Discussion on Surface Quality and Precision Control of Metal Materials in Machining Process

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Abstract. Based on the analysis of the influence of the surface quality of metal materials on the use of machinery, this paper discusses the influence of raw material quality, technical level, residual stress, cold work hardening, machine tool machining error, cutting tool machining error, mechanical positioning error and mechanical adjustment error on the surface quality and machining accuracy of metal materials. By studying the measures such as strengthening the quality control of raw materials, reasonably selecting processing technology, controlling the processing process, reducing the original error and making error compensation, the aim is to optimize the machining environment and improve the processing quality of finished products.

1. Introduction
With the rapid development of industrial production activities, the machinery manufacturing industry has gradually become the pillar industry of the national economy, affecting all aspects of people's lives. In the process of machining, influenced by equipment factors, artificial factors and environmental factors, it is easy to affect the surface quality and machining accuracy of metal materials, thus reducing the service life of machinery. Based on this situation, it is of positive significance to formulate the corresponding treatment measures for speeding up the machining speed and improving the application quality of finished products.

2. Influence of Metal Surface Quality on Mechanical Use

2.1. Mechanical Fatigue Strength
Based on the application experience, it can be known that in the process of machining, there will be loads between machines and parts collision, which also makes the surface of metal materials more prone to fatigue cracks. Especially for metal materials with higher roughness, there are more fatigue cracks and higher crack depth. Moreover, the worse the destructive resistance of materials, thus reducing the service life of metal materials.

2.2. Mechanical Abrasion Resistance
The influence of surface quality on wear resistance is mainly manifested in the following two aspects: 1) From the point of view of the influence of surface roughness on wear resistance, the smoother the surface of parts, the smaller the wear between mechanical surfaces, that is, the better the wear resistance. However, considering the storage of lubricating oil, the mechanical surface should not be too smooth, but should maintain a relatively stable degree; 2) From the influence of surface cold-working hardening on wear resistance, cold-working hardening can improve the hardness of mechanical surface to a certain extent, so the wear resistance is also relatively improved. However,
excessive cold-working hardening will lead to looseness and weakness of metal, and even the surface layer of metal will fall off seriously, which will lead to serious reduction of its wear resistance.

3. Factors Affecting the Surface Quality of Metal Materials

3.1. Raw Material Quality
Based on the previous calculation data, it can be concluded that the influence weight of raw material quality is over 70%, which is also the basic condition to ensure the smooth progress of machining activities. The reasons for the poor quality of raw materials are as follows: First, in the selection of metal materials, the corresponding specifications and standards are not followed, which makes the quality of metal materials in the initial state unable to meet the processing requirements, thus affecting the surface quality of molded materials. Secondly, when metal materials are stored, they are influenced by external environmental factors, which leads to corrosion of raw materials. These corrosion traces are not processed in advance before processing, thus increasing the friction between metal materials and cutting tools and affecting the surface processing quality of mechanical parts.

3.2. Technical Level

In mechanical processing, many processing technologies are used, as shown in Figure 1, including quenching, cutting, normalizing and so on. The technical level is also an important factor affecting the surface quality of metal materials, which is mainly reflected in the following aspects: (1) In the application of processing technology, various parameters such as quenching temperature, cutting speed and cutting temperature are not well controlled, thus affecting the reliability of processing results and the surface quality of metal materials. (2) Although the machining process has been basically automated at present, there are still some jobs that need to be operated manually. Due to the
poor comprehensive ability of manual operation, the value of machining technology cannot be fully exerted, which affects the surface quality of metal materials.

3.3. Residual Stress

In the process of metal material processing, it will be affected by various technological factors. After these factors disappear, the effects will not disappear immediately, but some of them will remain in the metal material, and this effect is residual stress. Residual stress is related to many factors, including cutting speed, feed rate, cutting force, etc. As shown in Figure 2, there is a great correlation between cutting speed and residual stress. When the cutting speed reaches 150m/min, the maximum residual stress reaches the minimum value of about 670MPa, which will also have a great impact on the surface quality of metal materials, thus increasing the probability of fracture risk of metal materials.

3.4. Cold Work Hardening

In addition to the related contents mentioned above, the cold-working hardening of the surface layer will also be an important factor affecting the mechanical surface quality. In the process of machining, it will always be accompanied by plastic deformation and metallographic structure changes, thus affecting the stability of the machining results of metal materials. Moreover, after the machining process is finished, the volume and shape of metal materials are changed due to the influence of cold work hardening, and the uncertainty of the process is strong, which also makes the machining quality unable to be effectively guaranteed, thus affecting the service life of materials.

4. Factors Affecting the Processing Precision of Metal Materials

4.1. Machine Tool Machining Error

Because the machining process is completed on the machine tool, the geometric error of the machine tool will have a direct impact on the quality and precision control of the machined surface. Geometric errors of machine tools mainly include spindle rotation error, guide rail error and transmission chain error. Among them, as the machining power source, the spindle rotation error is the key factor affecting the quality control of machined surface. In addition, machining depends on the relative motion between the machine tool and the workpiece, and the guide rail is the key to control the relative position between the tool and the workpiece on the machine tool. If there is an error in the
guide rail, the relative position of each component on the machine tool will be deviated, which will eventually lead to the degradation of the mechanical surface quality.

4.2. Cutting Tool Machining Error
In the process of machining metal materials, the machining error of cutting tools will also be an important factor affecting the machining accuracy. Specifically, it shows the following contents: First, in the process of machining, the tool is affected by the long-term working load, which causes it to wear to a certain extent, so that when machining parts, it will also affect the accuracy of machined parts, which will reduce the qualified rate of finished products by 15%-25%. Second, different types of tool errors will be affected by the quality of tool making. Combined with the statistical results of big data technology and information technology, it shows that ordinary carbon steel or alloy steel is a common tool material, and the wear resistance of alloy steel is 20%-35% higher than that of ordinary carbon steel, so the influence of errors caused by it is relatively low.

4.3. Mechanical Positioning Error
In the process of metal material machining, the mechanical positioning error will also be an important factor affecting the machining accuracy. Based on the past practice, we can know that the errors in the positioning process can be subdivided into two situations: inaccurate positioning and non-coincidence of benchmarks. The former refers to the fact that in practice, the original parts used for positioning on the fixture are not accurate enough, which also makes it impossible for metal materials to be manufactured according to the established specification size. According to statistical data, the maximum fault tolerance rate can reach 15%, thus affecting the accuracy of the manufacturing results of metal materials. The latter means that the design is not carried out according to the corresponding design criteria in application, which involves the fixed position of parts, machining size, etc., which also reduces the machining quality of finished products and affects the reliability of machining results of parts.

4.4. Mechanical Adjustment Error
In addition to the above-mentioned influencing factors, the mechanical adjustment error is also an important factor affecting the machining accuracy. In the process of machining, due to the adjustment of the configuration requirements of mechanical parts, it is necessary to make technological adjustment of metal materials during machining, which leads to the problem of mechanical errors. According to the statistical results of big data technology, the occurrence probability of this kind of error problem is 10%-15%, which is also the key content in application. This kind of error problem occurs because the amplitude in the adjustment process can't dynamically control the parameters, and can't ensure that the adjustment parameters are controlled within a reasonable range, which leads to the problem of poor machining accuracy of metal materials [1].

5. Key Points of Surface Quality and Precision Control of Metal Materials

5.1. Surface Quality Control Measures

5.1.1. Strengthen the Quality Control of Raw Materials. By strengthening the quality control of raw materials, we can provide guarantee for the orderly operation of the follow-up activities, thus ensuring the reliability of the processing results of metal materials. In concrete practice, we should pay attention to the following contents: First, in the selection of metal materials, it is necessary to do a good job of finishing the machining process, which involves machining benchmarks, precision requirements, durability requirements, etc. On this basis, we should draw up a reliable material purchasing plan, refine the contents of the purchasing plan, such as purchasing quantity, purchasing requirements and so on, and purchase strictly according to the requirements to ensure the compliance of raw material purchasing quality. Secondly, metal materials are prone to raw material corrosion in the external
oxidation environment. Therefore, after checking the quality compliance of purchased materials, it is necessary to draw up a reliable material storage plan, place it in a dry and ventilated environment, and give priority to the use of the last batch of surplus materials when taking materials, so as to adjust the qualified rate of surface quality of metal materials to over 96% [2].

5.1.2. **Reasonable Selection of Processing Technology.** Reasonable selection of processing technology can ensure the order in machining process and improve the rationality of processing results of metal materials. In practice, we need to pay attention to the following contents: First, make full use of big data technology, Internet technology and information technology to sort out the related technologies involved in the processing process, and sort out the technology application process, including processing cost and applicable environment, so as to set up the construction technology management system and provide reference for processing technology selection. Second, sort out the processing technology flow. Taking the cutting process as an example, it is necessary to determine the cutting speed, cutting depth and other contents in the process carding, and to determine the contents that each node needs to pay attention to. Moreover, it is also necessary to do a good job of personnel communication before the process application, so as to help them get familiar with the contents that should be paid attention to in the process application, thereby reducing the negative effects caused by human factors and ensuring the orderly advancement of machining activities [3].

5.1.3. **Do a Good Job in Machining Process Control.** Good control of machining process can ensure the rationality of machining results in each link and improve the reliability of machining results. From the practical application, first, refer to the contents in Figure 1, subdivide the machining process into multiple stages, and then refine the contents of each stage. During this period, big data technology will also be used to sort out the data, and with the help of information technology, 30%-50% of the value data will be screened from the sorted data, which will be used as the basis to complete the construction of the machining management system and ensure the guidance of the system. Second, do a good job in the construction of management team. In order to ensure that the surface quality of metal materials can meet the standard smoothly, besides relying on the precision of the machinery itself to supervise the machining process, it is also necessary to set up a supervision and management team on the spot to supervise the whole machining process, and to ensure the compliance of operation quality of each link with random sampling. At the same time, it can also speed up the discovery of problems and make timely adjustments, which can also reduce the waste of resources by 20%-30% and improve the rationality of material processing results [4].

5.1.4. **Reasonable Selection of Cooling Conditions.** Reasonable cooling conditions can ensure the compliance of cooling quality of parts and reduce the probability of irregular deformation. From the practical application, the cooling liquid is generally used as the carrier during cooling treatment, so as to relieve the high temperature generated during grinding of metal materials and avoid the negative effects caused by thermal expansion of metal materials. In the use of coolant, it will be sprayed directly on the surface of mechanical parts, so as to achieve effective cooling. The selection of nozzles also needs to be adjusted according to the pressure value when cutting parts, which can ensure the cooling effect and avoid the problem of coolant waste. In addition, considering the complex structure of grinding wheel used in metal material processing, it is easy for the sprayed coolant to stay on the surface and not cool the inside. In this cooling liquid spraying, it is also necessary to do a good job of liquid drainage, so that it can be fully introduced into the cavity of the structure, to ensure that the grinding wheel structure can maintain a uniform temperature state, to exert the application effect of cooling liquid above 85%, and at the same time, to increase the resource utilization rate to above 90% [5].
5.2. Precision Control Measures

5.2.1. Reduce the Original Error. Reducing or avoiding the original errors can greatly improve the geometric accuracy of machine tools, which not only needs to improve the accuracy of fixtures, measuring tools and precision parts themselves, but also relies on process control to avoid the occurrence of original errors such as thermal deformation. First, the main causes of original errors should be analyzed, and corresponding schemes and measures should be taken according to different situations. For example, for machining the forming surface of parts, it is necessary to reduce the tool errors to improve the accuracy, while for machining precision parts, it is necessary to improve the rigidity and hot machining of machine tools [6]. Secondly, the error transfer method can be used to reduce the error, which refers to transferring the sensitive direction of the error so that it stays in the non-sensitive area and reduces its interference to the core parts and precision parts. Thus, although the error is always inevitable, the damage caused by the error can be correspondingly reduced by technological means, thus improving the machining quality and accuracy [7].

5.2.2. Make Error Compensation. If error compensation is done well, the accumulated value of machining error can be controlled in a very small range to improve the accuracy of machined parts. The essence of this method in use is to create a new error under the condition of human intervention, which will be offset with the original error of parts, so as to realize the stable improvement of machining accuracy. From the practical application point of view, it is necessary to do a good job of sorting out the original errors in the application, use information technology to sort out the basic data, screen about 30% of the value data under the background of mining technology application, and obtain objective calculation results in a quantitative way [8]. According to the calculated results, the error compensation values are determined, and these contents are orderly and evenly integrated into the machining activities to improve the rationality of the error compensation results.

5.2.3. Differentiation Error Control. By doing a good job of differentiation error control, the influence of uncertainty error can be further reduced, and the accuracy of machining results of parts can be improved. The so-called differentiation error is the way of unified planning of errors and the method of averaging the original error data. In practical application, it is also necessary to combine the basic situation of the original error feedback, sort out the workpieces in groups, count the errors of each group of workpieces, and adjust the parameters according to the sorting results to improve the reliability of the positioning results [9].

6. Conclusion

To sum up, strengthening the quality control of raw materials can guarantee the orderly progress of the follow-up operations; Reasonable selection of processing technology can ensure the order in the machining process; Good processing control can ensure the rationality of processing results in each link; Reasonable cooling conditions can ensure the compliance of cooling quality of parts; Good error compensation can control the cumulative value of machining error in a very small range; Doing a good job of differentiation error control can further reduce the influence of uncertainty error. Taking appropriate measures to improve the surface quality and precision control level of metal materials is of positive significance for promoting the stable economic development of the mechanical processing industry.

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