

## A Review: Literature Summary on the Relationship Between Cutting Parameters and Machinability in Turning Operations

Yunus Kaplan<sup>1</sup>, Rüstem Binali<sup>2</sup>, Tayfun Çetin<sup>3</sup>, Muhammet Enver Gökdemir<sup>4\*</sup>  
Saeed Yaghoubi<sup>5</sup>, Mehmet Topuz<sup>6</sup>

<sup>1</sup> Selçuk University, Faculty of Technology, Department of Mechanical Engineering, Konya

<sup>2</sup>Bursa Technical University, Faculty of Engineering and Natural Sciences, Department of Mechanical Engineering, Bursa

<sup>3</sup>Hakkari University, Yüksekova Vocational School, Department of Electricity and Energy, Hakkari

<sup>5</sup>Iran University of Science & Technology, School of Industrial Engineering, Iran

<sup>6</sup>Van Yüzüncü Yıl University, Department of Mechanical Engineering, Van

email: [menvergokdemir@hakkari.edu.tr](mailto:menvergokdemir@hakkari.edu.tr)

DOI: 10.57244/dfbd.1829991

Geliş tarihi/Received: 26/11/2025

Kabul tarihi/Accepted:23/12/2025

### Abstract

This study presents a comprehensive evaluation of machinability in turning operations by reviewing and synthesizing the literature based on the parameters of cutting forces, tool wear, and surface roughness. Previous studies clearly present the significance of cutting parameters. While an increase in speed mainly reduces the forces and roughness, increases in feed and depth tend to increase cutting forces, temperature, and wear by enlarging the contact area. Tool wear directly affects the surface integrity and process stability through flank/crater wear and BUE formation. In particular, austenitic stainless steels, titanium and nickel-based superalloys, and particle-reinforced composites are sensitive to the cutting mechanism, tool-material interaction, and speed. Environmentally sustainable cooling-lubrication strategies (MQL, plant-based oils, cryogenic/CO<sub>2</sub>-based solutions) reduce wear by reducing friction and temperature, improving the surface quality. In the case of ultrasonic turning, similar benefits are provided by reducing instantaneous contact and average forces. In the examined studies, dynamometers, scanning electron microscopes, surface roughness measurement instruments, and various software were used. Additionally, optimum parameter windows were reported based on Taguchi/ANOVA/RSM methods. Consequently, the combination of appropriate parameter selection and environmentally friendly cooling and lubrication and/or auxiliary processes extends tool life, improves surface integrity, and increases energy and cost efficiency. This approach offers a repeatable and industrially applicable roadmap, even for materials that are difficult to machine.

**Keywords:** Turning process, Cutting forces, Surface roughness, Tool wear.

## Bir İnceleme: Tornalama İşlemlerinde Kesme Parametreleri ile İşlenebilirlik Arasındaki İlişkiye İlişkin Literatür Özeti

### Özet

Bu çalışma, kesme kuvvetleri, takım aşınması ve yüzey pürüzlülüğü parametrelerine dayalı literatür çalışmalarını inceleyip sentezleyerek tornalama işlemlerinde işlenebilirliğin kapsamlı bir değerlendirmesini sunmaktadır. Önceki çalışmalar, kesme parametrelerinin önemini açıkça ortaya koymaktadır. Kesme hızındaki artış esas olarak kuvvetleri ve pürüzlülüğü azaltırken, ilerleme ve derinlikteki artışlar temas alanını genişleterek kesme kuvvetlerini, sıcaklığı ve aşınmayı artırma eğilimindedir. Takım aşınması, flanş/krater aşınması ve BUE oluşumu yoluyla yüzey bütünlüğünü ve işlem kararlılığını doğrudan etkilemektedir. Özellikle östenitik paslanmaz çelikler, titanyum ve nikel bazlı süper alaşımlar ve parçacık takviyeli kompozitler kesme mekanizmasına, takım-malzeme etkileşimine ve hıza duyarlıdır. Çevresel olarak sürdürülebilir soğutma-yağlama stratejileri (MQL, bitkisel bazlı yağlar, kriyojenik/CO<sub>2</sub> bazlı

çözümler) sürtünmeyi ve sıcaklığı azaltarak aşınmayı azaltır ve yüzey kalitesini iyileştirir. Ultrasonik tormalama durumunda, anlık temas ve ortalama kuvvetler azaltılarak benzer faydalar sağlanır. İncelenen çalışmalarda dinamometreler, taramalı elektron mikroskopları, yüzey pürüzlülüğü ölçüm cihazları ve çeşitli yazılımlar kullanılmıştır. Ayrıca, Taguchi/ANOVA/RSM yöntemlerine dayalı olarak optimum parametre pencereleri raporlanmıştır. Sonuç olarak, uygun parametre seçimi ile çevre dostu soğutma ve yağlama ve/veya yardımcı işlemlerin birleşimi, takım ömrünü uzatır, yüzey bütünlüğünü iyileştirir ve enerji ve maliyet verimliliğini artırır. Bu yaklaşım, işlenmesi zor malzemeler için bile tekrarlanabilir ve endüstriyel olarak uygulanabilir bir yol haritası sunar.

**Anahtar Kelimeler:** Tormalama işlemi, Kesme kuvvetleri, Yüzey pürüzlülüğü, Takım aşınması.

## **Introduction**

Turning is the most widely used primary machining method for shaping cylindrical objects (Binali, Demirpolat, Kuntoğlu, & Kaya; Hekimoğlu & Bayraktar, 2023; Kul & Yamaner; Kuntoğlu, Kaya, & Binali, 2023; Yamaner & Kul, 2025) along with other methods such as milling, drilling and grinding (Binali, 2023; Demirpolat, Kuntoğlu, & Binali, 2023; Makhesana, Patel, Ghetiya, Binali, & Kuntoğlu, 2024; Pimenov et al., 2025; Yaşar, Korkmaz, & Günay, 2017). Nowadays, with the development of the manufacturing industry, the machinability of materials with superior properties has become an important research topic and many studies have been done in this field (Binali, 2024; Binali, Patange, Kuntoğlu, Mikolajczyk, & Salur, 2022; Pul, 2023; Salur, 2022). Alloys and composites, particularly used in high-technology fields such as aerospace, automotive, defense and biomedical, are difficult to process due to their high strength, hardness and thermal resistance (Akgün & Demir, 2021; da Silva et al., 2025; Demirbaş, 2023). The most influential factors on the evaluation of the machinability on turning processes are the forces, wear, roughness and chip formation (Ağar, Mahmat, & Tosun; Bagga, Makhesana, Patel, & Patel, 2021; Binali, Korkmaz, Özdemir, & Günay, 2025; Barış Özlü, Akgün, & Demir, 2019; Pul, 2023; Salur et al., 2025). In addition to these fundamental factors, cutting vibrations, directly related to surface roughness and tool wear, increase the difficulty of machining, especially in alloys such as Ti6Al4V. Furthermore, positional deviations caused by clamping errors, which affect the desired form accuracy, are another machinability problem in the machining of small-diameter workpieces frequently used in the aerospace and automotive industries (Elsheikh, Guo, Bai, & Lee, 2020; Yi et al., 2020). The parameters of speed, feed and depth directly affect these outcomes. While an increase in the speed generally reduces the forces and surface roughness, increasing the feed increases these values (Hekimoğlu & Bayraktar, 2023; Korkmaz, Gupta, Çelik, Ross, & Günay, 2024; Yurtkuran et al., 2024). Thus, selecting the appropriate combination of parameters increases quality and decreases cost (Binali et al., 2022; Barış Özlü, Uğur, & Yıldız, 2023; Öztürk & Kara, 2025; Pul, 2023). In recent years, as well as classical turning methods, innovative methods such as cryogenic processing, minimum lubrication (MQL), and ultrasonic turning have gained prominence in order to increase tool life by decreasing the temperature, particularly when machining difficult-to-machine alloys, providing more environmentally sustainable solutions (Ağar et al.; Aydın, 2023; Demirbaş, 2023; Korkmaz & Gupta, 2024). In addition, even at high cost, the use of plant-based cutting fluids provides significant advantages in terms of machinability, environmental and human health. By continuing these, a production process with high recycling, high efficiency and minimal harm to human and environmental health will be realized (Aydın,

2023; Sivalingam et al., 2023; Şap, Usca, Uzun, Kuntoğlu, & Salur, 2022). Therefore, current studies on turning processes examine the effects of material properties, cutting parameters and cooling/lubrication methods on machinability criteria and their effects on human and environmental health in a multidimensional manner (Ağar et al.; Aydın, 2023; Demirbaş, 2023; Demirpolat, 2024; Erdem, Özdemir, Rafighi, & Yavuz, 2023; Kaya, Çetin, Binali, & Gündoğmuş, 2025; Kul; Ngoc, Duc, Tuan, Hoang, & Long, 2023). The main criteria taken into consideration in evaluating machinability in turning operations are forces, roughness, tool wear, chip formation and material removal rate (MRR). Since each of these criteria directly affects both production efficiency and product quality and cost, studies in the literature are mostly conducted on these parameters.

The novelty of this study lies in its provision of a holistic evaluation framework for machinability in turning operations, considering not only individual output parameters but also cutting forces, surface roughness, tool wear, and chip formation in conjunction with each other.

**Cutting Forces:** Cutting forces in turning operations occur as a result of the interaction between the cutting tool and the material, and are usually analyzed with cutting, feed and radial force components ( $F_x$ ,  $F_y$ ,  $F_z$ ) (Akgün, Özlü, & Kara, 2023; Binali, Yıldız, & Neşeli, 2021; Hekimoğlu & Bayraktar, 2023; BARIŞ ÖZLÜ, 2022; Barış Özlü & Akgün, 2024). These forces have a direct effect on chip formation, tool wear and surface finish (Ağar et al.; Binali & Kuntoğlu, 2023; Gupta et al., 2022; Kuntoğlu et al., 2021; Makhesana et al., 2023; Ozlu & Ugur, 2021). While increasing the speed reduces the forces, increasing the feed and cutting depth increases the forces (Pul, 2023). In addition, methods such as MQL, cryogenic and ultrasonic turning reduce friction, reduce cutting forces and increase tool life (Binali, Demirpolat, Kuntoğlu, & Salur, 2023; Demirbaş, 2023).

**Surface Roughness:** Surface roughness is a critical factor in evaluating machinability during turning operations. It is a parameter that directly results from the direct contact between the cutting tool and the workpiece. Surface roughness is affected by the cutting tool geometry, feed rate, cutting speed, coolant, and stability of the machining conditions, and the resulting roughness values are a consequence of the influence of these factors. Increasing the feed rate increases the surface roughness value. Increasing the cutting speed decreases the roughness value. Increasing the depth of cut can negatively affect roughness by increasing cutting forces and vibration. Therefore, surface roughness is not only a definition of surface quality but also a machinability parameter that should be evaluated together with cutting forces, tool wear, and chip morphology (Binali et al., 2023; Ruban, Dev Wins, Raja Selvam, & S Rai, 2023; Tefera, Sinha, & Gupta, 2023).

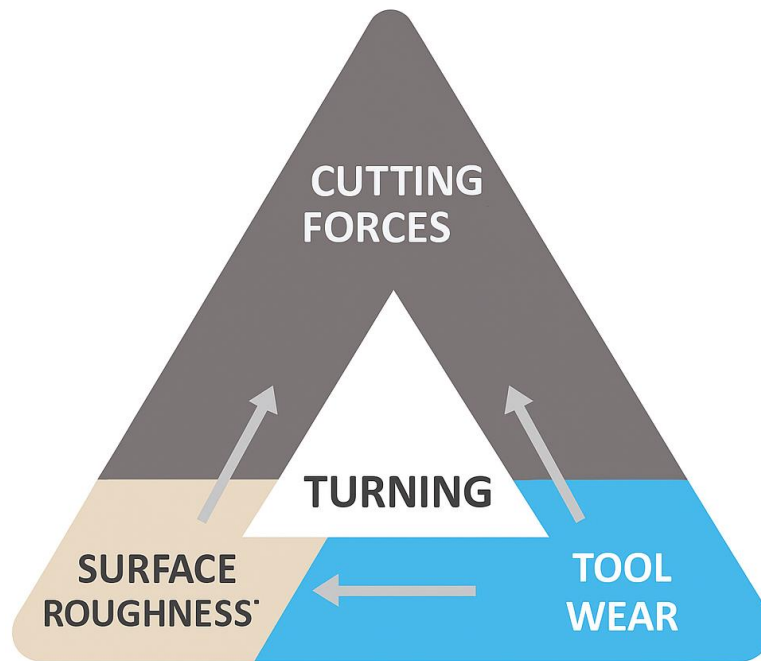
**Tool Wear:** Cutting tools wear over time because of exposing to high temperatures and friction, and these wear types are generally classified as crater wear, flank wear, and corner wear (Ağar et al.; Bagga et al., 2021; Korkmaz et al., 2022). Tool wear is affected by factors such as temperature, forces and the hardness of the workpiece material during processing, and short tool life is one of the most important factors that increase production costs (Demirbaş, 2023; Mikolajczyk, Paczkowski, Kuntoglu, Patange, & Binali, 2022). Vibration-assisted processes such as ultrasonic turning, advanced cooling/lubrication strategies such as MQL and cryogenic cooling, and low-coefficient tool coatings (such as DLC) significantly reduce the friction between the cutting tool and the material and the

resulting cutting temperature, extending tool life (Ağar et al.; Airao, Nirala, Bertolini, Krolczyk, & Khanna, 2022; Khanna, Airao, Nirala, & Krolczyk, 2022).

**Chip Formation:** The chip removal mechanism occurs through plastic deformation of the workpiece. Chip formation occurs in various types, including continuous chips, interrupted chips, and accumulated chips. The type of chip varies depending on the material's mechanical properties, speed, feed, and the use of cutting fluid (Hekimoğlu & Bayraktar, 2023; Kuntoğlu, Binali, Demirpolat, & Makhesana, 2025; Pul, 2023). Particularly, accumulated chips adversely affect the surface quality and accelerate tool wear. (Hekimoğlu & Bayraktar, 2023; Korkmaz et al., 2023; Kuntoğlu, Binali, et al., 2025).

**MRR:** MRR, the volume of material removed in a given time, is one of the most important indicators of manufacturing efficiency. As speed, feed, and depth increase, so does MRR (Kuntoğlu, Demirpolat, et al., 2025; Pul, 2023; Ruban et al., 2023). However, because the increase in these parameters also increases the forces and tool wear, the selection of optimum parameters is critical (Hekimoğlu & Bayraktar, 2023).

Figure 1 shows a schematic representation of the topics discussed in general.



**Figure 1.** The Concept of Review.

### **Effect of the Turning Operation on Cutting Force**

Cutting forces in turning operations are the most fundamental indicators of the mechanical interaction occurring at the tool-material interface and are of great importance in evaluating machinability (Hekimoğlu & Bayraktar, 2023; Turkes, Orak, Neşeli, Sahin, & Selvi, 2017). Cutting forces usually consist of three components: cutting, feed, and radial force directly affecting many output parameters, such as chip formation, tool life, surface finish, and energy consumption (Ağar et al.; Barış Özlü & Uğur, 2023a, 2023b). The cutting parameters of cutting speed, feed rate and depth of cut are the most important variables affecting the magnitude of cutting forces. In reference to previous studies,

increase in cutting speed reduces deformation resistance and reduces the forces (Kağıtçı & Neşeli, 2024; Pul, 2023). On the other hand, increasing the feed and depth increases the forces because it expands the tool-workpiece contact area (Hekimoğlu & Bayraktar, 2023). A study investigating the turning of DIN 1.2367 hot work tool steel concluded that the feed rate was the most effective factor, accounting for up to 97% of the influence on cutting forces. The study also observed that increasing the cutting speed resulted in a significant force reduction (Erdem et al., 2023; Uğur, Kazan, & Özlü, 2022). Similarly, in another study conducted on AISI 1050 steel, it was concluded that increasing the friction coefficient and depth of cut significantly increased the cutting forces, and the optimum friction coefficient was in the range of 0.4–0.5 (Sekmen, Kurt, & Şeker, 2023). In another study on the machinability of Al-Si-based alloys, the effects of speed, feed, and depth on forces were experimentally investigated, and a decrease in forces was observed with increasing speed and an increase in forces with increasing feed. Furthermore, the  $F_x$ ,  $F_y$ , and  $F_z$  components were measured separately using a triaxial Kistler 9257A dynamometer, and the total cutting force was calculated from the resultant of the forces (Hekimoğlu & Bayraktar, 2023). Another study conducted on the turning of AISI 304 stainless steel compared the MQL method with dry machining conditions. The results showed that the MQL system reduced friction, resulting in a reduction in forces of up to 20%, and controlled temperature increases (Binali et al., 2023). Similarly, in machining AISI 304 austenitic stainless steel with minimal lubrication, it has been observed that nanofluids containing hybrid nanoparticles reduce both cutting force and friction coefficient compared to monofluids of a single type. In difficult-to-machine materials such as Ti6Al4V, the use of graphene oxide nanofluids has been reported to reduce cutting force and friction coefficient compared to conventional cooling. In a study conducted on AISI 1045 steel, the addition of plant-based aluminum oxide nanoparticles to the MQL fluid provided significant benefits in optimizing cutting force (Sharma, Tiwari, Dixit, & Singh, 2020; Yi et al., 2020). In experiments conducted on the machining of AISI 52100 bearing steel using ultrasonic turning, it was determined that the cutting forces decreased and the tool life extended with increasing vibration frequency. In this study, ultrasonic vibration (20–30 kHz, 10  $\mu$ m amplitude) reduced the tool-workpiece contact time, thus reducing the average force values (Ağar et al.).

In general, it is emphasized in the literature that forces decrease as cutting speed increases, whereas they increase with higher feed rates and depths. It is also noted that cooling and lubrication methods play a critical role in controlling cutting forces. A common finding for MQL, cryogenic, and ultrasonic-assisted methods is that they significantly reduce cutting forces by mitigating friction and temperature, consequently extending tool life and improving surface finish. An abstract of some of the studies conducted is given in Table 1.

**Table 1.** Literature review related to cutting forces

Process	Machine	Purpose	Used Material	Output Parameters	Measuring Tools	Reference
Turning	CNC horizontal lathe	To investigate the effect of different parameters on roughness and forces in turning of 1.2367 hardened (55 HRC) hot tool steel.	1.2367 hardened (55 HRC) steel	Surface roughness, cutting forces.	Mitutoyo SJ-201, Kistler 9129AA dynamometer.	(Erdem et al., 2023)

Turning	CNC horizontal lathe	To investigate the effects of friction occurring at the tool-chip interface during turning operation on machining performance and to investigate the effects of the change of friction coefficient on forces, cutting tool temperature and stresses occurring in the cutting tool.	AISI 1050 steel	Cutting force, cutting tool temperature, Cutting tool stresses, Tool wear areas.	Deform-3D Machining module, Mitutoyo CV Hexagon 3D coordinate measuring device, Kistler 9257B dynamometer	(Sekmen et al., 2023)
Turning	CNC horizontal lathe	To contribute to the optimization of parameters by defining the machinability behavior of this new Al-Si based alloy.	Al-9Si-0,1Sr-0,6Mg alloy	Cutting force, roughness, chip formation, tool wear.	Kistler 9257A dynamometer, Kistler 5070A amplifier, Mahr Perthometer, optical microscope, ICP-OES spectrometer	(Hekimoğlu & Bayraktar, 2023)
Turning	Universal lathe	To experimentally investigate the effects of machining method, speed, and vibration frequency on cutting tool life during the machining of AISI 52100 bearing steel by ultrasonic turning and conventional turning methods.	AISI 52100 bearing steel	Cutting speed, machining method, tool wear, tool life.	Optical microscope, vibration generator	(Ağar et al.)
Turning	Universal lathe	To compare dry and MQL conditions in turning AISI 304 austenitic stainless steel with a two-level full factorial design; to evaluate the effects of speed, feed and depth on tool tip temperature, cutting force and roughness (Ra); and to investigate chip morphology.	AISI 304 austenitic stainless steel	Cutting force, surface roughness, chip morphology, temperature.	Kistler 9275 dynamometer, InGaAs radiation sensor, Mahr Co. portable perthometer, Kar-tes STN15 MQL instrument, scanning electron microscope	(Binali et al., 2023)
Turning	Semi-automatic horizontal lathe	To investigate the effect of different cutting-edge radius on the machinability in the finishing pass of Ti6Al4V alloy.	Ti6Al4V rod	Roughness, tool wear, forces, chip morphology, temperature.	Kistler 9257B dynamometer, FLIR T540 infrared thermal camera, OLYMPUS measuring microscope, SURFCOM 1500 SD3 + ACC Tee software	(Selvakumar S & Raj. D, 2024)

Turning	CNC horizontal lathe	To examine the machinability performance of Inconel 718 under different microstructure conditions and to prepare the ground for both industrial cutting optimization and numerical modeling (simulation) studies with these data.	Inconel 718 nickel-based superalloy	Cutting forces, tool wear, tool life, MRR, chip morphology (SEM observations).	Piezoelectric Kistler 9129A dynamometer, Kistler 5070A dynamometer, kistler 5697A dynoware software, scanning electron microscope, instron 5900R tester, optical microscope.	(Matos et al., 2023)
Turning	Universal lathe	To reveal the effects of speed, feed, depth and reinforcement percentage on cutting forces and roughness in dry turning of AA6061/ZrB <sub>2</sub> -ZrC hybrid; and also to investigate the tool, surface and chip morphology.	AA6061/ZrB <sub>2</sub> -ZrC composite	Cutting forces, roughness, tool surface morphology, chip morphology, machined surface morphology.	Kistler 9257B dynamometer, Mitutoyo SJ-210, scanning electron microscope.	(Ruban et al., 2023)
Turning	Universal lathe	The aim is to optimize the main cutting force in turning AISI 1045 steel.	AISI 1045	Cutting force	Kistler piezoelectric dynamometer.	(Usha & Rao, 2020)
Turning	Universal lathe	The aim is to investigate the machining performance of Inconel 825 superalloy after dry cutting.	Inconel 825	Cutting force, tool tip temperature, chip morphology,	Dynamometer, optical microscope, electron microscope, scanning electron microscope, energy dispersion spectroscopy, tool tip temperature indicator.	(Behera, Thrinadh, & Datta, 2021)
Turning	Universal lathe	The aim is to investigate cutting forces and surface roughness in turning operations performed using cutting fluid enriched with hybrid nanoparticles.	AISI 304	Cutting force, surface roughness	Kistler piezoelectric dynamometer, Mitutoyo SJ-210	(Sharma et al., 2020)

### Effect of Turning Process on Surface Roughness

In turning operations, roughness (Ra, Rz) is one of the most important criteria determining the geometric quality and functional performance of the machined surface. Surface quality directly affects not only the aesthetic appearance but also the part's wear resistance, fatigue life, corrosion resistance, and assembly compatibility (Binali et al., 2023; Mahapatro & Krishna, 2023; Ross et al., 2024).

The primary factors affecting surface roughness in the turning process include cutting speed, cutting tool feed rate, depth, tool geometry, tool wear, and cooling/lubrication conditions. The effects of these parameters on surface quality have been extensively studied in the literature (Nas & Altan Özbek, 2020; Barış Özlü, 2021; Barış Özlü, Demir, Türkmen, & Gündüz, 2021). In a study, DIN 1.2367 hot work tool steel was hard turned and surface roughness values were measured at three different points. The experimental results showed that increasing the feed significantly increased surface roughness, while the effect of cutting speed was more limited (Erdem et al., 2023). Similarly, a study conducted on AISI 304 stainless steel using MQL assisted turning showed that surface roughness decreased by up to 25% compared to dry machining conditions, with feed rate being the most influential parameter. The MQL system reduces temperature and friction in the cutting zone, resulting in lower roughness (Binali et al., 2023). In cryogenic turning studies on Monel 400 superalloy, it was determined that the roughness values obtained using PVD-TiAlN-coated inserts were significantly reduced compared to uncoated inserts. This difference was reported to be due to reduced friction and temperature in the cutting zone, and under optimum conditions, the surface roughness value was reported to be 0.667  $\mu\text{m}$  (Demirbaş, 2023). In a study conducted on dry turning of CuZr and CuCrZr alloys, the effects of depth of cut and feed on roughness were investigated. It was determined that roughness decreased with increasing cutting speed, but increased feed. The analyses indicated that the lowest roughness values were obtained at high speed (1200 rpm) and low feed (0.05 mm/rev) (Tefera et al., 2023). Another study conducted on the Ti6Al4V alloy focused the effect of cutting-edge radius on roughness and reported that the minimum Ra value was reached at an edge radius of 52  $\mu\text{m}$ . Increasing the edge radius resulted in a polishing effect, improving surface quality, however, excessive increases in the edge radius resulted in a dominant drag effect, increasing roughness (Selvakumar S & Raj. D, 2024). Tool geometry has a significant effect on surface roughness. Studies on AISI 420 steel have shown that surface roughness decreases as the nose radius of the cutting tool increases (Palanisamy, Devaraju, Arulkirubakaran, & Manikandan, 2020). Surface quality is directly related not only to geometric parameters but also to cooling methods. In CO<sub>2</sub>-based VTCS-assisted turning experiments, the highest roughness values were measured in a dry environment, while the lowest surface roughness was achieved with the dual-nozzle VTCS system. This is explained by the coolant's ability to lower the temperature at the chip-tool interface and reduce friction (Mahapatro & Krishna, 2023). However, experiments on turning MgO-reinforced Al2024 composites have shown that the reinforcement particle size directly affects the surface quality. Measurements with a MarSurf PS1 prototype roughness meter showed that Ra values decreased with smaller reinforcement sizes (Pul, 2023). Studies have shown that adding graphene to a canola oil-based MQL application improves the surface roughness of Ti6Al4V steel, which is difficult to machine (Singh et al., 2020). In general, the approaches suggested in the literature to reduce surface roughness in turning process are listed as;

- Reducing the feed rate,
- Increasing the cutting force,
- Use of coated cutting edges,
- Application of appropriate cooling methods (MQL, cryogenic, VTCS) (Binali et al., 2023; Demirbaş, 2023).

In addition to surface roughness, other important factors defining the surface integrity of a machined part are subsurface microhardness and residual stresses. Machining can cause

plastic deformation at and below the surface, leading to an increase in hardness. This has been observed in materials such as AISI 420 steel (Jiang, He, Ren, Shao, & Yuan, 2020; Palanisamy et al., 2020). These findings clearly demonstrate that surface roughness is not only an output parameter but also a quality indicator that is interrelated with other performance indicators such as tool wear, cutting temperature and cutting forces. An abstract of some of the studies conducted is given in Table 2.

**Table 2.** Literature review related to surface roughness studies.

Process	Machin e	Purpose	Used Material	Output Parameters	Measurement Tools	Refer ence
Turning	CNC horizontal lathe	To investigate the effect of different parameters on roughness and cutting forces in turning 1.2367 hardened (55 HRC) hot tool steel.	1.2367 hardened (55 HRC) steel	Surface roughness, cutting forces	Mitutoyo SJ-201, Kistler 9129AA dynamometer	(Erdem et al., 2023)
Turning	Universal lathe	To compare dry and MQL conditions in turning AISI 304 austenitic stainless steel with a two-level full factorial design; to evaluate the effects of cutting speed, feed and depth of cut on tool tip temperature, force and roughness (Ra); and to investigate chip morphology.	AISI 304 austenitic stainless steel	Cutting force, roughness, chip morphology, cutting temperature	Kistler 9275 dynamometer, InGaAs radiation sensor, Mahr Co. portable perthometer, Kar-tes STN15 MQL instrument, scanning electron microscope	(Binali et al., 2023)
Turning	Lathe	To optimize the cutting parameters in the dry turning of C15000 (CuZr) and C18150 (CuCrZr) copper alloys and to investigate their effects on surface roughness, MRR, tool tip temperature and surface morphology.	C15000 (CuZr) and C18150 (CuCrZr)	Surface roughness, MRR, tool tip temperature, surface morphology	Portable OES	(Tefera et al., 2023)
Turning	Semi-automatic horizontal lathe	To investigate the effect of different cutting edge radius on the machinability in the finishing pass of Ti6Al4V alloy.	Ti6Al4V rod	Roughness, tool wear, forces, chip morphology, temperature	Kistler 9257B dynamometer, FLIR T540 infrared thermal camera, OLYMPUS measuring microscope, SURFCOM 1500 SD3 + ACC Tee software	(Selvakumar S & Raj. D., 2024)
Turning	Lathe	To reduce the cutting zone temperature in the turning of Ti-6Al-4V alloy by CO <sub>2</sub> -based vortex tube cooling system (VTCS) and to investigate the effects on cutting force, temperature and roughness by comparing dry, compressed air, single-nozzle VTCS and double-nozzle VTCS conditions.	Ti-6Al-4V rod	Surface roughness, cutting force, cutting temperature	Kistler 5070 dynamometer, fluke TI400 thermal camera, Surtronic S128 roughness device	(Mahapatro & Krishna, 2023)
Turning	Universal lathe	To investigate the effect of MgO (magnesia) particles of different sizes on the machinability properties of Al 2024 matrix composites.	Al 2024 aluminum alloy	Surface roughness, chip form, cutting tool wear	MarSurf PS1 portable roughness meter, scanning electron microscope	(Pul, 2023)
Turning	Universal lathe	To reveal the effects of speed, feed, depth and reinforcement percentage on cutting forces and surface roughness in dry	AA6061/Zr B <sub>2</sub> -ZrC composite	Cutting forces, roughness, tool surface morphology,	Kistler 9257B dynamometer, Mitutoyo SJ-210, scanning electron microscope	(Ruban et al., 2023)

		turning of AA6061/ZrB <sub>2</sub> -ZrC hybrid; and also to investigate the tool, surface and chip morphology.		chip morphology, machined surface morphology		
Turning	Universal lathe	The aim is to investigate the effects of turning operations performed in dry, MQL, and graphene-assisted minimally lubricated environments on cutting force, surface roughness, coefficient of friction, and cutting angle.	Ti6Al4V	Surface roughness, tool wear, cutting angle, chip morphology, coefficient of friction	Mitutoyo SJ-210, tool microscope	(Singh et al., 2020)
Turning	CNC horizontal lathe	The aim is to examine the surface integrity of the workpiece during machining of AISI 420 workpieces.	AISI 420	Cutting force, surface roughness, microstructure	Kistler 9257B dynamometer, SJ-410, optical microscope	(Palanisamy et al., 2020)
Turning	Universal lathe	The aim is to compare machining conditions in dry and MQL environments when machining AISI 52100 steel alloy.	AISI 52100	Surface roughness, tool-workpiece interface temperature.	Mitutoyo SJ 310, thermocouple	(Rajarajan, Ramesh Kannan, & Dennison, 2022)

### Effect of Tool Wear in Turning

Tool wear in turning determines the friction, temperature, and stress fields in the cutting zone, directly affecting process stability, surface integrity, and productivity. While flank wear and surface roughness increase in austenitic stainless steels under dry conditions due to low thermal conductivity and work hardening, appropriate lubrication (especially MQL) can significantly improve these trends. The significant effects of the cutting environment and cutting speed on surface finish and force output have been experimentally demonstrated (Binali et al., 2023; Kara, 2017; Kara, Karabatak, Ayyıldız, & Nas, 2020; Kara & Öztürk, 2019; Barış Özlü, Demir, & Türkmen, 2019; Barış Özlü, Demir, Türkmen, & Gündüz, 2018; Salur, 2022). Similar results are observed in materials that are difficult to machine. In experiments conducted on the TC21 titanium alloy, speed and depth had the greatest impact on tool wear and roughness, and wear was significantly reduced with appropriate parameter combinations (medium-high speed, medium feed, and depth) (Sobh, Sayed, Barakat, & Elshaer, 2023). Innovative approaches at the process level can also reduce wear load. Preheating the workpiece in laser-assisted hard turning has been shown to reduce forces and roughness; such load reduction creates an environment that positively influences wear tendency by limiting the thermo-mechanical stress to which the tool is exposed (Sahoo, Dutta, Bartarya, Mullick, & Nayak, 2023). The wear mechanism in particle reinforced Al matrix composites is mostly abrasive. In the turning of AA6061/(ZrB<sub>2</sub>-ZrC) hybrid reinforced composites with PCD tools, tool wear was reported to accelerate as speed and depth, as well as as reinforcement content, increased; however, at low speeds, the formation of stuck edge (BUE) increased, changing the wear patterns (Ruban et al., 2023). These findings indicate that the mechanisms specific to the material-tool pair (abrasive wear/adhesion/BUE) are sensitive to the cutting speed, thus the correct selection of the parameter window is critical on the

life (Ruban et al., 2023). In machining Ti6Al4V alloy, tool geometry and cooling methods must be combined to manage tool and material interaction. The use of laser-textured tools in combination with graphene-reinforced MQL has increased tool life compared to dry conditions (Singh et al., 2020; Yi et al., 2020). The cutting environment and lubrication strategies significantly alter the course of tool wear. Extensive experiments on turning AISI 304 have shown that MQL reduces wear by producing lower temperatures and forces compared to dry cutting, while vegetable-based oils, as an alternative to mineral-based oils, provide additional improvements in wear and roughness (Binali et al., 2023). In this context, nanofluid MQL stands out. In the hard turning of 90CrSi, Al<sub>2</sub>O<sub>3</sub>/MoS<sub>2</sub> hybrid nanofluids significantly reduced cutting temperature, cutting and thrust forces, and surface roughness compared to single nanofluids and pure MQL. They also improved wear performance by reducing friction and thermal loads to which the tool was exposed through increased cooling and lubrication. Furthermore, studies have shown that the BUE tendency is suppressed under nanofluid MQL conditions due to tribo-film formation and the "micro-bearing" effect (Ngoc et al., 2023). Another demonstration of the parameter-temperature-wear relationship is dry turning of copper alloys, where the thermal load is directly monitored. When the combined effects of speed, feed and depth of cut on tool tip temperature and surface output are systematically optimized, it has been observed that the risk of wear can be controlled by reducing the process temperature (Tefera et al., 2023). When all these results are considered together, it can be seen that as cutting speed and depth of cut increase, the thermo-mechanical load increases and accelerates wear, that the mechanism transitions (abrasive-adhesion) depending on the material-tool match can be managed with speed and lubrication, and that load-reducing process innovations such as MQL, especially hybrid nanofluids, have the potential to reduce wear and extend tool life (Binali et al., 2023; Ngoc et al., 2023; Ruban et al., 2023; Sahoo et al., 2023). An abstract of some of the studies conducted is given in Table 3.

**Table 3.** Literature review on tool wear studies.

Process	Machine	Purpose	Used material	Output parameters	Measurement tools	Reference
Turning	Universal lathe	To experimentally investigate the effects of machining method, speed, and vibration frequency on cutting tool life during the machining of AISI 52100 bearing steel by ultrasonic turning and conventional turning methods.	AISI 52100 bearing steel	Cutting speed, machining method, tool wear, tool life	Optical microscope, vibration generator	(Ağar et al.)
Turning	CNC horizontal lathe	To examine the machinability performance of Inconel 718 under different microstructure conditions and to prepare the	Inconel 718 nickel-based superalloy	Cutting forces, tool wear, tool life, MRR, chip morphology (SEM observations)	Kistler 9129A dynamometer, Kistler 5070A dynamometer, Kistler 5697A dynoware software, scanning electron	(Matos et al., 2023)

		ground for both industrial cutting optimization and numerical modeling (simulation) studies with these data.			microscope, instron 5900R tester, optical microscope.	
Turning	CNC horizontal lathe	To contribute to the optimization of cutting parameters by defining the machinability behavior of this new Al-Si based alloy.	Al-9Si-0,1Sr-0,6Mg alloy	Cutting force, surface roughness, chip formation, tool wear	Kistler 9257A dynamometer, Kistler 5070A amplifier, Mahr Perthometer, optical microscope, ICP-OES spectrometer	(Hekimoğlu & Bayraktar, 2023)
Turning	Universal lathe	To focus the effect of MgO (magnesia) particles of different sizes on the machinability properties of Al 2024 matrix composites.	Al 2024 aluminum alloy	Surface roughness, chip form, cutting tool wear	MarSurf PS1 portable roughness measuring device, scanning electron microscope	(Pul, 2023)
Turning	Universal lathe	To reveal the effects of cutting speed, feed, depth of cut and reinforcement percentage on forces and roughness in dry turning of AA6061/ZrB <sub>2</sub> -ZrC hybrid; and also to investigate the tool, surface and chip morphology.	AA6061/ZrB <sub>2</sub> -ZrC composite	Cutting forces, surface roughness, tool surface morphology, chip morphology, machined surface morphology	Kistler 9257B dynamometer, Mitutoyo SJ-210, scanning electron microscope	(Ruban et al., 2023)
Turning	CNC horizontal lathe	The aim is to conduct an integrated experimental investigation using tool-based and coolant strategies for the sustainable machining of Ti6Al4V alloy.	Ti6Al4V	Cutting forces, tool wear, chip formation, chip morphology	Kistler 9129AA dynamometer, optical microscope, X-ray spectrometer (Bruker-ASX QuanTax200)	(Mishra, Ghosh, & Aravindan, 2020)
Turning	CNC milling machine	The aim is to experimentally investigate the performance of graphene oxide-based cutting fluid in turning Ti6Al4V workpieces.	Ti6Al4V	Cutting force, tool wear, cutting vibration	Kistler 9257B and Kistler 5070A dynamometers, scanning electron microscope, alicona microscope, energy dispersive spectroscopy	(Yi et al., 2020)

Turning	CNC horizontal lathe	The aim is to investigate the performance of a whisker-reinforced cutting tool in turning Co-based Haynes 25 alloy.	Co-based Haynes 25 alloy	Tool wear, surface roughness, cutting temperature, microhardness, surface topography, notch wear.	Scanning electron microscope, optical profilometer, Mahr Marsurf PS 10, thermal camera, hardness tester	(Sarıkaya, Şirin, Yıldırım, Kıvak, & Gupta, 2021)
---------	----------------------	---	--------------------------	---	---	---

## Discussion and Results

The turning process initially determines the type and flow of the chip produced by the interaction between the tool and the workpiece. This interaction shapes the contact conditions, directly influencing the cutting mechanism and the primary output parameters (roughness, tool wear, and cutting forces). Correctly regulating the contact conditions, including speed, feed, depth, coolant selection, tool material, coating, and cutting environment (dry, cryogenic, etc.), determines the quality of the machining dynamics and the resulting output. Machined surface quality can be reliably predicted using predictive models that consider cutting conditions, vibration levels, and tool wear. When experiments using the appropriate parameters derived from these approaches are combined with in-cycle monitoring, process stability is increased and the need for rework is reduced.

Cutting forces are one of the most decisive indicators of surface integrity in turning. As edge sharpness decreases and local friction at the cutting-edge increases, these forces increase. This, combined with fluctuating contact conditions, can lead to increased roughness and increased surface undulations. As tool wear progresses (especially flank wear and crater wear), tool geometry changes dramatically. This disrupts cutting edge micromorphology, increasing forces, affecting chip continuity, and leading to irregularities in surface geometry. Utilizing optimal cutting parameters throughout the initial, steady-state, and accelerated wear stages is critical for both maintaining surface quality and extending tool life.

In turning operations, the evaluation of machinability is not limited solely to cutting forces, tool wear, and surface quality. Material removal rate, which directly represents machining efficiency and productivity, is also a critical evaluation criterion for machinability. Material removal rate reveals the economic dimension of the process by expressing the amount of material removed per unit time. In this respect, when interpreted together with quality-oriented indicators such as surface roughness and tool life, it offers a more realistic and holistic machinability assessment for the turning operation. However, in most scenarios, parameter selections aimed at increasing material removal rate in the literature increase cutting forces and the thermal load of the cutting zone, thus making material removal rate, surface roughness, and tool wear an integral part of machinability. Therefore, material removal rate should be evaluated within the framework of a multi-criteria optimization approach together with surface roughness, cutting forces, and tool wear. Furthermore, some studies have reported that "maximum metal removal rate" is achieved for certain parameter combinations in the turning of aluminum alloys, and such findings support the explicit discussion of productivity-oriented parameter selection in the conclusion section (Hekimoğlu & Bayraktar, 2023; Pul, 2023; Ruban et al., 2023).

In terms of real-time monitoring, dynamometers, infrared thermal imaging, accelerometers, and acoustic emission sensors are widely and effectively used to reliably

monitor both force-temperature fields and tool condition in turning. Tool microscopy and SEM observations play a complementary role in verifying wear mechanisms. Establishing effective tools based on physics and the resulting optimal parameters using these multiple data sources allows for successful prediction of surface roughness and power consumption through force/wear indicators, thereby improving process energy efficiency.

The use of coolant in turning operations directly affects the thermal and tribological conditions in the cutting zone, playing a significant role in determining machinability. Literature confirms that MQL with nanofluid additives, compared to dry conditions, reduces cutting temperature and tool wear, thereby improving surface quality. Studies using hybrid nanofluids have shown more stable cutting forces and higher-quality surfaces. Furthermore, cryogenic cooling has been found to significantly reduce cutting temperatures, extend tool life, and improve surface quality, especially for titanium-based and difficult-to-machine materials. However, some studies emphasize that the effect of cooling strategies on cutting forces can vary depending on the material type and process parameters. This suggests that cooling and lubrication methods should be considered as multiple performance criteria rather than a single output parameter in machinability evaluation (Aydın, 2023; Binali et al., 2023; Demirbaş, 2023; Singh et al., 2020).

Sustainability-focused cutting environments are crucial for managing tool wear. Strategies that provide minimal friction and adequate heat removal (MQL, plant-based oils, cryogenic/CO<sub>2</sub>-assisted solutions) reduce both forces and temperatures at the tool-material interface, reducing wear rates and improving surface finish. In this context, in alloys with challenging machinability, particle-reinforced composites, and hybrid composites, chip type and flow are practical indicators of mechanism transitions. By selecting the optimal parameter range, undesirable chip forms and adverse contact conditions can be mitigated, leading to improved machining results.

As a result, the ways to achieve high and consistent surface quality and long tool life in turning are;

- Managing the cutting forces-temperature-wear triangle together
- Correct matching of tool geometry/coating and material pair
- The use of predictive modeling-design of experiments approaches fed by online sensor data.

This holistic approach reduces energy consumption and tool change costs while increasing process stability, providing a repeatable, economical and sustainable turning strategy on an industrial scale.

## **References**

- Ağar, S., Mahmat, A., & Tosun, N. Investigation Of Cutting Tool Life By Ultrasonic Turning Method Of Aisi 52100 Bearing Steel.
- Airao, J., Nirala, C. K., Bertolini, R., Krolczyk, G. M., & Khanna, N. (2022). Sustainable cooling strategies to reduce tool wear, power consumption and surface roughness during ultrasonic assisted turning of Ti-6Al-4V. *Tribology International*, 169, 107494.
- Akgün, M., & Demir, H. (2021). Optimization of cutting parameters affecting surface roughness in turning of inconel 625 superalloy by cryogenically treated tungsten carbide inserts. *SN Applied Sciences*, 3(2), 277.

- Akgün, M., Özlü, B., & Kara, F. (2023). Effect of PVD-TiN and CVD-Al<sub>2</sub>O<sub>3</sub> coatings on cutting force, surface roughness, cutting power, and temperature in hard turning of AISI H13 steel. *Journal of Materials Engineering and Performance*, 32(3), 1390-1401.
- Aydın, E. (2023). Geleneksel ve bitkisel tabanlı kesme sıvılarının insan/çevre sağlığı ve işlenebilirlik bakımından değerlendirilmesi. *Niğde Ömer Halisdemir Üniversitesi Mühendislik Bilimleri Dergisi*, 12(4), 1360-1371.
- Bagga, P. J., Makhesana, M. A., Patel, K., & Patel, K. M. (2021). Tool wear monitoring in turning using image processing techniques. *Materials Today: Proceedings*, 44, 771-775.
- Behera, G. C., Thrinadh, J., & Datta, S. (2021). Influence of cutting insert (uncoated and coated carbide) on cutting force, tool-tip temperature, and chip morphology during dry machining of Inconel 825. *Materials Today: Proceedings*, 38, 2664-2670.
- Binali, R. (2023). Parametric optimization of cutting force and temperature in finite element milling of AISI P20 steel. *Journal of Materials and Mechatronics: A*, 4(1), 244-256.
- Binali, R. (2024). Experimental and machine learning comparison for measurement the machinability of nickel based alloy in pursuit of sustainability. *Measurement*, 236, 115142.
- Binali, R., Demirpolat, H., Kuntoğlu, M., & Kaya, K. Exploring the Tribological Performance of Mist Lubrication Technique on Machinability Characteristics During Turning S235JR Steel. *Manufacturing Technologies and Applications*, 5(3), 276-283.
- Binali, R., Demirpolat, H., Kuntoğlu, M., & Salur, E. (2023). Different aspects of machinability in turning of AISI 304 stainless steel: a sustainable approach with MQL technology. *Metals*, 13(6), 1088.
- Binali, R., Korkmaz, M. E., Özdemir, M. T., & Günay, M. (2025). A Holistic Perspective on Sustainable Machining of Al6082: Synergistic Effects of Nano-Enhanced Bio-Lubricants. *Machines*, 13(4).
- Binali, R., & Kuntoğlu, M. (2023). Evaluation of Machining Parameters Affecting Cutting Forces in Dry Turning of GGG50 Ductile Cast Iron. *Türk Doğa ve Fen Dergisi*, 12(2), 55-60.
- Binali, R., Patange, A. D., Kuntoğlu, M., Mikolajczyk, T., & Salur, E. (2022). Energy saving by parametric optimization and advanced lubri-cooling techniques in the machining of composites and superalloys: A systematic review. *Energies*, 15(21), 8313.
- Binali, R., Yaldız, S., & Neşeli, S. (2021). S960QL yapı çeliğinin işlenebilirliğinin sonlu elemanlar yöntemi ile incelenmesi. *Avrupa Bilim ve Teknoloji Dergisi*(31), 85-91.
- da Silva, L. R. R., Pereira, A. C., Monteiro, S. N., Kuntoğlu, M., Binali, R., Khan, A. M., . . . Pimenov, D. Y. (2025). Review of advances and challenges in machining of metal matrix composites. *Journal of Materials Research and Technology*, 37, 1061-1085.
- Demirbaş, A. (2023). *Monel 400 alaşımının kriyojenik koşullar altında işlenebilirliğinin araştırılması*. Karamanoğlu Mehmetbey Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi.

- Demirpolat, H. (2024). Evaluation of the turning parameters of AISI 5115 steel in dry and MQL cutting environments with the use of a coated carbide cutting insert: An experimental study. *Journal of Materials and Mechatronics: A*, 5(1), 168-182.
- Demirpolat, H., Kuntoğlu, M., & Binali, R. (2023). A review on machinability in the milling processes. *Sustainable Production, Instrumentation and Engineering Sciences*, 1.
- Elsheikh, A. H., Guo, J., Bai, K., & Lee, K.-M. (2020). *Improving clamping accuracy of thin-walled workpiece in turning operation*. Paper presented at the IOP Conference Series: Materials Science and Engineering.
- Erdem, S., Özdemir, M., Rafighi, M., & Yavuz, M. (2023). 1.2367 Sıcak İş Takım Çeliğinin Sert Tornalanmasında Kesme Parametrelerin Yüzey Pürüzlülüğü ve Kesme Kuvvetleri Üzerinde Etkisi. *Politeknik Dergisi*, 26(3), 1071-1077.
- Gupta, M. K., Korkmaz, M. E., Sarıkaya, M., Krolczyk, G. M., Günay, M., & Wojciechowski, S. (2022). Cutting forces and temperature measurements in cryogenic assisted turning of AA2024-T351 alloy: An experimentally validated simulation approach. *Measurement*, 188, 110594.
- Hekimoğlu, A. P., & Bayraktar, Ş. (2023). Al-9Si-0.1 Sr-0.6 Mg Alaşımının Tornalanmasında İşlenebilirlik Karakteristiklerinin Araştırılması. *International Journal of Engineering Research and Development*, 15(2), 517-525.
- Jiang, H., He, L., Ren, Z., Shao, F., & Yuan, S. (2020). Prediction of residual stress in the process of turning high strength alloy steel by innovative coated carbide microgroove tools. *The International Journal of Advanced Manufacturing Technology*, 106(11), 4693-4705.
- Kağıtıcı, Y. Ç., & Neşeli, S. (2024). The effect of cutting forces on bone related operational processes: a literature review. *Konya Journal of Engineering Sciences*, 12(3), 801-821.
- Kara, F. (2017). Taguchi optimization of surface roughness and flank wear during the turning of DIN 1.2344 tool steel. *Materials Testing*, 59(10), 903-908.
- Kara, F., Karabatak, M., Ayyıldız, M., & Nas, E. (2020). Effect of machinability, microstructure and hardness of deep cryogenic treatment in hard turning of AISI D2 steel with ceramic cutting. *Journal of Materials Research and Technology*, 9(1), 969-983.
- Kara, F., & Öztürk, B. (2019). Comparison and optimization of PVD and CVD method on surface roughness and flank wear in hard-machining of DIN 1.2738 mold steel. *Sensor Review*, 39(1), 24-33.
- Kaya, K., Çetin, T., Binali, R., & Gündoğmuş, H. An Investigation of Machinability of Hot Work Tool Steel Toolox 44 with Cutting Tools with Different Nose Radius Using Machine Learning. *Manufacturing Technologies and Applications*, 6(2), 164-183.
- Kaya, K., Çetin, T., Binali, R., & Gündoğmuş, H. (2025). Finish turning of toolox 33 to improve machining parameters with different nose radius tools. *European Mechanical Science*, 9(3), 234-245.
- Khanna, N., Airao, J., Nirala, C. K., & Krolczyk, G. M. (2022). Novel sustainable cryo-lubrication strategies for reducing tool wear during ultrasonic-assisted turning of Inconel 718. *Tribology International*, 174, 107728.
- Korkmaz, M. E., & Gupta, M. K. (2024). A state of the art on cryogenic cooling and its applications in the machining of difficult-to-machine alloys. *Materials*, 17(9), 2057.

- Korkmaz, M. E., Gupta, M. K., Çelik, E., Ross, N. S., & Günay, M. (2024). A sustainable cooling/lubrication method focusing on energy consumption and other machining characteristics in high-speed turning of aluminum alloy. *Sustainable Materials and Technologies*, 40, e00919.
- Korkmaz, M. E., Gupta, M. K., Günay, M., Boy, M., Yaşar, N., Demirsoez, R., . . . Abbas, Y. (2023). Comprehensive analysis of tool wear, surface roughness and chip morphology in sustainable turning of Inconel-601 alloy. *Journal of Manufacturing Processes*, 103, 156-167.
- Korkmaz, M. E., Gupta, M. K., Li, Z., Krolczyk, G. M., Kuntoğlu, M., Binali, R., . . . Pimenov, D. Y. (2022). Indirect monitoring of machining characteristics via advanced sensor systems: a critical review. *The International Journal of Advanced Manufacturing Technology*, 120(11), 7043-7078.
- Kul, B. S. Effect of Cutting Parameters in Turning of AISI 1015 Steel: Comparison of Dry and MQL Conditions. *European Journal of Technique (EJT)*, 14(2), 154-159.
- Kul, B. S., & Yamaner, A. S. A Comparative Evaluation of Dry-MQL Turning Applications for AISI 5115 Steel. *Manufacturing Technologies and Applications*, 6(1), 23-32.
- Kuntoğlu, M., Acar, O., Gupta, M. K., Sağlam, H., Sarikaya, M., Giasin, K., & Pimenov, D. Y. (2021). Parametric optimization for cutting forces and material removal rate in the turning of AISI 5140. *Machines*, 9(5), 90.
- Kuntoğlu, M., Binali, R., Demirpolat, H., & Makhesana, M. (2025). Built-up-edge Formation and its Effect on Surface Topography and Machinability Indicators in Sustainable Minimum Quantity Lubrication Turning of Al2024-T6. *Journal of Materials Engineering and Performance*, 1-12.
- Kuntoğlu, M., Demirpolat, H., Binali, R., Korkmaz, M. E., Makhesana, M., & Kaya, K. (2025). Sustainable Lubrication Strategies in Eco-friendly Machining of AISI 4140 Steel: Performance and Environmental Impact Analysis Using Machine Learning. *Journal of Materials Engineering and Performance*, 1-17.
- Kuntoğlu, M., Kaya, K., & Binali, R. (2023). *Investigation of surface roughness changes in the machining of carbon steel under sustainable conditions*. Paper presented at the Int. Conf. Pioneer Innov. Stud.
- Mahapatro, K., & Krishna, P. V. (2023). Machinability study in turning of Ti-6Al-4V under CO<sub>2</sub>-based vortex tube cooling system. *International Journal of Automotive and Mechanical Engineering*, 20(1), 10298.
- Makhesana, M. A., Patel, K., Ghetiya, N., Binali, R., & Kuntoğlu, M. (2024). Evaluation of drilling and hole quality characteristics in green machining aluminium alloys: A new approach towards green machining. *Journal of Manufacturing Processes*, 129, 176-186.
- Makhesana, M. A., Patel, K. M., Krolczyk, G. M., Danish, M., Singla, A. K., & Khanna, N. (2023). Influence of MoS<sub>2</sub> and graphite-reinforced nanofluid-MQL on surface roughness, tool wear, cutting temperature and microhardness in machining of Inconel 625. *CIRP Journal of Manufacturing Science and Technology*, 41, 225-238.
- Matos, F., Silva, T., Marques, F., Figueiredo, D., Rosa, P., & De Jesus, A. (2023). Machinability assessment of Inconel 718 turning using PCBN cutting tools. *Procedia CIRP*, 117, 468-473.

- Mikolajczyk, T., Paczkowski, T., Kuntoglu, M., Patange, A. D., & Binali, R. (2022). Research on using an unconventional tool for increasing tool life by selective exchange of worn cutting edge. *Applied Sciences*, 13(1), 460.
- Mishra, S. K., Ghosh, S., & Aravindan, S. (2020). Machining performance evaluation of Ti6Al4V alloy with laser textured tools under MQL and nano-MQL environments. *Journal of Manufacturing Processes*, 53, 174-189.
- Nas, E., & Altan Özbek, N. (2020). Optimization of the machining parameters in turning of hardened hot work tool steel using cryogenically treated tools. *Surface Review and Letters*, 27(05), 1950177.
- Ngoc, T. B., Duc, T. M., Tuan, N. M., Hoang, V. L., & Long, T. T. (2023). Machinability assessment of hybrid nano cutting oil for minimum quantity lubrication (MQL) in hard turning of 90CrSi steel. *Lubricants*, 11(2), 54.
- Ozlu, B., & Ugur, L. (2021). Optimization of cutting forces on turning of Ti-6Al-4V Alloy by 3D FEM simulation analysis. *Journal of Engineering Research and Applied Science*, 10(2), 1789-1795.
- Özlü, B. (2021). Investigation of the effect of cutting parameters on cutting force, surface roughness and chip shape in turning of Sleipner cold work tool steel. *Journal of the Faculty of Engineering and Architecture of Gazi University*, 36(3), 1241-1251.
- ÖZLÜ, B. (2022). Evaluation of energy consumption, cutting force, surface roughness and vibration in machining toolox 44 steel using taguchi-based gray relational analysis. *Surface Review and Letters*, 29(08), 2250103.
- Özlü, B., & Akgün, M. (2024). Evaluation of the machinability performance of PH 13-8 Mo maraging steel used in the aerospace industry. *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering*, 238(2), 687-699.
- Özlü, B., Akgün, M., & Demir, H. (2019). AA 6061 Alaşımının tornalanmasında kesme parametrelerinin yüzey pürüzlülüğü üzerine etkisinin analizi ve optimizasyonu. *Gazi Journal of Engineering Sciences*, 5(2), 151-158.
- Özlü, B., Demir, H., & Türkmen, M. (2019). The effect of mechanical properties and the cutting parameters on machinability of AISI 5140 steel cooled at high cooling rates after hot forging. *Politeknik Dergisi*, 22(4), 879-887.
- Özlü, B., Demir, H., Türkmen, M., & Gündüz, S. (2018). Investigation of machinability of cooled microalloy steel in oil after the hot forging with coated and uncoated CBN cutting tools. *Sigma Journal of Engineering and Natural Sciences*, 36(4), 1165-1174.
- Özlü, B., Demir, H., Türkmen, M., & Gündüz, S. (2021). Examining the machinability of 38MnVS6 microalloyed steel, cooled in different mediums after hot forging with the coated carbide and ceramic tool. *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, 235(22), 6228-6239.
- Özlü, B., & Uğur, L. (2023a). Investigation of Cutting Forces in Turning of AISI 316L Stainless Steel with Experimental and Finite Element Analysis on Prediction with Artificial Neural Networks. *Gaziosmanpaşa Bilimsel Araştırma Dergisi*.
- Özlü, B., & Uğur, L. (2023b). Monel 400 Nikel Esaslı Süper Alaşımın Tornalanmasında Oluşan Kesme Kuvveti Bileşenlerinin Değerlendirilmesi ve Yapay Sinir Ağları ile Modellenmesi. *Adıyaman Üniversitesi Mühendislik Bilimleri Dergisi*, 10(21), 252-265.

- Özlu, B., Uğur, L., & Yıldız, A. (2023). AISI 420 Çeliğinin Tornalamasında Kesme Parametrelerinin Yüzey Pürüzlülüğüne Etkisinin Sonlu Elemanlar Analizi ve Taguchi Deney Tasarımıyla İncelenmesi. *Bayburt Üniversitesi Fen Bilimleri Dergisi*, 6(2), 232-241.
- Öztürk, B., & Kara, F. (2025). A new specific carbon footprint (SCF) theory of serial aluminum alloys in hard turning. *Multidiscipline Modeling in Materials and Structures*.
- Palanisamy, D., Devaraju, A., Arulkirubakaran, D., & Manikandan, N. (2020). Experimental investigation on surface integrity during machining of AISI 420 steel with tungsten carbide insert. *Materials Today: Proceedings*, 22, 992-997.
- Pimenov, D. Y., da Silva, L. R. R., Kuntoğlu, M., Abrão, B. S., dos Santos Paes, L. E., & Linul, E. (2025). Review of advanced sensor system applications in grinding operations. *Journal of Advanced Research*.
- Pul, M. (2023). Al 2024 Matrisli Farklı Boyutlarda MgO Takviyeli Kompozitlerin Farklı Kesici Takımlarla Tornalanmasında Yüzey Pürüzlülüğü Takım Aşınması ve Talaş Formunun İncelenmesi. *Duzce University Journal of Science and Technology*, 11(1), 399-413.
- Rajarajan, S., Ramesh Kannan, C., & Dennison, M. S. (2022). A comparative study on the machining characteristics on turning AISI 52100 alloy steel in dry and microlubrication condition. *Australian Journal of Mechanical Engineering*, 20(2), 360-371.
- Ross, N. S., Mashinini, P. M., Shibi, C. S., Gupta, M. K., Korkmaz, M. E., Krolczyk, G. M., & Sharma, V. S. (2024). A new intelligent approach of surface roughness measurement in sustainable machining of AM-316L stainless steel with deep learning models. *Measurement*, 230, 114515.
- Ruban, S. R., Dev Wins, K. L., Raja Selvam, J. D., & S Rai, R. (2023). Influence of turning parameters on the machinability of Al6061/ZrB<sub>2</sub> & ZrC hybrid in-situ Aluminium Matrix Composite. *Australian Journal of Mechanical Engineering*, 21(4), 1218-1229.
- Sahoo, M. R., Dutta, P., Bartarya, G., Mullick, S., & Nayak, R. K. (2023). Numerical modeling and experimental study of laser-assisted hard turning of EN31 steel for enhanced surface integrity. *The International Journal of Advanced Manufacturing Technology*, 128(3), 1015-1028.
- Salur, E. (2022). Understandings the tribological mechanism of Inconel 718 alloy machined under different cooling/lubrication conditions. *Tribology International*, 174, 107677.
- Salur, E., Okcu, N., Korkmaz, M. E., Kaya, K., Binali, R., & Çetinkal, S. B. (2025). Effect of Cooling/Lubrication Conditions on Machining Performance: An Experimental Investigation of 1040 Steel Under Dry, MQL, and Nano-MQL Environments. *Materials*, 18(17), 4063.
- Sarıkaya, M., Şirin, Ş., Yıldırım, Ç. V., Kıvak, T., & Gupta, M. K. (2021). Performance evaluation of whisker-reinforced ceramic tools under nano-sized solid lubricants assisted MQL turning of Co-based Haynes 25 superalloy. *Ceramics international*, 47(11), 15542-15560.
- Sekmen, M., Kurt, A., & Şeker, U. (2023). Talaş Kaldırma İşleminde Sürtünme Katsayısının Kesme Kuvvetleri, Sıcaklık ve Kesici Takım Gerilmeleri Üzerine Etkisi. *Journal of the Institute of Science and Technology*, 13(2), 1176-1188.

- Selvakumar S, J., & Raj. D, S. (2024). Machinability analysis during finish turning Ti6Al4V with varying cutting edge radius. *Materials and Manufacturing Processes*, 39(1), 144-160.
- Sharma, A. K., Tiwari, A. K., Dixit, A. R., & Singh, R. K. (2020). Measurement of machining forces and surface roughness in turning of AISI 304 steel using alumina-MWCNT hybrid nanoparticles enriched cutting fluid. *Measurement*, 150, 107078.
- Singh, R., Dureja, J., Dogra, M., Gupta, M. K., Mia, M., & Song, Q. (2020). Wear behavior of textured tools under graphene-assisted minimum quantity lubrication system in machining Ti-6Al-4V alloy. *Tribology International*, 145, 106183.
- Sivalingam, V., Zhou, Q., Manickajothi, G., Ross, N. S., Sun, J., Gupta, M. K., . . . Nagamalai, T. (2023). Understanding the machining characteristics of Al6082 hybrid metal matrix composites milled under cryogenic cooling conditions. *The International Journal of Advanced Manufacturing Technology*, 129(7), 3387-3402.
- Sobh, A. S., Sayed, E. M., Barakat, A. F., & Elshaer, R. N. (2023). Turning parameters optimization for TC21 Ti-alloy using Taguchi technique. *Beni-Suef University Journal of Basic and Applied Sciences*, 12(1), 20.
- Şap, S., Usca, Ü. A., Uzun, M., Kuntoğlu, M., & Salur, E. (2022). Performance evaluation of AlTiN coated carbide tools during machining of ceramic reinforced Cu-based hybrid composites under cryogenic, pure-minimum quantity lubrication and dry regimes. *Journal of Composite Materials*, 56(22), 3401-3421.
- Tefera, A. G., Sinha, D. K., & Gupta, G. (2023). Experimental investigation and optimization of cutting parameters during dry turning process of copper alloy. *Journal of Engineering and Applied Science*, 70(1), 145.
- Turkes, E., Orak, S., Neşeli, S., Sahin, M., & Selvi, S. (2017). Modelling of dynamic cutting force coefficients and chatter stability dependent on shear angle oscillation. *The International Journal of Advanced Manufacturing Technology*, 91(1), 679-686.
- Uğur, L., Kazan, H., & Özlü, B. (2022). Investigation of the impacts of cutting parameters on power usage in cryogenic-assisted turning of AISI 52100 bearing steel by FEM. *Manufacturing Technologies and Applications*, 3(3), 55-61.
- Usha, M., & Rao, G. S. (2020). Optimisation of parameters in turning using herbal based nano cutting fluid with MQL. *Materials Today: Proceedings*, 22, 1535-1544.
- Yamaner, A. S., & Kul, B. S. (2025). Evaluation of tool radius and machining parameters on cutting forces and surface roughness for AA 6082 aluminum alloy. *European Mechanical Science*, 9(2), 125-138.
- Yaşar, N., Korkmaz, M. E., & Günay, M. (2017). *Investigation on hole quality of cutting conditions in drilling of CFRP composite*. Paper presented at the MATEC web of conferences.
- Yi, S., Li, J., Zhu, J., Wang, X., Mo, J., & Ding, S. (2020). Investigation of machining Ti-6Al-4V with graphene oxide nanofluids: Tool wear, cutting forces and cutting vibration. *Journal of Manufacturing Processes*, 49, 35-49.
- Yurtkuran, H., Korkmaz, M. E., Gupta, M. K., Yılmaz, H., Günay, M., & Vashishtha, G. (2024). Prediction of power consumption and its signals in sustainable turning of PH13-8Mo steel with different machine learning models. *The International Journal of Advanced Manufacturing Technology*, 133(5), 2171-2188.