Scientific Research

Computer Simulation for 4-Step 3D Variable Braided of Rectangular Cross-Sessional

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Abstract: In reality, a lot of cross-section of 3D braiding are variable. But on the whole cross-section 3D variable braiding study is less. In this paper, computer-aided design of 3D braiding and simulation systems were developed based on the 4-step 3D variable braided technology. The system can carry out the computer simulation of yarns movement and display 3D variable braiding visualization model. In the system, enter the parameters of 3D braiding to decide the condition of add/cut yarns and then produce 3D variable braiding visualization model. Combine with the methods of the twice 4-step, produce 3D variable braiding of complex rectangular cross-session. Program to simulate the motion of yarns was worked out by using the script language of Python and Tkinter. The visualized models of the 3D braided perform were constructed by VTK.

Keywords: 4-step; rectangular cross-session; variable; 3D braided perform

1.Introduction

Since 1960s, many solutions of 3D braiding have been proposed. There are still many new process and technology are proposed now. But in the scheme, there are two major kinds of 3D braiding technology: 4-step and 2-step.

The 4-step method was proposed by Florentine originally in 1982.It has different path through length, width, thickness, and all the three direction do not parallel with the braiding, and forma 3Dstructure at last[7].Using the method of 4-step can composite many skeletons, such as pipe, taper sleeve, strip, beam, T beam, L beam, Π beam, the box beam, etc.

In reality, a lot of cross-section of 3D braiding are variable, such as aerospace shuttle engine blades, engine support, airplane reinforcing plate and shell, helmets, etc[7].So far, researchers on the 4-step of 3D has gained plenty of achievements[1-4],speak to the variable cross-section, JiaoYa-nan[6] have discussed two method: decrease in the number of units and unit size reduction, but on the whole cross-section 3D braiding study is less, using computer simulation research of 3D as well.

In the paper, on the basis of the method of 4-step and combine the method of the twice 4-step ,expounds the algorithm of 3D braiding which cross-section is changable, and form 3D model using computer simulation.

2.The principle of four-step 3D single rectangular braiding composites

The 4-step 3D single rectangular braiding is carried out by yarns displacement and dislocation through the carrier move according to certain rule. Now, a 3×4 rectangular is given to show the rule of the yarns movement.

The carrier movement in a machine cycle is shown in figure1,figure1(a)is the initial state, the first step is shown in figrue1(b),the yarns with adjacent line move a unit,the second step is shown in figure 1(c),the yarns with adjacent columns move a unit,the third step is shown in figure 1(d) ,the yarn with adjacent line move a unit with contrary direction compare with the first step, the fourth step is shown in figure 1(e),the yarns with adjacent columns move a unit with contrary direction compare with the third step,

After a machine circular,the arrangement of yarns is the same as the initial state.

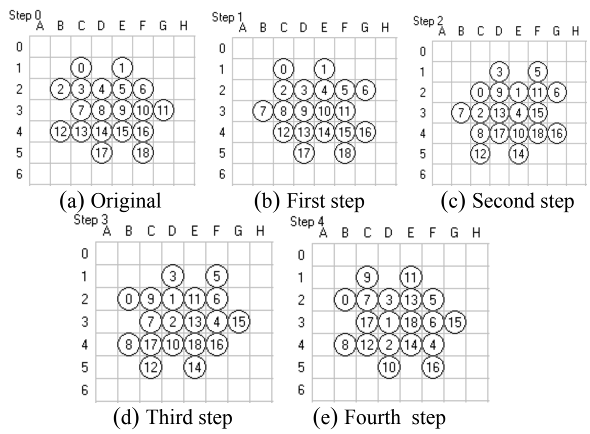

Figure 1. The carrier movement in 3×4 single rectangular cross-section

3. The principle of 3D braiding with the method of the twice 4-step

Currently the complex cross-section of 3D braiding use the method of the twice 4-step or the twice 2-step, the specific step of the method as follows: divided the complex cross-section into several groups, and then handle these units respectively[5].

Divide the rectangle which shown in figure 2 into two

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groups:the group 1 include rectangle AMBN,LCDK and the group 2 include rectangle APCR,QBSD.

In a machine cycle,the carrier moves eight steps,the first four steps move according to the following rules:

The first step,as shown in figure3(b),travel all the main yarns in group 1 and the yarns with adjacent line move a unit with opposite direction.

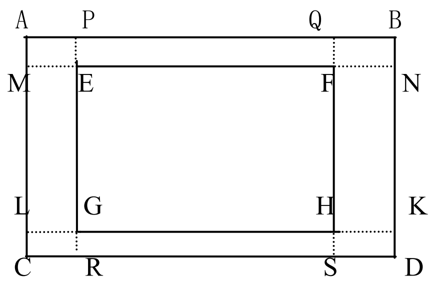


Figure 2. The split of complex rectangular cross-section

The second step, as shown in figure 3(c),travel all the yarns by column and judge that the yarns are the column boundary yarns or not, if yes, the carrier does not move, otherwise, the adjacent yarns in the column move a unit with opposite direction.

The third step, as shown in figure3(d),the yarns move a unit in opposite direction compare with the first step.

The fourth step, as shown in figure3(e),the yarns move a unit in opposite direction compare with the second step.

After the carrier's movement, the chassis arrangement return to initial state, and then the last four steps ,the carrier move according to the following rule:

The fifth step, as shown in figure 3(f),travel all the yarns by row and judge that the yarns are the row boundary yarns or not, if yes, the carrier does not move, otherwise, the adjacent yarns in the row move a unit with opposite direction.

The sixth step, as shown in figure 3(g),travel all the yarns in group 2 and the yarns with adjacent column move a unit with opposite direction.

The seventh step, as shown in figure 3(h),the yarns move a unit in opposite direction compare with the fifth step.

The eighth step, as shown in figure 3(i),the yarns move a unit in opposite direction compare with the sixth step.

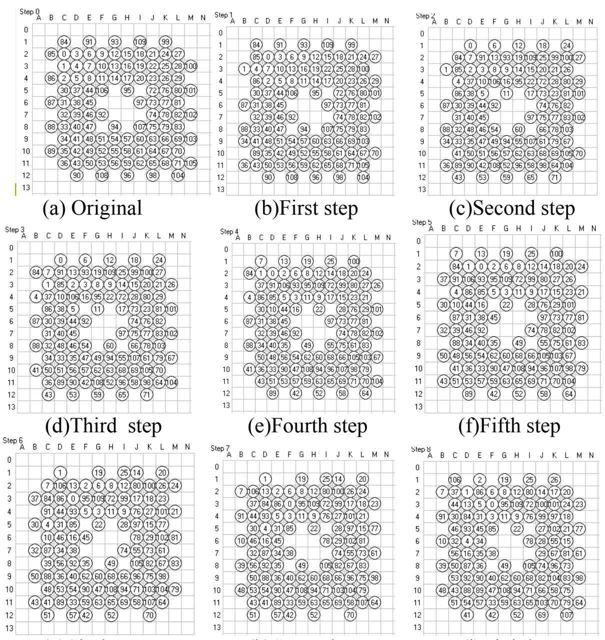
After the last four step, the chassis arrangement return to initial state again, and prepare for the next cycle.

The carrier's movement as shown in figure 3:

4. The design of 4-step 3d variable cross-section

4.1. The chassis design of 4-step3d variable cross-section

In this paper ,the chassis design can be arranged automatic when you input the size of cross-section, you need to enter the following parameters :the number of the outer yarns'row at the bottom Out_M and the number of the outer yarns'column at the bottom Out_N, the number of the interior yarns'row In_M and the number of the interior yarns'column In_N, the number of the outer yarns'row at the top Out_End_M and the number of the outer yarns'column at the top,the number of the Interior yarns'row at the top In_End_M and the yarns'column at the top In_End_N. After you input the parameters, click the button ,then through execute the program of yarn-s'arrangement, the chassis yarns can be designed. The chassis yarns arrangement can be shown in figure 4.



(a) Original (b)First step (c)Second step

(d)Third step (e)Fourth step (f)Fifth step

(g)Sixth step (h)Seventh step (i)Eighth step

Figure 3. The carrier movement in rectangular cross-section

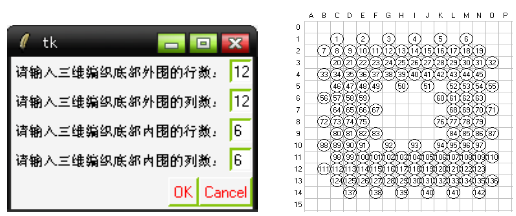


Figure 4. The arrangement of chassis yarns

4.2.The principle of 4-step 3D variable braided

The principle of 4-step 3D variable braided as follows: based on 4-step 3D braided ,we can determine to whether add/cut yarns or not according to the change of the cross-section, after add/cut yarns ,the arrangement of all yarns still accord with the rule of the chassis arrangement of 3Dbraided.

4.3.The arithmetic of 4-step 3D variable braided

Some parameters are needed to describe the 3D variable braided cross-section,besides the height of the 3D braided composites,there are also four groups parameters need to describe,the four groups parameters as follows: the number of the outer yarns'row at the bottom Out_M and the number of the outer yarns'column at the bottom Out_N, the number of the interior yarns'row In_Mand the number of the interior yarns'colunmIn_N,the number of the outer yarns'row at the top Out_End_M and the number of the outer yarns'column at the top,the number of the Interior yarns'row at the top In_End_M and the yarns'colunm at the top In_End_N.In fact,the 3D braided composites'angle can be decided according by the parameter,and then decide how to cut/add yarns.Based on the twice 4-step 3D braided,according by the parameter of "angle",we can add/cut yarns and then form the 3D variable braided composites.The script that describe how to control add/cut yarns as follow:

```
    Initialize data: ln = 1, lt = 1, Lat ,Lon means the size
of the array which storage yarns
#Delete the yarns at the left     #Delete the yarns at the
right
for i in range(1,Lat-1):          for i in range(1,Lat-1):
   if a[i][ln] <> 0：                 if a[i][Lon-2] <> 0:
          a[i][ln] = 0                      a[i][Lon-2] = 0
   elif a[i][ln+1]<>0:                elif a[i][Lon-3]<>0:
          a[i][ln+1] = 0                    a[i][Lon-3] = 0
 ln += 1                          Lon -= 1
#Delete the yarns at the top  #Delete the yarns at the bot-
tom
for j in range(1,Lon-1):          for j in range(1,Lon-1):
   if a[lt][j] <> 0:                 if a[Lat-2][j] <> 0:
      a[lt][j] = 0                       a[Lat-2][j] = 0
   elif a[lt+1][j]<>0:               elif a[Lat-3][j]<>0:
        a[lt+1][j] = 0                   a[Lat-3][j] = 0
lt += 1                           Lat -= 1
```

The arithmetic of the 3D variable braided in a machine cycle as follows:

```
#the boundary of row and column
Boundary_list_H = H
Boundary_list_L = L
#1st step
For  row in H :
  If row is even:
      yarns in the row move a position to the right
If row is odd:
     yarns in the row move a position to the left
 If 1 step satisfies the condition of cut off yarns
      Execute the module that yarns cut off
#2nd step
Tracerse the column of  yarns except the Outermost
yarns:
 If column is even:
      yarns in the column move down a unit
 If column is odd:
     yarns in the column move up a unit
 If 2 step satisfies the condition of cut off yarns
     Execute the module that yarns cut off
#3rd step
The movement of yarns are similar with the first step,but
the yarns move  in opposite direction .
#4th step
The movement of yarns are similar with the second
step,but the yarns move  in opposite direction .
#5th step
Tracerse the row of the yarns except the Outermost yarns:
 If row is even:
   The yarns in the row move a position to the right
If row is odd:
  The yarns in the row move a position to the left
If 5step satisfies the condition of cut off yarns
  Execute the module that yarns cut off
#6 step
If the chassis design is the single rectangular
Tracerse the column of the main yarns
 If row is even:
   The yarns in the column move down a unit
 If row is odd:
    The yarns in the column move up a unit
 If 6 step satisfies the condition of cut off yarn
     Execute the module that yarns cut off
Else：
 For the row in L
     If row is even:
        The yarns in the column move down a unit
     If row is odd:
        The yarns in the column move up a unit
 If 6step satisfies the condition of cut off yarns
       Execute the module that yarns cut off
# 7 step
The movement of yarns are similar with the fifth step,but
the yarns move  in opposite direction .
# 8 step
The movement of yarns are similar with the sixth
step,but the yarns move  in opposite direction .
```

5.The rule of yarns movement of 4-step 3D braiding cross-section

The rule of 4-step 3D variable braided yarns' movement is the similar to the 3D braided with the method of the twice 4-step , the difference is the former add/cut yarns when satisfy condition ,in the paper give a example to describe how to cut yarns in a machine cycle.Enter parameters that given in this paper: Out_M=28, Out_N=28, In_M=6,In_N=6,Out_End_M=12,Out_End_N=12,In_End_M=6,In_End_N=6, Height=8,the rule of yarns' movement as shown in figure 5:

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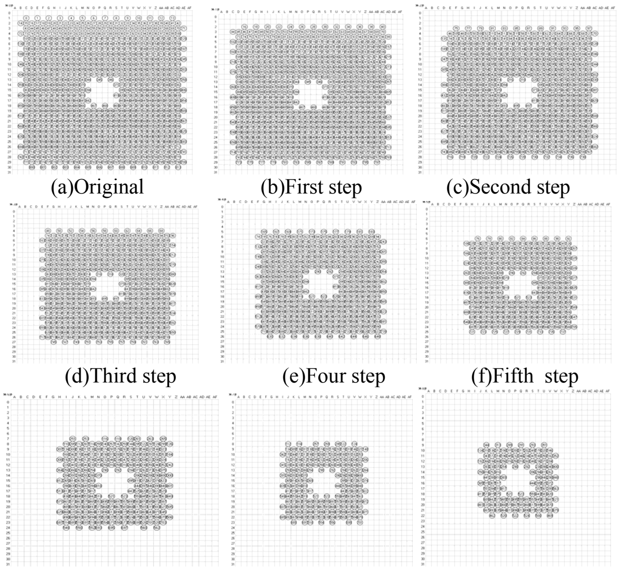

Figure 5.The carrier movement in variable rectangular cross-section

6. Result

At first, using a displayed input box,the user enters the parameters which are shown in figure 6 ,click the "Ok" button,the system can form the 3D variable braiding composites automaticly and the 3D visualization model as shown in figure 7.

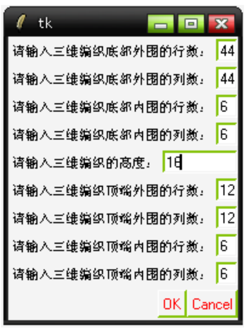

Figure 6.The input box

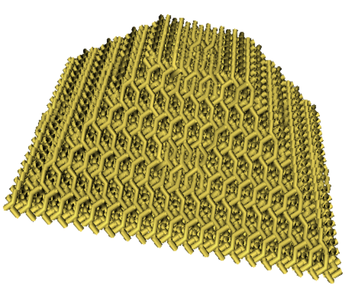

Figure 7.Computer simulation for 3D variable braided

7.Conclusion

1）In this paper, a arithmetic is given to describe how to add/cut yarns when satisfy the condition based on the method of the twice 4-step 3D braided.

2）In this paper, computer-aided design of 3D braiding and simulation systems was developed based on the 4-step 3D braided technology. The system can carry out the computer simulation of yarns movement and display 3D variable braiding visualization model.

3）In this paper, we control the condition of add/cut yarns through input the size of 3D braided composites, but only control the outer yarns how to add/cut yarns, how to control the interior yarns still need to study, so when you input parameters, the number of the interior yarns must be same.

References

[1] Han Qi-rui, Li Jia-lu, Li Xue-ming, “The unit model of 3d braided composite materials,”vol.13, no.3,pp 76-79,1996.

[2] Chen Li, Li Jia-Lu, Li Xue-ming, “The yarns braided structures of 3d braided rectangular,” Journal of composite materials, vol.17, no.3, pp.1-5,2000

[3] Chen Li, Li Jia-lu, Li Xue-ming, “The yarn motion analysis of 3d braided,” Journal of composite materials,vol.19,no.2, pp 71-74,2002 .

[4] Han Qi-rui, Li Jia-lu, Li Xue-ming,“The unit model of 3d braided composite materials,”vol.13,no.3,pp 76-79,1996.

[5] Chen Li, Li Jia-Lu, Li Xue-ming, “The yarns braided structures of 3d braided rectangular,” Journal of composite materials, vol.17, no.3, pp.1-5,2000

[6] Chen Li, Li Jia-lu, Li Xue-ming, “The yarn motion analysis of 3d braided,” Journal of composite materials,vol.19,no.2, pp 71-74,2002 .

[7] Li Ze-hong,Gu Bo-hong,Deng Xin,“Simulation for 3d rectangular and rectangular cross-section using the method of 4-step,”Journal of Donghua university, vol.28, no.2, pp 71-76,.2002 .

[8] Yan Su-min, Han Qi-rui,“2-step 3d braided yarn layout of combination of rectangular cross-section and computer design,” Tianjin textile technology, vol.41, no.4, pp 29-32,2003 .

[9] Jiao Ya-nan, Li Jia-lu, Fu Jing-yun,“The mechanism of 3d variable braided composites,” Journal of textile, vol.28no.1, pp 44-47,.2007 .

[10] Huang Gu, Yang Lian-he, Modern textile composites, China textile university press,2000 .

[11] Brian A Barsky. The Beta-Spline: A Local Representation Measures[D], PhD dissertation, Department of Computer Science, University of Utah, Salt Lake City, Dec 1981.

[12] Kostar TD and Chou TW. “Design and automated fabrication of 3D braided preforms for advanced structural composites”. Computer Aided Design in Composite Material Technology,1999