A new type of microprocessor controlled positive dobby

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A new microprocessor controlled positive dobby has been developed which is converted from model Staubli 2521, a negative mechanical control dobby. The new model has been proved to be practicable by motion simulation and a prototype. The main construction is simpler than that of many present positive dobbies, such as Staubli 2232 and Staubli 2600 series. The new model is expected to perform better than Staubli 2232.

Keywords: Kinematic analysis, Microprocessor, Motion simulation, Positive dobby

1 Introduction

In positive dobby shedding, the dobby machine both raises and lowers the shafts and, therefore, it can satisfy the requirement of weaving heavy fabrics and high loom speed. But the current positive dobby, such as Staubli 2232 and Staubli 2600 series, are too sophisticated and expensive. It is worthwhile to develop a new type of positive dobby, which is simple in construction, easy to be produced, and cheap. Model Staubli 2521, a negative one, which has simple construction and can run at a relatively high speed, is ideal for being converted into a positive dobby to meet the requirements. The present work was, therefore, aimed at converting Staubli 2521 into a positive dobby.

2 Materials and Methods

2.1 The Principle of Staubli 2521

Fig.1 shows the driving mechanism of Staubli 2521. Matched shedding cams 20 drive their follower 19 and the pushing bars 1 and 2 fixed on 19 drive the heald frame shedding control mechanism shown in Fig. 2. In Fig.2, the hook 3 engages the control hook 6. When the pushing bar 1 moves leftward and bar 2 moves rightward, the bar 2 pushes the baulk 5 to swing to the right, which, in turn, pulls jack 10 rightward and then the corresponding heald shaft is raised. If the next pick needs the heald shaft to be lowered, the control hook 7 does not engage the hook 4, and when bar 1 moves rightward and bar 2 moves leftward, the spring reverses the motion forces and the baulk 5 to swings to the left to lower the heald shaft. The other motion possibilities can be analyzed after this manner, or can be referred to the following introduction of the new positive dobby.

2.2 The Principle of the New Type of Positive Dobby

The new type is also made up of three parts: driving mechanism, selection mechanism and heald frame shedding control mechanism.

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### 2.2.1 Driving Mechanism

As shown in Fig. 3, the driving mechanism also has matched shedding cams 1 and cam follower 2. But the pushing bars in Staubli 2521 have been changed into pushing-and-pulling bars 3 and 4. In Staubli 2521, the function of pushing bars is to push the ends of baulk, while in the new type the two bars are not only to push the baulk but also to pull it by their left notch. The rotating speed of the cams is half of the loom speed.

### 2.2.2 Selection Mechanism

The selection mechanism is shown in Fig. 4. The functions of this mechanism are: (i) to enable the right tip of the dual hook to engage or keep engaged with its fixed hook knife in order to lift the heald frame (dual hook and fixed hook knife are shown in Fig. 5); (ii) to enable the dual hook to disengage or keep disengaged with its fixed hook knife in order to lower the heald shaft; and (iii) to make sure engaging of the dual hook with its fixed hook knife during shedding to avoid the accident of disengagement.

![Driving mechanism of new type](image)

**Fig. 3**—Driving mechanism of new type

![Selection mechanism of new type](image)

**Fig. 4**—The selection mechanism of new type

The mechanism is composed of action bar 33, restoring spring 31, nearing bar 35, spring 37, nearing cam 39, selection bar 41, spring 43, selection knife 45 (with a bowl), selection cam 47, keeping bar 49 and solenoid 51. After the matched shedding cams 1 come to dwell period, the selection mechanism begins action. The nearing cam 39 pushes down the selection bar 41 via nearing bar 35. If the next pick needs the heald shaft to be lifted, the solenoid 51 is energized and the selection bar 41 is attracted. Then the selection cam 47 pushes the selection knife 45 leftward and forces the selection bar 41 to move leftward. This drives the action bar 33 to swing down to engage the dual hook 5 with the fixed hook knife 9. This condition is shown in Fig. 4.

If the next pick needs the heald shaft to be lowered, the solenoid 51 should be de-energized or kept de-energized. The solenoid cannot attract the selection bar 41. Before the selection knife 45 moves left, the selection bar 41 is returned by the spring 43 and the selection knife 45 cannot push the selection bar 41. In the previous pick, if the dual hook 5 engages with the fixed hook knife 9, the action bar 33 is pulled upward by the restoring spring 31 and then the dual hook 5 is disengaged with fixed hook knife 9 by the plate spring 7. In the previous pick, if the dual hook 5 does not engage with fixed hook knife 9, the action bar 33 remains in a high position. This makes sure that the mechanism has no redundant motion.

Under the selection bar 41, there is an inset magnetic substance, such as moving iron, to enhance the attraction force between the solenoid and the selection bar. Before the selection knife moves left, all the selection bars have been pushed down to near their solenoids by the nearing bar 35 and so the...
solenoids only need small circuit to attract their selection bars. Furthermore, the small circuit can shorten the time of the solenoid’s de-energizing. These measures make the whole mechanism respond quickly to the selection instruction from the microprocessor. At the lower right corner of the selection bar, there is a protrusion. When the selection knife 45 pushes the selection bar 41 to the most left position, with the attracting force of the solenoid, the selection bar 41 will be pulled down. After the selection knife moves back, the selection bar 41 will be locked by the keeping bar 49. This will avoid any mishap to make the dual hook disengage with its fixed hook knife during the shedding. This makes the whole mechanism more reliable.

2.2.3 Heald Frame Shedding Control Mechanism

In Fig. 5, the heald frame shedding control mechanism is composed of fixed hook knives 9 and 10, dual hooks 5 and 6, plate springs 7 and 8, baulk 11, jack 12, link 15 and lever 16. The left side of the bar 3 has a notch to enable the left tip of the dual hook 5 to engage with, the right side of the bar 3 has a circular arc surface with which bar 3 can push the baulk 11 at the inset 13 (the inset also has a circular arc surface and is fixed on the upper end of the baulk 11). The jack 12 links the baulk 11 at point P.

In Fig. 5, the next pick needs the heald shaft to be lifted, the hook 5 engages knife 9 and the hook 6 engages with bar 4 at its left notch. When the bar 3 moves leftward and the bar 4 moves rightward, the bar 4 pushes the baulk 11 to swing to right at inset 14 and then the baulk 11 pulls the jack 12 to swing to right at the link point P. Through the link 15 and lever 16, the heald shaft will be lifted. After this pick, if the next pick requires the heald shaft to be lowered, the hook 6 does not engage the knife 10 and the left tip of dual hook 6 still engages the bar 4 at its left notch. When the bar 3 moves rightward and the bar 4 moves leftward, the bar 4 will pull the baulk 11 to swing to left via the hook 6. This condition is shown in Fig. 6 (a). If the next pick requires the heald shaft to keep at the top position, the hook 6 should engage the knife 10. This is shown in Fig. 6 (b).

In Fig. 5, the heald shaft is in a bottom position and if this pick needs the heald shaft to keep at the bottom position, the hook 5 should disengage the knife 9. By the restoring force of plate spring 7, the left tip of the hook 5 will be engaged with the bar 3 at its left notch. Now, before the movement of bars 3 and 4, the link point P is at the same position of the shaft C (Fig. 3). When the bar 3 moves leftward and the bar 4 moves rightward, the bars 3 and 4 carry the baulk 11 rotate
Table 1—Eight motion modes of the new type dobby

<table>
<thead>
<tr>
<th>Mode</th>
<th>Solenoid 51</th>
<th>Solenoid 52</th>
<th>Dual hook 5 and fixed hook knife 9</th>
<th>Dual hook 6 and fixed hook knife 10</th>
<th>Moving direction of bar 3</th>
<th>Moving direction of bar 4</th>
<th>Heald shaft 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Energized</td>
<td>De-energized</td>
<td>Engaged</td>
<td>Disengaged</td>
<td>Leftward</td>
<td>Rightward</td>
<td>Lifted</td>
</tr>
<tr>
<td>2</td>
<td>Energized</td>
<td>De-energized</td>
<td>Engaged</td>
<td>Disengaged</td>
<td>Leftward</td>
<td>Leftward</td>
<td>Lowered</td>
</tr>
<tr>
<td>3</td>
<td>De-energized</td>
<td>Energized</td>
<td>Disengaged</td>
<td>Engaged</td>
<td>Rightward</td>
<td>Rightward</td>
<td>Lifted</td>
</tr>
<tr>
<td>4</td>
<td>De-energized</td>
<td>Energized</td>
<td>Disengaged</td>
<td>Engaged</td>
<td>Leftward</td>
<td>Rightward</td>
<td>Lowered</td>
</tr>
<tr>
<td>5,6</td>
<td>Energized</td>
<td>Energized</td>
<td>Engaged</td>
<td>Engaged</td>
<td>Leftward (Rightward)</td>
<td>Rightward (Leftward)</td>
<td>Remain in top position</td>
</tr>
<tr>
<td>7,8</td>
<td>De-energized</td>
<td>De-energized</td>
<td>Disengaged</td>
<td>Disengaged</td>
<td>Leftward (Rightward)</td>
<td>Rightward (Leftward)</td>
<td>Remain in bottom position</td>
</tr>
</tbody>
</table>

Fig. 7—Timing diagram of 2/2 twill weave

Top position
- Bottom position
- Right most
- Left most
- Engaged
- Disengaged

Bottom position
- Right most
- Left most
- Engaged
- Disengaged

Left position
- Right most
- Left most
- Engaged
- Disengaged

Around the center C and the heald shaft keeps still in the bottom position. This is shown in the Fig. 6(c).

In a manner similar to the foregoing analysis, all the eight motion modes can be found. The motion modes are listed in Table 1.

2.2.4 Timing

Fig. 7 shows the timing diagram of 2/2 twill weave. In the diagram, the 0° on the horizontal axis is not the position of front center of the loom's crankshaft, but the beginning of the action of the selection mechanism for a pick. To accelerate the response of the solenoid, double voltage DC power supply is adopted. At the beginning of the solenoid's energizing, high voltage is exerted on the solenoid and after the selection bar has been attracted, low voltage is exerted to lower the circuit to eliminate the solenoid's heat generation and to shorten the time of the solenoid's de-energizing.
3 Results and Discussion

3.1 Kinematic Analysis

The foregoing analysis shows that the dobbv has eight motion modes. But when the dobbv is in any of the motion modes 5-8, the main parts, such as baulk and jack, remain motionless and, therefore they need not to be analyzed. The analysis of motion modes 1-4 is similar. So, the motion mode 1 is taken as an example.

From Figs. 3, 4 and 5, the kinematic model of the dobbv mechanisms can be constructed as in Fig. 8. CP1 represents the cam follower 2 (in Fig. 3). The pushing-and-pulling bar 4 contacts the inset 14 with a circular arc surface, which is simplified as a bar P1P4. P5P6 represents the baulk, P6P7 represents the dual hook 5, P7P8P9 represents the jack 12, P8P9 is the link 15, and P9P10 is the lever 16. As the process of kinematic analysis is very verbose, only the result is given.

Fig. 9 shows the motion regulation of the matched shedding cams, where $\beta(\phi), \dot{\beta}(\phi)$ and $\ddot{\beta}(\phi)$ are the angular, angular velocity and angular acceleration respectively, and $\phi$ is the angular of the shaft O (in Fig. 3). In Fig. 10, the curves 1, 2 and 3 show the angular, angular velocity and angular acceleration of lever 16, the output part of the dobbv. In Fig. 11, the curves 1, 2 and 3 show the position, velocity and acceleration of the heald shaft.

3.2 Motion Simulation

Fortran programming language is used to analyze every machine part's motion. The AutoCAD (mainly AutoLisp) is applied to simulate the motion of the mechanisms according to the data of kinematic analysis. Every part has been drawn and defined as a block in AutoCAD beforehand. In AutoCAD, every
part (block) can be put in a position at a moment by the program of AutoLisp according to the kinematic analysis data and then it can be put in another position at the next moment, i.e. the snapshots of all the parts at each moment during the motion can be obtained. So, the whole process of shedding can be animated. According to the animation, the mechanisms move as expected. Motion simulation proves the design preliminary. After simulation, a simplified prototype was made to test the design. The prototype works well, proving that the reform is successful.

4 Conclusions

The main modifications in the new type from Staubli 2521 are:

- Change of single tip hook into a dual one.
- Change of pushing bar into a pushing-and-pulling one.
- Change of multiple control hooks to a fixed hook knife.
- Design of a new selection mechanism, which makes the new dobby respond quickly, reliably and easily controllable by a microprocessor.

Because the new dobby’s main construction is simpler than Staubli 2232 and several measures have been taken to accelerate the response of the selection mechanism, the new type can run at a higher speed than Staubli 2232. As the new type is simple in construction and easy to be manufactured, it can be very cheap.

Acknowledgement

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References

2 Chen Ming & Ma Fengxia, A positive dobby for weaving converted from a negative one (Staubli 2500), J China Text University (Engl. edn.), 15(2) (1998) 39.
3 Marks R, Principles of Weaving (The Textile Institute, Manchester), 1976, 47.