observed that the feed rate contributes 68.64% in MRR and for surface roughness feed rate contributes 43.04%. A.Venkata Vishnu et al. [16] studied the Taguchi approach to optimize the hardness and used CNC lathe and uncoated tool insert, PVD coated (TiAN) insert and CVD coated (CVD Al2O3 film MT-TiCN+TiC+Al2O3) tool insert was used for the purpose, and it was found that the hardness value was improved by using PVD coated tool insert at 80m/min cutting speed, 0.4mm/rev feed rate and 1mm depth of cut. M. MuraliMohan et al. [17] used tungsten carbide tool insert and adopted 'Response Surface Methodology'(RSM) to optimize the turning process and found that depth of cut mainly contributes to temperature variation and feed, depth of cut, as well as speed, contribute in surface roughness. A. Venkata Vishnu et al. [18]machined annealed EN36 steel alloy by using CNC lathe mounted with three types of tool inserts "uncoated, PVD coated (TiAlN), CVD coated(CVD Al2O3 film MT-TiCN + TiC + Al2O3)and used Taguchi robust design methodology.It was concluded the 100m/min cutting speed, 0.4mm/rev feed, 1 mm depth of cut was the optimum values.

1. Experimental procedure

Present machining work was performed considering material work types as EN24 and EN36C steels. The chemical composition of EN24 steel is shown in table 1, and the chemical composition of EN36C steel is shown in table 2.

TABLE 1 Chemical composition of steel 1 (EN24 steel)

%Fe	%C	%Mn	%Si	%P	%Cr	%Mo	%Ni	%Al	%S
Balanced	0.398	0.582	0.206	0.029	1.04	0.246	1.36	0.0235	0.0164

TABLE 2 Chemical composition of steel 2 (EN36C steel)

%Fe	%C	%Mn	%Si	%P	%Cr	%Mo	%Ni	%Al	%S
Balanced	0.159	0.386	0.182	0.0164	0.820	0.131	3.10	0.0182	0.0199

Experimental plan was according to 3^3 factorial design. (Table 3)

Table 3 Input parameters used for machining.

Factors	Level 1	Level 2	Level 3
Coding	-1	0	1
Speed (m/min)	36	60	100
Feed (mm/rev)	0.49	0.63	0.86
DOC (mm)	0.67	1	1.5

Based on 3^3 factorial design, 27 different combinations of machining parameters were used for experimentation.

Table 4 3 factorial design is showing the input parameters for machining.

S.No.	Assigned Codes			Velocity (V) m/min	Feed (f) mm/rev	Depth of cut (d) mm
	V	f	d			
1	-1	-1	-1	36	0.49	0.67
2	-1	-1	0	36	0.49	1
3	-1	-1	1	36	0.49	1.5
4	-1	0	-1	36	0.63	0.67
5	-1	0	0	36	0.63	1
6	-1	0	1	36	0.63	1.5
7	-1	1	-1	36	0.86	0.67
8	-1	1	0	36	0.86	1
9	-1	1	1	36	0.86	1.5
10	0	-1	-1	60	0.49	0.67
11	0	-1	0	60	0.49	1
12	0	-1	1	60	0.49	1.5
13	0	0	-1	60	0.63	0.67
14	0	0	0	60	0.63	1
15	0	0	1	60	0.63	1.5
16	0	1	-1	60	0.86	0.67
17	0	1	0	60	0.86	1
18	0	1	1	60	0.86	1.5
19	1	-1	-1	100	0.49	0.67
20	1	-1	0	100	0.49	1
21	1	-1	1	100	0.49	1.5
22	1	0	-1	100	0.63	0.67
23	1	0	0	100	0.63	1
24	1	0	1	100	0.63	1.5
25	1	1	-1	100	0.86	0.67
26	1	1	0	100	0.86	1
27	1	1	1	100	0.86	1.5

After mounting the work material on the lathe, the machining was carried out by using the different combinations of input process parameters. The initial average temperature of the work material was recorded by infrared thermometer 1050P (IRT 1050P) having temperature range -50^0C to 1050^0C.

During the machining for the time period of 30 seconds, the average temperature at the tooltip - work interface was recorded, and the temperature differential was calculated for each experiment. From the experimentation, 27 different types of chip samples were collected, and from each sample, one chip was selected, and its weight and length were measured in order to determine the cut chip thickness.

After the machining, a tensile test specimen (ASTM-E8) of the work material was prepared for tensile testing using INSTRON 1195 UTM machine. From the tensile test, a true stress-true strain curve was obtained.

From the true stress-true strain curve, three points were selected which lie in between yield point and ultimate point of the curve. Using the points, the log-log graph was obtained. The straight line was extrapolated in order to obtain the values of strength coefficient ‘K’ and strain hardening exponent ‘n’ of the material. By getting the values of ‘K’ and ‘n’, power equation ($\sigma = K\varepsilon n$) was obtained.

Where,

σ = true stress (MPa)

ε = true strain.

Values of K and n were found as 1240 MPa and 0.207 for EN24 steel and 1495 MPa and 0.178 for EN36C steel.[9,10]

From the above material properties ,Von Mises stresses were calculated from the relation given as:-

Von Mises stress $\sigma v = 1.74 * K * (\ln\xi)n$ (MPa)

Where, ξ = Chip reduction coefficient.

Results and discussions

From input data as speed, feed and depth of cut and output data as chip reduction coefficient, Von Mises stress and temperature difference, regression equations were obtained by using MINITAB software.

Second order equation on CRC and VMS for EN24 steel and EN36C steel were obtained and reported earlier [9,10] during the continuing study.

For EN24 Steel

$b_{CRC} = 2.3193 + 0.1127x_1 - 0.2205x_2 + 0.0156x_3 - 0.4538x_1^2 + 0.036x_2^2 - 0.35x_3^2 - 0.030x_1x_2 - 0.056x_1x_3 - 0.161x_2x_3$ (eq.a)

$b_{VMS} = 2106.5 + 18x_1 - 87.5x_2 + 14.5x_3 - 234x_1^2 + 33.7x_2^2 - 170.9x_3^2 - 50.2x_1x_2 - 13.9x_1x_3 - 93.6x_2x_3$ (eq.b)

$b_{TEMP} = 24.75 + 9.31x_1 - 3.66x_2 + 14.39x_3 - 11.14x_1^2 + 1.5x_2^2 + 7.55x_3^2 + 1.37x_1x_2 + 14.68x_1x_3 - 1.33x_2x_3$ (eq.c)

For EN36C Steel

$b_{CRC} = 1.3334 - 0.0561x_1 - 0.0322x_2 - 0.0163x_3 - 0.2708x_1^2 + 0.1474x_2^2 + 0.0563x_3^2 + 0.0366x_1x_2 + 0.0183x_1x_3 - 0.0093x_2x_3$ (eq. d)

$b_{VMS} = 1810.7 - 76.2x_1 – 25.1x_2 - 7x_3 - 324x_1^2 + 265.7x_2^2 + 157.9x_3^2 + 101.5x_1x_2 + 129.5x_1x_3 - 374x_2x_3$ (eq. e)

$b_{TEMP} = 5.20 + 12.19x_1 + 2.18x_2 + 4.22x_3 + 18.15x_1^2 + 2.91x_2^2 + 4.70x_3^2 - 1.95x_1x_2 + 2.56x_1x_3 – 1.64x_2x_3$ (eq. f)

From the regression equation graphs were formed using 3D MATLAB2013 software which depicts the variation of CRC, Von Mises stress and temperature difference with respect to speed and the depth of cut for the high feed, moderate feed and the lowest feed.

Results and discussion from DOE study

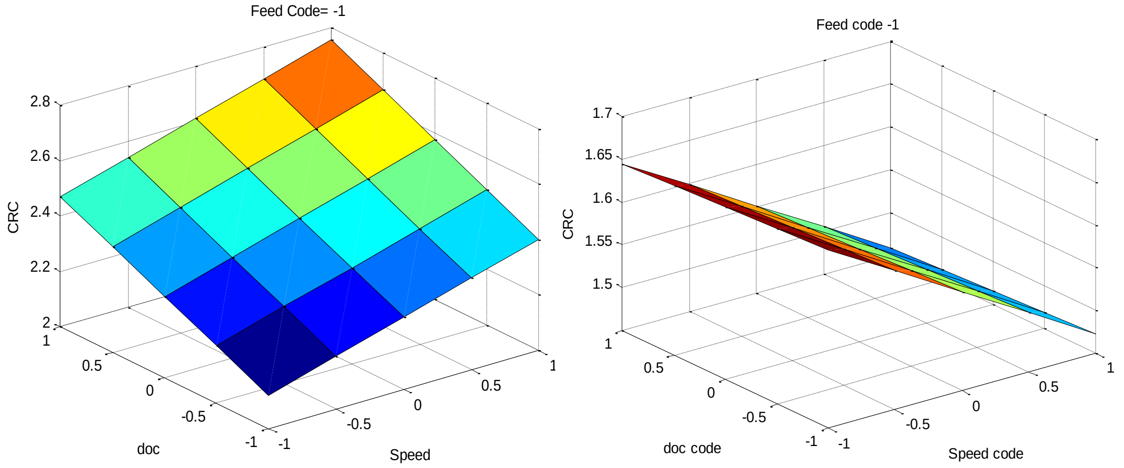
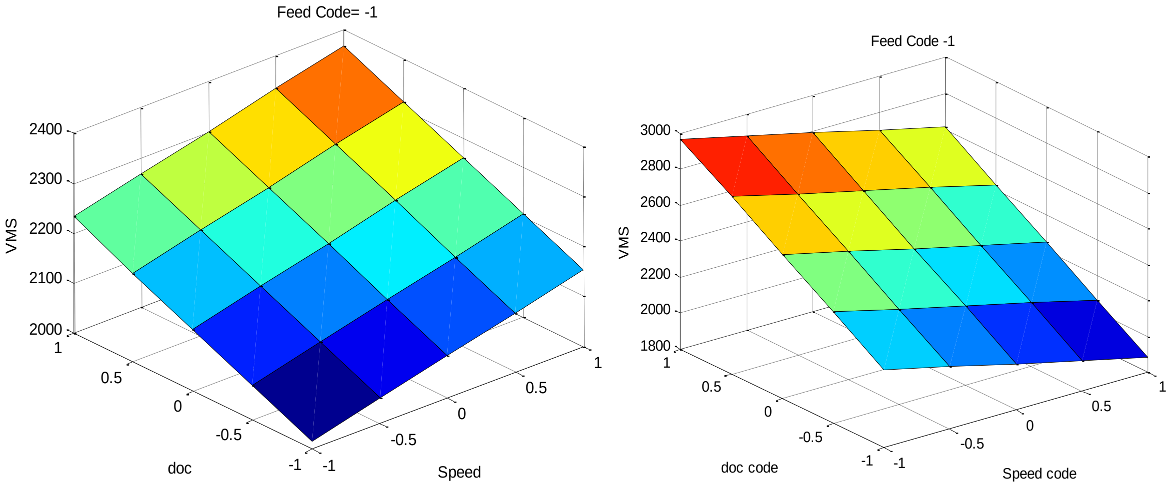


Figure 1. a) Variation of CRC w.r.t. the speed and depth of cut at lowest feed code (-1) for EN24 steel. b) Variation of CRC w.r.t. the speed and depth of cut at lowest feed code (-1) for EN36C steel.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)



(a) (b)

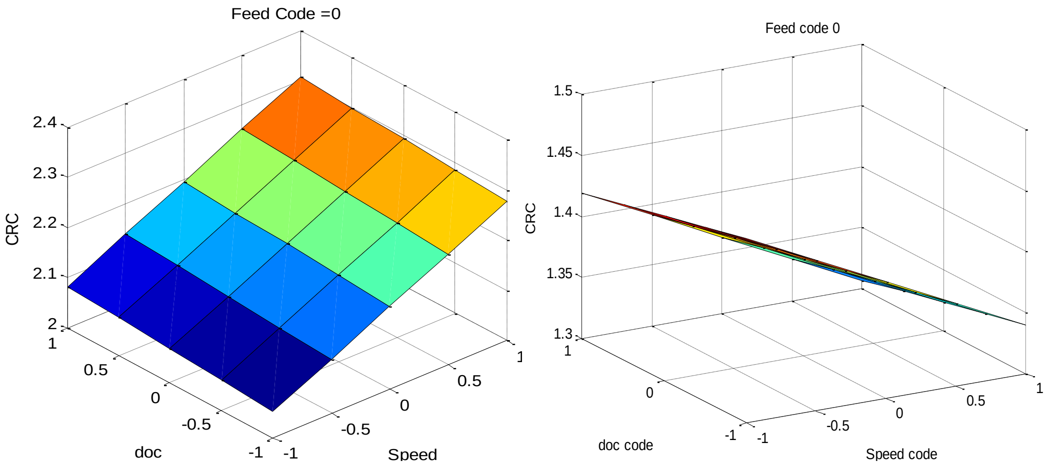
Figure 2 a)Variation of Von Mises stress w.r.t. the speed and depth of cut at lowest feed code (-1) for EN24 steel. b) Variation of Von Mises stress w.r.t. the speed and depth of cut at lowest feed code (-1) for EN36C steel.

At lowest feed(-1), EN24 Steel

CRC increases with an increase in both speed and d.o.c(fig.1(a)). The same trend is also observed in case of dependency of VMS on speed and d,o.c(fig. 2.(a)). The increase of CRC and VMS w.r.t. speed and d.o.c. is mainly attributed to the ductility transition of work material(EN24 Steel) at higher speed and d.o.c. conditions. Built up cohesive energy at the cutting zone during the chip formation process is influencing much to raise the VMS.

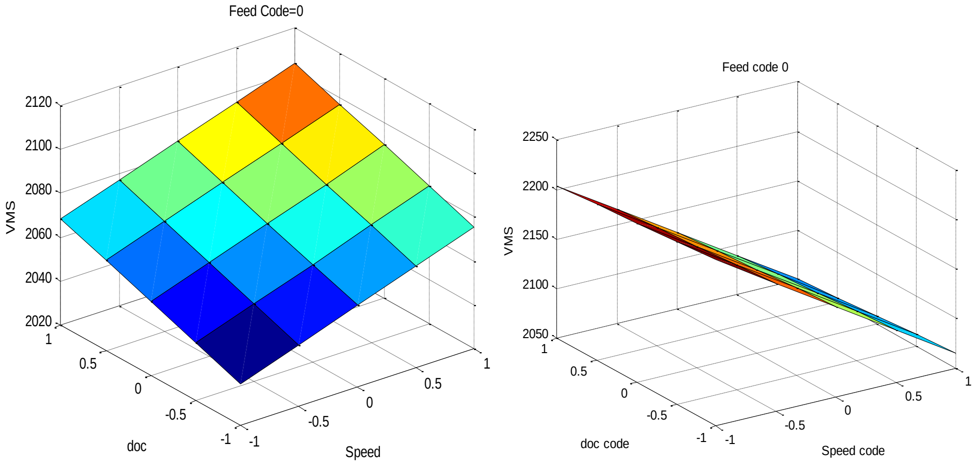
At lowest feed(-1), EN36C Steel

For En36C steel, however, increase in speed reduces the values of CRC and VMS(fig. 1.(b),2(b)). This indicates that the chip formation process at this cutting condition is taking place with predominated brittleness transition of work material. But the increase of depth of cut causes ductility transition of work material at the cutting zone to raise the VMS(fig. 2(b)).



(a) (b)

Figure 3. a) Variation of CRC w.r.t. the speed and depth of cut at moderate feed code (0) for EN24 steel. b) Variation of CRC w.r.t. the speed and depth of cut at moderate feed code (0) for EN36C steel.



(b)

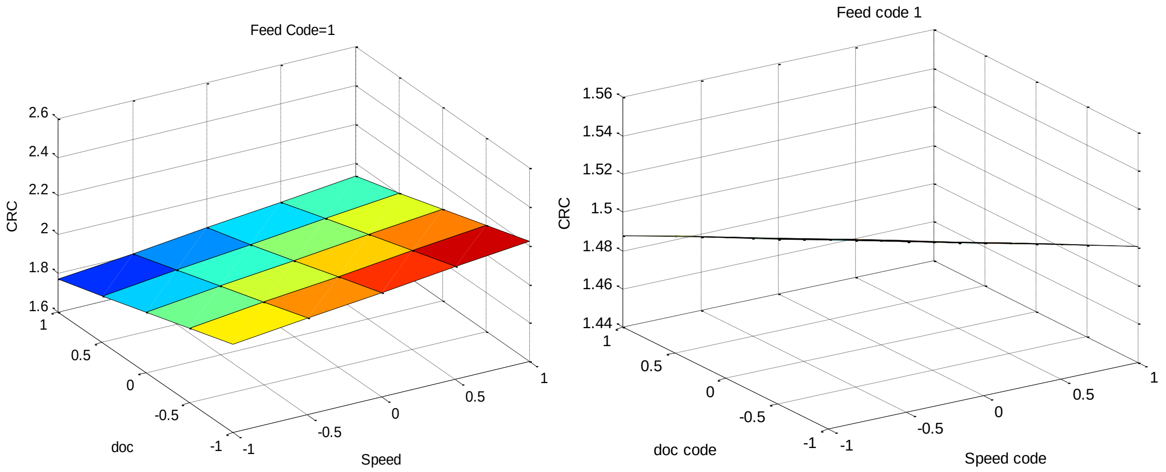
Figure 4. a) Variation of Von Mises stress w.r.t. the speed and depth of cut at moderate feed code (0) for EN24 steel. b) Variation of Von Mises stress w.r.t. the speed and depth of cut at moderate feed code (0) for EN36C steel

At moderate feed(0), EN24 Steel

Trends on variations of CRC and VMS on speed and d.o.c. remain unaltered in comparison with the case at lower feed code(-1). (fig.3(a),fig.4(a)) and fig1(a),fig2(a)).

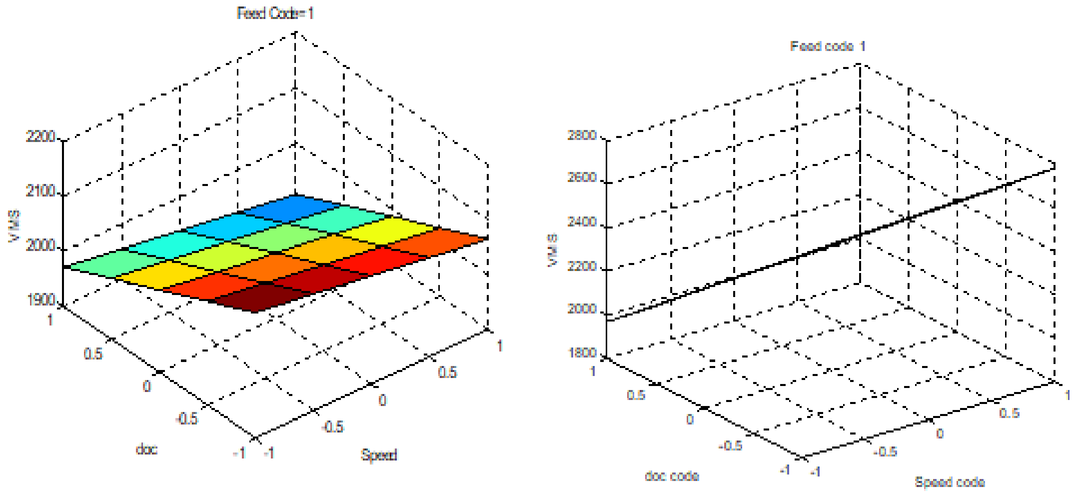
At moderate feed(0), EN36C Steel

Almost similar patterns of variations of CRC and VMS w.r.t. speed and depth of cut were found in comparison with that of feed code(-1) [fig.3(b), fig.4(b) and fig1(b) fig2(b)].



(a) (b)

Figure 5. a) Variation of CRC w.r.t. the speed and depth of cut at highest feed code (+1) for EN24 steel. b) Variation of CRC w.r.t. the speed and depth of cut at highest feed code (+1) for EN36C steel.



(a) (b)

Figure 6. a) Variation of Von Mises stress w.r.t. the speed and depth of cut at highest feed code (+1) for EN24 steel. b) Variation of Von Mises stress w.r.t. the speed and depth of cut at highest feed code (+1) for EN36C steel.

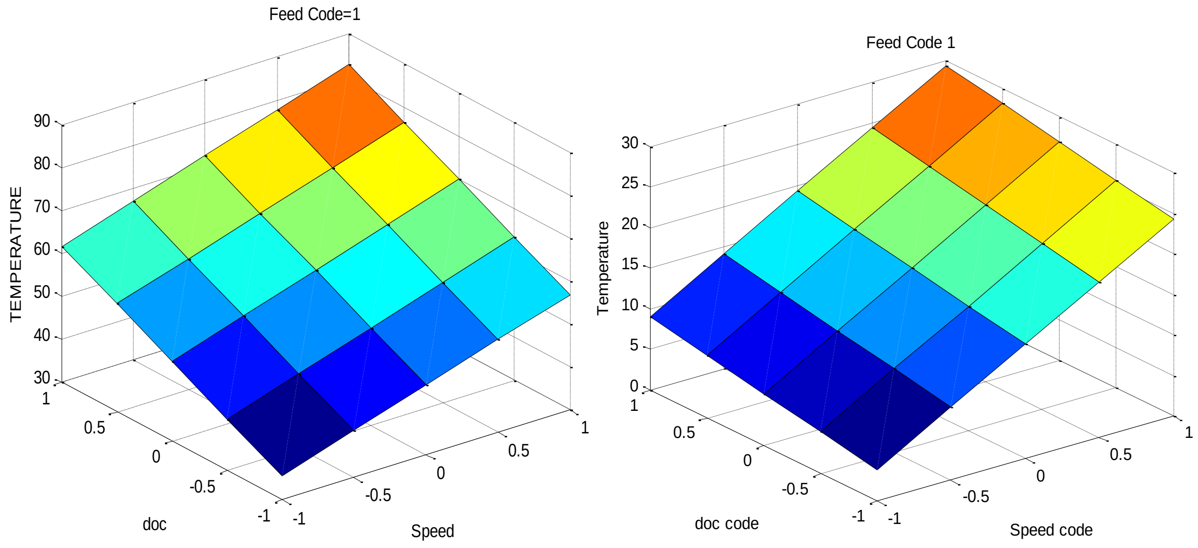
Considering overall variations on responses for CRC and VMS from regression equations, comparative assessments in specific ranges were identified and shown in Table(5)

Range in Variation

Table.5

	EN24		EN36C	
Feed code	CRC	VMS	CRC	VMS
-1	2.1-2.7	2000-2350	1-1.66	1800-3000
0	2.1-2.3	2040-2100	1.35-1.4	2000-2200
1	1.6-2	1500-2050	1.4-1.5	2000-2800

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)



(a) (b)

Figure 7. a) Variation of temperature change w.r.t. the speed and depth of cut at highest feed code (+1) for EN24 steel. b) Variation of temperature change w.r.t. the speed and depth of cut at highest feed code (+1) for EN36C steel.

At highest feed, (code+1),EN24 Steel

At this cutting condition, the significant influence of speed and feed on CRC and VMS was not seen [fig.5(a) and fig.6(a)]. This is attributed to the strain hardening effect that contributes towards the formation of the thermal softening effect during the process of chip formation. Thermal variation response at all speed and depth of cut condition is very much apparent in fig.7(a).

At highest feed, (code+1), EN36C Steel

CRC increased slightly with an increase in speed due to strain rate hardening causing brittleness transition of work material during chip formation[fig.5(b)]. Subsequently, VMS increased with an increase in speed because of higher strain rate hardening of the work material during the process of chip formation.[fig.6(b)]. Strain rate hardening contributes towards enhancing the thermal variation at increased speed condition[fig.7(b)].

Finally, it is understood that machining on EN24 steel at the highest feed(code+1) at all speed and d.o.c. conditions will be the appropriate judgement[fig.6(a)]. This type of acceptable response is not attainable for machining on EN36C steel in the present investigation [fig.6(b)].

TOOL WEAR STUDY

Table.6

Machining Time(min.)	Avg. Flank wear EN24 steel(µm)	Avg. Flank wear EN36C steel(µm)
1	32.14	11.11
2	12.33	32.14
3	10.52	47.36

Comparative assessment on tool wear

Table(6) shows that the extent of tool wear during machining on EN24 steel is lesser in comparison to the tool wear with machining on EN36C steel under identical machining condition.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

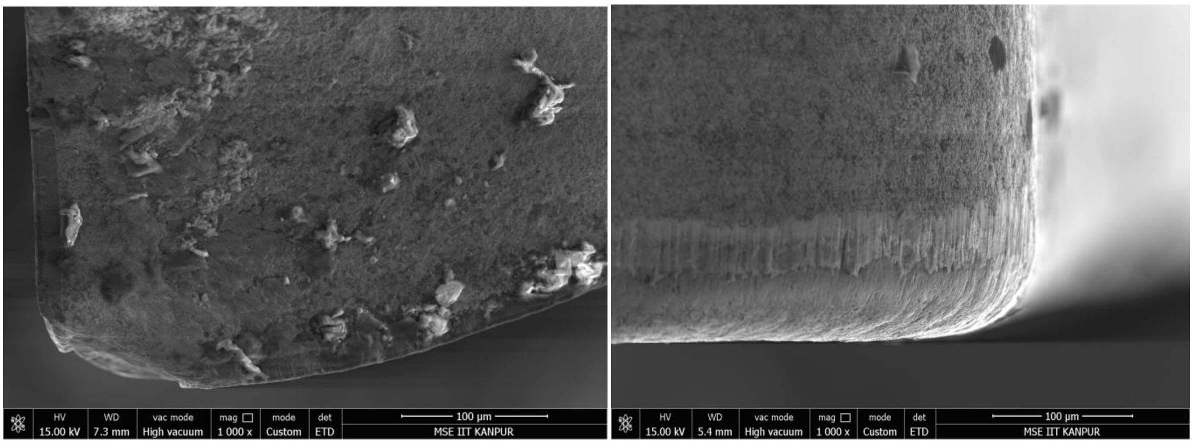


Figure.8.a) SEM image at 1000X **Figure. 8.b) SEM image at 1000X**

Fig.8.a) Showing adhesive segments on the rake face after 3min. machining time on EN24 Steel.
Fig.8.b) No such adhesive segments are available on the rake face after 3min. machining time on EN36C steel.

II. CONCLUSION

1. Considering the extent of tool wear and VMS, machinability of EN24 steel is better than that of EN36C steel.
2. For EN24 steel, the extent of developed VMS is less compared to the case with that of EN36C steel.
3. For EN24 steel, tool wear takes place through chipping and adhesion whereas, for EN36C steel, tool wear takes place through abrasion.

III. ACKNOWLEDGEMENT

The authors sincerely and gratefully acknowledge the assistance provided by IIT Kanpur while using SEM lab and the material testing lab of IIT Kanpur.

REFERENCE

1. M. Korat, N.Agarwal, “Optimization of Different Machining Parameters of En24 Alloy Steel In CNC Turning by Use of Taguchi Method”, International Journal of engineering research and applications (IJERA),vol. 2, 2012, pp. 160-164.
2. Krishankant, J. Taneja, M. Bettor, R. Kumar. “Application of Taguchi Method for Optimizing Turning Process by the effects of Machining Parameters”, International Journal of engineering and advanced technology (IJEAT), vol. 2,2012, pp. 9-15.
3. Raman Kumar, Raman Kumar, Jasper Singh Ray and Avnet Singh Virk“Analysis the effects of process parameters in EN24 alloy steel During CNC turning by using madm”, International Journal of Innovative Research in Science, Engineering and Technology, vol. 2, 2013, pp. 1131-1145.
4. Eshwara Prasad Koorapati, Mohandas KN, Ramesh C S, Balashanmugam N, “Optimization of Surface Roughness during Hard Machining of Hard Chrome Plated Surfaces on EN24 Base Substrate”, International Journal of Mining, Metallurgy & Mechanical Engineering (IJMMME) ,vol. 1, 2013, pp. 27-38.
5. Rahul Davis, Jitendra Singh Madhukar, “A parametric analysis and optimization of tool life In dry turning of En24 steel using Taguchi method”, International Journal of Production Technology and Management(IJPTM),vol. 3,2012, pp. 9-15.
6. M. Adinarayana, G. Prasanthi, G. Krishnaiah, “Multi-Objective Optimization during Turning of EN24 Alloy Steel”, Journal of Engineering Research and Applications , vol. 3, 2013, pp. 1193-1198.
7. Umesh Gupta, Amit Kohli, “Experimental Investigation of surface roughness in dry turning of AISI 4340 alloy steel using PVD- and CVD- coated carbide inserts”, International Journal of Innovations in Engineering and Technology, vol. 4, August 2014, ISSN 2319-1058.
8. AmitAherwar, Deepak Unune, BhargavPathri, Jai Kishan, “Statistical and regression analysis of vibration of carbon steel cutting tool for turning of en24 steel using design of experiments”, International Journal of Recent advances in Mechanical Engineering (IJMECH) Vol.3, August 2014.
9. Nikhil Bharat, Dr Kalyan Chakraborty, "Machinability of en24 steel (817m40)", International Journal of Latest Trends in Engineering and Technology (IJLTET)Volume 12 Issue 3 - January 2019 , pp.001-007 e-ISSN:2278-621X Print-ISSN : 2319-3778 https://www.ijltet.org/journal_details.php?id=942&j_id=4743
10. VishalMishra and Dr KalyanChakraborty, “Machinability of Nickel-Chromium Case Hardened Steel (EN36C)”. Global Journal of Researches in Engineering: A Mechanical and Mechanics Engineering Volume 19 Issue 1 Version 1.0 the Year 2019. Online ISSN:2249-4596 Print ISSN:0975-5861.
11. Amritpal Singh, Harjeet Singh. “Effects of Process Parameters on Surface roughness and MRR in hard turning of EN36 Steel”. International Journal of Scientific & Engineering Research, Volume 7,June-2017.
12. A.Venkata Vishnu, E.Sanjana, G.Guruvaiah Naidu. “Experimental Investigations on CNC Turning of-36 Material Using Taguchi Method”. Vol-2 Issue-2 2017IJARIIE-ISSN(O)-2395-4396.
13. MehulGosai, Sanket N. Bhavsar. “Experimental Study on Temperature Measurement in Turning Operation of Hardened Steel (EN36)”. Procedia Technology 23 (2016) 311 – 318
14. Rahul Singh, Diplesh Gautam. “Experimental Analysis of the Cutting Forces and Material Removal Rate during Dry Turning of En-36 Steel.” International Journal of scientific research and management. Volume 4, Issue 06, Pages 4351-4354, year2016. ISSN (e): 2321-3418.
15. P.Surulimani, A.Karthikraja, V.Sivaganesan, J.Gowthaman, M.Yojiith. “Optimization of CNC Turning Parameters on EN36B Steel Using Taguchi Method.” International Journal of Innovative Research in Science, Engineering and Technology. Vol. 5, Issue 2, February 2016. ISSN(Online): 2319-8753 ISSN (Print) : 2347-6710
16. A.Venkata Vishnu, G.Guruvaiah.Naidu, Ch.PranavSrivatsav, A.Srikar.“Optimization of Process Parameters for hardness in Turning of EN36 using Taguchi Robust Design Methodology.”National Conference on Recent Trends & Innovations in Mechanical Engineering, April 2016 ISSN(online): 2321-0613.
17. M. Murali Mohan, N.V.S.S. Sagar, M. Lava Kumar, E. VenugopalGoud. “Multi-Objective optimization of machining parameters of EN36 Steel using RSM”. International Journal of Scientific Research in engineering and Technology,Volume 4,April-2015
18. A.Venkata Vishnu, G.Guruvaiah Naidu, K.B.G.Tilak, J.Ramakrishna. “Application of Taguchi Method in the Optimization of Turning Parameters for Material Removal Rate of En-36 Material”. International Journal of Advance Engineering and Research Development. (Scientific Journal of Impact Factor(SJIF): 3.134). Volume 2,Issue 8, August-2015 e-ISSN(O): 2348-4470 p-ISSN(P): 2348-6406.

AUTHOR PROFILE

Vishal Mishra received the B.Tech degree in Mechanical Engineering from Lovely Professional University, Jalandhar, Punjab, India in year 2015. Currently, he is pursuing his M.Tech in Materials and Manufacturing Technology from National Institute of Technology Silchar, Assam, India. His area of interest is conventional metal cutting and stress-analysis.

Nikhil Bharat received the B.Tech degree in Mechanical Engineering from Saroj Mohan Institute of Technology, Guptipara, West Bengal, India in year 2016. Presently, he is pursuing M.Tech in Materials and Manufacturing Techgnology from National Institute of Technology Silchar, Assam, India. He has won the first prize for outstanding academic performance in college during his Batch. His areas of interest are metal cutting, micromachining and manufacturing science.

Dr. Kalyan Chakraborty, received B.E. degree in Mechanical engineering from Regional Engineering College, under Burdwan University in 1984, M.Tech from Indian Institute of Technology Kharagpur in 1988, and Ph. D. in Mechanical Engineering from Indian Institute of Technology Kharagpur in 1996. Presently he is serving as Associate Professor in National Institute of Technology Silchar. He has been serving in this Institution since 1984. He has international papers and presented number of papers in various national seminars. His areas of interest are Metal machining, Micromachining, Manufacturing Science, Material Science, Metrology, Quality Control.