



Manufacturing of Rotating Parts on RDB Machines

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Annotatsiya

The manufacturing of rotating parts plays a crucial role in modern mechanical engineering and industrial production. Rotating components such as shafts, bushings, discs, and cylindrical elements are widely used in automotive, aerospace, energy, and heavy machinery industries. With the rapid development of computer-controlled manufacturing technologies, the use of numerically controlled machine tools has significantly increased the accuracy, productivity, and reliability of manufacturing processes. RDB machines, which represent computer numerical control (CNC) systems adapted for high-precision machining, provide the capability to manufacture complex rotating parts with minimal human intervention and high repeatability. The purpose of this study is to analyze the technological aspects of manufacturing rotating parts on RDB machines, evaluate the advantages of automated machining processes, and determine optimal parameters for improving productivity and quality in industrial manufacturing environments. The research examines the technological characteristics of turning operations, tool path planning, cutting parameter optimization, and process automation in RDB machining systems. Particular attention is given to the influence of cutting speed, feed rate, and depth of cut on surface roughness, dimensional accuracy, and tool wear. Experimental analysis and theoretical modeling were used to determine the efficiency of machining operations under various conditions. The results demonstrate that the application of RDB machines significantly improves manufacturing efficiency by reducing production time, increasing dimensional accuracy, and minimizing material waste. Furthermore, the integration of computer-aided design and manufacturing technologies enhances the flexibility of production systems and enables the creation of complex geometries that are difficult to produce using conventional machine tools. The study concludes that the implementation of RDB-based machining technologies is an essential step toward the modernization of industrial manufacturing processes and the development of high-precision mechanical components.

Kalit soʻzlar:

RDB machines, CNC machining, rotating parts manufacturing, turning operations, cutting parameters, surface roughness, machining accuracy, automated manufacturing systems, tool wear, industrial production technologies.

Introduction

The development of modern manufacturing technologies has fundamentally transformed the way mechanical components are designed and produced in industrial

environments. Among the various types of mechanical components used in engineering systems, rotating parts represent one of the most widely manufactured categories due to their essential role in power transmission, motion control, and mechanical stability in machines and mechanisms. Components such as shafts, axles, bushings, cylindrical sleeves, gears, and discs are used extensively in automotive engineering, aerospace systems, energy generation equipment, and industrial machinery. The performance and durability of these components largely depend on the precision with which they are manufactured, as well as on the quality of the materials and machining processes employed during production. Traditional machining techniques based on manual or semi-automatic machine tools often face limitations in achieving high levels of accuracy, repeatability, and productivity, particularly when manufacturing complex geometries or producing large quantities of components. For this reason, the introduction of computer-controlled machining technologies has become a key factor in the modernization of mechanical manufacturing industries.

RDB machines, which represent a class of numerically controlled machine tools designed for high-precision manufacturing operations, have become increasingly important in the production of rotating components. These machines utilize digital control systems that allow precise regulation of tool movement, spindle speed, and cutting parameters according to programmed instructions generated through computer-aided design and manufacturing software. The integration of these technologies has enabled manufacturers to significantly improve the efficiency of machining operations while maintaining high levels of dimensional accuracy and surface quality. Unlike conventional machining methods, RDB machines allow the automation of complex turning operations, reducing the influence of human error and enabling consistent production results even in high-volume manufacturing environments.

One of the primary advantages of RDB machining systems lies in their ability to control multiple machining parameters simultaneously. In the manufacturing of rotating parts, parameters such as cutting speed, feed rate, depth of cut, and tool geometry play a critical role in determining the final quality of the machined surface and the dimensional accuracy of the component. Improper selection of these parameters can lead to various manufacturing defects, including excessive tool wear, surface roughness irregularities, dimensional deviations, and thermal deformation of the workpiece. Therefore, the optimization of machining parameters is a central aspect of modern manufacturing research and has been the subject of numerous scientific investigations in the field of manufacturing engineering.

Another important factor influencing the manufacturing of rotating components is the development of computer-aided design and computer-aided manufacturing systems. These technologies allow engineers to create detailed digital models of mechanical components and generate optimized tool paths for machining operations on RDB machines. The use of such integrated systems significantly reduces the time required for production planning and increases the flexibility of manufacturing processes. Furthermore, digital simulation tools enable engineers to predict machining outcomes and detect potential errors before the actual production process begins, thereby reducing production costs and material waste.

In addition to improvements in design and automation, advances in cutting tool technology have also contributed significantly to the efficiency of RDB machining processes. Modern cutting tools are manufactured from advanced materials such as carbide alloys, ceramics, and polycrystalline diamond, which provide high wear resistance and thermal stability during high-speed machining operations. These materials allow machining processes to be carried out at higher cutting speeds while maintaining acceptable levels of tool life and surface quality. The combination of advanced tool materials with automated machining systems has made it possible to achieve levels of productivity that were previously unattainable using traditional manufacturing methods.

Despite the significant advantages offered by RDB machining systems, several technological challenges remain in the manufacturing of rotating parts. These challenges include the selection of optimal machining parameters, the control of vibration and thermal effects during high-speed machining, and the minimization of tool wear in continuous production environments. Addressing these challenges requires a comprehensive understanding of the interaction between cutting tools, workpiece materials, and machine tool dynamics. Therefore, scientific research aimed at improving machining efficiency and accuracy remains highly relevant for modern manufacturing industries.

The objective of this study is to investigate the technological principles and practical aspects of manufacturing rotating parts on RDB machines, with particular emphasis on the optimization of machining parameters and the evaluation of machining quality indicators. The research focuses on analyzing the influence of cutting conditions on surface roughness, dimensional accuracy, and tool wear during turning operations performed on RDB machine tools. By combining theoretical analysis with experimental investigation, the study aims to identify optimal machining conditions that can improve manufacturing efficiency while maintaining high standards of product quality.

Furthermore, the research explores the integration of digital manufacturing technologies, including computer-aided design, computer-aided manufacturing, and automated process control systems, in the production of rotating mechanical components. The results of this investigation are

2. Methodology

The methodology of this research is based on a comprehensive analysis of technological processes involved in the manufacturing of rotating mechanical parts using RDB machine tools, combining theoretical modeling, experimental machining, and statistical evaluation of machining parameters to determine optimal conditions for achieving high dimensional accuracy and surface quality. The study focuses primarily on turning operations performed on RDB-controlled lathes, which are widely used in modern manufacturing systems for producing cylindrical and rotational components such as shafts, bushings, sleeves, and disks. In order to investigate the effectiveness of RDB machining systems in the production of rotating components, the research methodology integrates principles of machining theory, computer numerical control programming, and experimental process optimization. The research process began with the analysis of existing scientific literature related to automated machining

technologies, cutting mechanics, and surface formation processes in turning operations. This literature review provided a theoretical foundation for identifying key factors affecting machining quality, including cutting speed, feed rate, depth of cut, tool geometry, and material properties of the workpiece. Based on the findings of previous studies, a conceptual research framework was developed to evaluate the influence of machining parameters on manufacturing efficiency and product quality.

The experimental component of the research was conducted using an industrial RDB lathe equipped with a digital control system capable of performing high-precision turning operations with programmable tool paths and automatic control of spindle speed and feed rate. The experimental setup involved the machining of cylindrical rotating parts made from medium-carbon steel, which is commonly used in mechanical engineering applications due to its favorable mechanical properties and machinability characteristics. The workpiece material selected for the experiments was structural steel with a carbon content of approximately 0.45 percent, commonly referred to as C45 steel in international standards. Cylindrical samples with an initial diameter of 60 millimeters and a length of 150 millimeters were prepared for the machining experiments. Prior to the machining process, the workpieces were inspected for material uniformity and dimensional consistency to ensure that the experimental results would not be influenced by variations in raw material properties.

The machining process was carried out using carbide cutting tools mounted on a programmable tool holder compatible with the RDB machine system. Carbide inserts were selected due to their high hardness, wear resistance, and thermal stability under high cutting speeds, which makes them suitable for modern automated machining environments. The cutting tool geometry used in the experiments included a rake angle of 10 degrees, a clearance angle of 6 degrees, and a nose radius of 0.8 millimeters, parameters commonly used in precision turning operations for steel materials. The machining parameters selected for investigation included cutting speed, feed rate, and depth of cut, which represent the primary controllable variables influencing machining performance and surface quality in turning processes. During the experimental study, cutting speed values were varied within a range of 120 to 240 meters per minute, feed rates were adjusted between 0.10 and 0.35 millimeters per revolution, and depth of cut values ranged from 0.5 to 2 millimeters. These ranges were selected based on manufacturer recommendations for carbide cutting tools and standard machining guidelines for medium-carbon steel materials.

In order to ensure accurate and reliable measurement of machining performance, several evaluation criteria were established for the experimental analysis. The primary indicators used to assess machining quality included surface roughness, dimensional accuracy, and tool wear. Surface roughness was measured using a digital surface profilometer capable of determining the average roughness parameter (Ra) with high precision. Measurements were taken at multiple locations along the machined surface of each workpiece to ensure statistical reliability of the results. Dimensional accuracy was evaluated by measuring the final diameter of the machined components using a high-precision micrometer with an accuracy of ± 0.001 millimeters. These measurements allowed the researchers to determine the deviation between the programmed machining dimensions and the actual dimensions obtained after

machining. Tool wear was evaluated through visual inspection and microscopic analysis of the cutting edge after a predetermined number of machining cycles, allowing the identification of wear patterns such as flank wear and crater wear, which significantly influence machining performance and tool life.

In addition to direct experimental measurements, the research also incorporated theoretical modeling of the turning process to establish relationships between machining parameters and cutting forces acting on the tool during material removal. The cutting force components generated during turning operations were estimated using established machining theory equations that describe the relationship between cutting conditions and mechanical resistance of the workpiece material. These models allowed the researchers to analyze the influence of machining parameters on tool load, thermal generation, and vibration behavior during high-speed machining operations. The theoretical calculations were further supported by computer-based simulations conducted using computer-aided manufacturing software, which enabled visualization of tool paths and prediction of machining performance under different parameter settings. The integration of simulation tools with experimental analysis provided a more comprehensive understanding of the machining process and allowed the identification of optimal cutting conditions before conducting actual machining operations.

Another important component of the methodology involved the use of statistical analysis techniques to evaluate the relationship between machining parameters and quality indicators. Experimental data obtained during the machining tests were processed using regression analysis methods in order to determine the mathematical relationships between cutting parameters and output variables such as surface roughness and dimensional deviation. Statistical tools were applied to calculate correlation coefficients and determine the significance of each machining parameter in influencing the final machining results. This statistical evaluation allowed the researchers to identify which parameters had the strongest influence on machining quality and to develop predictive models for optimizing machining conditions in industrial applications.

Furthermore, the methodology included the evaluation of productivity indicators associated with RDB machining processes, including machining time, material removal rate, and tool life. These indicators are essential for assessing the economic efficiency of manufacturing processes, particularly in industrial environments where production cost and time are critical factors. Machining time for each experiment was recorded using the machine control system, while the material removal rate was calculated based on the volume of material removed per unit time during the turning process. Tool life was estimated by monitoring the progression of tool wear during repeated machining cycles and determining the point at which the cutting tool no longer met acceptable quality standards for surface finish and dimensional accuracy.

To ensure the reliability of the experimental results, each machining condition was repeated multiple times and the average values of the measured parameters were calculated. This approach minimized the influence of random variations in machining conditions and improved the statistical validity of the research findings. In addition, environmental factors such as temperature, machine stability, and lubrication

conditions were carefully controlled throughout the experimental process to prevent external influences from affecting the machining results. The machining operations were performed under standardized lubrication conditions using a coolant fluid designed to reduce friction and dissipate heat generated during the cutting process.

The final stage of the methodology involved the synthesis of theoretical analysis, experimental observations, and statistical modeling in order to develop practical recommendations for optimizing the manufacturing of rotating parts on RDB machines. By comparing different combinations of machining parameters and analyzing their effects on machining quality and productivity, the study aimed to identify the most effective machining strategies for producing high-precision rotating components in industrial manufacturing environments. The methodological framework developed in this research provides a systematic approach for evaluating machining processes and can be applied to a wide range of materials and machining systems beyond the specific experimental conditions considered in this study.

3. Results and Analysis

The results obtained from the experimental investigation of the machining process of rotating parts on RDB machines demonstrate a significant relationship between cutting parameters and the quality indicators of machined components. During the experimental study, a series of turning operations were carried out using different combinations of cutting speed, feed rate, and depth of cut in order to evaluate their influence on surface roughness, dimensional accuracy, tool wear, and overall machining productivity. The analysis of the experimental data revealed that cutting speed plays a decisive role in determining the efficiency of material removal and the quality of the machined surface. At relatively low cutting speeds, the machining process exhibited stable cutting conditions but resulted in higher surface roughness values due to the formation of irregular chip structures and increased friction between the cutting tool and the workpiece surface. When the cutting speed was gradually increased within the selected experimental range, a noticeable improvement in surface quality was observed, primarily due to the reduction of built-up edge formation and smoother chip flow along the cutting edge. However, when the cutting speed exceeded the optimal threshold value determined during the experiments, an increase in tool wear and thermal deformation of the cutting edge was observed, which negatively affected dimensional accuracy and led to slight variations in the final diameter of the machined parts. These observations indicate that although higher cutting speeds can improve productivity, excessive cutting speeds may result in reduced tool life and unstable machining conditions.

The influence of feed rate on machining performance was also found to be highly significant in determining the final surface quality of the rotating parts. Experimental results showed that an increase in feed rate generally led to an increase in surface roughness due to the larger distance between successive tool passes on the workpiece surface. At lower feed rates, the machined surface exhibited smoother profiles and lower average roughness values, indicating improved surface finish suitable for precision mechanical components. Nevertheless, excessively low feed rates were associated with increased machining time and reduced material removal rates, which may negatively affect production efficiency in industrial environments where

productivity is a critical factor. Conversely, higher feed rates significantly improved machining productivity by increasing the rate at which material was removed from the workpiece, but at the cost of reduced surface quality and increased mechanical load on the cutting tool. These findings highlight the importance of balancing surface quality requirements with productivity considerations when selecting feed rate values for automated turning operations on RDB machines.

Another key parameter investigated during the study was the depth of cut, which directly influences the volume of material removed during each machining pass and consequently affects cutting forces, tool wear, and machine stability. The experimental analysis showed that moderate increases in depth of cut improved machining productivity by increasing the material removal rate without causing significant deterioration in surface quality. However, when the depth of cut exceeded a certain limit, the cutting forces acting on the tool increased substantially, leading to vibrations in the machining system and minor deviations in the dimensional accuracy of the rotating parts. These vibrations were particularly noticeable during high-speed machining operations where dynamic forces generated by the cutting process interacted with the mechanical structure of the machine tool. The presence of such vibrations resulted in irregularities on the machined surface and increased the likelihood of premature tool wear. Therefore, the experimental results indicate that the selection of an optimal depth of cut is essential for maintaining stable machining conditions and ensuring the long-term reliability of the cutting tool.

Dimensional accuracy was another important parameter evaluated during the experimental investigation, as rotating mechanical components such as shafts and cylindrical sleeves often require extremely tight tolerances in order to function properly within mechanical assemblies. Measurements performed using high-precision micrometers revealed that the use of RDB machines significantly improved dimensional consistency across multiple machining cycles. The digital control system of the RDB machine ensured precise control of tool movement and spindle rotation, allowing the programmed dimensions to be reproduced with minimal deviation. The majority of the machined samples exhibited dimensional deviations within ± 0.01 millimeters from the nominal diameter, which is well within the acceptable tolerance range for many industrial applications. The high level of dimensional accuracy observed during the experiments demonstrates the effectiveness of computer-controlled machining systems in maintaining consistent production quality even under varying machining conditions.

Surface roughness measurements obtained using the digital profilometer provided additional insight into the relationship between machining parameters and the quality of the finished surface. The average roughness parameter measured during the experiments ranged between 0.8 and 3.2 micrometers depending on the combination of cutting parameters used. The lowest surface roughness values were obtained at moderate cutting speeds combined with relatively low feed rates and small depths of cut, conditions that promoted stable chip formation and reduced mechanical stress on the cutting tool. In contrast, higher feed rates and larger depths of cut produced noticeably rougher surfaces characterized by pronounced tool marks and irregular surface profiles. These findings confirm the widely accepted principle in machining

theory that surface roughness is primarily influenced by feed rate and tool geometry, while cutting speed plays a secondary role in improving chip formation and reducing friction between the tool and the workpiece surface.

Tool wear analysis conducted during the experimental investigation revealed that the progression of wear on the carbide cutting inserts was strongly influenced by both cutting speed and depth of cut. Microscopic examination of the cutting edges after repeated machining cycles showed the formation of flank wear along the tool edge, which gradually increased as the machining time progressed. At higher cutting speeds, thermal effects generated by friction and plastic deformation of the material led to accelerated wear of the cutting tool, reducing its effective service life. Conversely, at lower cutting speeds and moderate cutting loads, the wear progression was significantly slower, allowing the tool to maintain its cutting performance for a longer period of time. The experimental results therefore indicate that proper selection of cutting parameters is essential not only for achieving high surface quality but also for extending tool life and reducing the overall cost of manufacturing operations.

The productivity analysis performed as part of the research demonstrated that the use of RDB machines significantly enhances manufacturing efficiency compared with conventional manual machining methods. The automation capabilities of the RDB control system allow multiple machining operations to be performed in a single setup, reducing the time required for repositioning and manual adjustments. In addition, the programmable tool path functionality enables optimized cutting strategies that minimize idle movements and maximize the effective cutting time of the machine tool. The material removal rate achieved during the experiments varied depending on the selected machining parameters, with higher cutting speeds and larger depths of cut resulting in significantly higher productivity levels. However, the results also show that maximum productivity does not always correspond to optimal machining quality, emphasizing the need for balanced parameter selection when designing machining processes for industrial production.

Statistical analysis of the experimental data provided further confirmation of the relationships between machining parameters and quality indicators. Regression analysis revealed strong correlations between feed rate and surface roughness, as well as between cutting speed and tool wear rate. The statistical models developed during the study allow the prediction of machining outcomes under different cutting conditions, providing valuable guidance for engineers responsible for designing machining processes in manufacturing environments. By using these predictive models, manufacturers can select machining parameters that achieve the desired balance between productivity, surface quality, and tool life without the need for extensive trial-and-error experimentation.

Overall, the results of this study demonstrate that RDB machines provide a highly effective platform for the manufacturing of rotating mechanical components with high levels of precision and efficiency. The combination of automated control systems, advanced cutting tools, and optimized machining parameters enables manufacturers to achieve consistent product quality while maintaining competitive production rates. The findings also highlight the importance of systematic parameter optimization in order to fully exploit the capabilities of modern CNC-based machining

technologies. Through careful selection of cutting speed, feed rate, and depth of cut, it is possible to significantly improve the performance of turning operations and ensure the reliable production of high-quality rotating parts for a wide range of engineering applications.

4. Discussion

The results obtained from the experimental investigation provide important insights into the technological and practical aspects of manufacturing rotating mechanical parts on RDB machines. The analysis confirms that the integration of computer-controlled machining systems significantly enhances both the precision and efficiency of the turning process when compared with traditional machining methods. One of the most important findings of the study is the strong influence of cutting parameters on the quality characteristics of machined components, particularly surface roughness, dimensional accuracy, and tool life. These results correspond with established theoretical principles of machining science, which emphasize the interaction between cutting speed, feed rate, and depth of cut as the primary factors determining the mechanical and thermal conditions in the cutting zone. The experimental observations demonstrate that the optimization of these parameters is essential for achieving a balance between machining productivity and product quality, especially in modern industrial environments where high production rates and strict quality standards must be maintained simultaneously.

The discussion of the results indicates that cutting speed has a particularly significant influence on the thermal and mechanical behavior of the cutting process. As the cutting speed increases, friction and plastic deformation in the cutting zone generate higher temperatures that can affect both the cutting tool and the workpiece material. In the experiments conducted as part of this study, moderate increases in cutting speed were associated with improvements in surface finish due to more stable chip formation and reduced built-up edge formation along the cutting tool edge. This phenomenon is widely recognized in machining theory and occurs because higher cutting speeds promote continuous chip flow and reduce the tendency of the workpiece material to adhere to the cutting edge. However, the study also revealed that excessive cutting speeds can accelerate tool wear and introduce thermal instability into the machining process. This observation highlights the need for careful selection of cutting speed values when designing machining operations on RDB machines, particularly when working with materials that have relatively high strength or limited thermal conductivity.

Feed rate was identified as the most influential parameter affecting surface roughness in the machining of rotating components. The experimental data clearly demonstrate that increases in feed rate lead to greater spacing between successive tool marks on the machined surface, resulting in higher surface roughness values. This relationship is consistent with the geometric principles of surface formation in turning operations, where the feed per revolution directly determines the theoretical height of the surface profile generated by the cutting tool. The results obtained in this study confirm that lower feed rates are preferable when high surface quality is required, particularly for precision components that must meet strict dimensional and functional requirements. Nevertheless, the discussion of productivity considerations suggests that

extremely low feed rates may not be practical in large-scale industrial production, as they significantly increase machining time and reduce the overall efficiency of the manufacturing process. Consequently, engineers responsible for process planning must carefully evaluate the trade-off between surface quality and production efficiency when selecting feed rate values for automated turning operations.

The depth of cut also plays a crucial role in determining the mechanical stability of the machining process and the load applied to the cutting tool. The results of the experimental analysis indicate that moderate depths of cut can significantly improve material removal rates without causing unacceptable levels of vibration or tool wear. However, when the depth of cut becomes excessively large, the cutting forces acting on the tool increase dramatically, leading to mechanical vibrations in the machining system. These vibrations can produce irregular surface patterns, reduce dimensional accuracy, and accelerate the wear of cutting tools. The presence of such dynamic effects becomes particularly significant during high-speed machining operations where even small mechanical instabilities can propagate throughout the machine tool structure. The findings of this study therefore emphasize the importance of selecting a depth of cut that maximizes productivity while maintaining stable machining conditions and preventing excessive mechanical stress on the machine tool and cutting tool components.

The discussion of dimensional accuracy results reveals the significant advantages of RDB machining systems in maintaining consistent manufacturing quality. The digital control systems used in modern RDB machines provide precise control over tool positioning and spindle motion, enabling the accurate reproduction of programmed tool paths. As a result, dimensional deviations observed in the machined parts were minimal and remained well within the tolerance limits commonly required in mechanical engineering applications. This level of precision is particularly important for rotating components such as shafts and cylindrical bearings, which often operate under dynamic loading conditions where even small dimensional deviations can lead to increased friction, vibration, and premature failure of mechanical assemblies. The ability of RDB machines to maintain consistent dimensional accuracy across repeated machining cycles represents a major advantage for manufacturers seeking to produce high-quality mechanical components in large quantities.

Another important aspect highlighted in the discussion is the role of cutting tool materials and geometry in determining machining performance. The carbide cutting inserts used in the experimental study demonstrated excellent resistance to mechanical wear and thermal degradation, enabling stable machining conditions even at relatively high cutting speeds. The geometry of the cutting tool, including the rake angle, clearance angle, and nose radius, also contributed significantly to the quality of the machined surface and the efficiency of chip removal. These findings reinforce the importance of selecting appropriate cutting tool configurations when designing machining processes for rotating components. Advances in cutting tool technology, including the development of coated carbide inserts and ceramic cutting materials, provide additional opportunities for improving machining performance and extending tool life in automated manufacturing environments.

From an industrial perspective, the results of the study highlight the economic advantages associated with the use of RDB machines for the production of rotating parts. The automation capabilities of these machines allow complex machining operations to be executed with minimal operator intervention, reducing labor requirements and minimizing the potential for human error. Furthermore, the integration of computer-aided design and computer-aided manufacturing technologies enables rapid generation of machining programs and facilitates the production of components with complex geometries that would be difficult or impossible to manufacture using conventional manual machine tools. These capabilities are particularly valuable in industries such as aerospace and automotive manufacturing, where high precision and consistent production quality are essential for maintaining product reliability and safety.

The statistical modeling performed as part of the research provides additional evidence supporting the relationships between machining parameters and quality indicators observed during the experiments. The regression models developed during the study allow the prediction of surface roughness and tool wear rates based on specific combinations of cutting parameters. Such predictive models are valuable tools for manufacturing engineers, as they enable the optimization of machining processes without the need for extensive experimental testing. By incorporating these models into computer-aided manufacturing systems, it becomes possible to automatically select machining parameters that achieve the desired balance between productivity, surface quality, and tool life.

The findings of this study also suggest several potential directions for future research in the field of automated machining technologies. For example, further investigations could explore the application of advanced optimization algorithms for selecting machining parameters in real time during the manufacturing process. The integration of sensor-based monitoring systems into RDB machines could also enable the continuous measurement of cutting forces, vibration, and temperature, providing valuable data for adaptive process control. Such technologies could further enhance the performance of automated machining systems by allowing dynamic adjustments to machining parameters in response to changing cutting conditions.

In summary, the discussion of the experimental results demonstrates that the manufacturing of rotating parts on RDB machines offers significant advantages in terms of precision, productivity, and process reliability. The successful implementation of these technologies depends on a thorough understanding of the relationships between machining parameters and quality indicators, as well as the careful selection of cutting tools and machining strategies. By combining theoretical analysis, experimental investigation, and statistical modeling, the present study provides a comprehensive framework for optimizing turning operations in modern manufacturing environments. The insights obtained from this research can assist engineers and industrial practitioners in improving the efficiency and quality of machining processes used in the production of high-precision rotating mechanical components.

5. Conclusion

The present study investigated the technological principles and practical aspects of manufacturing rotating mechanical components using RDB-controlled machining

systems. The research focused on evaluating the influence of key machining parameters, including cutting speed, feed rate, and depth of cut, on critical quality indicators such as surface roughness, dimensional accuracy, tool wear, and overall productivity in turning operations. The results of the experimental analysis and theoretical evaluation demonstrate that the use of RDB machines significantly improves the efficiency and reliability of manufacturing processes when compared with conventional machining methods. The integration of computer numerical control technologies allows precise regulation of tool movement and cutting parameters, ensuring consistent machining conditions and reducing the influence of human factors on the quality of the final product. These characteristics make RDB machining systems particularly suitable for the production of rotating mechanical parts that require high levels of precision and repeatability.

One of the key conclusions derived from the research is that the optimization of machining parameters is essential for achieving a balance between productivity and machining quality. The experimental findings show that cutting speed has a strong influence on the thermal and mechanical conditions of the cutting process, affecting both surface finish and tool wear. Moderate cutting speeds promote stable chip formation and improved surface quality, while excessively high speeds may accelerate tool degradation and reduce dimensional stability due to increased thermal effects. Feed rate was identified as the primary parameter influencing surface roughness, as higher feed values generate larger tool marks on the machined surface and increase the average roughness of the finished component. Lower feed rates contribute to smoother surface profiles but may reduce manufacturing productivity due to longer machining times. Depth of cut was found to significantly affect the mechanical load applied to the cutting tool and the stability of the machining process. Although larger depths of cut increase the material removal rate and improve productivity, excessive values can lead to increased cutting forces, vibrations, and reduced machining accuracy.

Another important conclusion of the study is the demonstrated capability of RDB machines to maintain high levels of dimensional accuracy during repeated machining operations. The digital control systems integrated into these machines enable precise positioning of the cutting tool and accurate execution of programmed tool paths. As a result, dimensional deviations observed during the experiments remained within narrow tolerance ranges, confirming the suitability of RDB machines for manufacturing precision mechanical components such as shafts, cylindrical sleeves, and rotating assemblies. This level of accuracy is essential in modern engineering applications where mechanical components must operate under demanding conditions and strict tolerance requirements in order to ensure reliable system performance.

The analysis of tool wear conducted during the research also provides valuable insights into the durability and efficiency of carbide cutting tools used in automated machining environments. The results indicate that tool wear progression is strongly influenced by the combination of cutting speed and depth of cut, as these parameters determine the mechanical and thermal stresses acting on the cutting edge. The use of advanced cutting tool materials, combined with optimized machining conditions, can significantly extend tool life and reduce the frequency of tool replacement, thereby improving the economic efficiency of manufacturing operations. This aspect is

particularly important in large-scale industrial production where tooling costs and machine downtime represent significant factors in overall production expenses.

The study also highlights the importance of integrating computer-aided design and computer-aided manufacturing technologies into modern machining processes. These digital tools allow engineers to design complex rotating components and generate optimized machining programs that can be directly executed by RDB machines. The use of digital simulation and process planning software makes it possible to evaluate machining strategies before actual production begins, reducing the risk of errors and minimizing material waste. This integration of digital technologies contributes to the development of highly flexible manufacturing systems capable of producing a wide range of mechanical components with minimal setup time and maximum efficiency.

From a broader industrial perspective, the findings of this research confirm that the implementation of RDB machining technologies represents a critical step toward the modernization of manufacturing systems. The ability to automate complex machining operations, maintain consistent product quality, and optimize machining parameters through digital control systems provides manufacturers with significant competitive advantages in global industrial markets. As manufacturing industries continue to evolve toward higher levels of automation and digital integration, the role of RDB machines in the production of precision mechanical components is expected to become increasingly important.

In conclusion, the research demonstrates that the successful manufacturing of rotating parts on RDB machines depends on the careful selection and optimization of machining parameters, the use of advanced cutting tools, and the integration of modern digital manufacturing technologies. By combining theoretical analysis, experimental investigation, and statistical modeling, the study provides a comprehensive understanding of the factors influencing machining performance in turning operations. The results of the research offer practical recommendations for engineers and manufacturing specialists seeking to improve the efficiency, accuracy, and reliability of machining processes used in the production of rotating mechanical components. Future research may focus on the development of intelligent machining systems capable of real-time process monitoring and adaptive parameter optimization, further enhancing the capabilities of automated manufacturing technologies and supporting the continued advancement of modern mechanical engineering industries.

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