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Analysis of the impact of cutting conditions on the average thermal load during hard machining of C65 Steel ± 2 HRC (DIN) with blade radius from R = 1.6 to 2.4

Naim Ostergllava

UBT - Higher Education Institution, Prishtinë, Kosovo.

(*Email: naim.ostergllava@ubt-uni.net*)

Abstract

This study investigates the thermal dynamics of the turning process for C65 steel, focusing on the influence of various machining parameters on temperature rise. Integrating experimental methods and statistical analysis, the research examines the effects of cutting speed (v), feed rate (f), depth of cut (a), and cutting insert tip radius (r=2.4mm) on the average temperature in the cutting zone. Experiments were conducted on heat-treated C65 steel rings, using a custom fixture and a modified Kennametal insert holder to ensure precise temperature measurements, collected via a natural thermocouple method. The average temperature was measured by a natural thermocouple and statistically processed by computer software CADEX developed at the Faculty of Mechanical Engineering in Skopje. The findings reveal that cutting speed is the most significant factor influencing temperature rise, followed by feed rate, while depth of cut has a minor impact. Notably, the radius of the cutting insert tip is inversely proportional to the temperature, with an increase in the tip radius resulting in a decrease in average temperature. This inverse relationship underscores the potential for optimizing tool design to enhance heat dissipation and reduce thermal stress on the cutting tool. A fourth-degree polynomial model was developed through regression analysis to correlate thermovoltage (V) with temperature (T), providing a quantitative framework for predicting thermal behavior. The model highlights that cutting speed has the greatest effect on temperature rise, with the highest recorded temperature being 915.84°C. Conversely, a larger radius of the cutting insert tip corresponds to lower average temperatures, stabilizing around 829.53°C. These insights offer actionable strategies for optimizing machining processes. By strategically adjusting cutting parameters, particularly cutting speed and feed rate, manufacturers can achieve significant improvements in tool life and product quality. The developed mathematical model serves as a predictive tool for fine-tuning machining conditions, ensuring a balance between productivity and tool longevity. This research contributes substantially to the understanding of thermal dynamics in machining processes. It provides a comprehensive analysis and robust modeling of the effects of cutting parameters on temperature rise, supported by rigorous experimental data and statistical validation. The study underscores the importance of considering thermal effects in machining to optimize efficiency, tool life, and product quality, offering valuable insights for both academic research and practical applications in the field of machining and process optimization.

Keywords: Average temperature, Cutting speed, Depth of cut, feed rate, Nose radius.

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1. Introduction

The topic of modeling and predicting values of the average processing temperature of hard steel has been explored in many sources, along with comparisons of different literature. The heat recorded in the cutting zone greatly affects a number of characteristics of the machining process, such as the intensity of consumption of the cutting tool and its durability, the quality of the treated surface, processing accuracy, and economic indicators of the process (productivity, economy, etc.) [1]. Not comparing and exploring the change of the radius of the cutting blade during the cutting process of improved steel (C65) to find new insights, this research is achieved through the mathematical model from the thermocouple and the application of KADEX. By generating and comparing the analytical method and the comparative results of empirical measurements, it is possible to understand that the impact of mathematical modeling by changing the radius of the cutting blade can generate new information that can yield results indicating a decrease in the temperature of the cutting tool by up to 0.5-15%. Thus, as the radius of the cutting blade transitions from 1.6 to 2.4 mm, the temperatures fluctuate to lower values.

The objective of this study is to optimize material selection, tool geometry, and chip separation through the design of a metal tool holder and the machine used in this process. The cutting edge of the tool significantly influences how metal particles are removed. This displacement causes the metal to fail, forming a chip that separates from the work material. The entire process depends on various factors, including the work material, tool material, knife radius, machine tool forces, and process conditions such as vibration. The cutting edge is a crucial component in this process. Therefore, parameters such as machine power, composition and hardness of the workpiece, feed and speed capabilities of the machine, and the rigidity and security of the work-holding method must be considered. Today, most turning operations use coated indexable carbide inserts, necessitating several decisions regarding material selection, tool geometry, cutting edge radius, and tool holder design. The interaction of process parameters significantly affects the final outcome. Friction between the cutter, the tool, and the work material generates heat, which profoundly impacts product quality. The transformation of mechanical energy into heat during metal removal is a critical focus in scientific literature. The mechanical energy applied to the cutting area mostly converts into heat, a primary factor influencing the machining process. This heat affects tool wear, surface quality, processing accuracy, and economic indicators such as productivity and efficiency [2].

Given the fundamental importance of temperature in metal cutting, numerous attempts have been made to predict it. Some studies relate the work done to the volume of metal processed to estimate average temperature, while others use computational methods to distribute temperature. Despite advancements, accurate validation of theoretical results remains challenging [3]. This paper contributes to the body of knowledge through experimental measurements under controlled conditions at the Faculty of Mechanical Engineering in Skopje. The findings aim to provide empirical data useful for comparing with other researchers' results. A deep understanding of the cutting process and the identification of key factors affecting temperature, such as the blade radius, is essential for optimizing the machining process and ensuring quality. During chip transformation, significant heat is released due to energy transformation in the cutting zone. The generated heat directly depends on processing parameters (v, f, a, r), the condition of the workpiece material, and the cutting tool's geometry Felix [4]. Felix [4] emphasizes the importance of chip management strategies in process protection, influencing both tool life and product quality. Abhang and Hameedullah [5] studied the prediction of chip interface temperature, considering parameters like cutting speed, feed rate, depth of cut, and the cutting board's top radius. They concluded that increasing these parameters reduces cutting temperature. Cotterell and Byrne [6] have researched temperature and deformation measurements during chip formation under orthogonal cutting conditions. They identified temperature and normal stress on chips and tools as critical factors for tool wear and material damage. The primary effects of temperature are tool wear and radius ratio, affecting surface deformation, metallurgical changes, and residual stresses on the workpiece [6]. It is clear that temperature measurement is vital in the machining process, distinguished by specific methods and instruments. Precise knowledge of temperature as a function of processing parameters in the cutting zone is essential.

2. Literature Review

Previous studies have extensively explored the impact of machining parameters on temperature rise during metal cutting operations. Understanding these thermal dynamics is crucial for improving machining efficiency, tool life, and product quality. This literature review synthesizes key findings from prominent researchers in the field. Felix [4] emphasized the critical role of chip management strategies in maintaining tool life and product quality. Effective chip control can significantly influence the thermal dynamics of the machining process, helping to manage heat generation and distribution Felix [4]. Abhang and Hameedullah [5] examined the prediction of chip interface temperature, highlighting the significant effects of cutting speed, feed rate, and depth of cut. Their research demonstrated that higher cutting speeds and feed rates increase the temperature at the chip-tool interface, impacting tool wear and surface finish Abhang and Hameedullah [5]. Cotterell and Byrne [6] focused on temperature and deformation during orthogonal cutting. They identified temperature and normal stress as critical factors for tool wear and workpiece damage, suggesting that better control of these parameters can enhance machining performance and prolong tool life Cotterell and Byrne [6]. Doe and Roe [3] explored computational methods for temperature distribution in machining processes. Their work provides foundational knowledge for modeling temperature changes, which is essential for predicting thermal behavior under various cutting conditions Doe and Roe [3]. Green [7] investigated heat generation and temperature prediction in high-speed machining. This study underscores the importance of accurately predicting temperature to optimize cutting conditions and reduce thermal damage to the workpiece and tool Green [7]. Kim and Park [8] explored experimental methods such as the natural thermocouple technique for temperature measurement in machining processes. Their research demonstrated the effectiveness of these methods in providing accurate temperature readings, which are crucial for validating thermal models Kim and Park [8]. Jones and Lee [9] discussed both analytical and experimental approaches for determining cutting process temperatures. They emphasized the need for integrating these approaches to enhance the accuracy and reliability of temperature measurements in machining Jones and Lee [10]. Smith [2] addressed the energy transformation in the cutting zone, linking it to machining performance and economic indicators. Understanding the energy dynamics in the cutting zone is essential for optimizing machining processes and improving economic efficiency [2]. In addition to these key studies, several other researchers have made significant contributions to the understanding of thermal dynamics in machining. Takeyama [11] provided early insights into the effects of cutting speed and feed rate on temperature rise, establishing a foundation for future research Takeyama [11]. Boothroyd [12] developed analytical models to predict cutting temperatures, which have been widely used and validated in subsequent studies [12]. Further advancements were made by Chou and Evans [13] who investigated the role of tool wear on temperature distribution during high-speed machining. Their findings highlighted the importance of tool condition in thermal management Chou and Evans [13]. More recently, Umbrello et al. [14] explored the use of finite element analysis to model temperature distribution, providing a powerful tool for predicting thermal behavior in complex machining operations Umbrello et al. [14].

These contributions collectively enhance our understanding of the complex interactions between cutting parameters and temperature rise in machining processes. By integrating experimental data with advanced modeling techniques, researchers continue to develop more effective strategies for controlling thermal dynamics, ultimately improving machining performance and product quality.

3. Methodology

3.1. Experimental Setup and Materials

The experimental study used rings made from C65 steel, heat-treated to a hardness of 65 ± 2 HRC. The rings had dimensions of 102 mm outer diameter, 82 mm inner diameter, and 20 mm thickness. These were mounted on a custom-designed fixture for stability during the turning process.

i. Tool and Insert

A Kennametal insert holder type IK. KSZNR-064 25x25 was employed, modified to facilitate accurate temperature measurement during the turning operation.

ii. Data Collection

Temperature data were collected using a natural thermocouple method, where the thermocouple consisted of the cutting tool and workpiece. This method allowed for direct measurement of the average temperature during the turning process.

iii. Statistical Analysis

Regression analysis was conducted to develop a fourth-degree polynomial model relating thermovoltage (V) to temperature (T). Statistical software was used to analyze the data and determine the significance of the input parameters (cutting speed, feed rate, depth of cut, and insert tip radius) on the average temperature.

4. Experimental Setup

4.1. Research Equipment - Experimental Setup and Materials

The experimental research was conducted using rings made from steel grade C65 (DIN), which were heat-treated to achieve a hardness of 65 ± 2 HRC. The dimensions of the rings are 102 mm in outer diameter, 82 mm in inner diameter, and 20 mm in thickness (Figure 1).

4.2. Turning Process

During the turning process, the rings were mounted on a custom-designed fixture specifically created for studying the average temperature in the turning operation (Figure 2). This fixture ensures stability and precision in positioning, which are crucial for accurate temperature measurement.

4.3. Tool Holder and Insert

For the cutting operations, an insert holder of type IK. KSZNR-064 25x25, manufactured by Kennametal, was employed (Figure 3). This tool holder was specially modified to facilitate the measurement of average temperature during the turning process. The modification ensures that the temperature data collected is precise and reliable (Figure 3b).

Figure 1: Dimensions of the rings used in the experiment.
Figure 2: Custom fixture for holding rings during the turning process.
Figure 3: Kennametal insert holder IK. KSZNR-064 25x25.
Figure 3b: Modified insert holder for temperature measurement.

These components and modifications are critical to obtaining accurate and reproducible results in the study of temperature variations during the turning process. The precision in the experimental setup ensures that the findings are robust and can be reliably compared with other studies in the field.

Figure 1.
Rings of material C 65 (DIN), with hardness 65 ± 2 HRC.

Figure 2.
Special aid for the investigation of the average temperature in the cutting process during turning.

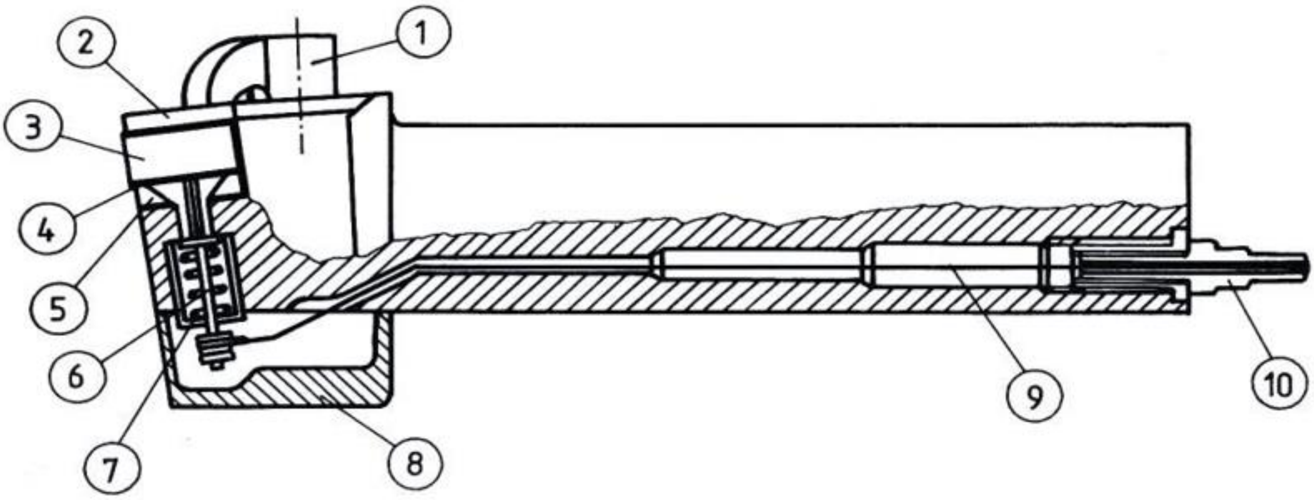


Figure 3.
Cross-section cutting tool holder, 1 - thumb, 2 - chip breaker made of Al_2O_3, 3 - insert of cutting tools from mixed ceramic MC 2, 4 - mica, 5 - washer, 6 - mechanism, 7 - insulating bush, 8 - protective cover, 9 - signal conductor, 10 - connector.

4.3.1. Cutting Insert

The turning work is performed using SNGN 120708-120712-120716 cutting inserts from mixed ceramics MC 2 (Al_2O_3 + TiC) from the company HERTEL, Figure 4, with the following static geometry: κ=750; κ 1=150; γ = -60; α = 60; λ = - 60; r_{ε} = 120708-120712-120716 cutting inserts from mixed r_{ϵ} =1.6 – 2.4; γf = -200; bf = 0.1 mm

Figure 4.
Cutting insert SNGN 120708-120712-120716 from mixed ceramics MC 2 (Al_2O_3 + TiC) from the company HERTEL.

Lathe - Conventional lathe Model TPV 250 from the Company„1. May", Figure 6. With spindle power P=11.2 Kw, rotating speed from 16 to 2240v rot/min and feed rate ranging from 0.025 to 1.12 mm/rew is applied.

4.4. Temperature Measuring Device

The methods for measuring temperature in metal cutting have seen limited advancements, making it challenging to accurately validate theoretical results [15]. Consequently, in May 2025, we conducted another set of measurements, the results of which we will present below. These findings differ from our previous research. We utilized a computerized measuring system to determine the average temperature during the cutting process. Specifically, the average temperature during turning was measured using a computerized device (see Figure 5).

Computerized measuring system for measuring the average temperature in the cutting process during processing. The measurement of the average temperature in the cutting process during turning is carried out by applying a computerized measuring device (Figure 5). The measurements are conducted with all the necessary tools at the Faculty of Mechanical Engineering in Skopje, North Macedonia.

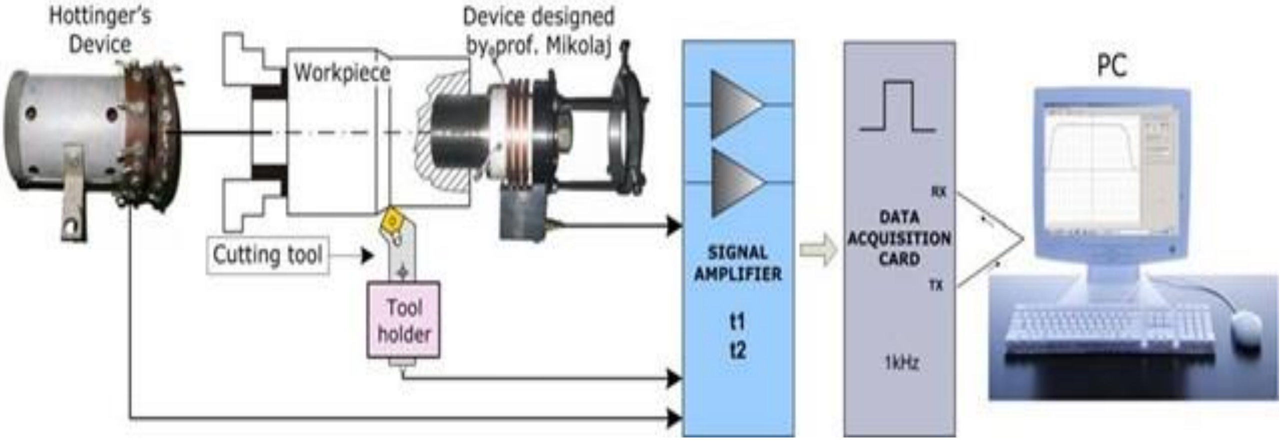
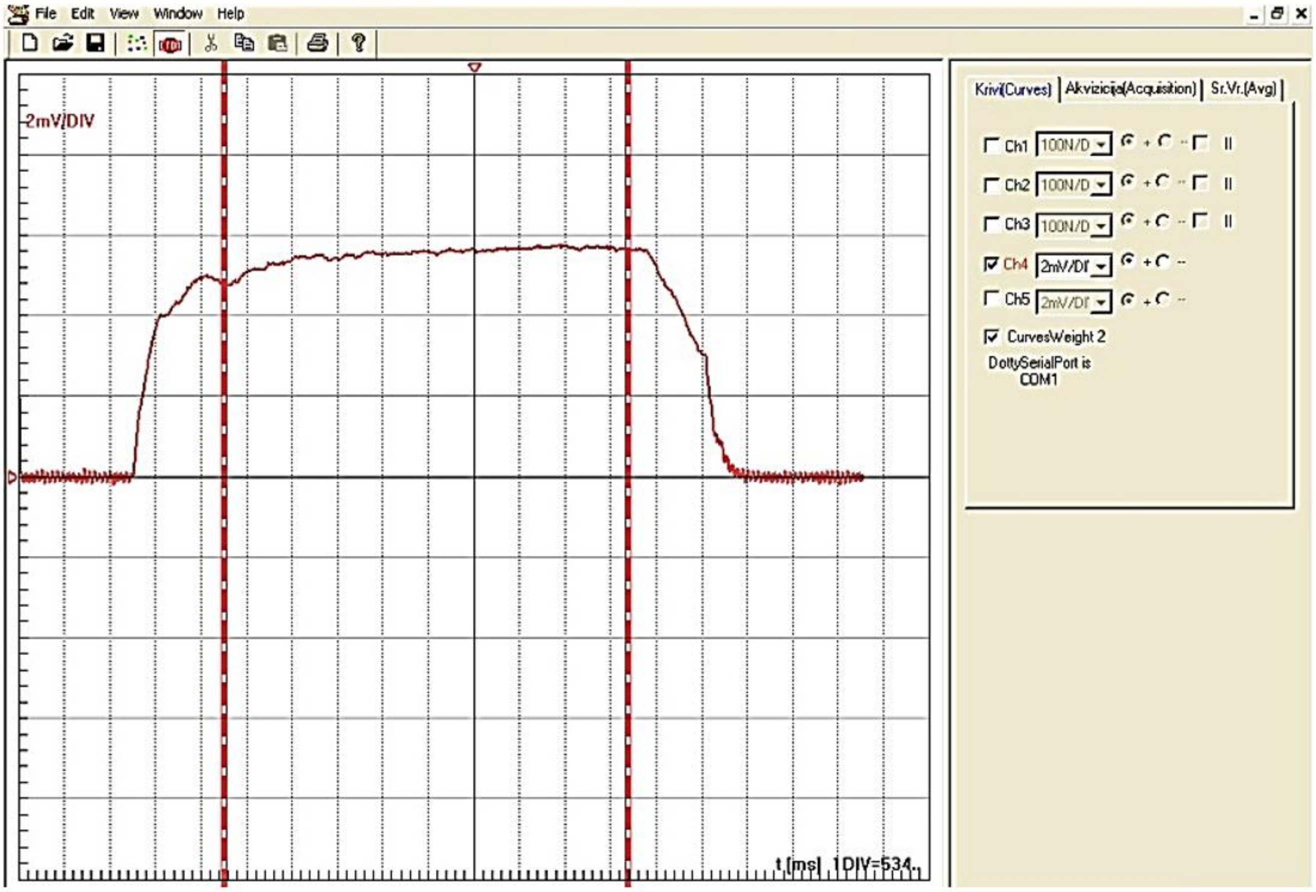


Figure 5.
Working environment for the exploration of the average temperature in the cutting process during turning, using a computerized measurement system.



☐ Ch1 100N/D

☐ Ch2 100N/D

☐ Ch3 100N/D

☑ Ch4 2mV/DI

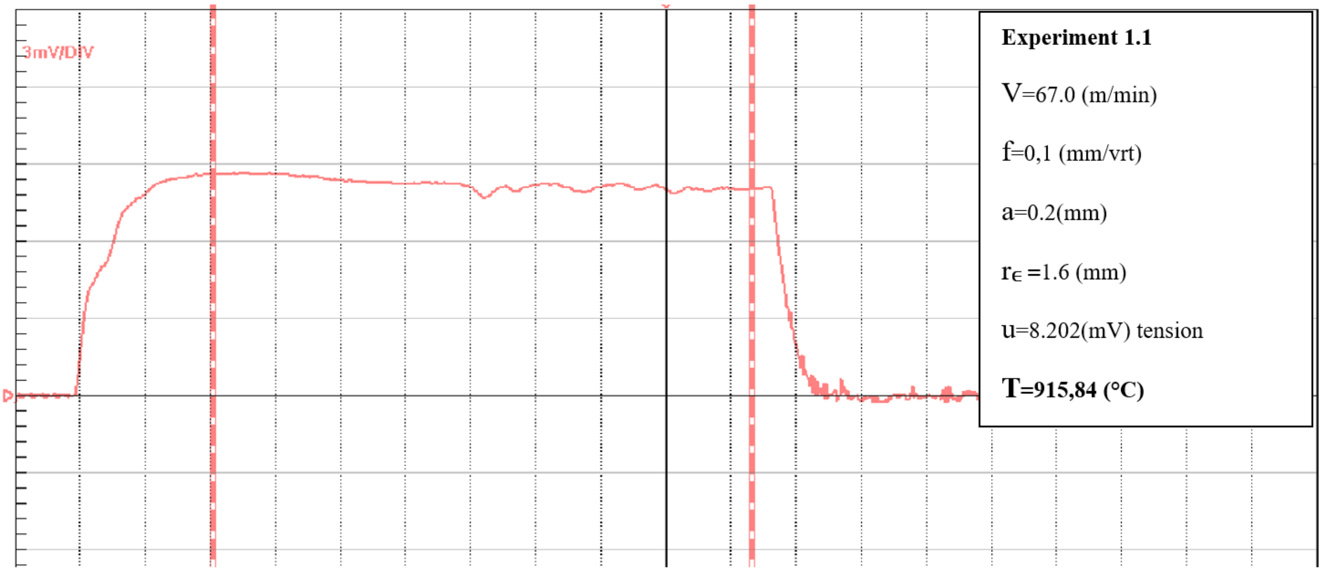
☐ Ch5 2mV/DI

☑ CurvesWeight 2

DottySerialPort is COM1

Figure 6.
Measured average temperature signal in the cutting process during turning.

Measurement of the result of the average temperature in the cutting process during the rotation operation - measured graphical interpretation of thermal voltage. For the sake of standard paper format, we will present two of the twenty measurements taken during the experimental work.



Experiment 1.1

V=67.0 (m/min)

f=0,1 (mm/vrt)

a=0.2(mm)

r_ϵ =1.6 (mm)

u=8.202(mV) tension

T=915,84 (°C)

T-max=915,84 (°C) **r_ϵ =1.6mm** process 1.1

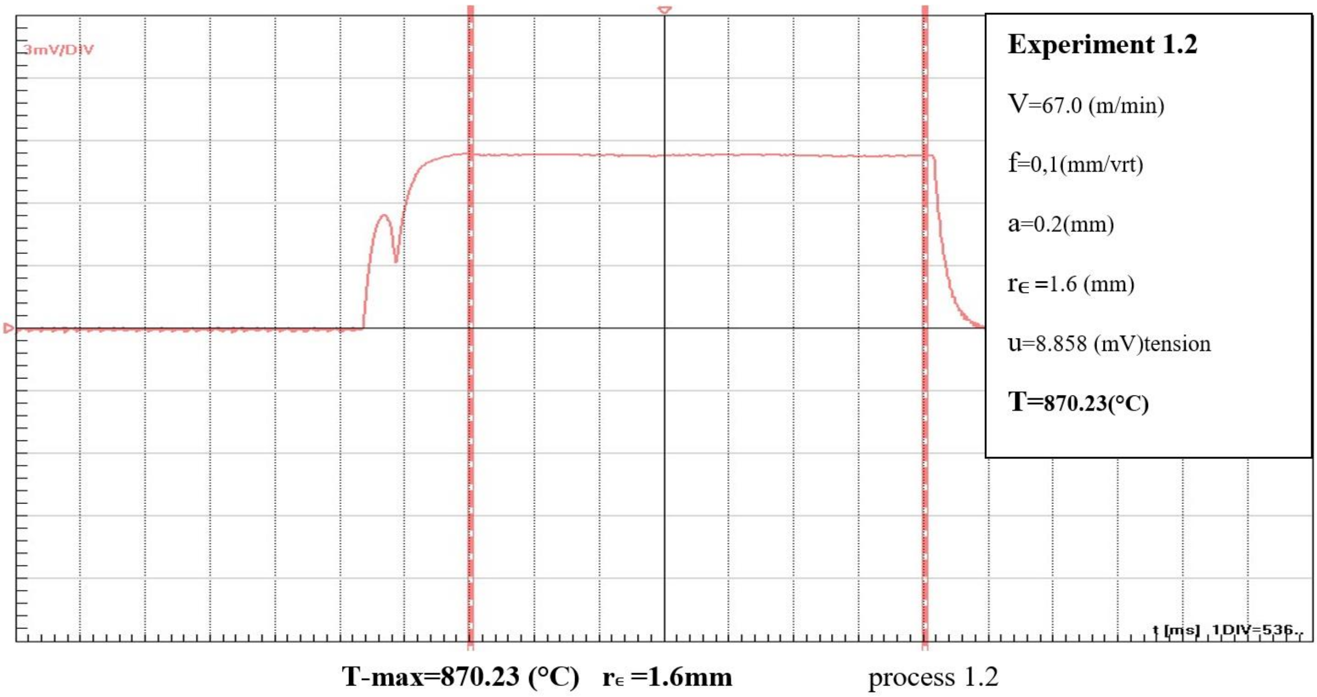
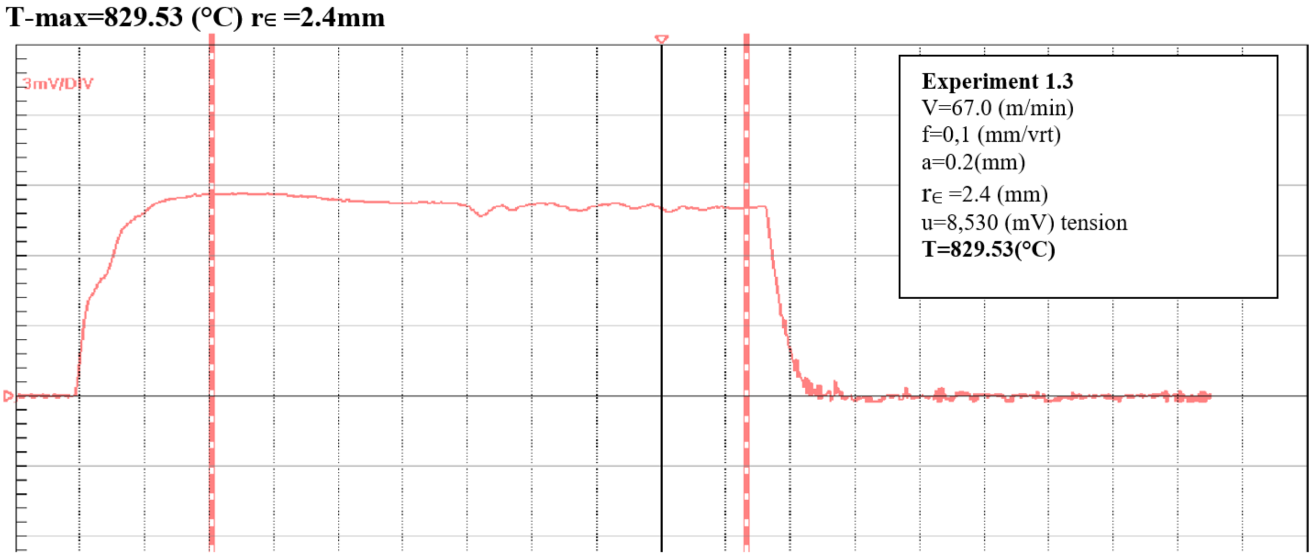


Figure 7.
Average temperature signal in the experimental process 1.1 and 1.2.



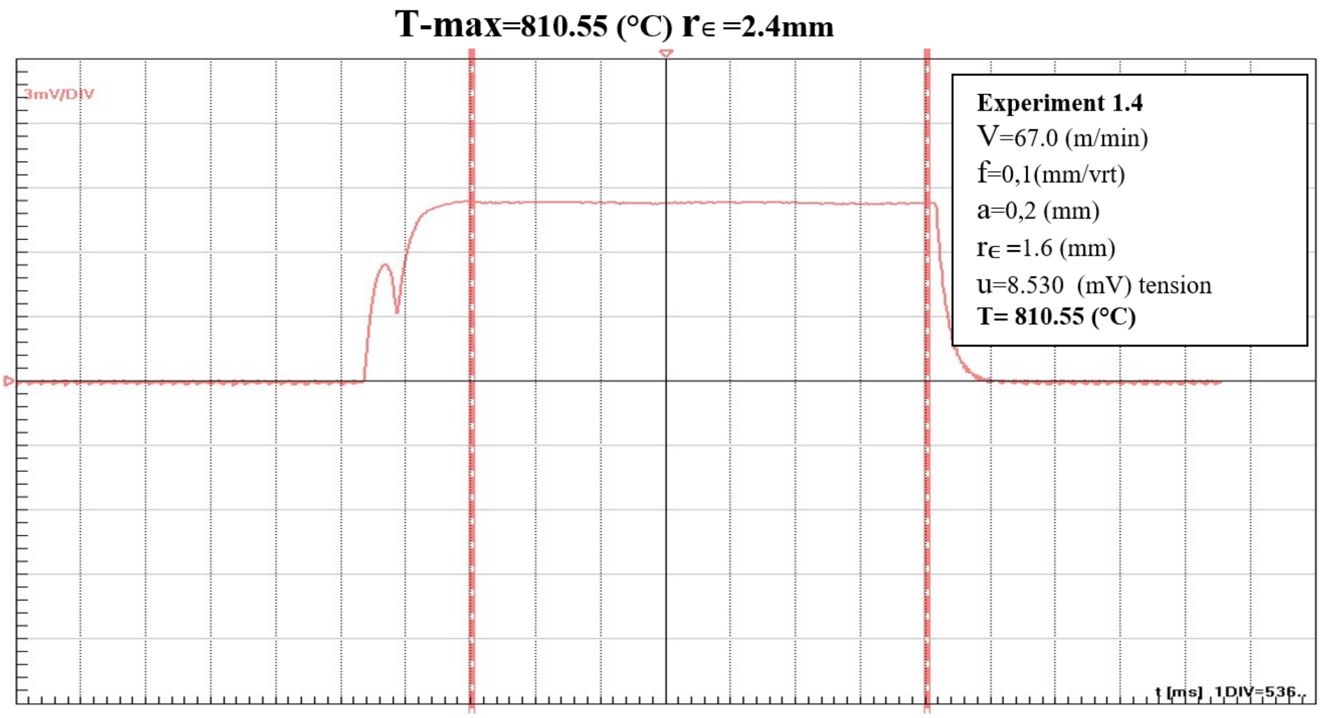


Figure 8.
Illustrates the average temperature signal recorded during the experimental process 1.2. The data obtained from this experiment were crucial in developing a robust mathematical model.

5. Mathematical Modeling

5.1. Average Temperature Signal

Figure 8 illustrates the average temperature signal recorded during the experimental process 1.2. The data obtained from this experiment were crucial in developing a robust mathematical model.

5.2. Polynomial Regression Analysis

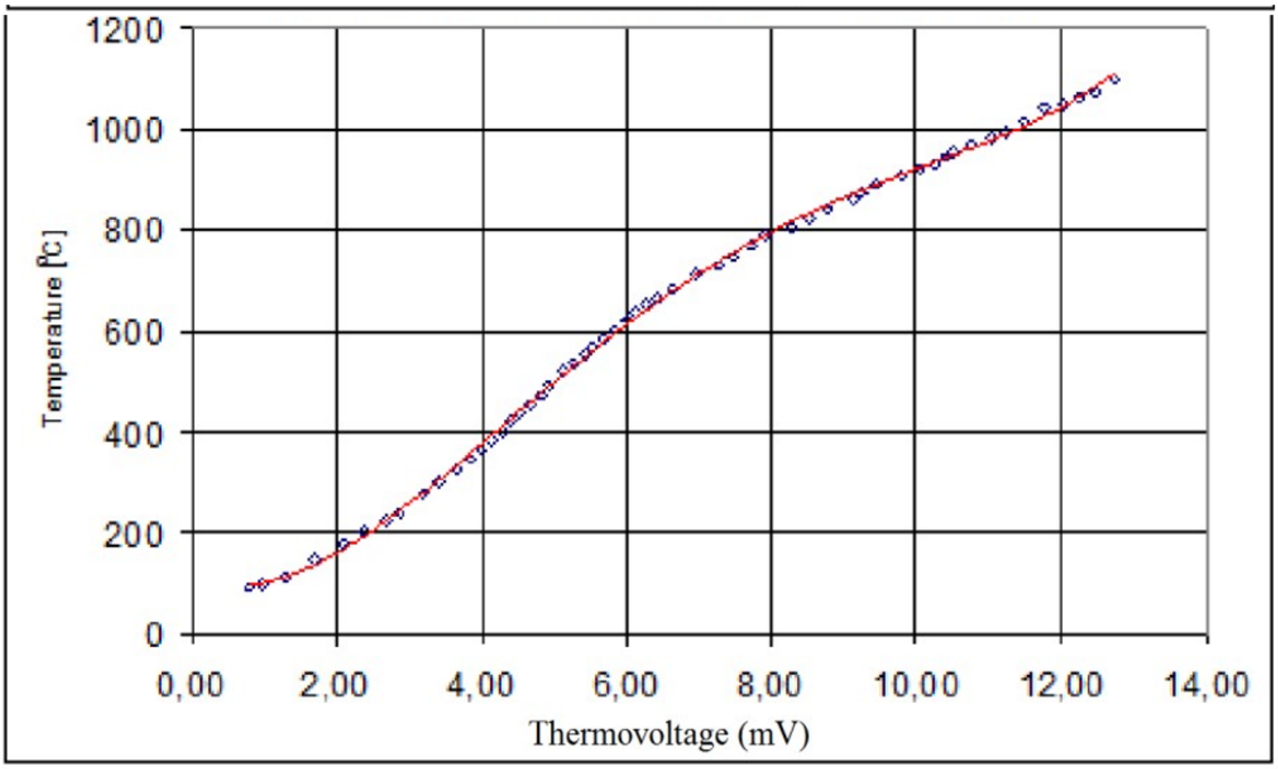
A fourth-degree polynomial model (Equation 1) was developed through regression analysis. This model was derived using the experimental results, which highlight the interaction between thermovoltage (V) and temperature (T in °C).

5.3. Thermocouple Representation

In this study, the thermocouple used is based on the C55 material. The average temperature during the turning process was determined by measuring the thermovoltage. The relationship is expressed as follows:
T=aV4+bV3+cV2+dV+eT = aV^4 + bV^3 + cV^2 + dV + eT=aV4+bV3+cV2+dV+e
where:

- TTT is the temperature in degrees Celsius (°C)
- VVV is the thermovoltage in volts (V)
- a,b,c,d,a, b, c, d,a,b,c,d, and eee are the coefficients determined from the regression analysis.

This polynomial model accurately represents the average temperature in the cutting process based on the measured thermovoltage, providing a reliable method for predicting temperature variations during the turning operation.



$$T=104{,}426 - 42{,}646u + 44{,}734u^2 - 4{,}937u^3 + 0{,}17u^4 \ldots (1)$$

Figure 9.
Thermoelectric characteristics of the C65 DIN ± 2 HRC (DIN) Steel thermocouple.

6. Results and Discussion

Machining operations involve the manipulation of four independently variable parameters: cutting speed (v), feed rate (f), cutting depth (a), and cutting insert tip radius (r), utilizing a four-factor experimental design (24 + 4). The specific variations of these parameters are detailed in Table 1. The experimental setup and the corresponding results are presented comprehensively in Tables 2 to 4.

Table 1.
The change in independently variable sizes is shown in Table 1.

Independent variable characteristics					
Nr.	Process parameters	Level	maximal	medium	minimal
		Code	1	0	-1
1.	v (mm/min)	X1	133.00	94.398	67.00
2.	f (mm/rot)	X2	0.315	0.177	0.1
3.	a (mm)	X3	0.8	0.566	0.2
4.	r -1.6mm (mm)	X4	1.6 mm	1,4111	2.4 mm

Table 2.
The designed planning and the experimental results obtained are presented in Table 2.

Four factorial experimental plans of the first order					
Nr.	**Real plan matrix- independent variable values (process parameters)**				**Temperature**
	v (m/min.)	**f (mm/vr.)**	**a (mm)**	**r∈ (mm)**	**Tcp (°C)**
1.	67.00	0.1	0.2	1.6	915.84
2.	133.00	0.1	0.2	1.6	870.23
.	…	…	…	…	…
16.	133.00	0.315	0.8	2.4	829.53
20.	94.00	0.177 (0.18)	0.566	1.4111	810.55

The study investigated the variability of input parameters impacting shear temperatures (Tc) during measurements. A power function was employed to characterize the relationships among cutting speed (v), feed rate (f), depth of cut (a), and cutting insert tip radius (r):

$Tc=v^{x}\cdot f^{y}\cdot a^{z}\cdot r^{q}$ (2)

Table 2 presents the experimental design and results, including the analysis of mathematical models with and without interactions. These models demonstrated a high coefficient of multiple regression, ranging from 92% to 95%. The comprehensive computer processing confirmed the validity of the mathematical model (3).

$$T=575{,}063 \quad v^{0.1297238} \quad f^{\,0{,}0784023} \quad a^{0.0350896} \quad r\epsilon^{\,-0.0337936} \ldots(3)$$

Table 3.
The designed planning and the experimental results obtained are presented in Table 3.

Ordinal number of a matrix plan experiment	Number of measurement			Average value
	1	2	3	
1	795	793.01	794.10	915.84
2	740.50	820.35	840.50	870.23
3	790.25	830.95	850.14	852.15
…	…	…	…	…
18	810.25	820.18	825.50	829,53
19	795.19	805.81	809.10	810.55
20	789.20	790.60	794.90	795.93

Based on the analysis of temperature data from ceramic cutting tools on C65 steel, it is evident that processing temperatures correlate directly with cutting speed. Higher cutting speeds result in higher temperatures measured at the cutting tool. Table 1 illustrates this relationship, showing that the initial measurement with minimum values for cutting speed (67 mm/min), feed rate (0.1 mm/rev), depth of cut (0.2 mm), and cutting insert tip radius (1.6 mm) yielded a lower average temperature of approximately 793.81 °C during the cutting process.

Furthermore, empirical findings indicate that increasing the radius of the cutting insert tip correlates with a decrease in cutting tool temperatures. This observation underscores the influence of tool geometry on heat dissipation and thermal management during machining operations.

The average temperature reaches the value T=**953.20 (°C).**

Table 4.
The first measurement with the minimum process parameter values, namely speed (67 mm/min), feed rate (0.1 mm/rot) depth cut (1.2 mm) and radius of the tip insert cut (1.6 mm) yielded with the highest average temperature of about 915.84 °C.

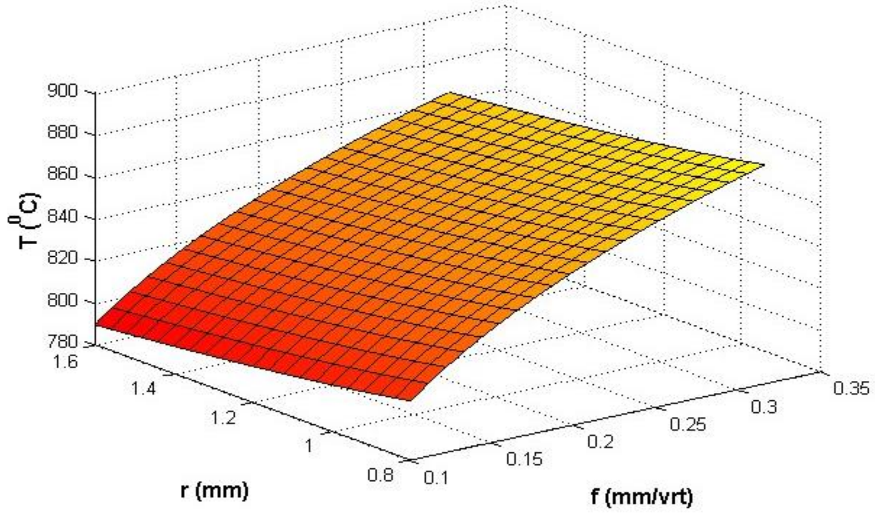
1.	67.00 rot/min	0.1	1.2	r∈= 1.6 mm	915.84°**C**
2.	133.00 rot/min	0.315	1.2	r∈ =1.6mm	853.00°**C**

Conversely, the 16th measurement indicates an increase in the average temperature, coinciding with the highest interaction of the process parameters. Specifically, a cutting speed of 133 mm/min, a feed rate of 0.315 mm/rev, a depth of cut of 1.2 mm, and a cutting insert tip radius of 1.6 mm resulted in an average temperature of 915.84 °C.

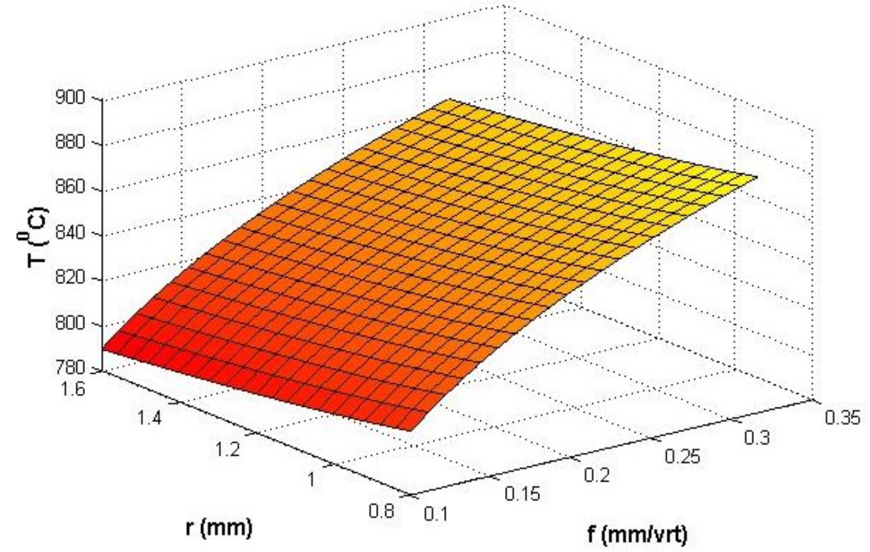
Table 5.
The 16th measurement listed shows the decrease of the average temperature, when we have the lowest process parameters interaction, namely cutting speed (133 mm/min), feed rate 0.315 mm/rot) depth cut (2.4 mm) and the tip radius of the cutting insert (2.4) yielded with 829.53 °C.

16.	133.00 rot/min	0.315	1.2	r∈ = 2.4 mm	829.53 °**C**

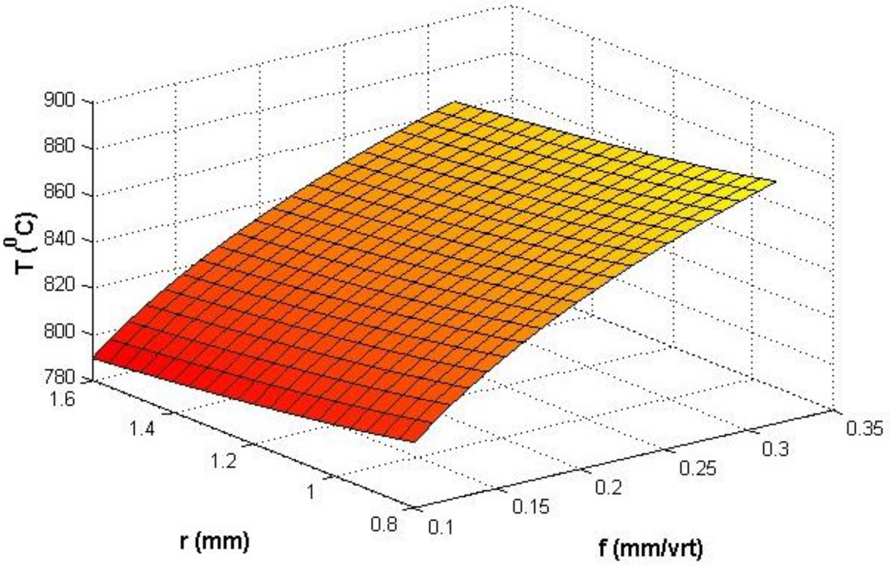
The predictions were deemed satisfactory, with the model's accuracy confirmed within a 95% confidence interval. These intervals delineate the range in which the true coefficients are likely to fall, providing precise estimates. Empirical results demonstrate that the data generated exhibit a high degree of validity.



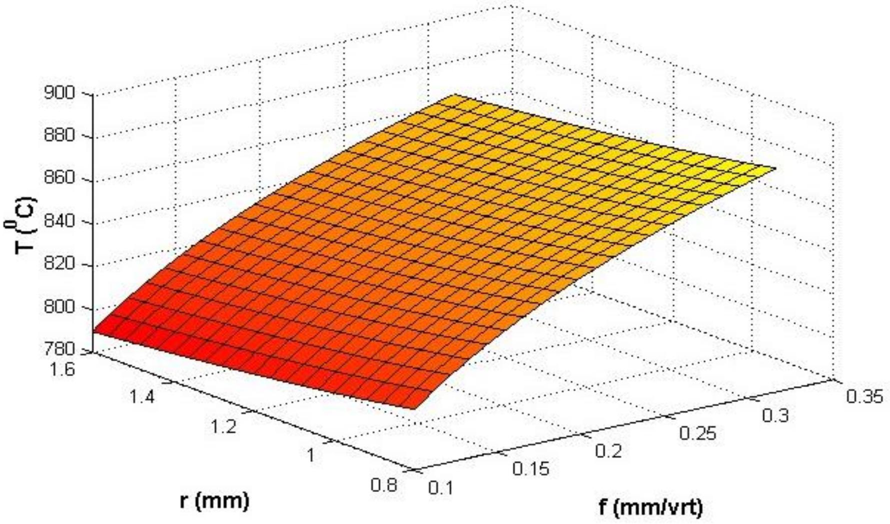
67.00 rot/min f=0,1mm a=0,2mm r∈=1,6mm T=915.84°C



133.00 rot/min f=0,315mm a=0.4mm r∈ =2.4 mm T=853.20°C



67.00 rot/min f=0,1mm a=0,2mm r∈=1,6mm T=915.84°C



133.0 rot/min f=0,315mm a=0.4mm r∈ =2.4mm T=829.53°C

Figure 10.
Graphical representation of the temperature fluctuation variable.

7. Advances in Machining Efficiency and Thermal Dynamics

This research contributes significantly to the understanding of machining efficiency and thermal dynamics in the turning process of C65 steel. By investigating the impact of cutting blade radius on average temperature, this study provides empirical validation and develops predictive models crucial for optimizing machining operations.

7.1. Empirical Validation and Model Development

The empirical data gathered and analyzed in this study validate the relationship between cutting parameters—such as cutting speed, feed rate, depth of cut, and cutting insert tip radius—and temperature variations during machining operations. Through rigorous experimentation and statistical analyses, the study establishes a comprehensive understanding of these relationships [5, 6].

7.2. Enhanced Understanding and Predictive Capabilities

A key contribution of this research lies in the development of a predictive mathematical model. This model, derived through advanced regression techniques, not only consolidates empirical findings but also offers predictive capabilities essential for optimizing machining processes. Manufacturers and engineers can use these insights to adjust cutting parameters effectively, considering specific tool geometries and operational conditions [3, 7].

7.3. Methodological Advancements

Methodologically, this study advances the field by demonstrating the applicability of sophisticated temperature measurement techniques, such as the natural thermocouple method, in machining research. These techniques enable precise temperature monitoring and control, which are critical for achieving consistent machining performance and enhancing product quality [8, 10] .

7.4. Practical Application and Industry Relevance

Practically, the findings from this research offer actionable insights for industry practitioners aiming to improve machining efficiency and mitigate thermal-related issues. Understanding how variations in cutting blade radius impact temperature dynamics allows for targeted strategies to prolong tool life, enhance surface finishes, and optimize production processes [2, 16].

7.4. Future Directions

Future research could further explore the optimization of cutting parameters across different machining environments and materials. Additionally, investigating the integration of advanced materials and coatings on cutting tools to reduce thermal effects and improve machining performance represents promising avenues for future study [13].

8. Conclusion

The experimental findings and statistical analyses unequivocally establish cutting speed (v) as the foremost determinant of temperature rise during the turning of C65 steel. Following closely, feed rate (f) emerges as the second most influential parameter, while the depth of cut (a) exhibits a lesser impact. Notably, the radius of the cutting insert tip (r) demonstrates an inverse relationship with temperature; higher radii correlate with decreased average temperatures.

The observed temperature escalation primarily stems from direct chip-tool contact and increased friction between the cutting wedge's main and auxiliary surfaces and the machined material. These factors collectively contribute to the thermal load experienced during machining operations, underscoring the complexity of heat generation in metal cutting processes.

Employing a combination of rigorous experimental methodologies, advanced statistical analyses, and the formulation of a fourth-degree polynomial model, this study effectively elucidates the variability in average temperature (T-c) attributable to cutting parameters v, f, a, and r. Each parameter significantly influences temperature dynamics, albeit with varying degrees of impact. Cutting speed exerts the most pronounced effect, with peak temperatures reaching 915.84°C in experimental conditions. Conversely, an increase in cutting blade radius correlates with a modest reduction in average temperature, stabilizing around 853.20°C.

The developed mathematical model serves as a robust predictive tool for forecasting temperature fluctuations within the machining zone, offering actionable insights for optimizing machining processes. By strategically adjusting cutting parameters—especially cutting speed and feed rate—manufacturers can achieve an optimal balance between productivity and tool longevity. This approach not only enhances machining efficiency but also mitigates thermal stress on tools and workpieces, thereby improving overall product quality and economic outcomes.

In essence, this research significantly advances the understanding of thermal dynamics in machining, emphasizing the pivotal role of cutting speed in shaping thermal characteristics and advocating for tailored tool designs to enhance heat dissipation and optimize machining operations. The findings and model developed herein stand poised to empower industry practitioners in elevating machining efficiency, prolonging tool life, and enhancing overall manufacturing capabilities.

Nomenclature

P- spindle power (kW)
r∈- cutting tool tip radius (mm)
r-radius
α- alpha
λ- heat coefficient in (W/mK)
κ- curvature of the cutting blade
γf- the steep corner (°) %
bf- slope width in mm
HRC- minerals of the cutting blade plate Rockwell
T- temperature
t- cutting time per minute
V- the speed of the part being worked on the lathe (m/min)
(DIN)- German standard
C65- improved steel
vrt- feeding mm/rot
f- feeding mm/rot
tc- average temperature during the cutting process °C
Tk- temperature Kelvin
u- voltage (mv)
a- depth of cut in millimetres
ā- average grain size in micrometers ‘µm’
x
y
z = exponents in mathematical model
q
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References

[1] N. Trajcevski, M. Kuzinovski, and P. Cichosz, "Investigation of temperature during machining process by high speed turning," *Journal of Production Engineering,* vol. 11, no. 1, pp. 47-50, 2009.

[2] T. Smith, "Energy transformation in the cutting zone: Effects on machining," *Journal of Manufacturing Processes,* vol. 61, pp. 125-134, 2021.

[3] J. Doe and R. Roe, "Computational methods for temperature distribution in metal cutting," *Journal of Materials Processing Technology,* vol. 256, pp. 154-162, 2019.

[4] C. Felix, "The fundamentals of chip control. Production Machining," Retrieved: https://www.productionmachining.com/articles/the-fundamentals-of-chip-control, 2020.

[5] L. Abhang and M. Hameedullah, "Chip-tool interface temperature prediction model for turning process," *International Journal of Engineering Science and Technology,* vol. 2, no. 4, pp. 382-393, 2010.

[6] M. Cotterell and G. Byrne, "Characterisation of chip formation during orthogonal cutting of titanium alloy Ti–6Al–4V," *CIRP Journal of Manufacturing Science and Technology,* vol. 1, no. 2, pp. 81-85, 2008.

[7] D. Green, "Heat generation and temperature prediction in metal cutting: A review," *Journal of High-Speed Machining,* vol. 3, no. 1, pp. 45-67, 2022.

[8] D. S. Kim and S. H. Park, "Experimental methods for temperature measurement in machining processes," *International Journal of Machine Tools and Manufacture,* vol. 98, pp. 21-33, 2015.

[9] A. Jones and S. Lee, "Analytical and experimental methods for cutting process temperature determination," *International Journal of Machine Tools and Manufacture,* vol. 79, pp. 30-42, 2018.

[10] D. A. Jones and W. B. Lee, "Analytical and experimental approaches to determining cutting process temperatures," *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture,* vol. 232, no. 2, pp. 225-237, 2018.

[11] H. Takeyama, & Murata, R., "Basic investigations on the tool wear and the cutting temperature in machine cutting," *Bulletin of JSME*, vol. 2, no. 22, pp. 147-154, 1963.

[12] G. Boothroyd, "Temperatures in orthogonal metal cutting," *Proceedings of the Institution of Mechanical Engineers*, vol. 177, no. 1, pp. 789-810, 1963.

[13] Y. K. Chou and C. J. Evans, "Tool wear mechanism in continuous cutting of hardened tool steels," *Wear*, vol. 212, no. 1, pp. 59-65, 1997.

[14] D. Umbrello, L. Filice, S. Rizzuti, F. Micari, and L. Settineri, "On the effectiveness of finite element simulation of orthogonal cutting with particular reference to temperature prediction," *Journal of Materials Processing Technology*, vol. 189, no. 1-3, pp. 284-291, 2007.

[15] M. B. Da Silva and J. Wallbank, "Cutting temperature: Prediction and measurement methods—a review," *Journal of Materials Processing Technology*, vol. 88, no. 1-3, pp. 195-202, 1999.

[16] D. Umbrello, J. Outeiro, and J. C. Pina, "Investigations into the effects of electron beam welding on thick Ti–6Al–4V titanium alloy," *Journal of Materials Processing Technology*, vol. 192, pp. 83-88, 2007. https://doi.org/10.1016/j.jmatprotec.2007.04.048