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Improvement of Coating for Softwood

Yasushi Anazawa, Yasuji Namizaki, Tamio Takahashi and Yasuhiro Aruga

Wood Industry Division, Iwate Industrial Research Instiute
3-35-2 Iiokashinden, Morioka-City, Iwate-Pref. 020 JAPAN

We investigated the surface reflection characteristics of clear coatings as part of our research into new applications for the softwood such as the Japanese Red Pine and Japanese Cryptomeria . We made a clear coating by dispersing 30% by volume polyurethane resin fine particles in a clear coating and applied this to wood from Japanese Red Pine. We also made a clear coating by dispersing 30% by volume acrylic resin fine particles in a clear coating and applied this to wood from Japanese Cryptomeria. Our results show that the distribution of rays reflected from the coated surfaces is similar to the distribution of rays reflected from the uncoated surfaces in both cases.

1. Introduction

Softwood has remarkable merits. Its appearance has a warmth and softness which inorganic materials do not have, and the differences in color and texture between early wood and late wood are striking. We intended to take advantage of these merits to develop new applications and to increase demand for softwood.

We investigated the surface reflection characteristics of coated softwood surfaces in order to develop a coating which retains its original function, namely to protect the surface of the wood, while bringing out the natural beauty of the underlying softwood.

2. Test Method

2.1. Specimens

We used wood from Japanese Red Pine and Japanese Cryptomeria, which are coniferous trees, from Iwate Prefecture. Table 1 lists the moisture content, specific gravity and mean annualring width of the specimens. Table 2 lists the names of the main resin ingredient, the nonvolatile contents and the abbreviation for each of the four clear coatings. We also investigated the effect of adding acrylic resin fine particles, polyurethane resin fine particles, and industrial collagen powder to the clear coating used for the top coat. Table 3 lists the particle sizes, specific gravity, and abbreviations of the materials added.

2.2. Specimen Preparation

We air-sprayed the samples with polyurethane sanding sealer for the under coat. Each of the three additives was added to each of the four types of clear coating in proportions of 5%, 10%, 20% and 30% to the nonvolatile contents by volume,and we air-sprayed the wood samples twice for top coat. The various combinations of clear coating, additive and volume density are described

Table 1
Characteristics of Softwood

Tree species	Moisture content (%)	Specific gravity	Annual ring width (mm)
Japanese red pine	12.0	0.55	2.5
Japanese Cryptomeria	10.5	0.35	2.1

Table 2
Characteristics of Resin

Abbreviation	Resin	Nonvolatile content (%)
PB	Polybutadiene modified polyol resin Polybutadiene modified polyisocyanate resin	56.4
SH	Modified acrylic resin Modified silicone resin	33.6
UL	Polyurethane resin Polyisocyanate resin	19.5
UG	Acrylic resin Polyisocyanate resin	32.8

Table 3
Characteristics of Compounds

Abbreviation	Compound	Specific gravity	Particle size (μm)
AB	Acrylic fine particles	1.1	20
UB	Polyurethane fine particles	1.2	10
CP	Collagen powder	0.17	8

below using abbreviations, e.g. PB-AB-10.

2.3. Measurement of Reflection Characteristics.

We used a specular gloss meter to measure 60-degree relative specular gloss, and a goniophotometer to measure the distribution of rays reflected from the coated surfaces of the Japanese Red Pine and Japanese Cryptomeria. We then compared these results to obtain reflection characteristics.

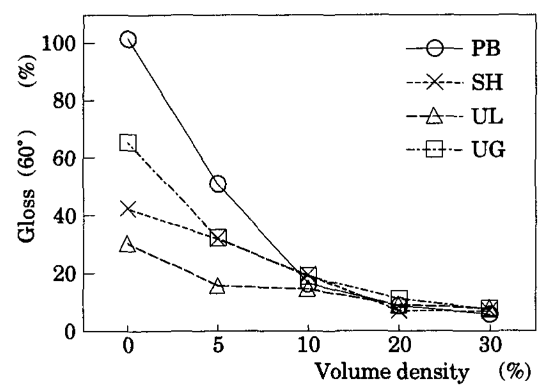

Figure 1. Specular gloss (60°) of Japanese red pine coated with PB,SH,UL,UG

3. Results and Discussion

3.1. Relative specular gloss

Figure 1 shows the specular gloss of red pine samples coated with PB, SH, UL or UG clear coating with from 0% to 30% by volume polyurethane resin fine particles added. With no polyurethane resin fine particles added, the reflection ratios were 98% for PB, 42% for SH, 30% for UL and 65% for UG. This result shows a clear difference in gloss caused by the main resin ingredient. The gloss for each clear coating decreases as the proportion of the polyurethane resin fine particles increases. When the volume density was 30%, reflection ratios were 6% for PB, 7% for SH, 8% for UL and 7% for UG. The main resin ingredient did not cause a difference in gloss. The same results were obtained with the cryptomeria samples. A reflection ratio of 6% was obtained on untreated surfaces of hand-planed red pine and cryptomeria. This ratio is almost the same as that of samples coated with clear coating

with polyurethane resin fine particles with volume density of 30%.
However, a considerable difference between the treated and untreated samples was obviously apparent in most cases from a visual check.

The gloss of a coated surface is expressed using the 60-degree specular reflection ratio defined in JIS-K-5400 7.6 relative-specular gloss. The angle between the incident light and the normal is 60 degrees, and the aperture stop of the light receiver is also 60 degrees. The positive reflective intensity is measured to obtain the reflection ratio.

However, in the visual gloss check, positive reflective intensity, diffusion of reflected light, image clarity and shape are judged synthetically. Therefore, gloss as judged by a visual check is expected to differ considerably from the measured reflection ratio.

3.2. Measurement of Reflective Distribution.

Using a goniophotometer that can measure the three-dimensional reflection characteristics of a surface, reflective distribution can be measured under conditions similar to those for visual observation. With this optical instrument, the angles of incidence and reception can be set freely and the normal angle on a specimen to be measured can be changed.

The goniophotometer can continuously measure reflective distribution, which indicates surface quality, under optical conditions suitable for the measurement purpose. Light reflected from nonmetallic surfaces such as wood, paper and paint films can be resolved into outer layer and inner layer reflection components. The "outer layer" in this case is the boundary between the clear coating on the specimen and the air, and is where most reflection occurs. Of the light that refracts into the clear coating, some is reflected at the boundary between clear coats or between the first clear coat and the specimen, some is absorbed, and a proportion refracts back out into the air. Factors that affect this "inner layer" reflection component are the refractive index of the clear coating and the smoothness of the various surfaces.

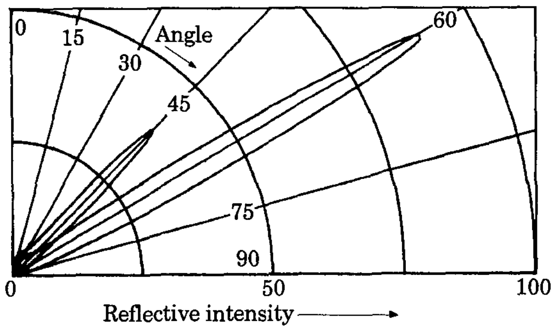

Figure 2. Reflective distribution of Japanese red pine coated with UL - 0

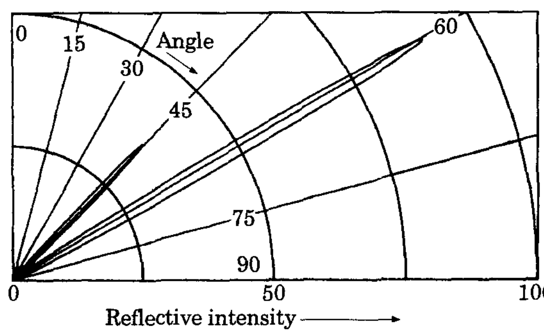

Figure 3. Reflective distribution of Japanese Cryptomeria coated with UG - 0

Figure 2 shows the reflective distribution of red pine samples coated with UL-0. Figure 3 shows the reflective distribution of cryptomeria samples coated with UG-0. They were measured using the goniophotometer with incidence angles of 45 and 60 degrees, and an inclination angle of 0 degrees. These figures show a strong outer layer reflection but weak inner layer reflection, most of the latter being absorbed by the clear coating. The results show similar reflective distributions for PB-0 and SH-0.

Figure 4 shows the reflective distribution of uncoated red pine samples and Figure 5 shows the reflective distribution of uncoated cryptomeria samples.

They were measured using the goniophotometer with an incidence angle of 45 degrees, and inclination angles of 0 to 20 degrees. Both sets of figures can be used to plot an ovoid inclined at 45 degrees almost

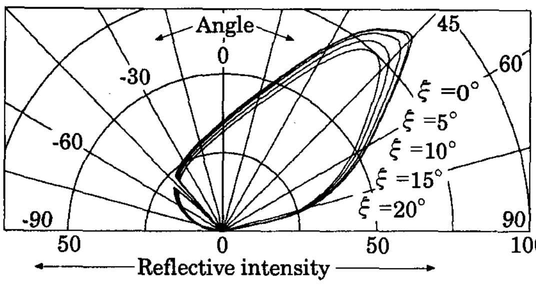

Figure 4. Reflective disutribution of Japanese red pine

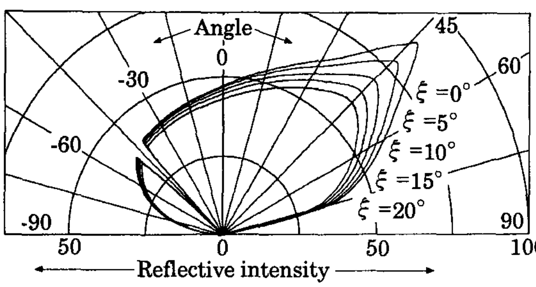

Figure 5. Reflective distribution of Japanese Cryptomeria

independently of the inclination angle. We conjecture that the reason for this reflective distribution is as follows:

Wood consists of cells stacked in parallel. When wood is cut with an edged tool, the concave inner surfaces of the cut cells act as microscopic concave mirrors and cause the reflective distribution specific to wood. We conjecture that most clear coatings smooth the wood surface and produce only the positive reflection and this suppresses changes in the grain and color tone, but mars the impression specific to wood.

Figure 6 shows the reflective distribution of red pine samples coated with UL-UB-30. Figure 7 shows the reflective distribution of cryptomeria samples coated with UG-AB-30. They were measured using the goniophotometer with an incidence angle of 45 degrees, and inclination angles of 0 to 20 degrees.

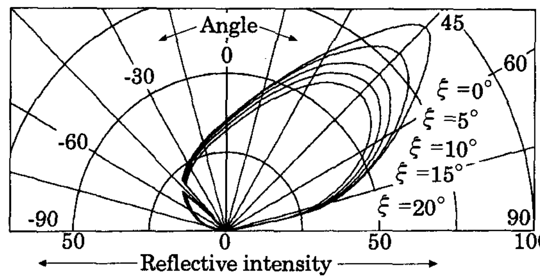

Figure 6. Reflective distribution of Japanese red pine coated with UL - UB - 30

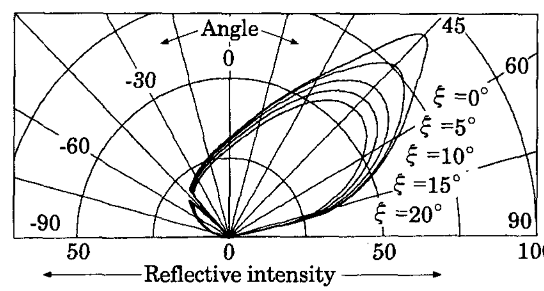

Figure 7. Reflective distribution of Japanese Cryptomeria coated with UG - AB - 30

These figures are similar to those in Figures 4 and 5. Figure 6 shows that red pine wood coated with clear coating UL containing 30% by volume polyurethane resin fine particles has reflection characteristics similar to those of uncoated red pine wood and gives a visual impression almost the same as uncoated red pine wood. Figure 7 shows that clear coating UG containing 30% by volume acrylic fine particles has the same effect on cryptomeria wood. Surfaces coated with clear coating containing polyurethane or acrylic fine particles appear slightly lighter in color than uncoated surfaces, but the fact that they are coated is not at all obvious.

Other combinations of additives and coatings provided reflective distributions somewhat similar to that of uncoated wood. We are still in the process of investigating the influence of the main resin ingredient and the reflection characteristics of the additives.