Increasing Of Efficiency Of Environmentally Friendly Technology Of AWJ Of A Glass Fiber Plastic

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Abstract. Special technological methods allowing to reduce the probability of stratifications spreading for the cut-off blank when applying environmentally friendly AWJ technology are developed by the authors of the article. As a result the quality of the item improves, its cost value decreases.

Introduction

One of the most widespread materials of polymeric group are glass fiber plastics. The glass fiber plastic is used for manufacturing of electrical distribution devices, panels which designs may contain a large number of through-elements (fastener holes, windows, slots of different configuration).

The condition of material, presence of micropores and microcracks, inherent stresses, discontinuity flaw of binding connection and other defects, connected with the process of manufacturing of sheet polymeric materials as well as their storage period, have an influence on the quality of machined surface.

The traditional methods of cutting which are not excluding manufacturing defects also have other shortcomings, such as low productivity; complexity of making details of a figured profile; significant waste of material because of irrational cutting, big allowances and overlapping. Usually, waste caused by technological features of machine processing, physical and chemical characteristics of material and their interference are considered in the manufacturing process by increasing the standard of a material consumption depending on the complexity of a details configuration, requirements for processing accuracy, batch size, etc.

To that end, environmentally friendly technology of waterjet cutting with liquid or hydro abrasive jet becomes widespread [1-4]. Absence of thermal influence (as the temperature in the cutting zone is 90 degrees) and power mechanical impact on the processing unit, as well as a small amount of material waste, distinguish this technology [5-10].

Main type of reject in the processing of glass fiber plastic by AWJ-method is stratification in the places where abrasive liquid jet cut into the material. The factors which significantly influence on the emergence of stratifications, are similar at the hydro abrasive cutting and processing by the edge tool, and can be divided into two groups:

1) the technological factors which depend on the modes of processing and technological parameters of the equipment;
2) a condition of material at the time of processing.
The influence of the first group of factors at the hydroabrasive processing of details made of glass fiber plastic was considered in [11 - 15] in detail. It is found out that the size of stratifications is highly affected by hydroabrasive jet outflow pressure during plunge cutting, abrasive grit, diameter of a nozzle outlet and its interference [11, 12].

A condition of material at the time of processing is understood as the presence or the absence of micropores or microcracks, inherent stresses, discontinuity flaw of binding connection and other defects, connected with the process of manufacturing of multilayer sheet materials as well as their storage period.

Though the influence of the first group of factors is subject of researches [16 - 19], it is difficult to predict the influence of the second group of factors in advance.

The complex of technological methods is developed to completely exclude or to reduce the influence of stratifications of material using AWJ, when the demanded parameters of quality of details made of glass fiber plastic with minimal labour inputs, costs of material and energy resources are ensured.

1. Development of complex of technological methods

1 Technological methods used for cutting of external contours [20]:

a) Increasing the length of the entry of a jet to the cutting-out blank contour (figure 1). Value of entry to a contour should be slightly larger than a size of stratification.

The consumption of the cut-out material increases, cutting becomes less rational. For more rational cutting it is possible to put the blanks as shown in figure 2. Plunge cutting for four blanks in this case is realized at one point, which saves the quantity of an abrasive necessary for plunge cutting for blanks 2, 3, 4 since the opening for jet entry is already made during plunge cutting for blank 1 at a point (1) and excludes emergence of stratifications. Cutting at a such positioning of blanks on a plate will look as shown in figure 3.

![Figure 1](image.png)

**Figure 1.** Technological method: increasing the length of entry to the blank outline for exclusion of reject. 1 – entry to the outline, 2 – leaving the outline.
b) To make plunge cutting outside the material. Cutting is made outside out of material at distance 0,5-1mm from the edge of the sheet.

Processing of the first group of blanks is shown in a figure 4.

As plunge cutting is made outside material, stratifications do not appear. Thus, it is possible to reduce the length of entry to a blank contour.

Processing of the second and the subsequent groups of blanks needs to be performed as follows: after cutting of the first group of blanks, the operator stops the process and extracts the cut out blanks. Plunge cutting for the second group of blanks has to be performed in the openings which remained from the taken blanks of the first row (figure 5). After cutting of the second group of blanks, the
operator extracts them from a sheet; plunge cutting for cutting of the third group of blanks is made in the openings which remained from the second row. Thus, cutting of a sheet is made consistently by rows.

**Figure 4.** Cutting of the first group of blanks with plunge cutting at the points (1), (2), (3) outside the material.

**Figure 5.** Processing of the second group of blanks with plunge cutting outside the material.

Such method of cutting has a shortcoming: the equipment downtime connected with a need of extraction of the cut-out details. It is expedient to use this method for processing of sheet material from 10 mm thick where time of a blank cutting is rather great, and also for cutting large-size blanks.

c) Use of the clipping cuts. Cutting of sheet material of relatively small thickness occurs with high enough speed (for example, from 1500 mm/min for STEF-1 with thickness of 6 mm, and to 10000 mm/min for STEF-1 with thickness of 1 mm). Therefore the technological method with plunge cutting
into the openings from the taken blanks will lead to considerable downtime of the expensive equipment. In this case it is expedient to use the clipping cuts.

For this purpose the technological clipping cut (figure 6) is made before cutting of the first group of details.

Cutting of the first row of blanks is made after the clipping cut. Plunge cutting into material is made on the left of the clipping cut, and the contour of the blank is located to the right (figure 7). Thus, the defect does not reach further than the clipping cut at the emergence of stratifications during entry into the material.

![Figure 6. Execution of the technological clipping cut](image)

![Figure 7. Layout of the blanks using clipping cut: a - a general view; b - closer view.](image)

Further, the second clipping cut and cutting of the subsequent row (fig. 8) are performed. It is possible to completely cut the material with the cut-off blanks and to remove it from an equipment desktop when performing of the second clipping cut; it is also possible to make the clipping cut as it is shown in fig. 8.

Before processing of the third row one more clipping cut is made, etc.
When using this technological method, it is important to make sure that the plunged cutting is made at a distance no more than 0.5-1 mm to the left of the clipping cut to avoid of hooking of an edge of material with a nozzle, that can lead to shift of sheet material or damage of a nozzle. It is connected with the fact that cutting thin-sheet materials up to 5 mm thick, very often results with the uplift of the cut-off material edge that can lead to collision of a nozzle and the edge and, correspondingly, to the damage of a nozzle and shift of sheet material during processing. Distance from a place of entry into the clipping cut has to be less than the outer diameter of a nozzle. It allows not to hook the rising material edge with the nozzle edge.

2. Summary
Authors of the article developed the following special technological methods for cuttings of external contours, cuttings of internal contours, a choice of a type of a basic surface for placing of material, a choice of the direction of execution of the contour and the sequence of cutting of blanks. Their use allows to decrease or to exclude the probability of distribution of stratifications on the cut-out blank using AWJ; that provides improvement of quality of items made of glass fiber plastic and decrease its prime cost.

References
[1] Tikhomirov R A, Petukhov E.N., Babanin V.F., Starikov I.D., Kovalev V.A. High-pressure jetcutting // Mechanical Engineering (1992)
[2] Ansari A.I., Hashish M. Effect of abrasive waterjet parameters on volume removal trends in turning // Journal of engineering for industry. (1995)
[3] Tikhomirov R.A. Waterjet cutting: process and equipment // Russian Engineering Research. (1997)
[4] Stepanov Yu.S., Barsukov G.V., Bishutin S.G. Technological Fundamentals for Efficiency Control of Hydroabrasive Cutting // 2nd International Conference on Industrial Engineering (ICIE-2016). Procedia Engineering. Volume 150, 2016, Pages 717–725.
[5] Bach F.W., Louis H., Versemann R., Schenk A., Characterization of a pure water-jet cleaning process - Process simulation, Strojniški vestnik/Journal of Mechanical Engineering. (2006).
[6] Chillman A., Hashish M., Ramulu M., A novel approach to energy based evaluations of ultra highpressure waterjets, American Society of Mechanical Engineers, Pressure Vessels and Piping Division (Publication) PVP. (2010).
[7] Salenko A.F., Shchetchin V.T., Fedotyev A.N., Improving accuracy of profile hydro-abrasive cutting of plates of hardmetals and superhard materials Improving accuracy of profile hydro-abrasive cutting of plates of hardmetals and superhard materials, Journal of Superhard Materials.
(2014).
[8] Chillman A., Hashish M., Ramulu M., Potential of waterjet peening for mainstream industrial applications, in: Proceeding of BHR Group - 21st International Conference on Water Jetting: Looking to the Future, Learning from the Past. (2012).
[9] Hashish M., Erosion modes during AWJ lathe slotting, American Society of Mechanical Engineers, Manufacturing Engineering Division, MED. (1995).
[10] I. Ajmal, Hashish M., Volume removal trends in abrasive waterjet turning effect of abrasive waterjet parameters, American Society of Mechanical Engineers, Production Engineering Division (Publication) PED. (1993).
[11] Koenig, W. Machining of Fibre Reinforced Plastics / W. Koenig, Ch. Wulf, P. Grass, H. Willersheild // Manufact. Tech., CIRP Annals, 1985.-Vol. 34.-P. 537-548.
[12] Hashish, M. Machining of advanced composites with abrasive-waterjets / M. Hashish // ASME Winter Annual Meeting, Chicago, Illinois, Nov.27-Dec.2, 1988.
[13] Hashish, M. Characteristics of surfaces machined with abrasive waterjet/ M. Hashish // MD.-1999.-Vol. 16. - P. 23 -32.
[14] Ho-Cheng, H. A failure analysis of water jet drilling in composite laminates / H. Ho-Cheng // Int. J. Mach. Tools Manufact., 1990.- Vol. 30.-P.423-429.
[15] Louis H., Pude F., Von Rad Ch., Versemann R. Abrasive water suspension jet technology fundamentals, application and developments // Welding in the World. (2007).
[16] M. Ramulu, T. Briggs, M. Hashish Quality and surface integrity of waterjet machined automotive composites // in: Proceeding of BHR Group - 22nd International Conference on Water Jetting (2014)
[17] Ansari A.I., Ohadi M.M., Hashish M., Effect of waterjet pressure on thermal energy distribution in the workpiece during cutting with an abrasive waterjet, American Society of Mechanical Engineers, Production Engineering Division (Publication) PED. (1988).
[18] Ohadi M.M., Ansari A.I., Hashish M., Experimental study of the role of thermal energy transfer in material removal processes using abrasive waterjets, American Society of Mechanical Engineers, Fluids Engineering Division (Publication) FED. (1988).
[19] Louis H., Pude F., Versemann R. Abrasive water suspension jet technology - Fundamentals, application and developments // Rivista Italiana della Saldatura (2007)
[20] Barsukov GV, Zhuravleva TA, Semes VV Patent RU №2577667 Method Waterjet cutting sheet layered polymeric materials.