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Probabilistic Approach for Modeling Electroerosion Removal of Grinding Wheel Bond

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Abstract

This study is focused on the development of mathematical models for the diamond-spark grinding process. The diamond-spark grinding is an efficient technique for the precision machining of hard and brittle materials. In comparison with conventional grinding, the diamond-spark grinding allows maintaining grinding wheel sharpness during machining cycle due to the directed destruction of its bond by electric discharges. The proposed model is based on probabilistic approach and it allows calculating the value of the bond layer removed with erosive discharges and predict the state of technological system at any moment. The example of the developed model practical use is also presented.

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Keywords: diamond-spark grinding; dressing; model; abrasive machining; hard and brittle materials.

1. Introduction

At the present stage of manufacturing engineering development one of the most important requirements is an increase in stability of parts quality parameters, which provides minimization of deviations from the rational values.

Particular attention should be given to the development of effective technologies of hard and brittle materials machining [1]. The most widely used hard-to-machine materials are tungsten carbide, high speed steels, stainless steels, ceramics, etc [1,2].

For such materials processing the most successful method is an abrasive machining [3], in particular the most progressive way of hard-to-machine materials machining is diamond grinding. During machining the diamond wheel is subjected to the glazing and loading. In order to maintain wheel sharpness it necessary to regenerate it by

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dressing. It is desirable to make it continuously without process interruption. Many investigations have been devoted to the studying of the in-process dressing [1-17]. The efficient technique for this purpose is a diamond-spark grinding, which allows to maintain the required condition of the tool due to directed destruction of its bond.

The effective use of this technology is possible on the basis of adequate mathematical models, which would allow to stabilize parameters of technological system in desirable area. Such model is presented in this paper.

2. Mathematical model

Removal of the material, as a result of erosion, is a stochastic process, which can be characterized by the fullness of the wheel bond removal.

The probability of the erosion removal of the wheel bond can be defined as a probability that a stochastic variable l_{zp} will be less than half of the width of two neighboring pits $b_{zp}(q)$ at the level q (Fig. 1):

$$P_{cb}(q) = P\left(0 < l_{zp} \le b_{zp}(q)\right) = \int_0^{b_{zp}(q)} f\left(l_{zp}\right) \cdot dl_{zp} \qquad (1)$$

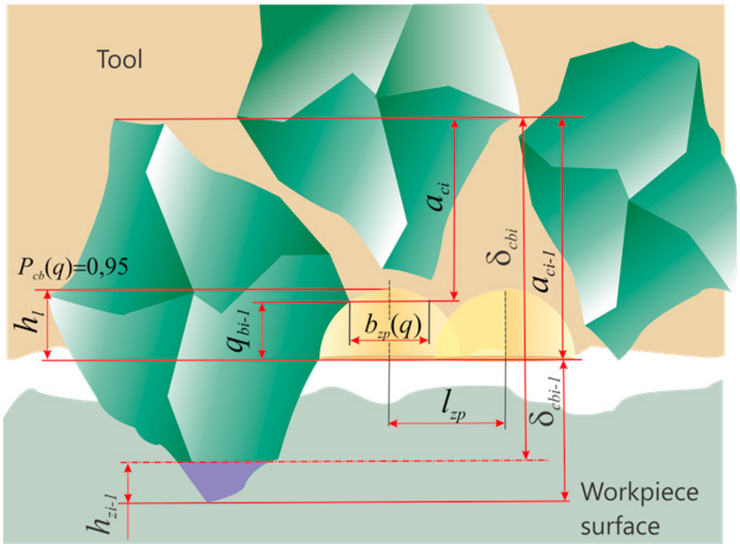

Fig. 1. The scheme for material removal calculation.

Let us define the density of distribution $f(l_{zp})$ by the describing the occurrence of events l_{zp} as a simple stream with exponential law of density distribution [18]:

$$f\left(l_{zP}\right) = \lambda \cdot e^{-\lambda l_{zp}} \qquad (2)$$

Then, expression (1) can be rewritten in a form:

$$P_{cb}(q) = \int_0^{b_{zp}(q)} \lambda_{l.cb} \cdot e^{-\lambda_{l.cb} l_{zp}} \cdot dl_{zp} = 1 - e^{-\lambda \cdot b(q)} = 1 - e^{-\Delta a_{cb}(q)} \qquad (3)$$

where $\lambda_{l.cb}$ is the average number of pits per bond surface unit $\Delta a_{cb(q)} = \Delta\, \lambda_{l.cb} \cdot b_{zp}(q)$.