

A Survey of CNC Lathe Machining Parameters and Their Perceived Effects on Surface Finish and Tool Wear in Government Technical College Workshops in Rivers and Bayelsa States, South-South Nigeria

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ABSTRACT

This study surveyed CNC lathe machining parameters such as cutting speed, feed rate, and depth of cut and their perceived effects on surface finish and tool wear in Government Technical College workshops in Rivers and Bayelsa States, South-South Nigeria. The general purpose of the study was to determine the extent to which these machining parameters are currently applied in the sampled workshops and how they are perceived to influence surface finish quality and tool wear. Three research questions were posed and three null hypotheses formulated to guide the study. A survey research design was adopted. The research was carried out in 8 Government Technical College workshops across Rivers and Bayelsa States: GSTC Okaka-Yenagoa, GSTC Swali, GTC Port Harcourt, GTC Tombia, GSTC Sampou, GSTC Ofoni, GTC Ahoada, and GSTC Ayamassa. The population of the study was 183 respondents, comprising 16 mechanical technology teachers, 8 workshop assistants, and 169 mechanical technology students. A 30-item structured questionnaire was used to collect data. The instrument was validated by experts from the Department of Industrial and Technical Education, University of Nigeria Nsukka, and yielded a Cronbach Alpha reliability coefficient of 0.78. Data were analyzed on a four-point scale using mean and standard deviation to answer the research questions, while Analysis of Variance (ANOVA) was used to test the null hypotheses at the 0.05 level of significance. Findings showed that respondents generally agreed that cutting speed, feed rate, and depth of cut are currently applied in their workshops, and that these parameters are perceived to influence both surface finish quality and tool wear. No significant difference was found in the perceptions of teachers, workshop assistants, and students across all three research questions, and all null hypotheses were therefore accepted. The study recommends the development of documented parameter charts and routine surface finish and tool wear inspection practices to strengthen consistency in machining outcomes.

Keywords: Cutting Speed, Feed Rate, Depth of Cut, CNC Lathe Machining Parameters, Surface Finish, Tool Wear, Technical College Workshops

INTRODUCTION

Computer Numeric Control (CNC) machines in Nigerian technical college workshops are very important for training future machinists who will ultimately contribute to the development of a more skilled and competitive technically oriented society and workforce. However, Nigerian technical college workshops are often faced with challenges ranging from obsolete and outdated equipment, inadequate funding, and shortage of qualified skilled manpower (instructors), which may hamper the effective use of these machines, leading to poor surface finishing, material wastage, and frequent replacement of worn tools. This study focuses on three specific CNC lathe machining parameters; Cutting Speed, Feed Rate, and Depth of Cut and their perceived effects on surface finish and tool wear, limiting the scope to Government Technical College workshops in Rivers and Bayelsa States, South-South Nigeria. The study seeks to reveal, through the

perceptions and reported practices of instructors, workshop assistants, and students, the extent to which these machining parameters are currently applied and how they are believed to affect surface finish quality and tool wear on CNC lathes.

Cutting speed is the speed at which the cutting edge of a lathe tool moves past the surface of the workpiece, how fast the tool cuts the workpiece usually measured in meters per minute (m/min). Csiszár and Bányai (2023) describe cutting speed as a machining parameter that directly influences the rate of material removal and the thermal dynamics at the cutting interface, noting that higher cutting speeds can raise temperatures in ways that affect both tool wear and surface quality. Ahmed and Hussain (2025) similarly note that cutting speed influences the thermal conditions at the tool-workpiece interface, and that increasing it often reduces surface roughness by minimizing built-up edge and improving chip flow. In the context of this study, cutting speed refers to the speed at which the cutting edge of the tool moves in relation to the workpiece, determined by spindle speed and workpiece diameter, and is a key factor believed to influence surface finish and tool life.

Feed rate refers to the rate at which the cutting tool advances along the workpiece per revolution or per unit time, typically measured in millimeters per revolution (mm/rev). It determines the thickness of material removed with each pass and is widely regarded in machining literature as one of the most influential parameters affecting surface roughness. Csiszár and Bányai (2023) note that feed per tooth plays a significant role in cutting force generation and surface outcome during machining operations, while Ahmed and Hussain (2025) identify feed rate, alongside cutting speed and depth of cut, as a primary factor affecting surface roughness in CNC operations. Operationally, feed rate in this study refers to how fast the cutting tool is advanced across or into the workpiece during each pass, a practice that respondents in the sampled workshops apply based on experience, machine manuals, or trial and error.

Depth of cut is an important CNC machining parameter concerned with the removal of a thickness of material from the surface of the workpiece in a single pass of the cutting tool. It is a critical factor influencing cutting forces, tool life, and final surface quality. Saini and Singh (2023) describe depth of cut as the distance between the uncut and cut surfaces of the workpiece, measured in millimeters, while Loh, Ooi, and Low (2020) describe it as the distance the cutting tool plunges into the workpiece in a vertical or axial direction, noting that increasing depth of cut can reduce machining time by decreasing the number of required passes. Operationally, depth of cut in this study refers to how deep the cutting tool penetrates into the workpiece during a single tool path to produce the required shape.

Computer Numerical Control (CNC) machines have been the subject of extensive literature reviews, generally focused on their technological evolution, operational optimization, and integration with advanced systems, tracing their development from basic numerical control (NC) systems using punched tape in the 1950s to today's computer-driven systems (Ayed, 2011; Ekengwu & Emeruwa, 2024). Breaz et al. (2024) describe CNC machines as highly advanced technological systems used for machining parts through metal-cutting processes, while Hazir (2018) focuses specifically on the optimization of CNC cutting parameters using statistical methods such as the Taguchi method to identify parameter settings associated with minimum surface roughness. Operationally, CNC machines in this study refer to digital manufacturing machines such as lathes, milling machines, and drilling machines, programmed by computer software to remove material from a workpiece using a variety of cutting tools within the technical college workshop.

Technical college workshops are unique learning environments where students practically experiment, test, construct, assemble, repair, design, and continue learning. These workshops are essential to technical education, and provide a space for students to gain firsthand experience with machines and equipment relevant to their trade area (Ezeji, 2005, as cited in Eyong, 2021). Uwaifo (2005) describes a technical college workshop as a space where skills, machines, tools, and repair work are acquired, governed by rules and regulations to ensure a safe and efficient working environment. The National Board for Technical Education (NBTE, 2013) similarly defines a workshop simply as a place where technical activities are carried out. The quality of this environment including the condition of equipment and the qualifications of instructors significantly shapes how well students develop practical machining skills, including the ability to

correctly set and manage parameters such as cutting speed, feed rate, and depth of cut. It is against this backdrop that the current study surveys instructors, workshop assistants, and students in Government Technical College workshops in Rivers and Bayelsa States to determine current machining practices and their perceived effects on surface finish and tool wear.

Statement of the Problem

Ideally, Optimized Computer Numeric Control (CNC) machine such as lathe, milling, drilling and shaping machines are vital in quality precision part production in achieving both a superior surface finish, Increased Efficiency, Enhanced Accuracy and minimal tool wear. This efficient and data-driven procedure is to balance the competing objectives results in optimal machine performance, reduced production costs and increased overall productivity.

Unfortunately, this has presented various optimization problems. Manufacturers currently rely on a combination of empirical data, trial-and-error, and operator experience to set machine parameters such as spindle speed, depth of cut and cutting Speed. In many cases, parameters that improve one aspect negatively impact the other. For instance, increasing the cutting speed to improve surface finish often results to increased tool wear, requiring frequent tool changes and increasing operational costs. Conversely, adjusting parameters to extend tool life can result in a poorer surface finish, potentially leading to part rejection and wasted materials.

This compelling research gap prompted the researchers to ascertain the extent to which CNC machines can improve the surface quality, efficiency, outcome of the materials and reduce the rate of tool-wear on the machines of government technical colleges workshops in Rivers and Bayelsa states, South-South Nigeria.

Research Question

Three research questions were formulated to guide the study:

1. What CNC lathe machining parameters (cutting speed, feed rate, and depth of cut) are currently used in Government Technical College workshops in Rivers and Bayelsa States?
2. What is the perceived effect of CNC lathe machining parameters (cutting speed, feed rate, and depth of cut) on the surface finish quality of workpieces machined on CNC lathes in the sampled workshops?
3. What is the perceived relationship between CNC lathe machining parameters and the rate of tool wear in the sampled workshops?

Hypotheses

The following null hypotheses are postulated to guide the study:

1. There is no significant difference in the CNC lathe machining parameters used across Government Technical College workshops in Rivers and Bayelsa States.
2. There is no significant perceived effect of machining parameters (cutting speed, feed rate, depth of cut) and perceived surface finish quality in the sampled workshops.
3. There is no significant relationship between machining parameters and perceived tool wear rate in the sampled workshops.

METHODOLOGY

This research adopted survey research design. The study was carried out in 8 Government Technical Colleges in Rivers and Bayelsa States. The population of the research was 183 respondents, comprising of 16 mechanical technology teachers, 8 workshop assistants and 169 mechanical technology students. A 30-item structured questionnaire was administered to collect data for this study. The instrument was validated by experts from the department of industrial and technical education, University of Nigeria Nsukka. Cronbach Alpha reliability coefficient was used to determine the reliability of the instrument which yielded a reliability coefficient of 0.78. indicating that the instrument was reliable. Two research assistants were engaged to assist the researchers. Data collected from the respondents were analyzed on four-point scale

using mean and standard to answer the research questions. Analysis of Variance (ANOVA) was used to test null hypotheses at 0.05 level of significance. Decision was taken as follows: if the calculated significant value is greater or equal to the 0.05, the null hypothesis will be accepted. On the other hand, if the calculated value is less than 0.05, the null hypothesis will not be rejected.

RESULTS

Research Question 1: What CNC lathe machining parameters (cutting speed, feed rate, and depth of cut) are currently used in Government Technical College workshops in Rivers and Bayelsa States?

Table 1: Mean responses of CNC lathe machining parameters currently used in Government Technical College workshops

S/N	Item	Mean	Remark	Sig.	Decision
1	Cutting speed is set based on standard or recommended values before machining operations begin	3.01	Agree	0.23	No sig
2	Feed rate is adjusted according to the type of material being machined	2.88	Agree	0.74	No sig
3	Depth of cut is determined using the machine manual or CNC software recommendations	3.05	Agree	0.47	No sig
4	Machining parameters (cutting speed, feed rate, depth of cut) are set mainly through trial and error rather than documented standards	3.02	Agree	0.73	No sig
5	Consistent machining parameters are applied across similar machining tasks in this workshop	3.07	Agree	0.90	No sig
6	Cutting speed values used in this workshop are guided by the specifications of the CNC lathe manufacturer	3.61	Agree	0.70	No sig
7	Feed rate settings are recorded or documented for future reference in this workshop	2.99	Agree	0.82	No sig
8	Depth of cut is adjusted based on the hardness of the workpiece material	3.67	Agree	0.73	No sig
9	Machining parameters are reviewed or updated periodically based on machining outcomes	3.04	Agree	0.53	No sig
10	Operators rely on personal experience rather than calculated values when setting machining parameters	3.11	Agree	0.60	No sig

Table 1 shows that the mean scores range from 2.88 to 3.67. All items are above the mean rating of 2.50. This means that all the items are CNC lathe machining parameters that are currently used in Government Technical College workshops. The result also shows that there is no significant difference in the mean response of mechanical technology teachers, workshop assistants and mechanical technology students on the CNC lathe machining parameters that are currently used in Government Technical College workshops. This is because they all have significant value above 0.05 level of significant ($P > 0.05$). Therefore, the null hypotheses of no significant different is accepted.

Research Question 2: What is the perceived effect of CNC lathe machining parameters (cutting speed, feed rate, and depth of cut) on the surface finish quality of workpieces machined on CNC lathes in the sampled workshops?

Table 2: Mean responses of perceived effect of CNC lathe machining parameters on the surface finish quality of workpieces

S/N	Item	Mean	Remark	Sig.	Decision
11	Increasing cutting speed improves the surface finish of machined workpieces	3.04	Agree	0.49	No sig
12	A lower feed rate produces a smoother surface finish on the workpiece	3.13	Agree	0.78	No sig
13	Increasing the depth of cut results in a rougher surface finish	2.82	Agree	0.35	No sig
14	The surface finish quality achieved on workpieces in this workshop meets acceptable standards	2.56	Agree	0.06	No sig
15	Poor combination of cutting speed, feed rate, and depth of cut is a major cause of poor surface finish in this workshop	2.66	Agree	0.48	No sig
16	High feed rate leads to visible tool marks on the machined surface	3.63	Agree	0.23	No sig
17	Surface roughness is measured or inspected after machining operations in this workshop	3.78	Agree	0.29	No sig
18	Reducing cutting speed helps minimize surface defects on soft materials	2.78	Agree	0.07	No sig
19	Vibration caused by incorrect machining parameters negatively affects surface finish	3.72	Agree	0.06	No sig
20	Proper selection of machining parameters increases the likelihood of achieving a good surface finish	3.52	Agree	0.06	No sig

Table 2 shows that the mean scores range from 2.56 to 3.72. All items are above the mean rating of 2.50. This means that all the items are perceived effect of CNC lathe machining parameters on the surface finish quality of workpieces machined on CNC lathes. The result also shows that there is no significant difference in the mean response of mechanical technology teachers, workshop assistants and mechanical technology students on the perceived effect of CNC lathe machining parameters on the surface finish quality of workpieces machined on CNC lathes. This is because they all have significant value above 0.05 level of significant ($P > 0.05$). Therefore, the null hypotheses of no significant different is accepted.

Research Question 3: What is the perceived relationship between CNC lathe machining parameters and the rate of tool wear in the sampled workshops?

Table 3: Mean responses of perceived relationship between CNC lathe machining parameters and the rate of tool wear

S/N	Item	Mean	Remark	Sig.	Decision
21	High cutting speed increases the rate of tool wear on CNC lathes	2.79	Agree	0.71	No sig
22	Higher feed rate accelerates the wear of cutting tools	2.56	Agree	0.68	No sig
23	Greater depth of cut leads to faster tool wear	3.92	Agree	0.10	No sig
24	Cutting tools in this workshop wear out faster than expected because of how machining parameters are set	2.86	Agree	0.99	No sig
25	Tool wear negatively affects the surface quality of workpieces machined in this workshop	3.00	Agree	0.56	No sig
26	Excessive heat generated from high cutting speed contributes to rapid tool wear	3.38	Agree	0.06	No sig
27	Cutting tools are inspected regularly for signs of wear in this workshop	3.33	Agree	0.32	No sig
28	Frequent tool replacement increases the cost of machining operations in this workshop	3.08	Agree	0.07	No sig
29	Reducing feed rate helps prolong the life of cutting tools	3.18	Agree	0.08	No sig
30	Tool wear is a common challenge affecting machining operations in this workshop	3.66	Agree	0.10	No sig

Table 3 shows that the mean scores range from 2.56 to 3.92. All items are above the mean rating of 2.50. This means that all the items are perceived relationship between CNC lathe machining parameters and the rate of tool wear. The result also shows that there is no significant difference in the mean response of mechanical technology teachers, workshop assistants and mechanical technology students on the perceived relationship between CNC lathe machining parameters and the rate of tool wear. This is because they all have significant value above 0.05 level of significant ($P > 0.05$). Therefore, the null hypotheses of no significant different is accepted.

DISCUSSION OF FINDINGS

This study surveyed the perceptions of mechanical technology teachers, workshop assistants, and students regarding the use of CNC lathe machining parameters cutting speed, feed rate, and depth of cut and their perceived effects on surface finish and tool wear in Government Technical College workshops in Rivers and

Bayelsa States. The findings are discussed in line with the three research questions and their corresponding hypotheses.

On the machining parameters currently in use (Research Question 1), Table 1 showed mean scores ranging from 2.88 to 3.67, all above the 2.50 benchmark, indicating that respondents generally agreed that cutting speed, feed rate, and depth of cut are actively applied in their workshops, guided variously by manufacturer specifications, workpiece material, and operator experience. Respondents' strong agreement that depth of cut is adjusted based on workpiece hardness and that operators often rely on personal experience rather than calculated values reflects the well-documented reality that practical machining environments frequently blend documented standards with experiential judgment (Putra et al., 2022). Analysis of variance showed no significant difference in these perceptions across teachers, workshop assistants, and students ($p > 0.05$ in all cases), leading to acceptance of the null hypothesis (H_{01}) and suggesting a shared understanding of current practice across respondent categories, regardless of role or experience level.

On the perceived effect of machining parameters on surface finish (Research Question 2), Table 2 results (mean range 2.56–3.72) showed that respondents agreed cutting speed and feed rate influence surface smoothness, with particularly strong agreement that surface roughness is routinely inspected after machining and that vibration from incorrect parameter settings negatively affects surface finish. This aligns with Ahmed and Hussain (2025) and Csiszár and Bányai (2023), who identify feed rate and cutting speed as primary determinants of surface roughness in CNC operations. Notably, the item with the lowest agreement (2.56) was whether surface finish quality in the workshops currently meets acceptable standards suggesting that while respondents understand how parameters affect finish, they are less confident that outcomes in their own workshops consistently meet that standard. As with Research Question 1, no significant difference was found across respondent categories ($p > 0.05$), and H_{02} was accepted.

On the perceived relationship between machining parameters and tool wear (Research Question 3), Table 3 results (mean range 2.56–3.92) showed the strongest agreement on the link between depth of cut and tool wear (mean 3.92), consistent with Das et al. (2017), who found that deeper cuts generate higher cutting forces that accelerate wear. Agreement that excessive heat from high cutting speed contributes to rapid tool wear (mean 3.38) further corroborates Usca et al. (2022) and Li (2024), both of whom emphasize the thermal dimension of tool degradation. The comparatively lower agreement that higher feed rate accelerates wear (mean 2.56) suggests feed rate's role in tool degradation is less intuitively recognized by respondents than that of depth of cut or cutting speed. Once again, no significant difference in perception was found across teachers, assistants, and students ($p > 0.05$), and H_{03} was accepted.

Taken together, the findings suggest that respondents across all three categories hold a broadly consistent and literature-aligned understanding of how cutting speed, feed rate, and depth of cut relate to surface finish and tool wear, even though this consistency was drawn from self-reported perception rather than measured machining outcomes. The absence of significant differences across respondent groups is encouraging for training consistency but also indicates that any gaps in practice, such as the comparatively weaker agreement on periodic review of parameters or confidence in current surface finish standards, are shared institutional gaps rather than differences tied to a particular role. These findings have practical implications for teaching in Government Technical Colleges: workshops should move beyond general awareness of machining parameters toward institutionalized practices, such as documented parameter charts, routine surface roughness checks, and structured tool wear inspection, that translate shared understanding into more consistent machining outcomes.

CONCLUSIONS

This study surveyed the perceptions of teachers, workshop assistants, and students on CNC lathe machining parameters cutting speed, feed rate, and depth of cut and their perceived effects on surface finish and tool wear in Government Technical College workshops in Rivers and Bayelsa States. Findings showed that all three parameters are perceived to be actively applied in current machining practice, though often guided as much by operator experience as by documented standards. Respondents also perceived cutting speed and

feed rate as meaningful influences on surface finish quality, and depth of cut, in particular, as a strong influence on tool wear, with cutting speed contributing indirectly through heat generation.

Across all three research questions, statistical analysis revealed no significant difference in perception between teachers, workshop assistants, and students, indicating a shared, fairly consistent understanding of machining parameters and their effects across respondent categories. The study concludes that while awareness of how cutting speed, feed rate, and depth of cut affect surface finish and tool wear is reasonably well established among respondents in these workshops, this awareness is not yet consistently backed by documented parameter standards or routine inspection practices, a gap that, if addressed, could translate existing understanding into more consistent machining outcomes.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are made:

1. **Develop and display machining parameter reference charts:** Government Technical Colleges should create material- and tool-specific charts for cutting speed, feed rate, and depth of cut, reducing current over-reliance on trial and error and personal experience when setting parameters.
2. **Institutionalize periodic review of machining parameters:** Since respondents showed comparatively weaker agreement that parameters are reviewed or updated based on machining outcomes, workshops should adopt a routine schedule for reassessing and documenting parameter settings.
3. **Strengthen surface finish inspection practices:** Given that respondents were least confident that surface finish in their workshops meets acceptable standards, colleges should introduce simple, low-cost surface roughness checks, such as comparator gauges or basic profilometers, to build measurable quality assurance into routine practice.
4. **Improve documentation of feed rate settings:** As feed rate's role in tool wear was less strongly recognized by respondents than cutting speed or depth of cut, targeted training should clarify this relationship, alongside better record-keeping of feed rate values used for different materials.
5. **Implement structured tool wear monitoring:** Instructors and students should be trained to conduct regular tool inspections, particularly after operations involving greater depth of cut, given respondents' strong recognition of its link to accelerated wear.
6. **Complement future studies with experimental measurement:** Since this study relied on perception data, future research should pair survey findings with actual surface roughness and tool wear measurements to validate the relationships respondents report, and to identify specific optimal parameter combinations.

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