Research on processing technology of alumina ceramic interlayer composites

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Abstract. Composite materials which the interlayer is alumina ceramics have the characteristics of high surface toughness, high hardness in the interlayer, high brittleness. To meet the precision of machining process, the quality requirement of the product surface and the requirements of machining processing schedule at the same time, it is difficult to process all kinds of angle and holes. Aiming to solve the difficulties in the processing technology of interlayer composite materials, the choice of machine, knife tools and the processing parameters, as well as the determination of process quality are researched deeply. Meanwhile, the equipment specifications, blade diameter, the relationship between cutting speed and the thickness of interlayer composite materials are all determined. The determination method of process quality is given by the section quality, size precision and the surface quality and other aspects. This paper can guide the processing of related defense composite materials.

1. Introduction
Alumina ceramic interlayer composite is composed of more than three kinds of materials. The commonly used sandwich materials are alumina, silicon nitride, silicon carbide, boron carbide, titanium boronized ceramics, etc. The sandwich materials are superhard materials. The products are widely used in the fields of heat resistance, corrosion resistance, wear resistance, sealing, precision components, elastic materials, etc. More and more products used this kind of materials are widely used [1]. The processing quality requirements of this kind of products are higher and higher, and the quantity is larger and larger. As the relationship between the processing method and technology of the external soft and internal hard materials and the performance and quality of the products had always been an important research field. The processing technology parameters play a very significant role in the alumina ceramic interlayer composite, and the performance and quality of the products obtained by different processing technology parameters are quite different [2-3]. With the deepening of the research on the processing technology of alumina ceramic interlayer composite, the processing technology is more and more mature, and the research and development of special equipment and cutting tools specially used for the processing have made continuous breakthroughs [4-5]. This paper take the alumina ceramics as an example, and the results are shown as follows.
2. Selection of resin
The selection of resin is usually based on the technical requirements of composite products and fiber materials. The commonly used resins are nylon 66, polypropylene, LDPE, EVA, TPU and PVC etc. Considering the price cost, molding process, bonding and composite properties, market scale, purchase difficulty, etc., EVA resin is selected.

3. Structure and composition of alumina ceramic sandwich composite components
Due to the particularity of sandwich materials, alumina ceramic sandwich composite materials usually adopt sandwich structure. Sandwich materials are located between two layers of fiber composite materials. According to different purposes, according to the requirements of performance indicators, sandwich composite structures of single or multi layers can be used. Common fiber materials include carbon fiber, glass fiber, basalt fiber, aramid fiber and their fabrics. The selection of fabrics can be comprehensively considered according to the technical requirements, application background, cost control, processing difficulties and other aspects of the product. The technical indicators of commonly used fibers are as follows:

| Material name | Density (g/m³) | Tensile Strength (MPa) | Tensile modulus of elasticity (GPa) | Elongation at break | Maximum operating temperature |
|---------------|----------------|------------------------|------------------------------------|-------------------|-------------------------------|
| E glass fibre | 2.55           | 3100–3800              | 72~75                              | 4.7%              | 380°C                         |
| S glass fibre | 2.54           | 4000–4600              | 83~86                              | 5.3%              | 300°C                         |
| carbon fibre  | 1.78           | 3500–6000              | 230–600                            | 1.5~2.0%          | 500°C                         |
| basalt        | 2.8            | 3000–4800              | 79~93                              | 3.1%              | 650°C                         |
| Aramid fiber  | 1.45           | 2900–3400              | 70~140                             | 2.8~3.6%          | 250°C                         |

In this paper, the fiber material is E-glass fabric, and the interlayer material is alumina ceramic.

4. Analysis of processing difficulties of alumina ceramic sandwich composite
Because of the high hardness and brittleness of alumina ceramic sandwich composite material, it is impossible to finish it by ordinary machining means, especially the machining of various angles and holes is very difficult. It is difficult to ensure not only the machining accuracy requirements, but also the quality requirements and processing progress requirements of the machining surface. To solve the above problems, we often adopt the following methods:

According to the quality requirements, the stainless steel formwork shall be processed first, and the alumina ceramic sandwich composite products shall be processed according to the corresponding formwork, so that the product size is completely consistent with the processed formwork.

The NC machining equipment is used to automatically complete the positioning and machining process after selecting the benchmark.

5. Selection of equipment and tools
Aluminum oxide ceramic sandwich composite processing equipment is limited by processing accuracy and other conditions. Generally, CNC equipment with heavy chassis is selected. CNC bridge cutting machine and three-dimensional CNC drilling machine are commonly used. If necessary, non-standard equipment can be used. Equipment manufacturers design the drilling and cutting equipment and tools
of the composite according to the processing requirements of our products. The working table of the bridge cutting machine is determined according to the size of the processed products. Generally, the table is made of water-resistant hardwood material, and the specific parameters are as follows: Table size: 2100mm×3300mm; Main motor power: 5kw; Cutting accuracy: ±0.2mm; Repeated cutting accuracy: ±0.1mm; Maximum cutting speed: 3000mm/min; Table rotation angle: 360°.

The worktop of the drilling machine is grinded granite worktop according to the product size; all the cutters are diamond cutters, and the cutters used are as shown in figure 1; during rough machining, sintered diamond cutters are used; during fine machining, electroplated diamond cutters or PCD diamond cutters are used; the cutters are sintered diamond saw blades.

6. Study on process parameters
The cutting process of alumina ceramic sandwich composite material is actually the grinding process of the tool to the material. The quality of the machining surface is closely related to the linear speed and feed speed of the tool. The best feed speed can achieve the best effect in the processing efficiency and quality.

6.1. Study of the feed speed
In general, the rotation speed of the blade is certain (2400-3200 RPM), and the feed speed is inversely proportional to the thickness of the ceramic composite plate to be processed. However, no matter how thin the plate is, the maximum feed amount cannot exceed 2000mm / min, and the excessive feed amount will cause shaking, severely affecting the processing quality and even causing damage to the ceramic sandwich material. The relationship between cutting speed and the thickness of alumina ceramic sandwich composite plate is shown in table 2.

| Thickness (mm) | Rotation speed (r/min) | Blade Diameter (mm) | Feed speed (mm/min) |
|----------------|------------------------|--------------------|---------------------|
| ≤5mm           | 2400~3000              | 300                | 1500~1600           |
| 6~10mm         | 2400~3000              | 300                | 1200~1300           |
| 11~15mm        | 2800~3000              | 350                | 1000~1100           |
| 16~20mm        | 3000~3200              | 400                | 900~1000            |
| 21~25mm        | 3000~3200              | 400                | 800~900             |
| 26~30mm        | 3200~3500              | 400                | 700~800             |

6.2. Study of the drilling speed
When drilling, considering the factors such as the size of the bit, the jitter of the bit and the discharge of drilling cuttings, the rotating speed of the bit is generally controlled at 700-1100 revolutions / min.
if the rotating speed is too high, it will cause quality problems, such as the hole diameter is too large and the interlayer is broken; in the process of drilling, the intermittent feeding process is generally adopted to ensure the timely discharge of processing cuttings from the drilling and the timely cooling of the bit.

It should be noted that the newly replaced saw blade and drill bit should be cut with firebrick before use, otherwise the cutting speed and section quality are difficult to be guaranteed; the cooling water should be kept uninterrupted during the cutting and drilling process, otherwise the tool will be damaged due to overheating.

7. Determination of process quality

7.1. Section quality
The quality of cutting section is an important factor to measure the quality of products. Generally, the cutting saw blade is sharp, rotating speed is appropriate and cutting speed is appropriate. The cutting section is smooth and flat without cracks or fewer cracks. If there are many cracks or stepped sections, the quality is poor, and the causes shall be found and solved in time according to the site conditions. The main causes of the problems are as follows: the saw blade is seriously worn and not sharp enough, and the saw blade shall be repaired or replaced in time; if the feed speed is too fast and the load of the saw blade is too large, the rotation speed of the saw blade will be reduced, which will lead to the increase of cracks or the appearance of steps. The cutting speed should be reduced in time. For round holes, when the bit speed is insufficient or the bit is damaged, the cross-section quality of the hole will be affected, so it needs to be adjusted in time.

7.2. Dimensional accuracy
Due to the limitation of machining equipment, the tolerance of ceramic composite is generally set at ± 0.5mm. The machining process must be strictly controlled. When the tolerance is beyond the positive value, it can be repaired, but it is very time-consuming. When the tolerance deviation is negative, it is determined as unqualified product.

7.3. Surface quality
The surface quality of alumina ceramic composite workpiece is greatly affected by the machining process. When the surface quality has special requirements, special attention should be paid to and corresponding protective measures should be taken during the processing process to prevent the workpiece surface damage. The common protective measure is to add a layer of soft protective material on the machine tool table.

8. Conclusion
There are many kinds of composite materials, and the processing technology involves many problems, such as mechanical equipment, material types, tool types, etc. the parameters of the processing technology change with the change of materials. In this paper, the processing technology of alumina ceramic sandwich composite materials is studied from several aspects, such as the selection of equipment and tools, the selection of process parameters, and the determination of process quality. The research conclusion is given.

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