International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

# "Investigation of Surface Finish in Turning Operations Using Adhesively Mounted Cutting Tools"

**VIVEK PATIL**
Research Scholar
Department of Mechanical Engineering.
Kalinga University, Raipur (C.G.)

**DR. NURESH KUMAR KHUNTE**
Research Supervisor
Department of Mechanical Engineering.
Kalinga University, Raipur (C.G.)

***Abstract:*** The surface finish plays a major role in turning operations as it influences the dimensional correctness, functioning performance, resistance to wear, and useful life of the produced parts. The surface quality of the manufactured part depends on the vibration, conditions of tool fixing, etc. The conventional turning process usually employs mechanical fastening of cutting inserts, causing certain stresses, micro-movements, and vibration during turning process in local places. Another way of supporting or attaching the cutting tool is to use adhesive attachment of cutting tools which can be used for the support of the cutting tool; it can be used to distribute the overall load more evenly and it can offer better vibration damping effects.

In the present study, SGM investigates the surface finish that is achievable in turning with cutting tools that are fixed in place with an adhesive. studied under certain controlled cutting conditions. Surface roughness is taken as the major response parameter for the evaluation of machining performance. The study also investigates the stability of the adhesively bonded tool in cutting operation and its ability to generate consistent surface finish. The outcomes are hoped to give valuable information about the possibility of an adhesive tool mounting and its capabilities in precision turning operations.

***Keywords:*** Adhesive mounting, Turning, Surface finish, Surface roughness, Cutting tool, Machining parameters.

## Introduction:

In industries, cylindrical and rotation parts with shape and dimensions to the desired one and surface quality. Turning refers to a single-piece cutting operation in which the material to be removed from the part comes into contact with a single-point cutting tool that also rotates in a circle. The various criteria used to assess the results of the turning process are basically such that dimensional accuracy, material removal rate, tool life, cutting forces, machining cost and surface finish.

Of these, the surface finish is an important factor as it has an impact on the performance of the final product. A poorly finished surface can cause friction, promote wear, minimize fatigue strength, and the fit of mating parts will be compromised. So, it is significant that the surface roughness is minimized and maintained at a consistent level in precision manufacturing.

The surface finish in turning depends upon various factors related to machining and tool. The speed at which a particular material is sliced depends on how fast the difference in velocities

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

that exists between the cutting edge and the material undercut. traverses a workpiece during each turn of the feed rotation. The thickness of the material taken off during the operation of machining gives the depth of cut. Changes in these parameters may greatly influence the cutting temperature, cutting forces, chip formation, vibration, and ultimately products made.

The location of the cutting tool can also have an impact on machine stability. Typically, in a conventional tool holder the cutting inserts are fixed into place by being either secured by a screwing system, or secured by a clamping system, or engaged in a wedging system, or other mechanical systems. These methods offer a certain degree of assurance regarding the correct positioning of the tools, but these positioning tools introduce a concentrated contact stress situation and small tool–holding interface movement in mechanical mounting. In specific machining conditions these effects can give rise to vibrations and degrade the surface finish.

Another method is adhesively mounting in which a special glue can be used to attach the cutting tool or the insert to the tool holder. The adhesive layer could be thicker and spread out the cutting loads at many points; this adhesive layer could also provide more damping to the cutting vibrations. This can help to ensure a more stable vibration at the cutting edge, potentially enhancing the stability of the tool and creating a smoother surface in the part.

The performance of the adhesively bonded cutting tool, however depends on a variety of factors such as the bonding strength, bond thickness, curing conditions, cutting temperature, cutting forces and selected cutting parameters. It is therefore important to study the relationship between the rigidity and stability of the adhesive joint achieved during the machining process and to assess joint.

surface finish produced during adhesion mounted turning operation was evaluated. Experimental tests of can be run at different levels, keeping other machining conditions at appropriate levels. The surface roughness data measured after the n machining tests will then be able to quantify the effect of each machining process parameters.

The research will help develop alternative cutting tool mounting methodology that would gain the ability to provide a more stable and better cutting surface quality with the machining process. The results can also be utilized to determine appropriate machining conditions for better surface finish with adhesively attached cutting tools in actual practical turning operations.

**Review of Literature:**

Surface finish is one of the pertinent quality parameters of a machine as it influences dimensional accuracy, friction characteristics, resistance to wear, fatigue characteristics and service behaviour of the product to be produced. Turning parameters vibration and cooling conditions will affect the surface roughness. Experimental, statistical and intelligent modeling techniques have been used by several researchers to study these factors.

Lalwani, et al., (2008) experimentally examined the cutting force and cutting surface roughness effect due to cutting parameters for finish hard turning of MDN250 steel. They found that turning surface quality is directly affected by the machining parameters. The study has highlighted the significance of the selection of cutting parameters to obtain the minimum cutting forces and good surface quality.

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

Karaya et al. (2009) studied the prediction and control of surface roughness of CNC turning based on Artificial neural network. The study proved that the intelligent prediction methods are helpful in developing relations between the machining parameters and the surface roughness. The study showed that a neural network can help to predict the quality produced during the manufacturing process and optimize the cutting parameters before production.

Bouacha et al. (2010) investigated surface roughness and cutting forces when turning AISI 52100 bearing steel hard with CBN cutting tool. The application of RSM is used for statistical evaluation of the machining performance. Their investigation revealed that the effects of the machine's variables can be well-explained by a statistical modelling technique and that it is possible to determine the machining conditions to achieve desired surface quality and cutting force characteristics which can be achieved from a statistical model.

Aouici et al. (2012) conducted the surface roughness and cutting force components analysis for hard turning process using CBN tool. The prediction and optimisation models were built to seek the most appropriate cutting conditions. Their research showed the correlation between cutting parameters and cutting forces versus the surface roughness, and emphasized the need of optimization for the production of surfaces with superior integrity.

In this regard, Philip Selvaraj et al (2014) carried out a study on optimization of surface roughness, cutting force and tool wear of dry turning of nitrogen alloyed duplex stainless steel. For evaluation of the influence of the process variables, the Taguchi method was used. They found that it was unsuitable to set the machining parameters individually, because certain changes in the cutting conditions may result in simultaneous changes of surface roughness, cutting forces, and wear of the cutting tool. Study confirmed the advisability of using systematic designing of parameters in turning processes.

Agrawal et al. (2015) studied the prediction of surface roughness in hard turning of 4340 steel. They investigated developing predictive models for surface quality in the different cutting conditions. The study has shown that sophisticated modelling approaches can be beneficial for comprehending the intricate relations between machining variables and surface roughness.

Mia and Dhar (2016) studied the prediction of surface roughness in the hard turning process with application of artificial neural network in high pressure coolant situation. They determined that machining conditions and cooling conditions are both important factors when considering the quality of the machined surface. Application of an artificial neural network yielded a successful approach for predicting the surface roughness under different cutting conditions.

Alajmi and Almeshal (2020) developed an adaptive neuro-fuzzy inference system with a quantum-behaved particle swarm optimization to develop a prediction and optimization technique for surface roughness in turning. Their research gave some examples of hybrid artificial intelligence methods applications in machining optimization. The developed approach was to enhance the capability of prediction, and find the condition for machining to produce a better surface finish.

Abu-Mahfouz et al. (2021) studied the application of vibration signals to estimate the surface roughness in turning of stainless steel, using clustering methods. They studied the application

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

of cutting-tool vibration and surface quality and pointed out the intimate correlation between them. The vibration signals were demonstrated to have certain merits in characterizing the surface roughness and assessing the machining behaviour. This work is significant to studies involving tool mounting, since the manner in which the cutting tool is mounted can affect the way in which vibration can be transmitted to the product and the stability of the machining process.

In the diamond turning process of PMMA, the surface roughness was investigated by Mahajan et al. (2022), which examined the surface roughness caused by vibration of the tool. Their study has shown that vibration produced during the machining process could have a very strong effect on the quality of the surface produced. The research result showed the need to have a better control of tool vibrations for obtaining higher surface quality, in precision machining process.

Machno et al. (2024) conducted an optimization study of the turning process of Inconel 625 and aimed to improve the surface quality of the workpiece by finishing. Their work highlighted the ever-important issue of the optimization of machining parameters of difficult-to-machine materials. The study also revealed that high cutting forces and thermal loads associated with certain materials can be dealt with by adjusting the turning conditions carefully and enhance surface quality.

As a whole, surface roughness of the turned products is analyzed by means of the reviewed studies and it has been found that the surface roughness depends on: cutting parameters, cutting forces, tool wear, vibration, cooling condition and tool stability. Previous studies focused primarily on experimental studies, while recent studies focused on using statistical methods, artificial neural networks, neuro-fuzzy systems, optimization methods and vibration monitoring to predict the surface quality.

Most literature available is for conventional mechanically clamped cutting tools. Very little research has been conducted in this area, comparing the surface finish effects of different kinds of tool mounting methods. The use of an adhesive layer between the cutting tool and the tool holder may contribute to surface roughness; however, the tool–holder interface impact acoustic and vibrational behavior, stiffness, load distribution, cutting stability and in this way its effect on surface roughness.

Accordingly, the applicability of adhesively attached cutting tools to the turning process is worthy of further study. This study can be a useful guide to establish the stability of the tools used for adhesive mounting and to verify if the tool damping capabilities of adhesive mounting are beneficial in producing a good surface quality. The present investigation therefore deals with the effect of the surface texture obtained at various values when cutting with an adhesive bonded cutting tool.

**Objectives:**

1. To investigate the surface finish obtained during turning operations using adhesively mounted cutting tools.
2. To study the influence of cutting speed, feed rate, and depth of cut on surface roughness during turning.

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

3. To determine suitable machining conditions for achieving improved and consistent surface finish with adhesively mounted cutting tools.

**Methods:**

Experimental study was conducted to check the surface finish of turning process by adhesive attachment of cutting tool. The machining tests aimed to investigate surface roughness in the machining of the material. The three parameters of the machine were chosen because the results of the chipping process, the cutting forces, the vibrations and the surface quality of the processed parts, are significantly affected by these three parameters.

A conventional centre lathe was used for conducting the turning experiments. The material chosen for subjecting to tests was cylindrical workpieces of mild steel, as they are widely used in general engineering applications and their ability to be subjected to controlled turning experiments. The surface of the workpieces was cleaned and inspected before every trial of the machining process in order to have the same initial conditions.

A carbide cutting insert was glued onto a tool holder that was normally mechanically clamped, by employing a high bond strength structural adhesive. The contact surfaces of insert and tool holder contact surface were cleaned properly without any oil, dust, and other contaminants. A controlled adhesive layer was used between mating surfaces and the insert was carefully placed in order to achieve the correct cutting geometry. However, the bonded assembly was fully cured prior to machining.

Three combinations of cutting speed, cutting feed and cutting depth were taken into consideration. To generate adequate variations in the experimental conditions while maintaining the count of experiments reasonably low, a three-level experimental plan was employed.

**Analysis of the study:**

**Table 1. Machining Parameters and Their Levels**

| Machining Parameter | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Cutting Speed (m/min) | 80 | 120 | 160 |
| Feed Rate (mm/rev) | 0.10 | 0.15 | 0.20 |
| Depth of Cut (mm) | 0.50 | 1.00 | 1.50 |

Parameter ranges selected are low, medium and relatively high machined conditions. The range of each parameter allowed enabled the effects of each parameter to be studied separately with regard to surface roughness.

**Table 2. Experimental Setup and Material Details**

| Experimental Factor | Specification |
|---|---|
| Machining Process | External cylindrical turning |
| Machine Tool | Conventional centre lathe |
| Workpiece Material | Mild steel |
| Cutting Tool Material | Carbide insert |
| Tool Mounting Method | Adhesive bonding |
| Adhesive Type | High-strength structural adhesive |

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

| | |
|---|---|
| Machining Condition | Dry machining |
| Surface Quality Parameter | Surface roughness, Ra |
| Measurement Unit | µm |
| Number of Experimental Runs | 9 |

The work pieces were firmly secured in a lathe chuck for each machining trial. The cutting tool was positioned on the centre height of the work piece with an adhesive mounting system. The used were varied as per the experimental combination.

A new area of work piece was always used if more surface area needs to be machined to reduce the effect of the previous surface. The surface roughness was determined after every turn by measuring it with a surface roughness tester. The measurements were made in a direction normal to the machining. As the principal response parameter, the average surface roughness Ra was considered.

The results of the experimental runs and values are given in Table 3.

**Table 3. Experimental Results for Surface Roughness**

| Run | Cutting Speed (m/min) | Feed Rate (mm/rev) | Depth of Cut (mm) | Surface Roughness, Ra (µm) |
|---|---|---|---|---|
| 1 | 80 | 0.10 | 0.50 | 1.62 |
| 2 | 80 | 0.15 | 1.00 | 2.15 |
| 3 | 80 | 0.20 | 1.50 | 2.78 |
| 4 | 120 | 0.10 | 1.00 | 1.38 |
| 5 | 120 | 0.15 | 1.50 | 1.88 |
| 6 | 120 | 0.20 | 0.50 | 2.32 |
| 7 | 160 | 0.10 | 1.50 | 1.21 |
| 8 | 160 | 0.15 | 0.50 | 1.55 |
| 9 | 160 | 0.20 | 1.00 | 2.05 |

Average surface roughness (RMS) parameters were determined at various cutting speeds, feeds, and depths of cut per each parameter set to find relative influence of these three parameters:

**Table 4. Effect of Machining Parameters on Mean Surface Roughness**

| Parameter | Level 1 Mean Ra (µm) | Level 2 Mean Ra (µm) | Level 3 Mean Ra (µm) | Difference | Influence Rank |
|---|---|---|---|---|---|
| Cutting Speed | 2.18 | 1.86 | 1.60 | 0.58 | 2 |
| Feed Rate | 1.40 | 1.86 | 2.38 | 0.98 | 1 |
| Depth of Cut | 1.83 | 1.86 | 1.96 | 0.13 | 3 |

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

**Results and Discussion:**

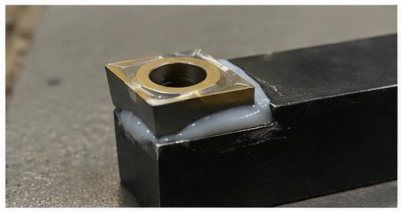
The experimental test results presented in this work showed that the surface finish obtained after cutting with the adhesively mounted cutting tool is strongly dependent on the machining parameters. The large variations in surface roughness, from 1.21 µm to 2.78 µm, were observed under the machining conditions studied.

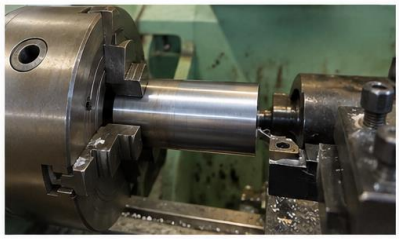
Experimental Run 7 at the cutting speed of 160 m/min, feed rate of 0.10 mm/rev and the depth of cut of -1.50 mm yielded the lowest surface roughness Rz = 1.21 µm. It is observed that the run at a speed of cutting 80 m/min, feed rate 0.20 mm/rev, and depth of cut 1.50 mm has the highest value of roughness which is equal to 2.78 µm for Run 3.


Workpiece (Mild steel)

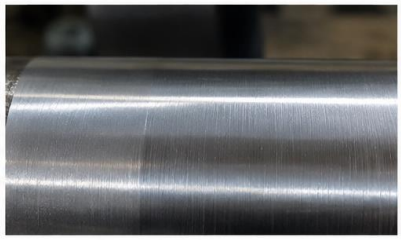


Carbide insert, tool holder and adhesive


Adhesively mounted cutting tool


Experimental setup on lathe


Turning operation

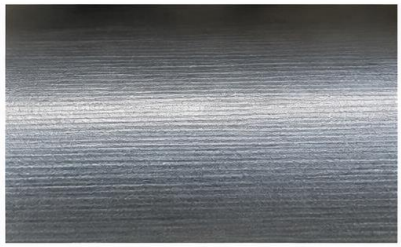

Machined surface after turning



Surface roughness measurement



Machined samples (Runs 1–9)


Close-up view of surface finish

This suggests that a higher cutting speed and lower feed rate is advantageous for a better surface finish of the components produced from the cutting process.

**Effect of Cutting Speed**

The surface roughness values for the average speeds have the cutting speed has also been increased. The mean surface roughness was about 2.18 µm at cutting speed of 80 m/min. At 120 m/min it was reduced to 1.86 µm and at 160 m/min it was further reduced to about 1.60 µm.

The enhanced surface texture at higher cutting speeds may relate to more stable chip formation, and a decreased tendency for material adhesion at the cutting edge. In addition, higher cutting speed can help to minimize the deformation rate of the material during cutting process, which could be irregular. The cutting tool was adhered to the workpiece with an adhesive and was stable under the cutting conditions selected, which indicates that there was no significant movement of the cutting tool during the cutting process.

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

**Effect of Feed Rate**

The surface finish had the greatest effect with feed rate. The surface mean roughness rose from average value of about 1.40 µm for a feed rate of 0.10 mm/rev, to 1.86 µm for 0.15 mm/rev and 2.38 µm for 0.20 mm/rev feed rate.

The greater the feed, the greater the surface roughness with the feed, as larger feed marks are produced on the machined surface and these affect the surface roughness. The distance that the tool travels with each turn of the work piece increases as the tool makes more cuts the farther it progresses. the spacing and the height of the cuts made by the tool will get further and larger as the tool advances further and further with each turn of the work piece. Hence, a lesser feed rate was determined to provide a more desirable surface finish.

The difference between maximum and minimum mean roughness due to feed rate was around 0.98 µm while the difference due to cutting speed and the difference due to depth of cut were around 0.01 µm and 0.06 µm respectively. This obviously signifies feed rate as most critical machining parameter in the present investigation.

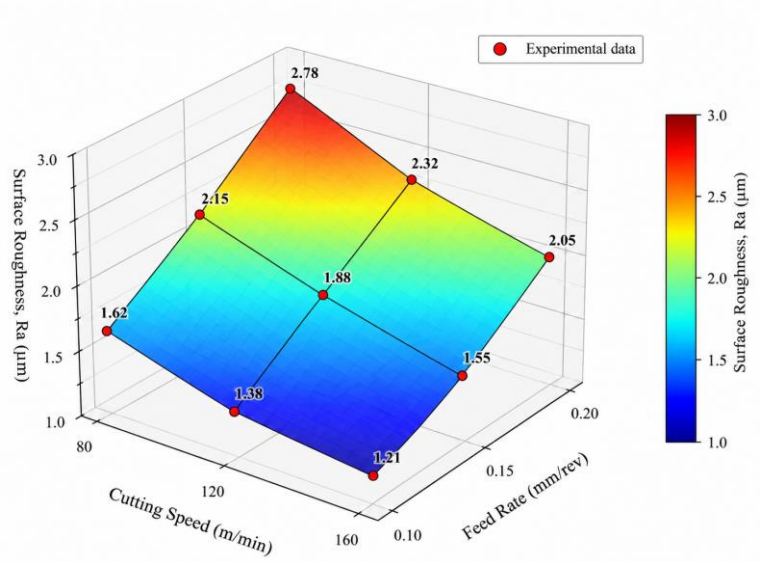
**Effect of Depth of Cut**

Surface roughness was less affected by the depth of cut. The average Ra value was approximately 1.83 µm at a depth of cut of 0.50 mm, 1.86 µm at 1.00 mm, and 1.96 µm at 1.50 mm.

A slight increase in surface roughness was found for a rise in the depth of cut, the more material that the cutting tool removes, and the greater cutting forces are likely to be. The small elastic deflection or vibrations could occur due to increased forces at tool–workpiece interface. The difference among these three depth-of-cut conditions, however, was relatively small, suggesting that the surface quality of the investigated range of depth of cut did not differ significantly from that of the other cutting parameters, feed rate and cutting speed.

**Performance of the Adhesively Mounted Cutting Tool**

However, it has been found from the experimental observations that the cutting tool attached with glue can perform turning operations at the selected machining parameters without any observable movement of the cutting insert. The adhesive layer was suitable for the bonding of cutting insert and tool holder during the experiments.



International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

The load-vibration path from the vibration sources to the tool–holder interface may also be one of the factors that determines the effects of vibration damping at the tool–holder interface. An adhesive layer subjects the bonded contact area to a distributed load compared with the mechanical clamping model based on local points. On the contrary, the clamping model based on rigid point contact transmits the load to the bonded contacting area; while an adhesive layer can transmit the load to the bonded contacting area, it can be spread. This property can help to minimize the vibration and small tool movements - affecting surface finish.

The strength and heat resistance of the glue used, however, affect the effectiveness of the adhesive mounting method. If cutting temperature or cutting force is too high, it can cause the bonded part to be weak. Hence, the selection of the adhesive, bonding thickness, surface cleanliness and curing conditions must be taken care in applying the technique for heavy machining process.

**Conclusion:**

The study was conducted to analyze the surface finish generated during turning operation using adhesively mounted cutting tools in the present study. From the experimental results, it was concluded that the adhesive tool attaching method can be used to ensure sufficient stability when machining and the surface roughness was acceptable under the chosen machining parameters. It was also found that the machining variables played a significant role in the quality of the surface of the machined product.

In the present case, feed rate was determined as being the single most important factor which influenced surface roughness among the selected parameters. When feed rate increased, the surface roughness value also increased and compared to the other sets, the surface finish was relatively poor. The second important parameter was cutting speed: it was found that increasing the cutting speed obtained smoother surfaces. Surface roughness was the most insensitive to the investigated parameter (depth of cut) as a slight increase in the roughness was noticed when the depth of cut increased.

The best finish was achieved at the higher cutting speed and lower cutting feed, suggesting their suitability for precision turning using adhesively mounted cutting tools. The adhesive layer also showed potential for stable positioning of the tools and may help to reduce vibrations at the interface between the tool and holder.

In general, the investigation suggests that cutting tools that are attached to the end-machine with adhesive might be regarded as a promising solution to mechanical tool mounting in selected turning operations. In order to obtain reliable performance, suitable adhesive material and bonding conditions, as well as adequate cutting parameters, need to be used. Additional research could be in the direction of tool life, cutting forces, effect of temperature, adhesive strengths, or near-life applications with diverse material to be cut and various machining conditions.

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

**References:**

1. Abu-Mahfouz, I., Banerjee, A., & Rahman, E. (2021). Evaluation of clustering techniques to predict surface roughness during turning of stainless-steel using vibration signals. *Materials, 14*(17), 5050. https://doi.org/10.3390/ma14175050
2. Agrawal, A., Goel, S., Rashid, W. B., & Price, M. (2015). Prediction of surface roughness during hard turning of AISI 4340 steel (69 HRC). *Applied Soft Computing, 30*, 279–286. https://doi.org/10.1016/j.asoc.2015.01.059
3. Alajmi, M. S., & Almeshal, A. M. (2020). Prediction and optimization of surface roughness in a turning process using the ANFIS-QPSO method. *Materials, 13*(13), 2986. https://doi.org/10.3390/ma13132986
4. Aouici, H., Yallese, M. A., Chaoui, K., Mabrouki, T., & Rigal, J. F. (2012). Analysis of surface roughness and cutting force components in hard turning with CBN tool: Prediction model and cutting conditions optimization. *Measurement, 45*(3), 344–353. https://doi.org/10.1016/j.measurement.2011.11.011
5. Bouacha, K., Yallese, M. A., Mabrouki, T., & Rigal, J. F. (2010). Statistical analysis of surface roughness and cutting forces using response surface methodology in hard turning of AISI 52100 bearing steel with CBN tool. *International Journal of Refractory Metals and Hard Materials, 28*(3), 349–361. https://doi.org/10.1016/j.ijrmhm.2009.11.011
6. Karayel, D. (2009). Prediction and control of surface roughness in CNC lathe using artificial neural network. *Journal of Materials Processing Technology, 209*(7), 3125–3137. https://doi.org/10.1016/j.jmatprotec.2008.07.023
7. Lalwani, D. I., Mehta, N. K., & Jain, P. K. (2008). Experimental investigations of cutting parameters influence on cutting forces and surface roughness in finish hard turning of MDN250 steel. *Journal of Materials Processing Technology, 206*(1–3), 167–179. https://doi.org/10.1016/j.jmatprotec.2007.12.018
8. Machno, M., Zębala, W., & Franczyk, E. (2024). Optimization of turning of Inconel 625 to improve surface quality after finishing process. *Materials, 17*(23), 6009. https://doi.org/10.3390/ma17236009
9. Mahajan, K. A., Pawade, R. S., & Mishra, V. (2022). Tool vibration effect on surface roughness of polymethylmethacrylate in diamond turning. *Materials and Manufacturing Processes, 37*(3), 271–282. https://doi.org/10.1080/10426914.2021.1973029
10. Mia, M., & Dhar, N. R. (2016). Prediction of surface roughness in hard turning under high pressure coolant using artificial neural network. *Measurement, 92*, 464–474. https://doi.org/10.1016/j.measurement.2016.06.048
11. Philip Selvaraj, D., Chandramohan, P., & Mohanraj, M. (2014). Optimization of surface roughness, cutting force and tool wear of nitrogen alloyed duplex stainless steel in a dry turning process using Taguchi method. *Measurement, 49*, 205–215. https://doi.org/10.1016/j.measurement.2013.11.037