Influence of Temperature of Applying Glue, Glue Dosage and Feed Rate on Peel Strength of Edge Band from Curved Edge Part

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Abstract. The peel strength of polyvinyl chloride (PVC) edge band on curved edge part was tested by using experimental method which was conducted to define the influence of many factors, including temperature of applying glue, glue dosage and feed rate on peel strength of edge band from curved edge part. The results showed that the temperature of applying glue, glue dosage and feed rate have a great effect on the peel strength of PVC edge band. The obtained optimum technical parameters were respectively as follow: temperature of applying glue was 140~150°C, glue dosage was 363~379g/m2 and feed rate was 13~15m/min.

1. Introduction
As one of the important parts of panel furniture, plastic edge band often occurs glue failure and peeling during use [1]. The soft peeling method was suitable for polyvinyl chloride, polypropylene edge band and the 2 mm thick polymethyl methacrylate edge band, it was also found that the soft peeling method of edge band adversely affects the effectiveness of adhesives. The peeling destruction occurs mainly between the edge band and the hot melt adhesive [2, 3]. Several key factors impacting peel strength of the most common edge band type, polyvinyl chloride, peeling from curved edge part including temperature of applying glue, glue dosage and feed rate were studied. This paper provides a basis for setting up technological parameters of special-shaped edge banding for small and medium-sized enterprises of panel furniture.

2. Materials and methods
2.1. Materials
Particle board sized in 1220×2440×18mm (width×length×thickness) was selected as sample materials, which was sawed into samples sized 280×300×18mm (width×length×thickness), then inner circular arcs of radius 100mm would be sawed on the length edge of samples. After placing 1d at room temperature, the further experiment was carried out [4]. Polyvinyl chloride (PVC) edge band sized in 22×1.5mm (width×thickness) was selected as edge banding material. EVA tape low temperature hot melt adhesive was selected as glue. Sliding table saw and semi-automatic special-shaped edge banding machine were used as processing equipments in this experiment. The tests were conducted by using a
Reger microcomputer-controlled electronic universal testing machine (Shenzhen Reger Instrument Co., Ltd. Shenzhen, China).

2.2. Methods
In the experiment, single-factor analysis was adopted and the influence of the temperature of applying glue, glue dosage and feed rate on the peel strength of PVC edge band on curved edge part was studied. This research consisted of three experiments and separately selected three factors: temperature of applying glue, glue dosage and feed rate. On the basis of preliminary experiment test, 8 levels were determined through each single-factor experiment. The peel speed in test is set to 48mm/min [5]. Test set up was shown in Figure 1.

![Figure 1](image)

**Figure 1.** Test set up of edge band peel strength.

3. Results and discussion

3.1. Results
The experimental results are calculated in accordance with QB/T3655-1999[6]. According to the width of the specimen and the failure load, the peel strength shall be calculated as follows:

\[ q = \frac{P}{b} \times 10^3 \]  

(1)

Here, \( q \) refers to the peel strength (N/m), \( P \) refers to the failure load (N), \( b \) refers to the width of the specimen (mm).

The expression mentioned above was statistically analyzed with SPSS 13.0 statistical software LSD Duncan method, which was shown in Table 1.

| Temperature | Average peel strength | Significant difference |
|-------------|-----------------------|------------------------|
|             |                       | 0.05 | 0.01       |
| 120         | 4955                  | e    |            |
| 130         | 6607                  | d    |            |
| 140         | 9143                  | a b  |            |
| 150         | 10684                 | a    |            |
| 160         | 8468                  | bc   |            |
| 170         | 8282                  | bcd  |            |
| 180         | 7142                  | cd   |            |
| 190         | 7090                  | cd   |            |
Note: the lowercase letters indicate the significant difference at 0.05 level, the capital letters indicate the significant difference at 0.01 level, the same letters mean that the two data are at the same level.

Figure 2. The correlation between temperature of applying glue and peel strength.

As shown in Figure 2, there exists a positive linear correlation between temperature of applying glue and peel strength from 120~150°C. When the temperature was 150°C, the values of peel strength reached the peak of 10684 N/m, which was also shown in Table 1. The peel strength ascended first and then descended. Meanwhile, The values of peel strength were remarkably higher than other levels, and there was greatly significant difference between 150°C and other temperature level except for 140°C.

The glue dosage shall be calculated as follows:

\[
Q = \frac{(m - m_0)}{s}
\]  \hspace{1cm} (2)

Here, Q refers to the glue dosage (g/m²), m refers to weight of edge band after sizing (g), m₀ refers to weight of edge band before sizing (g), s refers to surface area of edge band (m²).

The expression mentioned above was statistically analyzed with SPSS 13.0 statistical software LSD Duncan method, which was shown in Table 2.

| Glue dosage | Average peel strength | Significant difference |
|-------------|-----------------------|------------------------|
|             |                       | 0.05       | 0.01       |
| 171         | 6793                  | d          |            |
| 220         | 7741                  | c d        |            |
| 273         | 8084                  | c d        |            |
| 325         | 8521                  | b c d      |            |
| 347         | 9038                  | b c d      |            |
| 363         | 9597                  | b c        |            |
| 379         | 10678                 | b          |            |
| 386         | 12935                 | a          |            |
Note: the lowercase letters indicate the significant difference at 0.05 level, the capital letters indicate the significant difference at 0.01 level, the same letters mean that the two data are at the same level.

Figure 3. The correlation between glue dosage and peel strength

As shown in Figure 3, The results showed that there exists a positive linear correlation between glue dosage and peel strength, and the glue dosage have a great effect on the peel strength. The peel strength presented an overall trend of increase with increasing glue dosage. Meanwhile, the values of peel strength were remarkably higher than other levels when the glue dosage was 386 g/m$^2$, which was significantly higher than other levels. There was greatly significant difference between 386 g/m$^2$ and other glue dosage. Similarly, there was greatly significant difference between level 379 g/m$^2$ and other glue dosage level except for 363 g/m$^2$.

The expression mentioned about feed rate and peel strength was statistically analyzed with SPSS 13.0 statistical software LSD Duncan method, which was shown in Table 3.

| Feed rate | Average peel strength | Significant difference |
|-----------|-----------------------|------------------------|
|           |                       | 0.05       | 0.01     |
| 7         | 6933                  | b c        |          |
| 8.9       | 7997                  | a b        |          |
| 11.2      | 7898                  | a b        |          |
| 13.1      | 8387                  | a b        |          |
| 15.0      | 9009                  | a          |          |
| 17.2      | 6962                  | b c        |          |
| 19.2      | 6183                  | c          |          |
| 21.1      | 5630                  | a          |          |
As shown in Figure 4, there exists a positive linear correlation between feed rate and peel strength from 7 ~15 m/min. When the feed rate was 15 m/min, the values of peel strength reached the peak of 9009 N/m. The peel strength is decreased as the feed rate increased after this feed rate turning point of 15 m/min. Meanwhile, The values of peel strength were remarkably higher than other levels when the feed rate was 15 m/min, which was significantly higher than other levels. There was greatly significant difference between 15 and 7, 17.2, 19.2, 21.1 m/min.

3.2. Discussion
When the temperature of applying glue is low, hot melt adhesive is not completely melted, glue rolls become hard to coated with glue. Due to the small amount of glue spread and uneven coating, there are many gaps in the glue-line which leads to low glue strength and poor glue quality. With temperature increasing from 120~150°C, The hot melt adhesive melts completely, glue can be applied to edge band evenly with appropriate amount, which provides the best peel strength performance. With increasing the temperature higher than 150°C, the peel strength declined maybe due to poor viscosity of glue that have thinned down by high temperature. In addition, the high temperature may influence the stability of edge band, PVC edge band could be softened and elongated by high temperature, internal shrinkage in edge band could occurs after placed for a long time, which could destroy the stability of edge band, particle board and glue-line.

Overall, the peel strength increased gradually with the glue dosage increasing. When the glue dosage is greater than 379 g/m², various phenomena leading to quality problems related to coating's appearance such as glue-line and glue stain could be caused by excessive amount of glue, which was shown in Figure 5.

With a comprehensive consideration of peel strength and coating's appearance quality, the suggested values of the glue dosage from 363 ~379 g/m² are achieved.
When the feed rate is too slow, open time of hot melt adhesive increases, the glue dries easily, and fall short of peel strength; contrarily, when the feed rate is too fast, workers could not keep up with the feed rate, therefore, the proper pressure can not be applied, which could cause peel strength reduced with edge breakage, especially on curve edge parts in test.

The overall point of view, the peel strength reaches peak values when the feed rate 8.9–15m/min. Starting from the production practice, the suggested values of the feed rate from 13–15m/min are achieved, with efficiency being considered.

4. Conclusion
The effects of temperature of applying glue, glue dosage and feed rate on peel strength of edge band from curved edge parts were studied in this paper.

Experiments results prove that there exists a positive linear correlation between temperature of applying glue and peel strength in a particular temperature period. The suggested values of the glue dosage from 140–150°C are achieved. Moreover, ambient temperature also produce affects greatly. Experiments results also prove that there exists a positive linear correlation between glue dosage and peel strength, and the glue dosage has a great effect on the peel strength. With a comprehensive consideration of peel strength and coating's appearance quality, the suggested values of the glue dosage from 363–379g/m² are achieved. The peel strength is related linearly with the feed rate in a particular feed rate period. With a comprehensive consideration of peel strength and production efficiency, the suggested values of the feed rate from 13–15m/min are achieved.

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