Study on Job Analysis and Optimization of Solid Wood Puzzle Operation Based on Job Measurement

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Abstract. In this paper, three types of solid wood splicing are summarized: short material splicing, narrow material splicing and thin material lamination. The technological requirements of solid wood splicing are also summarized. On this basis, the work of jigsaw splicing is measured and analyzed by means of work sampling, and some suggestions for job improvement are put forward. Finally, the existing problems in the layout of jigsaw puzzle workplaces are analyzed and improved according to the principles of importance, frequency, sequence and functionality.

1. Introduction

The production of solid wood furniture cannot be separated from the application of wood, but because wood has the characteristics of wet expansion and drying shrinkage, wood components of furniture often warp and deform due to the change of moisture content. In order to stabilize the parts and shapes of products and reduce the deformation, the larger parts of solid wood furniture are often made of narrow board or small material glue in production, which can not only improve the quality of products, but also improve the utilization ratio of wood and save large blocks of wood [1].

2. Overview of solid wood parquet work

2.1 Types of panels

Solid wood square gluing occupies an important position in furniture production. Formally, it mainly includes: length gluing (short material joining length), width gluing (narrow material combining width) and thickness gluing (thin material lamination), etc. Generally, the former two are used more frequently in production workshop, as shown in Figure 1. Specifically speaking, the gluing on the length of square timber is the longitudinal length, in the form of butt joint, oblique joint and finger joint. Generally, finger joint is adopted. The application of finger joint material is more and more extensive. Its technical requirements can be referred to the national standard GB 11954-1989 "Finger Joint Material" and GB 11916-1989 "Physical and Mechanical Properties Test Method of Finger Joint Material". Solid wood square is also called narrow material width in the horizontal direction. The narrow material square is made into wide-width laminated wood components by pressure bonding with adhesive. It is generally used to make furniture panels, door panels, etc. The gluing forms are flat joint (side joint) and mortise joint (groove bonding). Square lamination in thickness is also called thin lamination. It is often used in the legs, columns and frames of furniture. Thickness gluing can directly laminate thin plates, or glue small materials into long, wide and thick ones. In addition to the above three forms, there are also mixed spelling, that is, the combination of length, width and thickness[2].
2.2 Equipment and process for splicing
Material needed for splicing is: solid wood, splicing glue. Equipments needed are: ferris wheel splicing machine, glue coating machine, as shown in Figure 2. The rest of the auxiliary tools needed are: tapes, clamps, protective gloves and so on. The moisture content of glued wood is controlled between 6% and 10%. Usually wood with high moisture content needs to extend the fixture time. The glue content is 250 g/m², the thickness of glue coating is about 0.2 mm, and the single side is glued; the pressure is 7.0-10.5 Kg/cm² for low-density wood, 8.8-12.3 Kg/cm² for medium-density wood and 12.3-17.6 Kg/cm² for high-density wood; and the pressing time is 45 min for high-density wood when the ambient temperature is 20°C. Winter time is slightly longer, generally controlled in about 2 hours. After pressure relief, it will be processed 6 hours later, usually every other day.

3. Measurement and analysis of solid wood parquet work

3.1 Research object and method
The research object of this paper is solid wood splitting. Two operators are required to cooperate with the use of splitting machine and gluing machine. Working time is long, which is one of the important processes in solid wood furniture production. In order to improve productivity, it is necessary to analyze and optimize the splicing operation.

The research method is job testing, specifically, measuring the time required to complete standard work, with the aim of reducing or eliminating invalid time and improving the operation system. The types of job measurement include stopwatch time study, job sampling, standard method of scheduled action time and standard data method. In this paper, work sampling is used, that is, in a long period of time, to observe the operators in a random way, to extract a certain number of work cycles, decompose the work units, classify and analyze according to the basic operation time, auxiliary operation time and relaxed operation time, find out the problems in the operation process and improve them. It is time-saving, economical and reliable to use job sampling method to study work efficiency. It is a general technology for investigating work efficiency and formulating man-hour quota.

3.2 Overview of jigsaw work
Two operators are responsible for the jigsaw positions, and their respective tasks are different. Operator 1’s task is to put the glued wood on the workbench, arrange the wood according to the
drawings, glue each wood in turn, and take charge of supplying glue and unloading and stacking the boards from the splitter. Operator 2 is mainly responsible for the assembly of glued wood, and transport to the jigsaw, fastening parts, while responsible for starting and unloading and stacking. The main motives involved are: fetching, gluing, billet forming, feeding, tightening, unloading and handling, as well as gluing, measuring, material sheet reading, feeding and so on, as shown in Figure 3.

Figure 3. On-site operation status of jigsaw

3.3 Measurement and analysis of putting-together work
Stopwatch and camera are used to measure the jigsaw puzzle on site, record the content of the work and the corresponding duration. When the work is done, the sheet is put on the workbench to start gluing and the sheet is unloaded from the jigsaw puzzle for one operation cycle. 20 operation cycles are selected for analysis at will. The average duration of one operation cycle is 272 seconds after the pressure time of the sheet on the jigsaw puzzle is removed. 2 seconds. The results are as follows:

Table 1. Work measurement of putting-up process.

| Date of study: | Research Workshop: Stock-up Workshop | Subjects: Matching of high-screen solid wood with glue |
|---------------|--------------------------------------|--------------------------------------------------------|
| Job description: | sizing real wood square and forming parts, fastening the parts on the ferris wheel splitting machine, and unloading the parts after meeting the time requirement |
| Equipment and tools: | ferris wheel splitting machine, glue coating machine, tape measure, etc. |
| Operator: | 2 persons |
| Duration record and statistics of each unit (in seconds) |

| Cycle feeding | Basic operation time | Auxiliary operation time | Relaxation time |
|---------------|----------------------|--------------------------|-----------------|
|               | Feeding | Gluing | Blank assembly | Loading | Unloading | Quasi-bonding | Mending | Measuring | Feeding | Cleaning | Physiology | Waiting | Finding tools |
|---------------|---------|--------|----------------|---------|-----------|------------|--------|-----------|---------|----------|-------------|---------|---------------|
| 1              | 76      | 80     | 40             | 6       |           | 75         | 50     |           |         |          |             | 57      | 426           |
| 2              | 80      | 45     |                | 18      | 100       | 18         | 18     | 89        | 21      |          |             |         |               |
| 3              | 28      | 40     | 20             | 6       | 62        | 11         | 16     | 2         |         |          |             |         |               |
| 4              | 39      | 40     | 44             | 35      | 24        | 11         | 64     | 15        |         |          |             |         |               |
| 5              | 42      | 43     | 67             | 30      | 16        | 22         | 11     | 13        |         |          |             |         |               |
| 6              | 52      | 54     | 69             | 46      | 13        | 42         | 8      | 8         |         |          |             |         |               |
| 7              | 8       | 43     | 70             | 40      | 20        | 18         | 45     | 31        | 16      |         |             |         |               |
| 8              | 43      | 20     | 27             | 25      |           | 113        | 19     | 40        | 52      |         |             |         |               |
| 9              | 28      | 25     | 32             | 40      | 240       | 13         | 28     | 6         | 15      |         |             |         |               |
| 10             | 25      | 37     | 38             |         |           | 49         | 15     |           |         |         |             |         |               |
| 11             | 43      |       | 940            |         |           | 80         |        |           |         |         |             |         |               |
| 12             | 46      | 93     | 120            | 88      |           | 44         | 48     | 16        | 43      | 25        |             |         |               |
| 13             | 56      | 66     | 53             | 4       |           | 32         | 28     | 38        |         |         |             |         |               |


As can be seen from Table 1, jigsaw puzzle operation is divided into basic operation time, auxiliary operation time and relaxed operation time. In the total observation time of 6970 seconds, the duration of the three occupies 49.41%, 35.14% and 15.45% of the total observation time. In proportion, basic operation takes up the most time, followed by auxiliary operation time, and relaxed operation lasts the least.

The basic operation time includes feeding, gluing, billet forming, loading and unloading. The most time consumed is gluing and billet forming, accounting for 13.99% and 13.76% of the total observation time. In actual operation, an operator is required to size each piece of wood. In one operation cycle, the average time of gluing operation is 48.75 seconds. Affected by the number of gluing components and the requirements of gluing quality, this part of operation time can not be arbitrarily compressed, and through field observation, the operator responsible for gluing can operate smoothly without invalid actions. It takes 47.95 seconds to make up the blanks in each operation cycle. During the operation, another worker will mix the wood which has been glued. This part of the time is affected by the glued operation. Only when the worker cooperates properly, can the efficiency of the billet be improved.

The assistant operation time includes preparation and completion, gluing, measurement, feeding and cleaning. In all the actions, the preparation and completion of the work consumed more time, accounting for 19.60% of the total observation time. Especially in the preparation work before the start of the work, the operator needs to calculate the proportion of mixing according to the working environment temperature of the day, mixing according to the proportion, reinforcing agent, and record the calculation results. At the same time, it is necessary to clean up the dried glue in the gluing machine to avoid the semi-solidified colloid mixing in the glue, which will affect the quality of the glue. In addition, it is also necessary to get the wood that needs gluing from other workplaces in the spare materials workshop on the same day, which greatly increases the preparation time before the operation. The second is the measurement time, accounting for 7.23% of the total observation time. Before gluing, the worker needs to measure the size of the board, arrange and combine the wood according to the measurement results, and often need to calculate the material sheet, which consumes a lot of time.

The action of relaxing working time includes physiological relaxation, waiting and finding tools. Physiological relaxation refers to the rest time caused by workers' drinking water, toilet and work fatigue. In the observed period, physiological relaxation time accounts for 5.80% of the total observation time.
observation time, basically within a reasonable range. Waiting time is more, accounting for 7.95% of the total observation time. In the field observation, waiting time is mainly caused by the time-consuming glue coating and the delay of work progress. In the relaxed operation, the time spent on finding tools accounted for 1.71% of the total observation time, mainly for forklift feeding. Although the proportion was low, it could be eliminated.

3.4 Suggestions for improvement

- Strengthen the cooperation between workers, especially in the preparatory work before the start of construction. When one person is mixing, the other person is responsible for cleaning the glue machine to avoid empty waiting.
- When cutting, the processing accuracy should be improved to avoid increasing the time of calculation and measurement due to the different length of wood.
- Enhance employee’s productive enthusiasm and avoid the phenomenon that one employee has too much work to do while another employee is free. For example, because of the time-consuming glue coating, another worker can work together to reduce waiting time.
- Increase forklift truck rationing in positions where material is often needed to be transported, standardize the placement of tools and equipment, and reduce the time spent in finding tools.
- Strengthen the cooperation between processes and arrange production plan reasonably so as to make production smoothly.
- Strengthen the management consciousness of enterprise managers, improve the management level, rationally arrange workshop production and post setting and cooperation, mobilize the enthusiasm of workers, and strengthen product quality management.

4. Evaluation and optimization of post space layout of solid wood splitting

The position of solid wood splitting is located in the spare material workshop, which consists of a splitting machine, a glue coating machine and a worktable. There is also a glue storage area and a number of material storage areas. In this area, wood splitting and related operations need to be completed.

According to field observation, jigsaw puzzle has the characteristics of large amount of work, heavy task, long operation cycle and high physical consumption. The following problems exist in the layout of post space:

- There are a lot of materials in the space and they are piled up in disorder, which not only increases the operation route, but also brings inconvenience to the operation.
- The distance of the mixing area is too far. Because of the need to replenish the glue machine at regular intervals during the operation, the location of the glue area is too far, which will inevitably prolong the time needed for the glue repairing, thus delaying the progress of the operation.
- The space occupies a large area, the utilization rate is low, and the workers work at will.

The layout of workplaces should follow the following principles [5]:

- Importance principle. According to the degree of importance, to determine the location of the facility farthest or nearest to the operator, and to arrange the most important equipment in the most convenient place from the operator;
- Principle of frequency of use. Arrange the equipment with high frequency near the operator for observation and operation;
- Functional Principles. The equipment with the same or similar functions is arranged in the same area, which is also easy to operate.
- The principle of using sequence. Arranging facilities according to the sequence of operations, shortening the execution time to the greatest extent, so that operators can operate conveniently and efficiently.
The above principles should be taken into account in the layout of workplaces, but it is difficult to face them in actual production. Therefore, the improvement of jigsaw puzzle workplaces can be carried out according to the above principles.

- Standardize the stacking of materials, separate the processed materials and the processed materials, avoid stacking materials in the passage, so as to avoid affecting the movement and handling;
- The dispatching area can be set a little closer to the drum glue coating machine to reduce the distance between back and forth during glue repairing and improve the efficiency of operation;
- Standardize the layout of the workshop and place the common equipment such as forklift trucks at fixed points, so as to avoid the delay of working time due to the search for tools;
- Strengthen 5S management, while requiring the progress of work, clean up and tidy the work place, regular inspection and spot check can be carried out to create a clean and orderly working environment.

5. Conclusion

There are three kinds of solid wood veneer: short material length, narrow material width and square material thickness. The amount of glue applied is 250 g/m². The pressure varies with the density of wood, and the time is more than 45 minutes. The results show that the basic operation time, auxiliary operation time and relaxed operation time account for 49.41%, 35.14% and 15.45% of the total observation time. The corresponding action units are analyzed and suggestions for improvement are put forward. At the same time, the analysis of the space layout of jigsaw puzzle workplaces shows that there are problems such as random stacking of materials, unreasonable location of equipment, and low space utilization. Finally, it is improved according to the four principles that should be followed in the layout of the workplaces.

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