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Research Article

SINGLE POINT CUTTING TOOL NOMENCLATURE ANALYSIS IN THE TURNING PROCESS FOR SURFACE QUALITY

G.ALAGASAMY, K,VINUKUMAR

Asistant Professor Department of Mechanical Engineering, Dr.Sivanthi Aditanar College of Engineering, Tiruchendur-628215,India.
Email: mgalagar76@gmail.com, er.vinukumar@gmail.com

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ABSTRACT

Generally machining operations are used to produce a desired shape and size by removing excess stock from a blank in the form of chips. New surfaces are generated through a process of plastic deformation and crack propagation. The workpiece is subjected to intense mechanical stresses and localized heating by tools having one or more shaped cutting edges. Each cutting edge leaves its own mark on the machined surface. Also the workpiece and tool, together with the machine on which they are mounted, form a vibratory system liable to random, forced are induced vibrations. These vibrations alter the relative distances between the tool and the workpiece and hence damage the surface quality as well as dimension of the component.From the literature survey, it is found that most affecting parameters for surface quality of the components are rack angles, cutting edge angles, relief angles and nose radius. Considering the above, this paper proposes Design of Experiments concepts for analyzing effect of back rack angle, side rack angle, side relief angle and nose radius on surface quality of turned aluminum components in a CNC trainer Lathe. Design of experiments is a powerful tool that can be used to manipulate multiple input factors to show their effect on a desired output (response). The orthogonal Array a powerful tool of DOE is chosen for analysis

Key words: Turning, Tool nomenclature, orthogonal array, Surface quality,

INTRODUCTION

The work piece is subjected to intense mechanical stresses by tools having single or more multiple cutting edges. Each cutting edge leaves its own mark on the machined surface. The work piece and tool, together with the machine on which they are mounted, form a vibratory system liable to random, forced are induced vibrations. These vibrations alter the relative distances between the tool and the work piece and hence damage the surface quality as well as dimension of the component. A considerable number of studies have investigated the general effects of the cutting speed, feed, and depth of cut on the surface roughness.

Surface finish in turning has been found to be influencing in varying amounts by a number of factors such as feed rate, work material characteristics, work hardness, unstable built-up edge, cutting speed, depth of cut, cutting time, tool nomenclature, stability of machine tool and work piece setup, chatter, and use of cutting fluids.

The major nomenclature influencing the surface quality for single point cutting tool are rake angle and back angle of the tool (Mingjum chen et al., 2008).It is proposed to focus on back rack angle, side rake angle, side relief angle and nose radius by analyzing their effects on surface quality. The analysis consists of three levels of tool nomenclature and totally nine experiments conducted. Design of Experiments (DOE) concepts are adopted for analyzing effect of tool nomenclature on surface quality. From the literature survey, most affecting parameter for surface roughness of the component was cutting parameters and tool parameters.

Marin MOŢOI CRISTESCU (2005)

proposed, As it is known, the surface condition has two constituents: dimensional accuracy and roughness of the machined surface. In this study it is presented only the condition of the machined surface from the roughness point of view. As regards the geometry of the lathe tool, this study presents only the influence of two tool parameters, radius of the tool point and the end cutting edge angle.

Hari Singh and Pradeep Kumar (2006)

proposed, optimal setting of turning process parameters (cutting speed, feed rate and depth of cut) resulting in an optimal value of the feed force when machining EN24 steel with TiC-coated tungsten carbide inserts. The effects of the selected turning process parameters on feed force and the subsequent optimal settings of the parameters have been accomplished using Taguchi's parameter design approach. The results indicate that the selected process parameters significantly affect the selected machining characteristics. The results are confirmed by further experiments.

Mingjun Chen et al., (2008)

proposed experiments conducts they are many factors affecting the surface quality that the rake angle and back angle of the tool have significant effects on machined surface roughness. In this thesis he has been proposed an efficient way to improve the surface roughness is to select a proper negative angle .In this study he has been adopted ANSIS statics analysis method was employed.

Christophe coudyzer and Thomas Richard (2005)

proposed by a testing program was undertaken to investigate the influence of cutter inclination on both the magnitudes and orientation of the cutting force. And he has been proposed mostly affected on the surface roughness by the back rake angle for the rock surface.

Yusuf sahin and riza motorcu (2004)

Proposed the surface roughness model in the turning of AISI 1040 carbon steel was developed in term of cutting speed, feed rate and depth of cut using the response surface methodology. In this work involved PVD coated ceramic toools and the CNC industrial type machine undre different conditions. In this work focused the feed rate was most significant factor than other parameters.

Hasan G.O KKAYA and Muammer NALBANT (2005)

Expalined the effects of a number of cutting tool coating materials on the surface quality of workpieces, depending on various cutting parameters were investigated. AISI 1015 steel was processed without cooling on a lathe using 4 different cemented carbide cutting tools, They are analyzed among the cutting parameters, the depth of cut was kept constant while the cutting speed and feed rate were changed. Five cutting speeds and two feed rates were used during the machining process. In the experiments, less average surface roughness was obtained by using a 3-layer coated tool coated outermost with TiN. The lessening of cutting speed by about 33% improves the surface roughness by about 26%, and increasing the cutting speed by about 310% resulted in an improvement of about 69%

Safeen Y. Kassab Younis and K. Khoshnaw (2007)

This work proposed to find a correlation between surface roughness and cutting tool vibration in turning. The ranges of process cutting parameters in the present study are cutting speed , depth of cut , feed rate and tool overhanging . The data are generated by lathe dry turning of medium carbon steel samples at different levels of the mentioned the parameters. The results were that the cutting speed has small effect on surface roughness than feed rate and tool overhang. The depth of cut has not a significant effect on surface roughness in this study. Finally experimental results were correlation between the cutting tool vibration and surface roughness .

W.S. Lin (2008)

Proposed on the surface roughness variation in high speed fine turning of the austenitic stainless steel. In this work a series of experimental tests have been done to evaluate the possibility of high speed fine turning of the austenitic stainless steel from the surface roughness variation and machining stability. In this work results were the smaller the feed rate, the smaller the surface roughness value. And this work also focused when the feed rate smaller than the critical feed rate, the chatter will occurs and the surface roughness of the work piece would be deteriorated. The higher the cutting speed is, the higher the cutting temperature of cutting tool is.

Sahoo and Routara(2008)

Proposed an experimental study of fractal characteristics surface profile produced in CNC turning and optimization of machining parameters and applied to the various material and approached by the Taghuchi method. In this work the feed rate was most significant parameter among the three parameter factor This work results were most significant factor.

Mahapatra S.S.et al., (2006)

In this work focused turning operation many parameters such as cutting speed, feed rate, and depth of cut. the Several statistical modeling techniques have been used to generate models including regression and Taguchi methods.They made to generate a surface roughness prediction model and optimize the process parameters Genetic algorithms.

Tugrul O zel, Yigit Karpat (2004)

Proposed on the surface roughness variation in high speed fine turning of the austenitic stainless steel. In this work A series of experimental tests have been done to evaluate the possibility of high speed fine turning of the austenitic stainless steel from the surface roughness variation and machining stability. The results were the smaller the feed rate, the smaller the surface roughness value. But when the feed rate smaller than the critical feed rate, the chatter will occurs and the surface roughness of the work piece would be deteriorated. The higher the cutting speed is, the higher the cutting temperature of cutting tool is. The cutting tool will be soften and the surface roughness of the work piece will be deteriorated.

Karin Kandananond (2009)

Proposed to achieve the best cutting conditions for minimizing surface roughness in a turning process of ferritic stainless steel, grade AISI 12L14. In this work concentrate the effect of three machining parameters like depth of cut, spindle speed and feed rate on the surface roughness was studied using the Taguchi technique. The turning experiments were carried out on a two-axis CNC lathe equipped with five uncoated carbide inserts and operated under wet cutting conditions. The orthogonal array L18 with five replicates, the signal-to-noise ratio (SNR) and the analysis of variance (ANOVA) were deployed to determine the optimal conditions for obtaining the desired surface roughness. The experimental results, all three factors have significant effects on the surface roughness and the response analysis indicates that the feed rate has the highest effect on the surface roughness, followed by spindle speed and depth of cut in that order.

Thamizhmanii A (2007)

This paper studied an application of the Taguchi method parameter design to optimize the surface roughness, tool wear and cutting force by hard turning process. In the process of analyses, material having hardness between 54-58 was considered and three CBN cutting tool were used to conduct 18 tests. The response of surface roughness and flank wear taken for discussion and analyses. The experimental results show that there is a good agreement between surface roughness and flank wear both by equations and experiments by Taguchi method.

Khalil Aslam Awan and Yasir A. Hadi (2008)

This research focuses on study and analyses of surface quality improvement in turning operation of Aluminium and Copper.This paper develops an empirical model for surface roughness (Ra) prediction in turning using Al (6061T) and Cu (ASME B152 annealed). The impact of cutting speed, feed, depth of cut, tool geometry and work piece material are studied on surface roughness by using Regression Analyses (RA). Finaly they were given the result An increase in speed will significantly reduce the surface roughness and An increase in feed will increase surface roughness and Increasing the depth of cut would slightly increase the surface roughness.

Most of the researchers Rech and Moisan(2002), Hari Singh and Pradeep Kumar (2006) , Mahapatra .S.S et al., (2008),Karin Kandananond (2009) **,** Khalil Aslam Awan and Yasir A. Hadi (2008) and Tugrul O zel, Yigit Karpat (2004) studied the effect of various cutting parameters such as cutting speed, feed rate, depth of cut, etc.

Although the above mentioned cutting parameters have only indirect effect on the surface quality the tool parameters have direct effect on the surface quality. The effect of the following cutting tool parameters viz rack angles Mingjun Chen et al., (2008) and cutting edge angle are often studied Chen et al., (2008), Coudyzer and Richard (2005). Number of papers which study the effect of tool radius is limited CRISTESCU (2005) studied the effect of nose radius along with end rake angle.

A few researchers Hasan G.O KKAYA and Muammer NALBANT (2005) concentrate various coated cutting tools in a work material by using the cutting parameters.In this paper the effects of four tool parameters such as back rake angle, side rake angle, and side relief angle and nose radius are considered. The simultaneous effect of all the four parameters is attempted in this paper although previous researchers have taken only three of the parameters. Thus the objective of this paper is to analyze the effect of single point cutting tool nomenclature on the surface quality of an aluminium bar turned using a CNC Lathe. In this work Chatter and inhered vibration are unaccountable during the turning process.

METHODOLOGY

In this work Design of Experiments have been adopted for analyzing the most influencing parameter in the surface roughness of the component.

Design of experiments (DOE) is a powerful tool that can be used in a variety of experimental situations. The following tools of DOE are chosen here orthogonal array, ANOVA (Analysis of Variance), ANOM (Analysis of Mean) and Signal to Noise ratio (S/N ratio). Orthogonal array describes the effect of interactions and control factors and explains how to analyze interactions.

Analysis of Variances (ANOVA) is one of the Design of Experiment tool that identifies factors the significantly influencing the experimental results.

EXPERIMENTAL DETAILS

Experiments are conducted on Aluminium of size to analyze the influence of the above said cutting parameters on CNC XL Turn Lathe and Surface roughness was measured using Surface roughness testing machine (Tally surf). Tool nomenclature is set, using Tool and Cutter grinding machine and tool angles are measured by the Mitutoya Profile projector. The tooling layout of the CNC lathe and single point cutting tool layout shown in Fig.1

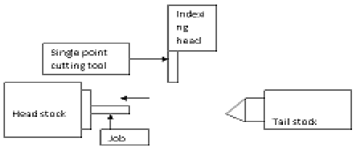

Fig 1. Tooling Layout

ENVIRONMENT

This work focuses on surface quality of turned components which are machined in the following production environment at room temperature

Machine tool :CNC XL Turn Lathe
Work material : Mild Steel
Size of Work material : Dia 25.4 X 100 mm
Tool material : HSS

Process Parameter

Cutting velocity :1.596 m/sec (1200rpm)
Feed rate :30 mm /min
Depth of cut : 0.5mm
Environment : Dry condition at room temperature
Coolant : Nil

Data for CNC XL Turn Lathe

No.of tools adopted : 4
Distance between the Centers : 250mm
Max. Spindle dia For the Gripping:25.4mm
Max. Cutting Speed : 3000rpm
Max.cutting Feed : 50mm/rev
Max.Depth of cut : 2mm
Length : 600mm (26")
Width : 425mm (16.25")
Height : 430mm (17")

Set of Experiments

The sets of Experiments conducted for Mild steel work piece are shown in table I. In this table consists of three levels such as low level, medium level and high level. Every experiments can followed in the order of table value. Finally out puts (response) are taken by the surface roughness testing machine. SS_A, SS_B, SS_C, SS_D and $T^2../N$ are calculated from the table value Table 2 shows the data for the ANOVA . In this table find out Sum of Square(SS), Degree of Freedom (DOE), Mean square(MS) and Percentage of contribution. Table III shows the data for ANOM respectively. The graphical representation of the ANOM is shown in figures 1 to 4. figure 1 explained the back rake of the status for the corresponding level similarly figure 2, figure 3 and figure 4 explained the status of the side rake angle, side relief angle and nose radius. Among the four graphical representation the back rake angle is highest value. The signal to Noise ratio data are shown in Table 4.

RESULT AND DISCUSSION

The following procedure followed for the calculation purpose for the material of Mild steel

$SS_A = \{[\Sigma A1]^2/nA1 + [\Sigma A2]^2/nA2 + [\Sigma A3]^2/nA3]\} - T^2../N$

$= [0.73+0.72+0.65]^2 / 3 + [0.99+0.53+0.47]^2 /3 + [0.36+0.38 + 0.41]^2/3 - 27.56^2/9$

$= 1.47+1.33+0.4408 - 3.0625$

$= 0.1783$

Similarly Taken the other values by using the corresponding formula the following

$SS_B = \{ [\Sigma B1]^2/nB1 + [\Sigma B2]2/nB2 + [\Sigma B3]2/nB3]\} - T^2../N = 0.0594$

$SS_C = \{ [\Sigma C1]^2/nC1 + [\Sigma C2]^2/nC2 + [\Sigma C3]^2/nC3]\} - T^2../N = 0.0441$

$SS_D = \{ [\Sigma D1]^2/nD1 + [\Sigma D2]^2/nD2 + [\Sigma D3]2/nD3]\} - T^2../N = 0.0415$

$SS_{TOTAL} = \sum\sum Yij^2 - T^2../N = 0.0.3552$

SS_{Error} = SSTOTAL- [SSA+ SSB+ SSC+ SSD]=0.0.0319

Where,

SS_A- Sum of Square of A
SS_B- Sum of Square of B
SS_C- Sum of Square of C
SS_D- Sum of Square of D
$T^2../N$ – Correction factor
N- Number of Experiments

Table. 1: L9(3^4) Orthogonal Array for Mild Steel

Experiment no	Parameter 1 (Back Rake angle)		Parameter 2 (Side Rake angle)		Parameter 3 (Side Relif angle)		Parameter 4 (Nose Radius) mm		Output
1	1	10	1	10	1	8	1	0.350	0.73
2	1	10	2	11	2	9	2	0.729	0.72
3	1	10	3	12	3	10	3	0.821	0.65
4	2	11	1	10	2	9	3	0.821	0.99
5	2	11	2	11	3	10	1	0.350	0.53
6	2	11	3	12	1	8	2	0.729	0.47
7	3	12	1	10	3	10	2	0.729	0.36
8	3	12	2	11	1	8	3	0.829	0.38
9	3	12	3	12	2	9	1	0.350	0.41
								Total	5.25

Table 2 Anova table

Source	Sum of Square(SS)	Degree of Freedom (DOE)	Mean square(MS) =SS/DOE	Fisher man test (F)=MS/MS error	Fα 1%=0.01	Percentage of contribution
A V(1)	0.1783	3-1=2	0.08915	8.286		51.75
B V(1)	0.05944	2	0.0297	0.0297		17.24
C V(1)	0.0441	2	0.02205	2.07431		12.79
D V(1)	0.0415	2	0.02075	1.9520		12.04
Error(V2)	0.0319	4-1= 3	0.01063			6.17
Total	0.3552	12-1=11	0.17228			100.00

Table 3:Means Value

Level	1	2	3
A	$\sum A_1/N_{A1}=0.7$	$\sum A_2/N_{A2}= 0.66$	$\sum A_3/N_{A3}= 0.38$
B	$\sum B_1/N_{B1}=0.696$	$\sum B_2/N_{B2}=0.543$	$\sum B3/N_{B3}=0.51$
C	$\sum C_1/N_{C1}=0.52$	$\sum C2/N_{C2}=0.71$	$\sum C3/N_{C3}=0.513$
D	$\sum D_1/N_{D1}=0.56$	$\sum D_2/N_{D2}=0.516$	$\sum D_3/N_{D3}=0.676$

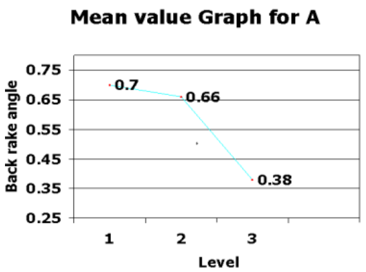

Figure 2 Mean value graph for A

Figure 2 show a status of the back rake angle by roughness value between the three levels by using the Mean Value. In the above graph the roughness value for level 1 is higher to the other two levels. In this diagram very low value of roughness value is level 3 when compared to other two levels

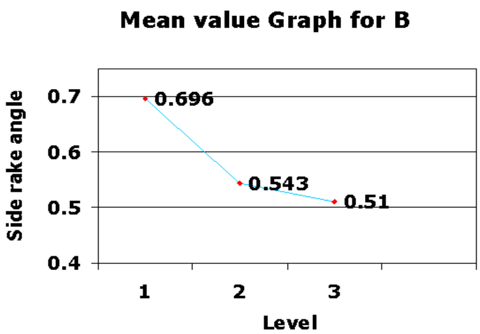

Figure 3 Mean value graph for B

Figure 3 show a status of the side rake angle by roughness value between the three levels by using the Mean Value. This diagram has same effect as status of the bake rake angle. But value of the roughness value is slightly different.In the above graph the roughness value for level 1 is higher to the other two levels. In this diagram very low value of roughness value(0.36μm) is level 3 when compared to other two levels

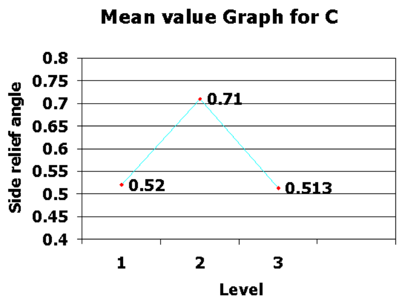

Figure 4Mean Value graph for C

Figure 4 show a status of the side relief angle by roughness value between the three levels by using the Mean Value. In the above graph the roughness value for level 1 is lower than the level 2 and higher than the level 3. In this diagram most higher value is level 2 and most lower value is level 3

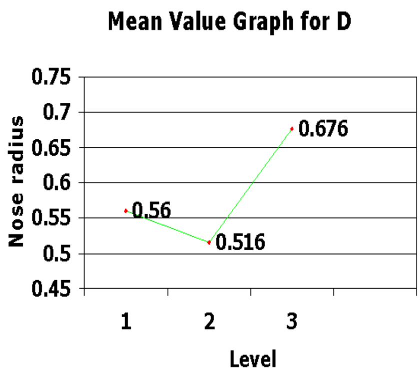

Figure.5 Mean Value Graph for D

Figure 5 show a status of the nose radius by roughness value between the three levels by using the Mean Value . In above diagram the roughness value of the level 3 is higher than the other two levels.The lower value of the roughness is at the stage of level 2

Table 4 : S/N Ratio

Experiments Number	Response	S/N RATIO=$10\text{Log}_{10}[1/n \sum (1/y^2)]$
1	0.73	$10 \log_{10}[1/1.73^2] = 2.73$
2	0.72	$10\log_{10}[1/0.72^2] = 2.85$
3	0.65	$10\log_{10}[1/0.65^2] = 3.74$
4	0.99	$10\log_{10}[1/0.99^2] = 0.0872$
5	0.53	$10\log_{10}[1/0.53^2] = 5.51$
6	0.47	$10\log_{10}[1/0.47^2] = 6.55$
7	0.36	$10\log_{10}[1/0.36^2] = 8.87$
8	0.38	$10\log_{10}[1/0.38^2] = 8.4$
9	0.41	$10\log_{10}[1/0.41^2] = 7.74$

Table : S / N Ratio Level

Level	1	2	3
A	3.106	4.046	8.336
B	3.895	5.586	6.01
C	5.89	3.559	6.01
D	5.326	6.09	4.075

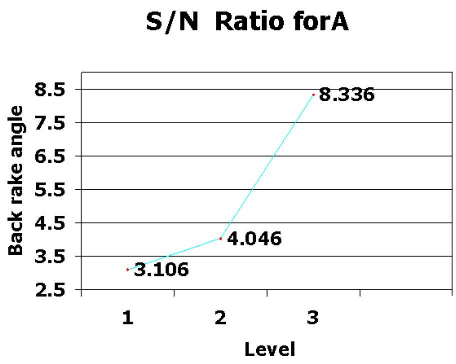

Figure.6 S/N Ratio for B

Figure 6 show a status of the bake rake angle by value between the three levels by using S/N ratio. In the above graph the value for level 1 is lower than the other two levels. value of level 3 higher than the other two levels and intermediate value is level 2.

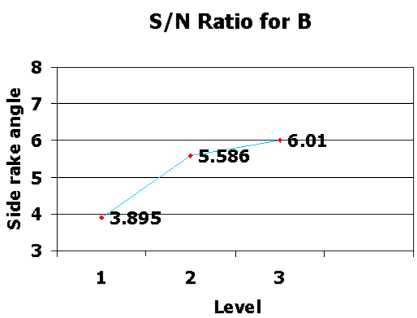

Figure.7 S/N Ratio for B

Figure 7 show a status of the side rake angle by value between the three levels by using S/N ratio. This diagram has same effect as status of the bake rake angle. But value of the roughness value is slightly different.In the above graph value for level 1 is lower than the other two levels. In this diagram very low value level 1 when compared to other two levels

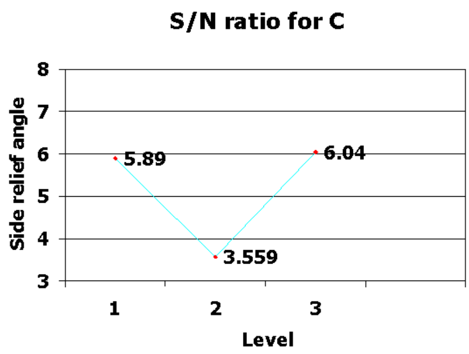

Figure .8 S/N Ratio for C

Figure 8 show a status of the side relief angle by value between the three levels by using S/N ratio. In above diagram the roughness value of the level 3 is higher than the other two levels. The lower value is at the stage of level 2

Figure 9 show a status of the nose radius by the value between the three levels by using S/N ratio. In above diagram the roughness value of the level 3 is lower than the other two levels. The higher value is at the stage of level 2 and the intermediate value is level 1

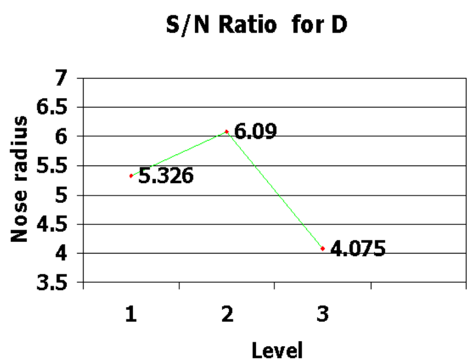

Figure .9 S/N Ratio for D

Expected outcome

To design of mechanical Component
To Dimensional Accuracy
To decrease Roughness value of the turning component
To increase the life of the tool
To find the influencing parameter on the surface finish of the turning process

CONCLUSION

In this work Design of Experiments concept have been proposed. A good knowledge of the system is one of the most important considerations to be taken into account any experimental analysis that uses equipment for manufacturing components. With the methodology proposed in this work it is possible to perform this analysis with efficiency and effectiveness. In this work considering these parameters back rack angle, side rake angle, Side relief angle and Nose radius. Based upon the DOE Result percentage of these parameter for Mild steel was Back rake angle (51.75%) , Side rack angle (17.24%) , side relief angle (12.79 %) and Nose radius(12.04%). From the above experimental design result we concluded that most influencing parameter was back rake angle of the surface quality. Next we consider as side rack angle and side relief angle. But need not more concentrate parameter as nose radius. And also from the result percentage of the contribution was varied of the mild steel materials.

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