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Features of plastics edge cutting machining

A V Handozhko, A N Shcherbakov, L A Zaharov and T V Gavrilenko
Bryansk State Technical University, 7, 50 years of October st., Bryansk, 241035, Russia

E-mail: msi@tu-bryansk.ru

Abstract. This article describes the features of pieces from thermoplastic materials in the form of electrical insulators cut by a disk edge tool. The problems in question are possible defects arising during machining and technological conditions that reduce their quantity. The necessity of required machining conditions matching substantiated in accordance with a specific grade of the material which is treated. Equipment and machining attachments, developed for experimental studies, determine the rational conditions of plastic electrical insulators machining. As a result of experiments the dependences of cut face quality parameters of plastics are obtained by machining conditions. The obtained results allowed us to make valid conclusions and recommendations.

1. Introduction

Good performance characteristics, high electrical properties, corrosion resistance, low-level noise during operation, high level of labor productivity during parts manufacture and low operating costs of plastics promote their integration into various branches of engineering.

The range of plastics application is wide: they are used as heat-insulating, electroinsulating, radio-technical, frictional, antifrictional, structural materials in units and mechanisms of machinery and devices.

Plastics are non-metallic materials, composition and production technology of which is different from metals composition and production technology. Details of plastics are produced by press forming, casting, molding, stamping. At the same time their size and shape are modified due to material shrinkage at cooling.

Except for polymer the plastic consists of: fillers, plasticizers, stabilizers, hardeners, lubricants, colorants, blowing agents and others. All these components affect the properties of plastics, including technological [1, 2, 3]. In terms of machining the fillers are very important. Fillers are used to improve mechanical properties of plastics, reduce shrinkage, and increase resistance to various types of ambient. The type of the filler, its properties and structure fundamentally affect the machinability of plastic and tool life [3, 4].

Plastics machining is required, widespread and one of important operations in the whole manufacture process for parts made of these materials. The necessity of machining requires the study of theoretical and practical issues of plastics cutting, edge tools progressive structures development, rational cutting conditions and special or specialized high-performance equipment.

Many scientists and nongraduates, such as A. Kobayashi, B.P. Shtuchnyi, V.I. Drozhzhin, N.V. Vyrezub et al., have studied machining of plastic materials. The guidance on practical implementation of different plastics machining, including requirements for cutting tools, have been developed according to these and other studies.

The influence of the tool cutting ability on the formed quality parameters of the workpieces surface layer is sufficiently large. The tool cutting ability changes during machining, which negatively affects the formation of quality parameters. The need to adjust machining conditions becomes inevitable. From this point of view an adaptive cutting process control system use is of great interest. One of them was developed by Russian scientists A.G. Suslov and D.I. Petreshin [5].

New types of plastics with special performance characteristics appearing in recent years are difficult to classify as proposed groups with cutting performance. This requires an additional research and development of new recommendations for their machinability.

A typical example is the manufacture of insulators of electrical connectors (Figure 1).

The main box-shaped workpiece of the electrical connector is an insulator made of thermoplastics of various grades, such as Lexan 3412R; Polyamide 66 structural and glass-filled; Teksan APK-2 black; Penlite GN-3130, Makrolon-8030 and others. Insulators are produced in wide range depending on operational characteristics and standard sizes of connectors.

A group of insulator with a maximum possible number of contacts is obtained by molding of plastics under pressure (Figure 1), which is subsequently cut up into required standard sizes depending on the number of contacts. This leads to a number of issues connected with machined surfaces required accuracy and quality provision (surface roughness, trims size, no chippings, melting).

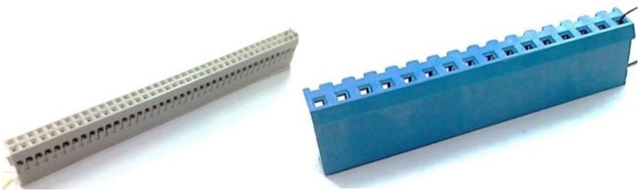


Figure 1. Insulators of electric connectors

Despite the widespread use of plastics in mechanical engineering, their cutting is most often carried out on equipment for metal working. In some cases, companies themselves design and manufacture special machine tools for plastics machining in order to fit their needs.

Disc cutters with a fine tooth of HSS (GOST2679-93) for metal working are used for plastics cutting.

The use of the cutter for metal as a cutter for plastics is a compulsory measure. The plastics, cut by the metal cutter, include thermoplastics (GOST 20324-74) produced only with a large diameter of 315 and 400 mm with thickness of 4 and 5 mm, respectively.

Insulators cutting by means of such technological equipment allows producing relatively reliable parts of required accuracy. However, roughness provision causes difficulties and the burr, which arises, is large in size and is strongly bounded with the part. Burr cutting and, in some cases, surfaces grinding must be done manually.

2. Task description

The following problems must be solved in order to study the cutting process of blanks of thermoplastic materials, such as electrical insulators:

- To develop a methodology for research;
- To design and manufacture the equipment and machining attachments for experimental studies;
- To conduct necessary studies on cutting the items from thermoplastic materials;

Process results will be obtained in order to identify dependencies of machined surfaces quality parameters on machining conditions and make appropriate conclusions and recommendations.

3. Hardware development for experimental studies

A special system based on the horizontal milling machine was developed in order to conduct researches to provide a required accuracy of the surface layer and quality parameters (Figure 2).

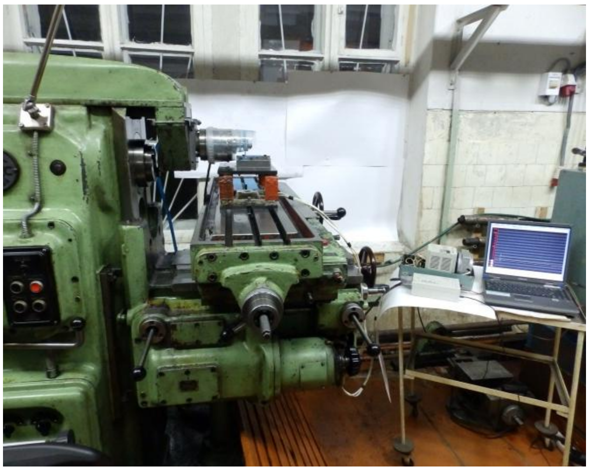


Figure 2. A system for experimental studies of plastic insulators cutting

The electric spindle of the SHFV grade with a capacity of 0.6 kW and the shaft with the speed of up to 18,000 min^{-1} were used in order to ensure a wide range of cutting rate control. The rotation of the electric spindle shaft (cutting speed) was changed by a variable frequency driver. The electric spindle is mounted on the support plate, attached on the machine arbor support. The pneumatic pipeline with an air-borne oil circulating system has been placed in order to provide its lubrication or cooling.

The capabilities of the drive of the machine axis were used for cross-feed movement. The cutting was performed by a disc cutter for metal working with increased (up to 15°) back angles.

A special device installed on the working surface of a special dynamometric table was designed and produced for insulators blanks cutting (Figure 3).

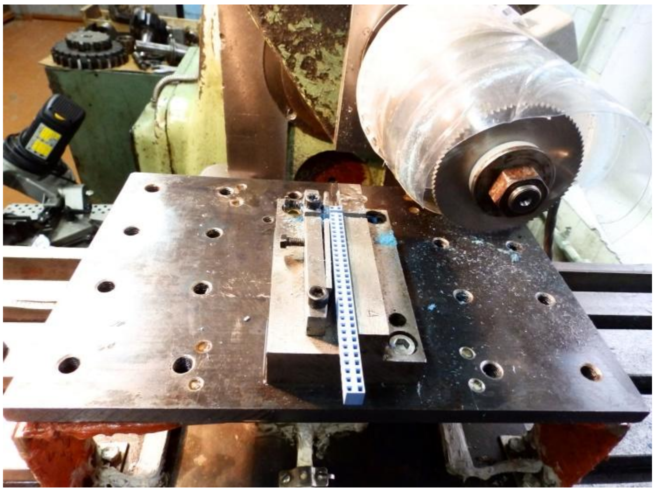


Figure 3. System for experimental studies of plastic insulators cutting

The dynamometric table was used in order to measure the cutting force components. Strain-measuring module LTR-212 of crate system L-CARD with appropriate software processed the obtained data.

Burr size was measured by means of a microscope with an output for connection to PC.

The roughness integrator, model 'ABRIS PM7', measured the roughness on the cut surface.

Machining preconditions, namely cutting depth, chosen equal to thickness of the insulator (from 4 to 10 mm), were selected on the basis of available literary recommendations. These recommendations include: the range of cutting speeds is from 750 to 4500 m/min, the feed per tooth is from 0.0005 mm to 0.01 mm, the cutter rake angle is 10 °, the back angle is15 °. The feed during cutting is associated.

The cutting and feed speed varied during experiments. The roughness and burr size were used as output parameters.

4. Results and conclusions

Electrical insulators made of material Lexan 3412R were used as the samples for research implementation.

During the experimental research the following results have been obtained.

A feed increase causes a significant increase of roughness within the feed change range under study. The cutting speed influence on generated surfaces roughness is insignificant (Figure 4.5).\

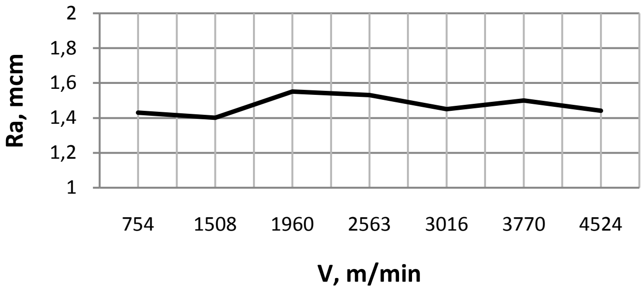


Figure 4. Diagram of the dependence of cut surface roughness on cutting speed Ra= f (V) at Vs = 500 mm/min,\

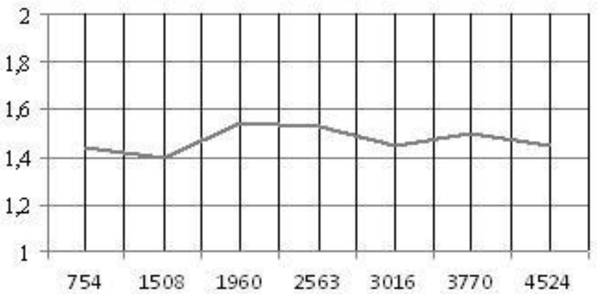
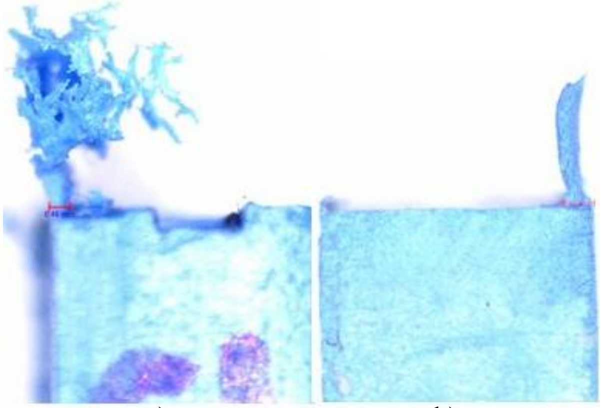


Figure 5. Diagram of the dependence of cut surface roughness on cutting speed Ra= f (V) at Vs = 1000 mm/min,

The burr size was evaluated through thickness (S) of its root when analyzing samples photos made by the microscope. Figure 6 shows the typical burrs arising at cutting.



a) b)

Figure 6. Photos of burrs at insulators cutting:
a) burr thickness is 0.46 mm, b) burr thickness is 0.85 mm

The results of measurements processing are presented in Figure 7.

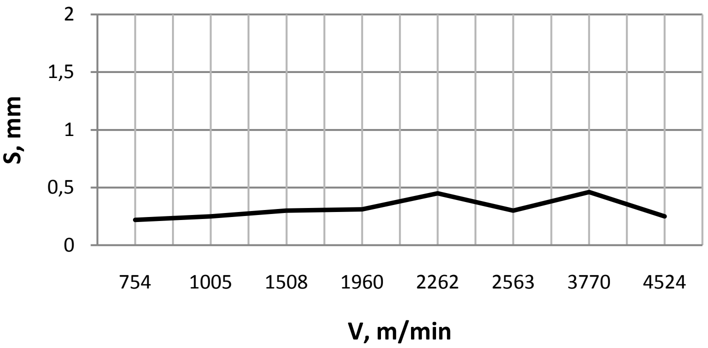


Figure 7. Diagram of the dependence of the burr size on cutting speed s = f (V) at Vs = 500 mm/min.

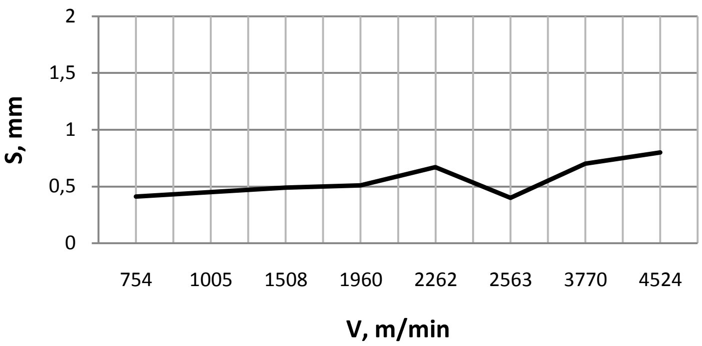


Figure 8. Diagram of the burr size dependence on cutting speed s = f (V) at Vs = 1000 mm/min.

Graphical dependences partly give an indication of cutting conditions influence on the burr size.

Burr bond strength is difficult to assess experimentally with detail. Therefore, this assessment can be considered as conditional. The efforts separating the burr declined with cutting forces increase and increased with feeds growth.

The radius of cut edge rounding and a wear rate along the rear surface greatly influence the cut quality. Cutter blunting leads to deterioration of the cutting quality. This effect decreases with the cutting speed increase.

According to the results of experiments a number of conclusions can be made: 1) high speed machining of thermoplastics allows improving a generated surfaces quality; 2) the cutting speed increase as a whole has a positive effect on cutting process characteristics and machining quality within the range under study; 3) the feed increase within the range under study leads to the cutting forces and roughness increase, in some cases the defects destruction are possible at material melting; 4) in some ranges of spindle rotational speed the resonance phenomena develops, tool and spindle equipment should be precisely balanced, as well as the strict regulation of their beating must be taken into account; 5) under proper selection of machining conditions, as well as the strict control of the cutting tool state the machining can proceed without burr formation.

The experimental data have been obtained relatively only one of the above-mentioned materials, which is Lexan 3412R.

The implementation of further experimental studies is required in order to subject plastics of other grades to DB machining.

The results of these studies were used to develop a special machine for cutting the parts of the electrical plastic insulator with low frequency.

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