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Optimization of Processing Conditions when Drilling Deep Holes: Twist Drills

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Abstract

The problems of optimization of parameters and modes of processing for drilling deep holes by twist drills were studied. Drilling was carried out under the control of a special control system that measures the torque on the tool. The drilling process and the beginning of the definition of packaging chips were monitored. The control algorithm was based on the limitation of the maximum torque resistance, acting on the tool. The torque limit has been set on the basis of the torsional strength of the tool. The analytical calculation and computer simulation processing time drilling deep holes were made on the basis of experimental studies. It is shown that there is extremal dependence of the time of drilling from the vertical feed rate depending on predetermined limits on the maximum torque

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1. Introduction

The process of deep holes drilling using twist drills is quite difficult to automate and many works take it as a subject of study. [1-9]. There are several reasons of this, and the main of which is the difficulty of chip escape along the grooves with increasing of hole depth. This effect is associated with an increase of the chip friction on surfaces of the drill and the hole as a result of its elongation and results to chip's accumulation and its packeting [10]. Packeting of chips increases the torque resistance to rotation with a positive feedback. Upon reaching a certain limit of torque resistance occurs:

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a) stop of drilling because of the wedge of tool due to low power of the main movement drive;

b) damage or destruction of the instrument, when the limit of its torsional strength is exceeded.

Case a) is described in detail, for example, in [11], and can be interpreted in terms of the nonlinear dynamics as a bifurcation of stability loss such as a "fork". Case b) corresponds to a "catastrophic" scenario [12] of the drilling system failure.

The foregoing underscores the importance of preventing scenarios of development a) and b) during the drilling of deep holes. One of the possible methods of control is the control of the translational movement of the tool with the restriction on the maximum value of resistance moment [13]. The setting value is estimated as the minimum of the possible technological limitations, including:

- Limit the torque of main drive
- The strength of the tool
- The possible rate of increase of the moment of resistance
- Performance of the control system, etc.

Naturally a question about the possibility of optimizing the process of drilling of deep holes and the choice of optimal conditions of treatment is appearing.

2. Justification of the optimization capabilities

The basis of the study opportunities to optimize (minimize) the processing time of one hole formed the experimental results obtained in the study of the process of deep holes drilling with control with the limiting of the resistance torque value [13].

The dependences of torque obtained when drilling of the titanium plate using the carbide tipped twist drill of 16,4 mm diameter are shown in Fig. 1. The modes of processing : a) the rotational speed is 500 rev / min, feed is 85 mm / min; b) the rotation speed is 500 rev / min, feed is 70 mm / min. In both cases, the limit of 25 N*m was set in the control system for torque limitation, after reaching which the drill extracted from the drill hole for chip removal.

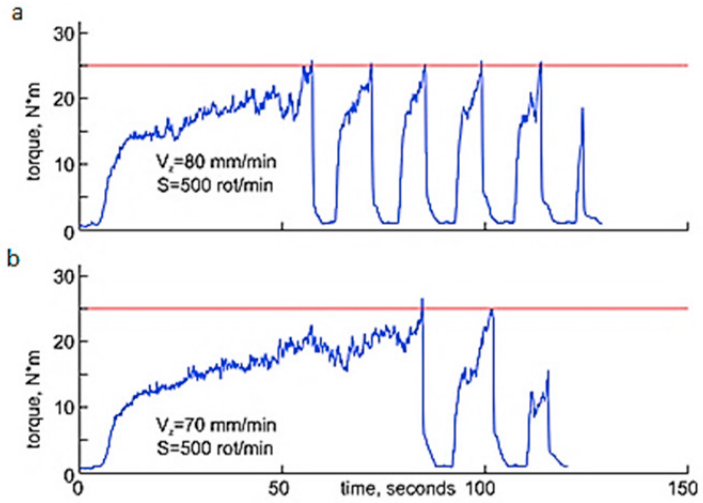

Fig. 1. Diagram of the moment of resistance against time for drilling deep holes. (a) feed V_z = 5 mm / min, drilling time - 135 seconds; (b) feed V_z = 70 mm / min, drilling time -120s.

As can be seen from the graphs, drilling holes in a higher feed took time to 15 seconds longer than the drill at a lower feed. That is, increasing the feed leads to an increase drilling time due to more rapid achievement of the torque limit and more frequent extraction the drill from the drilling hole. This means an increase the proportion of time of supporting movements in the overall balance of the drilling time. On the other hand, too small feed rate will also result in large drilling length. Thus, it follows, that at some intermediate feed rate the extremum (minimum) of