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THE MODELING OF RELATIONSHIP BETWEEN CUTTING FORCE AND MAIN TECHNOLOGICAL FACTORS IN CYLINDRICAL GRINDING

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Keywords: calculation model, productivity, metal removal, external cylindrical grinding, CNC machines, cycle, cutting force.

Abstract. This paper presents a model for calculating the productivity of the metal removal process in cylindrical external grinding on CNC machines for a given automatic step cycle. This model allows determining the current values of feeds, the amount of actually removed stock by cycle steps, the current values of the radii of the machined surface, and the basic time of stock removal. The model is based on the relationship of cutting force with the cycle parameters, elastic deformations of the technological system, and the main technological factors. The relevance of modeling the process of metal removal in automatic cycles of circular external grinding on CNC machines is due to the lack of automated design systems, regulatory and reference literature, and methods of cycle design that meet the requirements of modern automated production. The article presents the methodology for calculating actual feeds and cutting forces for a given cycle and grinding conditions.

МОДЕЛИРОВАНИЕ ВЗАИМОСВЯЗИ МЕЖДУ СИЛОЙ РЕЗАНИЯ И ОСНОВНЫМИ ТЕХНОЛОГИЧЕСКИМИ ФАКТОРАМИ ПРИ КРУГЛОМ ШЛИФОВАНИИ

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Ключевые слова: модель расчёта, производительность, съём металла, круглое наружное шлифование, станки с ЧПУ, цикл, сила резания.

Аннотация. В данной статье представлена модель расчёта производительности процесса съёма металла при круглом наружном шлифовании на станках с ЧПУ для заданного автоматического ступенчатого цикла. Эта модель позволяет определять текущие значения подач, величину фактически снятого припуска по ступеням цикла, текущие значения радиусов обрабатываемой поверхности и основного времени съёма припуска. Основой модели является взаимосвязь силы резания с режимными параметрами цикла, упругими деформациями технологической системы и основными технологическими факторами. Актуальность моделирования процесса съёма металла в автоматических циклах круглого наружного шлифования на станках с ЧПУ обусловлена отсутствием автоматизированных систем проектирования, нормативно-справочной литературы и методик проектирования циклов, отвечающих требованиям современного автоматизированного производства. В статье представлена методика расчёта фактических подач и сил резания для заданного цикла и условий шлифования.

Introduction

The purpose of this work is to increase the efficiency of circular external grinding operations with feed by selecting a rational structure and parameters for the working cycle, considering the grinding mode that accompanies the machining process on CNC machines for a given automatic step grinding cycle. Additionally, the geometric, physical, and mechanical properties of the processed metal significantly influence the magnitude of force and deformation. The productivity model allows for calculating the current values of feeds, the amount of actually removed allowance by cycle steps, and the current values of the radii of the machined surface.

Achieving high-quality and efficient production results relies on the utilization of current technology and equipment. The primary requirement for this equipment is to ensure high productivity while meeting stringent demands for machining accuracy. To fulfill these contemporary demands, machine tool manufacturers strive to implement various modern innovations promptly. This effort encompasses enhancements not only in mechanical components but also in electronic systems, while simultaneously focusing on ergonomics and equipment design.

Therefore, in designing high-performance cycles for circular external grinding with longitudinal feed, a model that relates cutting forces to cutting modes, elastic deformations, and grinding technological conditions becomes essential [1-2]. This model facilitates the calculation of operational productivity, current feed rates, the actual amount of material removed per cycle step, current radii of machined surfaces, and the basic operation time.

When subjected to cutting forces (Py) applied to the links of the elastic system comprising the machine-tool-workpiece interface, deformation occurs within this technological system. The system's ability to withstand these forces and resist deformation is characterized by its rigidity. The accuracy of machining is primarily influenced by deformations that alter the distance between the tool's cutting edge and the machined surface, specifically those deformations oriented perpendicular to the machined surface.

Grinding surfaces is a critical process in the manufacture of parts for strategic sectors such as automotive and aeronautics. Improving operational efficiency for external cylindrical grinding begins with designing an optimal grinding cycle that ensures precision and quality requirements of the drawing are met in the shortest possible time. This is a complex scientific and technical task that can be addressed using the dynamic programming method (DPM), which is considered a method of optimal control theory.

This article discusses the main aspects of applying DPM for optimizing short grinding cycles. The aim of increasing operational efficiency defines the objective function criteria as the shortest possible treatment time. This paper programmatically investigates the relationships between actual radial feed, programmed radial feed, grinding force, and elastic deformations that alter the wheel axis at all stages of the process [3].

The temperature in the contact zone with the wheel is calculated. Even greater differences are observed in studies when determining the amount of heat entering the chip, the wheel parts and the environment. Thus, the amount of heat entering the part is, according to various researchers [4], from 25 to 75%, sometimes more. According to various researchers, such as Korchak S.N., Ostrovsky V.I., Redko

S.G., Reznikov A.N., the amount of heat entering the part is from 25 to 78%, sometimes more. Researchers use analytical methods of calculation to establish general regularities and functional relations between temperature and change of properties of surface layers of parts or intensity of wear of grinding wheel grains. Thus, in a number of works [5] the entire contact area is taken as a heat source rather than individual grains. The method of calculation has led to doubtful results, when the value of heat flux density from the action of a single grain is less than from the action of the contact area. As analytical methods, the method of thermal sources is used. The main features of these methods are a large number of assumptions and the complex functional nature of the resulting dependencies. To calculate the grinding performance and quality of the machined surface, the local temperature, which occurs in the surface layers of the workpiece from the action of single wheel grains [6], is of greatest interest. Evaluating machinability requires understanding the temperature of the metal at the moment the abrasive wheel grain makes contact [7-9].

Conclusion

The complex mathematical correlation between the allowance removal model and the mathematically calculated cutting force provides a means of assessing the impact of various technological factors on productivity, accuracy and quality of processing during the working period. This assessment is carried out by changing the control parameters of the cylindrical external grinding cycle. These parameters include the number of cycle stages, the program speeds of the radial velocity at each stage of the cycle, the distribution of the allowance over the cycle stages. The results, outcomes, practical and scientific improvement include planning to increase the level of industrial automation programming of CNC machines in industrial processes within digital production.

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