Carbon fiber composite products molded finite element analysis

Ruyuan Qiu [a], Ruifeng Cao [b], Mengquan Shang [c]

College of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao 266590, China.

[a]240371902@qq.com, [b]1730369581@qq.com, [c]1643745559@qq.com

Abstract

Design of carbon composite reinforced parts in some sport equipment and their mould development are made. Since composites are thermoset, the technology of mould forming is adopted. A carbon composite blank is heat and soften in advance, then is put in mould cavity and the mould is clamped. The mould is heat and the blank is solidfied and formed. When the mould is cooled and unfolded, the whole process of the carbon composite product is finished. Reversal design technique is used to design mould. The combined mould cores are chosen to make mould unfolded easily. Some key parameters, such as the pressure in mould cavity and mould clamping force, are calculated. Desired effects in the material choice, precision and service life of moulds are reached. A carbon composite laminate is made of many layers. The angles and order of layers affect carrying capacity of structures. Based on the classical theory of laminated plates and shells, using a finite element of thin shells in ANSYS software, the stuctrue is analysed with many parameters under peak loads. The optimized ply-up scheme suitable to stuctural features is determined.

Keywords

Carbon Fibre-Reinforced Plastics; laminate; Mould forming; mould; Finte Element; Strength.

1. Introduction

1.1 Background and Significance

The product materials used in this paper are carbon fiber composites. Composite materials conceptually refer to multiphase materials composed of two or more different properties of materials on a macroscopic scale [1]. The performance of composite materials is better than that of component materials, which improves the stiffness, strength, and dynamic properties of component materials [2]. Among many composite materials, carbon fiber composite materials are representative of composite materials with superior performance. Their high elastic modulus and high strength mechanical properties have been widely used in many fields. Sporting goods generally require light weight, high strength and good damping performance, while carbon fiber composite materials have the required physical properties and are increasingly becoming the preferred materials for high-end sports equipment. The research on carbon fiber composite materials started in the 40s and 50s of the last century and is mainly used in cutting-edge technology fields and military products such as aerospace. With the maturity of production technology and cost control, carbon fiber composite materials have gradually entered the general public's daily necessities from high-end applications. Sports equipment has also become one of the main areas of use of carbon fiber materials [3], mainly due to three points:

(1). Carbon fiber composites have superior mechanical properties and physicochemical properties that other materials cannot achieve. Such as high temperature and corrosion resistance.

(2). The most obvious feature of the composite material is the designability. The user designs the material structure according to the type of the material and the content of the reinforcing fiber in the

material. In addition, when designing materials, the layering angle and order of the materials can be arbitrarily changed to meet the strength requirements of the materials, which is difficult to achieve in the general structural design of metal materials [4].

1.2 Research Status at Home and Abroad

Molding is a molding method suitable for thermosetting and thermoplastic materials. The process is as follows: firstly, the carbon fiber composite material blank is preheated and softened, and then the blank is manually placed in the cavity to mold. The mold is heat-cured and molded, cooled to mold, and demolded to obtain a carbon fiber composite product. The molding process has better forming effect and better precision control. However, this molding method also has certain limitations. The mold design and manufacturing are complicated, the investment of the press and the mold is high, and the product size is limited by the equipment, and generally only suitable for manufacturing large and medium-sized small and medium-sized products [5]. The products of this project belong to small size and large batch of products, so the molding process is selected. However, due to the technical constraints of the production of high-performance carbon fiber in China (hereinafter, Jiangsu Zhongfu Shenying Carbon Fiber Co., Ltd. has overcome the technology of mass production of high-performance carbon fiber, the degree of localization is accelerating), the production scale is small, and the composite product mold technology is currently Need to be improved and further developed. The author has done some research and discussion on the design of composite molding die.

2. Mould Design of Carbon Fibre Composite Products

According to the structural characteristics of the carbon fiber composite material, the concave mold is required to be a closed, semi-closed curved cavity. The processing technology and equipment requirements of the concave mold structure are relatively high, and the conventional processing method is difficult to realize. With the development of CAD\CAM technology, computers are widely used for auxiliary processing, which has made certain breakthroughs in the manufacture of parts with complex profiles, and has also greatly improved processing precision and production efficiency. For the cavity machining of the mold, the overall machining is difficult due to the curved surface features of the cavity. Therefore, the segmented electrode is used. After the combination of the electrodes, the outline of the segment is the same as that of the designed die. Finally, the discharge is performed through the electrodes. Machining the die. The processing method of the core is similar.

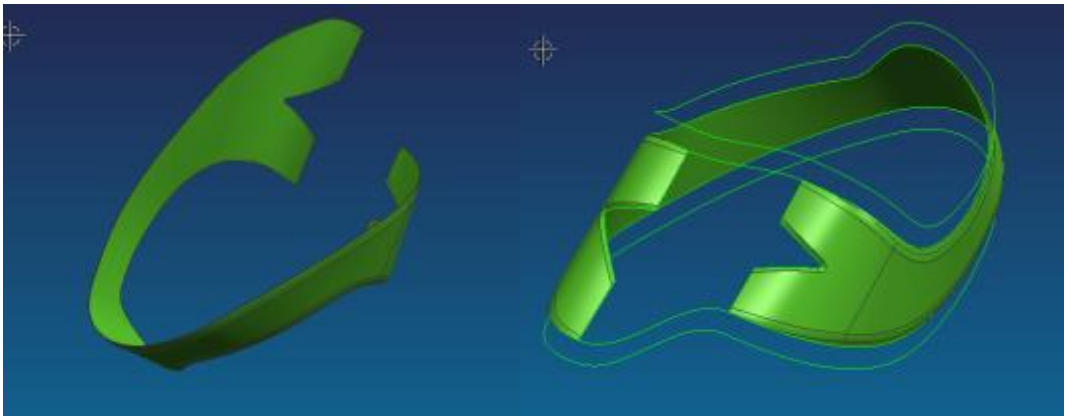

Fig. 1 Geometry of a composite product

3. Finite Element Analysis on Mould Forming of Com-posite Products Using ANSYS

This chapter aims to analyze the strength of composite products during compression molding. In view of the fact that the fiber composite material is a thermosetting material, a press molding process is employed. Since the material is softened by heat, the strength between the layers of the material is lowered, and when the pressure is applied after being placed in the mold, if the design of the mold is unreasonable or the applied pressure is not suitable, the material may be damaged or insufficiently .

Fig. 3-1 Finite element grids

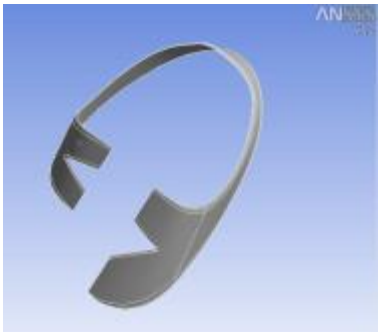

Fig. 3-2 Solid structure model

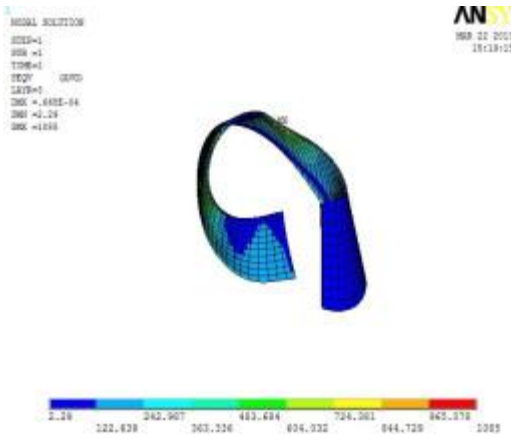

Fig. 3-3 Mises stress

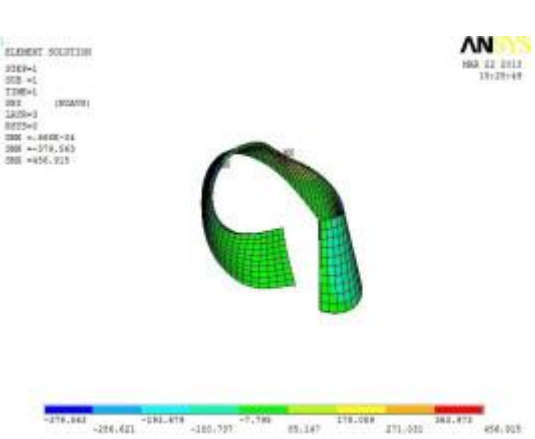

Fig. 3-4 Shear stress

Table3-1 Comparison of maximum stresses in 4 ply-up scheme (MPa)

铺 层	Mises应力	τxy	τyz	τxz
(0/90/0)	1085	456	203	256
(0/45/-45/0)	1215	554	194	336
(0/0/0)	1102	470	142	243
(30/-30/30/-30)	1321	597	373	533

4. ConclusionFinite Element Analysis of Composite Products und-er Sport Loads Using ANSYS

The composite product is a reinforced piece of a racing shoe that is glued to the main load-bearing part of the heel to increase the strength of the part. Although the load is complicated during the exercise, it is mainly loaded with the impact force and lateral pressure of the heel. The peak value of the load is 1000 N depending on the person's weight and other factors. The reinforced sheet is required to be damaged during continuous impact and has a light weight requirement for the reinforcement. In view of this requirement, both high strength and light weight, using conventional sports shoe materials, obviously cannot fully meet the design requirements. The use of the carbon fiber composite material can minimize the weight of the reinforcing sheet and has high specific strength and specific rigidity.

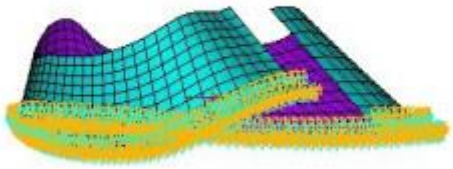

Fig. 4-1 Constraints

5. Conclusion

1. The material needs to be heated and solidified during the molding process, so thermoelastic coupling analysis is required. If the deformation is large, a nonlinear analysis is also required.

2. The results of the compression molding analysis should be fed back to the mold modification. For parts where excessive stress peaks occur, the shape and mold of the product need to be optimized to improve the quality of the product.

3. There is still room for improvement in mold structure design; the processing technology of the mold can be further optimized to improve the processing quality of the mold cavity surface and ensure the quality of the product.

4. The main parameters of the molding (such as mold pressure, heating curing temperature, holding time), etc. need to carry out more tests, comprehensively consider the molding effect, finished product quality and processing cost, optimize

References

[1] Bryan.Harris.Engineering Composite Materials [M].IOM Communications Ltd,1999:13-16.
[2] Peter Kohnke.ANSYS Theory Reference Release9.0 [Z],2004.
[3] Xiaopeng Zhang, Jiayu Zhang . Effect of different components of peanut sheller on the shelling performance of peanut[J].Journal of Laiyang Agricultural College,1990,7
[4] Yibing Shi. Food Machinery and Equipment [M]. Beijing: China Business Press, 1992.6
[5] Zhengrong Xie. Research on Cultivation Characteristics and Complementary Technology of Directly Harvested Rice [J]. China Rice, 1996.