Composite Self-healing U-shaped Canal Material and Fabrication Based on Computer 3D Modeling Technology

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Abstract. Attributing to multiple advantages such as lightweight and excellent impact resistance, plain-woven composite self-healing U-shaped canal material has been extensively applied in various fields. As it is used as the main bearing part, the existence of cracks can significantly reduce the service performance and safety factor of the material. During the usage, the internal cracks continue to expand and accelerate the material failure. In this paper, the features of four-step weaving technology are analyzed, and the yarn trajectory is simulated by the relevant computer software based on the simulation characteristics. The computer graphics technology is used to present the 3D weaving structure. The design and implementation process of composite self-healing U-shaped canal material based on the 3D modeling technology is simulated by the computer. Based on the relationship of the weaving process parameters, simulation parameters are set in the computer software to facilitate the generation of 3D weaving models for various sizes and simulation corners. This computer simulation method allows the model to approach the real structure of woven fabric infinitely, which has implemented the characterization for the damage evolution of plain woven glass fiber composite self-healing U-shaped canal material in the in-situ shear test. The geometric information of the yarn section is obtained by scanning the image, including the long and short axis in the elliptical section of the yarn and the yarn path. Spatial positioning is performed on the defects to obtain the material defect rate by statistical analysis of its volume fraction. Statistics on the geometric parameters of the yarn are performed to establish a finite element model. Given the impact of hole defects, the finite element model with defects is established. The corresponding numerical simulation of the shear test is conducted, and the impact of defects on material failure is analyzed and revealed from the aspects of modulus, strength and damage.

Keywords: 3D Modeling Technology; Woven Composite Self-healing U-shaped Canal Material; Computer Simulation

1. Introduction
In general, the internal structure of the woven fabric is highly complex. It is challenging to build the model in mechanical simulation [1-2] The design and simulation of computer-aided simulation can simplify the analysis of structural mechanics in the simulation process to a large extent. There are many studies of weaving simulation using computer technology in the world, but the simulation model is generally different from the simulation structure of things[3], and most of the simulation is woven prefabricated parts. There are few studies on self-healing U-shaped canal materials of 3D simulation composite materials. In this paper, the process of 3D modeling technology weaving composite self-healing U-shaped canal material structure is simulated by the computer [4-5]. The simulation model is simulated based on the corresponding parameters, which provide a reliable basis for the mechanical research of composite self-healing U-shaped canal material.

2. Simulation Process of 3D Modeling Technology
In the process of 3D weaving, four steps are used for structural weaving. The woven yarn is arranged with the yarn carrier according to the cross-section shape of the preform, and the yarns are interleaved with each other according to the rule to carry out the weaving movement. The structured shape of yarn simulation is determined by the motion law of the yarn carrier. The yarn carrier will form a different row and row distribution and movement on the knitting machine according to a certain pattern [5]. As shown in Figure 1, in a simulation cycle, the motion mode and steps of the yarn carrier always repeat the following four steps. Subsequently, through the tightening and weaving output of the machine, the material simulation process can be completed to form the final shape of the simulation.

![Figure 1. Diagram of 3D modeling technology simulation process](image)

3. Determination of Weaving Parameters
In a (m * n) rectangular woven fabric, the yarn will return to its original position after s cycles of weaving. S is the number of motion cycles of the yarn carrier, m and N are the number of rows and columns of the fabric, and G is the greatest common divisor of M and n.

\[ S = \left( \frac{mn + m + n}{g} \right) \]

In a square knitting array (4 * 4), the yarn is carried by the yarn carrier (12) through the trajectory on the horizontal plane in the way, where s = 6, i.e. the yarn carrier will return to its original position after 24 steps of 6 cycles.

Through the analysis of the yarn position, a coordinate system as shown in Figure 2 can be established, in which the x-axis represents the row direction of the horizontal cross section of the braid, the y-axis is the column direction of the horizontal cross section of the braid, and the z-axis is the
height of the braid. In this square knitting array, the distance of one step of the yarn carrier's row direction movement is x, and the distance of one step of the row direction movement is y. The height of the woven fabric is increased by Z for each step or row direction movement. According to the trajectory of the yarn in the horizontal plane, the movement distance of the yarn in the z-axis after a movement cycle is calculated, and the shape and position of the yarn in the 3D space can be obtained. After analysis, the cross-section of the 3D woven structure was observed[5-6]. The width of the weaving mechanism is w, the number of rows and columns are m and N respectively, and the horizontal orientation angle of the yarn is set as $\phi$ (in the prefabricated structure, $\phi = 45^\circ$, but in the composite self-healing U-shaped channel structure, $\phi$ is generally not 45°), and the horizontal weaving angle is $\alpha$. The size of the inner sub-cell of the fabric is as follows:

$$2X = \frac{4b}{\sin \phi}$$
$$2Y = \frac{4b}{\cos \phi}$$

The width and length of the 3D woven CMCs are as follows:

$$W = \frac{h(2n+1)}{\sin \phi}$$
$$h = \frac{4W}{(2n+1)\tan \alpha_t}$$

The following can be deduced from the above two equations:

$$X = \frac{2W}{2n+1}$$
$$Y = \frac{2W \tan \phi}{2n+1}$$
$$Z = h = \frac{2W}{4(2n+1)\tan \alpha}$$

![Figure 2. Coordinate system of 3D woven structure](image)

4. Yarn Trajectory Fitting

In general, the motion trajectory of the yarn carrier is a broken line, which will show an unsmooth curve form in the actual structure after being tightened by the machine. In the simulation, the motion trajectory needs to be processed to make the trajectory smooth. The location of each step of the fiber is set as the control center, and the relevant curve software is used for compliance fitting.

After the trajectory fitting, the yarn's trajectory will become smooth, and the path of each fiber will
approximate a straight line. Only when it meets the surface or weaving angle of the fabric, there will be an offset, and its trajectory will follow the law similar to light reflection. In the real fabric structure, the basic path of yarn running is a straight line. Only at the corner of the surface and the core, it shows that the simulation results are consistent with the actual direction of yarn in the practical textile.

5. Simulation of Composite Self-healing U-shaped Canal Material Structure Based on 3D Modeling Technology

Figure 3 is the flow chart of 3D modeling technology simulation of composite self-healing U-shaped channel material structure in this paper. The spatial structure and position data of the above-mentioned braids are determined. The position of each step of the yarn is taken as the control point, and the trajectory is fitted with the relevant curve software. The spatial shape and position data of 3D braids are designed by VC++ language development system. In the program, the spatial shape and position of the yarn are calculated according to the known relevant data and records them in the data file. Then take UGNX software as the 3D simulation platform to pre-fabricate the woven fabric, and set the cross-section of the yarn as an ellipse. The prototype will move along with the set trajectory and ensure the tangent direction of the trajectory is consistent with the normal of the cross-section of the yarn. Then simulate the real motion diagram of all the threads, and get the 3D space diagram of the value structure, and then realize the 3D modeling technology simulation composite Computer simulation of the material structure of self-healing U-shaped canal.

![Figure 3. Computer simulation flow chart of composite self-healing U-shaped canal material structure based on 3D modeling technology](image)

6. Conclusions

In this paper, mainly the features of woven composite self-healing U-shaped canal material structure based on 3D modeling technology are analyzed. In addition, the powerful graphics processing function
of computer is used to simulate the weaving process of 3D modeling technology based on its simulation principle. The woven preform and solid structure model are obtained in the computer, so that the formation process and specific spatial structure of the woven fabric can be observed before it is fabricated in real life. Such type of simulation can increase the design and manufacturing efficiency of the woven fabric to some extent and improve its solid quality, with a high practical value.

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