Evaluation of Machinability on duplex stainless steel 2205 under dry and Wet condition

Article *in* Materials Today: Proceedings · June 2022

DOI: 10.1016/j.matpr.2022.05.471

Rajeev Sharma
Bhartiya Skill Development University Jaipur

ARTICLE IN PRESS

Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Evaluation of Machinability on duplex stainless steel 2205 under dry and Wet condition

Rajeev Sharma [a,*], Vipin Pahuja [a], Binit Kumar Jha [a], Sagar Sharma [b]

[a] School of Manufacturing Skills (SMS), Bhartiya Skill Development University, Jaipur 302037, India
[b] Department of Mechanical Engineering, GLA University, Mathura 281406, India

ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Dry Machining
Wet Machining
Design of Experiment (DOE)
Taguchi Design
Surface Roughness

ABSTRACT

The examination of machinability in terms of surface roughness on duplex stainless steel under dry and wet machining conditions with a TiAlN coated solid carbide drill is presented in this paper. The experiments were carried out utilizing a CNCNC milling machine for drilling and a Taguchi design L8 set of orthogonal array(OA) for parametric optimization. Following the experimental optimization, it was discovered that dry machining produces a better surface quality than wet machining, with an R2 value of 0.990 for surface roughness. Finally, it was discovered that dry machining produces a superior surface finish than wet machining, and that the ideal process parameter for surface roughness (Ra) is a dry machining environment, a high spindle speed (900 RPM), and a low feed rate (0.03). After confirmation test were conducted for validation of experimental results and it was observed that experimental results and model results are close to each other.

Selection and peer-review under responsibility of the scientific committee of the 2022 International Conference on Materials and Sustainable Manufacturing Technology.

1. Introduction

Machinability is one of the significant utilized methods on the planet metal working setting. The predominant enterprises of Automobile, Aeronautics, substance, Naval, Nuclear, rocket and Underlying are most likely requesting the designing parts with great exactness and accuracy. Surface quality is one of the overall necessities expected by the architects and maker in the machining processes. In machining the mechanical work created is changed in to plastic distortion making grating among device and work piece coming about the higher hotness age. There are many variables impacts the machinability of hardware wear as: synthetic creation, microstructure and heat treatment.Fig. 1.Table 1..

The use of cooling techniques is a reliable requirement for the possibility of increasing machinability and, as a result, more developed cutting conditions. Consider the following: This groundbreaking work investigates numerous cooling and lubrication methods for drilling titanium alloy, including drilling without coolant (dry), with coolant (flood), and cryogenic with LCO2 and LN2 [1]. These findings show that cryogenic LN2 and LCO2 are viable cooling and lubricating techniques for lowering tool wear and power consumption, hence improving machining productivity and quality [2].

For drilling VT-20, a titanium alloy, this study examines the energy consumption and environmental impact of four cutting situations (dry, flood, liquid CO2, and liquid N2). LCO2 has utilized less cutting and total energy in comparison to them [3]. The impact of a newly designed cooling and lubrication technology on surface integrity parameters in Inconel 718 milling is investigated in this research. In addition to being environmentally friendly, MoS2 lubricated LCO2 exhibits surface qualities similar to flood lubrication. Furthermore, as compared to flood lubrication, lubricated LCO2 application produced the cleanest component surface [4]. In dry drilling, strong chip adhesion to tool is observed, while LCO2 + MQL assisted drilling improve chip breakability and reduce the work-piece material adhesion through combination of lower temperature and lubrication barrier [5].

In this research paper, experimental work was done on duplex stainless steel 2205 with a TiAlN coated solid carbide drill under input parameters e.g. machining conditions, spindle speed, and feed rate as well as surface roughness (Ra) as an output parameter and parametric optimization was completed by using the L8 set of orthogonal array. After the parametric optimization, it was

* Corresponding author.
E-mail address: Rajeev.sharma@ruj-bsdu.in (R. Sharma).

https://doi.org/10.1016/j.matpr.2022.05.471
2214-7853/
Selection and peer-review under responsibility of the scientific committee of the 2022 International Conference on Materials and Sustainable Manufacturing Technology.

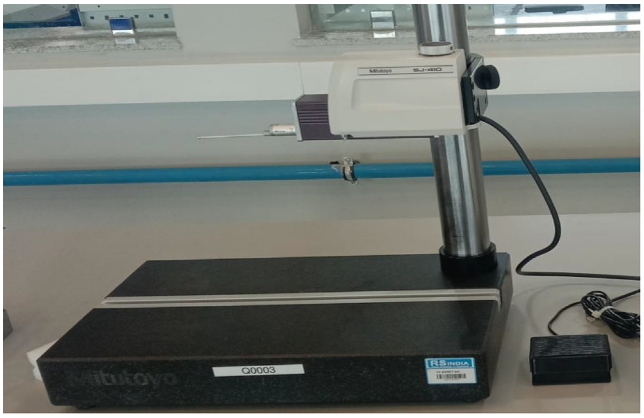

Fig. 1. Surface roughness tester.

Table 1
Showing Literature Review.

Ref.	Coolant Type	Research Out-comes
[6]	Dry, Wet and MQL	In comparison to other machining settings, cryogenic machining has yielded positive outcomes. As a result, cryogenic machining appears to be the most viable method for milling 17–4 PH SS.
[7]	Dry and Wet machining	Individual optimality of responses is achieved using SN ratios, and multi-response optimization is achieved using Grey Relational Analysis (GRA) for both machining circumstances and better responses in wet conditions while milling low machinability material.
[8]	Dry and wet	On both wet and dry machining environments, the impact of machining parameters on performance metrics was compared. After it was observed that dry machining.
[9]	Wet and MQL	For wet and MQL circumstances, the experimental findings of the tool's acceleration signal, work surface texture, surface roughness, chip form, and tool wear are provided and compared. The findings of this study reveal that wet or MQL cooling/ lubrication systems have a significant impact on SLDs.

observed that the minimum surface roughness is obtained under dry machining, high spindle speed, and low feed rate.

2. Literature Review

2.1. Experiment details

All of the experiments were carried out on a CNC milling machine with a variety of process input parameters such as machining conditions, spindle speed, and feed rate on duplex stainless steel 2205 with a solid carbide drill. Table 2 showing details of cutting process with variables.

Table 2
Details of cutting process with variable.

Work-Piece: Duplex Stainless Steel 2205 (5 mm), Cutting Tool: TiAlN coated solid carbide drill (6 mm), Operation: Drilling: (Through hole), Cutting Environment: Dry & Wet condition, Spindle Speed (RPM): 600 & 900, Feed Rate (mm/rev.): 0.03 & 0.05, Output variable: Surface roughness (Ra).

Table 3
Level of Process Parameters.

S.No.	Process Parameters	Unit	Level	
1	Environment	-	Dry	Wet
2	Spindle Speed	RPM	600	900
3	Feed Rate	mm/rev.	0.03	0.05

Table 4
Experimental Table.

S. No.	Machining Environment	Spindle speed (RPM)	Feed Rate (mm/ rev.)	Drill Diameter (mm)	Surface roughness (micron)
1	Dry	600	0.03	6	0.857
2	Dry	600	0.05	6	0.912
3	Dry	900	0.03	6	0.796
4	Dry	900	0.05	6	0.869
5	Wet	600	0.03	6	0.802
6	Wet	600	0.05	6	0.849
7	Wet	900	0.03	6	0.748
8	Wet	900	0.05	6	0.785

Table 5
Confirmation Test.

Test (Level)	Experimental value	Predicated Value	% of error
1 (1–600-0.03)	0.857	0.8598	0.32 %
2 (2–900-0.05)	0.785	0.7973	1.56 %

3. Parametric optimization through Taguchi method and confirmation test

3.1. Set of experiment through DOE

Every one of the investigations are led on duplex stainless steel 2205 with TiAlN covered strong carbide drill. For test plan Minitab programming is executed for parametric examination. This factual programming contained many kinds of trial plan that utilized for age the test set. In present trial examination Taguchi symmetrical exhibit is utilized for making the arrangement of tests and further total the investigation. The symmetrical cluster gives the complete L8analyze. In this machining system three ward boundaries, for

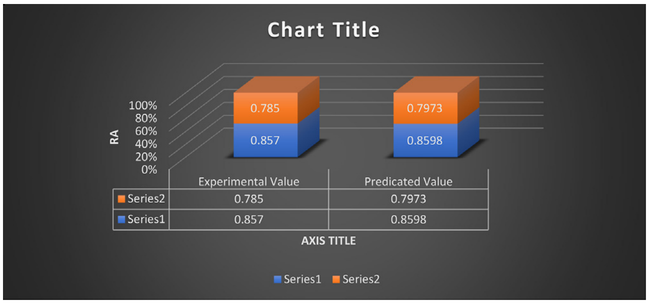

Fig. 2. Chart of confirmation test.

Fig. 3. Shown Main effect Plot for Means of Surface roughness (Ra).

example, spindle speed, feed rate and machining climate are considered for investigation. Table 3 appearance the level of process parameters; machining climate, spindle speed and feed rate.

Table 4 shown the experimental table. In this table shown surface roughness of each set of experiment which is measured by surface roughness tester. Figurer 1 showing surface roughness tester.

3.2. Confirmation test

For validation of experimental results, confirmation test in necessary. In this present study, Taguchi result is validated to predicated result by regression model. Table 5 show confirmation test.

After analysis of table and figure, it was observed that experimental value nearest to predicated value. Fig. 2 show error of experimental value and predicated value through chart.Fig. 3. Fig. 4.Fig. 5..

4. Results and discussion

In this research paper, for optimization of process parameters in term of surface roughness (Ra) Taguchi method L8 orthogonal array is used. The orthogonal arrays provide set of experiment. After the optimization of process parameter, Taguchi method provides variation of input variable to output variable.

4.1. Variation of surface roughness with input variables

Figurer 3 showing variation of response to input variables.

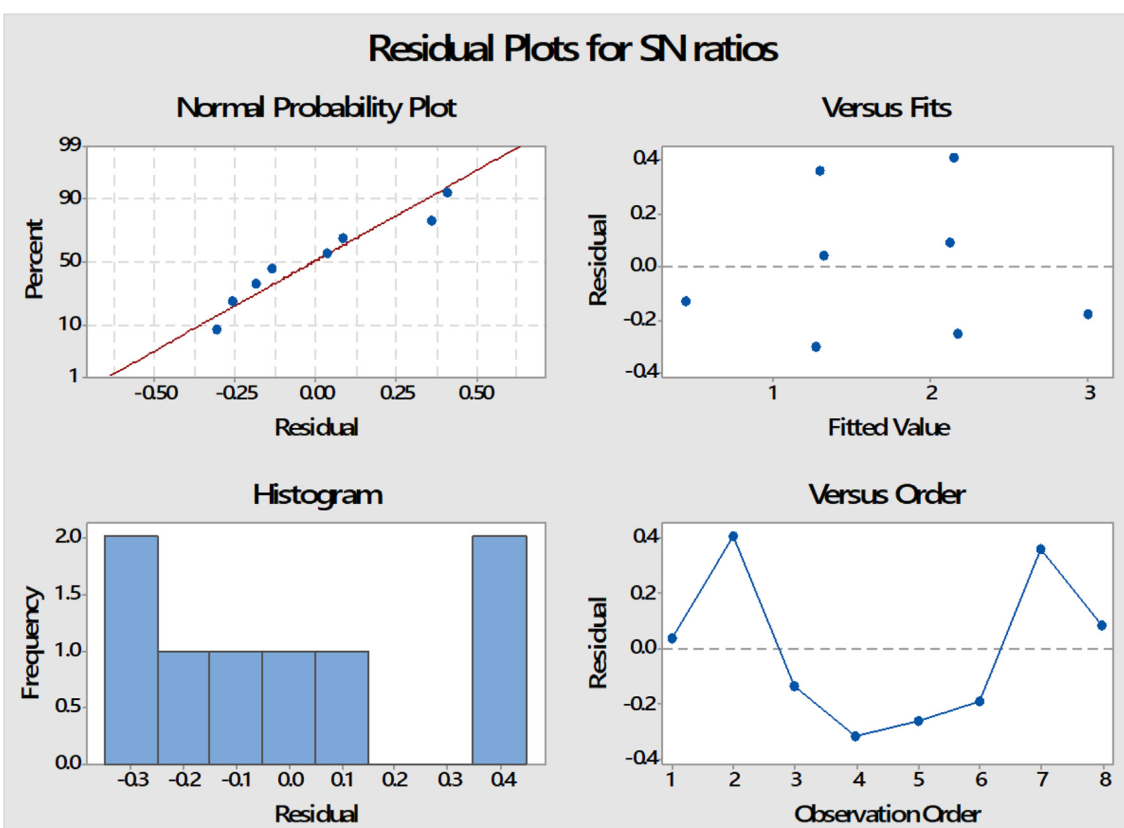

Fig. 4. Residual Plot for Ra.

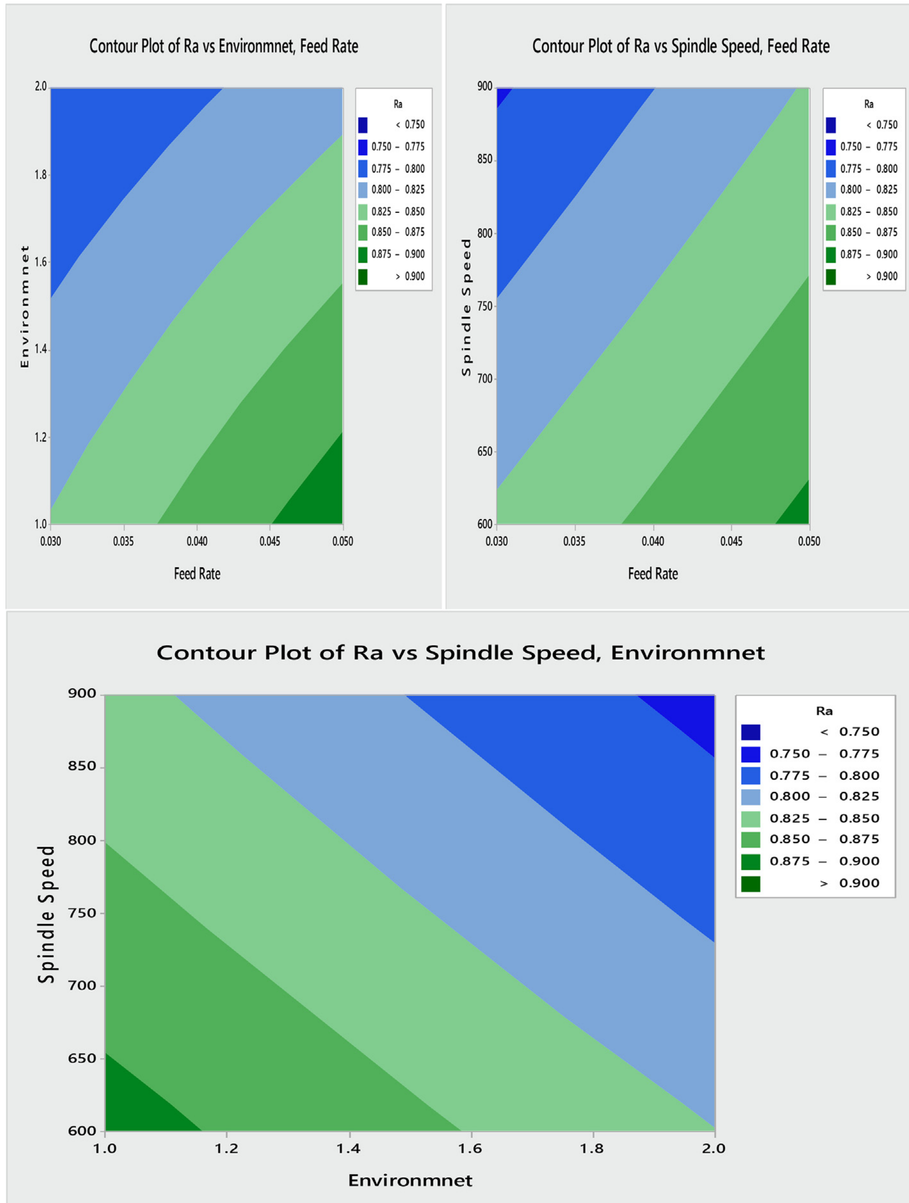

Fig. 5. Shown Counter plot between input variable to response.

Table 6
Response Table for S/N ratio.

Level	Spindle Speed	Feed Rate	Machining Conditions
1	1.370	**1.940**	1.335
2	**1.956**	1.386	**1.991**
Delta	0.587	0.554	0.665
Rank	**2**	**3**	**1**

The main effect of input variables e.g. Spindle speed, feed rate and machining condition are 0.587, 0.554, 0.665 respectively. After the analysis of response table, it was observed that the most effective parameter is machining condition compared to spindle speed and feed rate.

- After the graph analysis, it was observed that low spindle speed provide high surface roughness and high spindle speed provide low surface roughness (Ra). So, finally when spindle speed increase then surface roughness slightly decreases.
- In case of feed rate opposite to spindle speed. In this, when feed rate increases then surface roughness slightly increases.
- After process parameter optimization, it was observed that dry machining provide better surface finish compared to wet machining.

4.2. Response Table for S/N ratio

The response table shown range of most effective process parameter. Table 6 shown response table for Ra in term of S/N ratio.

4.3. Regression analysis for surface roughness (Ra)

The regression equation provides relation between input variable to output variable. The regression equation for Ra is below and figurer 4 shown residual plot for Ra.

Ra = 0.9538–0.06250 Environment − 0.000185 Spindle Speed + 2.650 Feed Rate.

4.4. Counter plot for surface roughness (Ra)

Counter plot is the graphical representation for input variable Vs response. Figurer 5 shown counter plot between spindle speed, feed rate and machining condition Vs surface roughness.

5. Conclusion

In the current work, the impact of different information boundaries with reaction has been examined. The examinations are directed by differing the different information boundaries. Spindle speed, feed rate and machining climate are considered as an info boundary though Ra is the reaction boundary.

The following conclusion can be drawn from the experiment study and data analysis.\.

- It has been discovered that the machining environment is a more effective input parameter compared to spindle speed and feed rate.
- After the parametric optimization, it was observed that the minimum surface roughness was obtained at a dry machining environment, high spindle speed, and low feed rate.
- The confirmation test was conducted to compare the experimental results with predicated model results. As per the confirmation test, the percent error ranges between 0.32 and 1.56 percent.
- Finally, it was found that dry conditions give better results in terms of surface roughness, but one negative effect of dry machining is tool wear possibility.

CRediT authorship contribution statement

Rajeev Sharma: . **Vipin Pahuja:** Supervision. **Binit Kumar Jha:** Supervision. **Sagar Sharma:** .

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] R. Sharma, B.K. Jha, V. Pahuja, Role of Environmental Friendly Machining on Machinability, Mater. Today:. Proc. 50 (5) (2022) 640–648.

[2] P. Shah, N. Khanna, Cetan, Comprehensive machining analysis to establish cryogenic LN2 and LCO2 as sustainable cooling and lubrication techniques, Tribol. Int. 148 (2020) 106314.

[3] N. Khanna, P. Shah, J. Wadhwa, A. Pitroda, J. Schoop, F. Pusavec, Energy consumption and lifecycle assessment comparison of cutting fluids for drilling titanium alloy, Procedia CIRP. 98 (2021) 175–180.

[4] L. Sterle, D. Mallipeddi, P. Krajnik, F. Pusavec, The influence of single-channel liquid CO2 and MQL delivery on surface integrity in machining of Inconel 718, Procedia CIRP. 87 (2020) 164–469.

[5] D. Graguras, L. Sterle, F. Pusavec, Cutting forces and chip morphology in LCO2 + MQL assisted robotic drilling of Ti6Al4V, Procedia CIRP. 102 (2021) 299–302.

[6] P. Sivaiah, D. Chakradhar, Effect of cryogenic coolant on turning performance characteristics during machining of 17–4 PH stainless steel: A comparison with MQL, wet, dry machining, CIRP J. Manuf. Sci. Technol. 21 (2018) 86–96.

[7] K. Arun Vikram, V.K.K. Lakshmi, A.M. Venkata Praveen, Evaluation of process parameters using GRA while machining low machinability material in dry and wet conditions, Mater. Toady Proc. 5 (11) (2018) 25477–25485.

[8] S. Dhanalakshmi, T. Rameshbabu, Comparative study of parametric influence on wet and dry machining of LM 25 aluminium alloy, Mater. Toady Proc. 39 (2021) 48–53.

[9] M. Emani, A. Karimipour, Theoretical and experimental study of the chatter vibration in wet and MQL machining conditions in turning process, Precis. Eng. 72 (2021) 45–58.