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Study on Carbon Layer Formation on Wood by Laser

Kaori Nagai and Tamami Iwamoto

Taisei Corporation Technology Research Center, Finishing Materials Section, Materials Research Department, 344-1,Nasecho,Totsuka-ku, Yokohama, 245, Japan.

Wood is one of the main architectural materials in Japan. When columns or boards are processed from wood, 20-30% of the wood is usually rejected because of defects such as knots, blurs or warps. This paper presents the results of a study on a new method of using laser energy to produce thin carbon layers on the surface of wood, with the aim of making effective use of rejected wood.

It was found that this method can be applied to many kind of woods and very thin timber sheets, because of the fact that fine control of the laser energy is possible. Thus, these laser treated woods can be effectively used as interior materials such as decorative wall paneling in building construction.

1.INTRODUCTION

Wood is one of the main architectural materials in Japan. When columns or boards are processed from wood, 20 -30% of the wood is usually rejected because of defects such as knots, blurs or warp. Also, in the manufacture of very thin timber sheets, about 50% of the wood is rejected due to stains or change of color.

There are many methods of modifying the surface appearance and surface properties of wood for interior use. Coloring,dyeing or carbon layer formation by burner treatment are typical methods.Except for carbon layer formation, other methods use paints and chemicals, resulting in the following problems:

1)Loss of the original character of wood grain.
2)Decline in the moisture absorption and release characteristics of wood.
3)Problems of environmental hygiene for workers.

On the other hand, carbon layer formation poses no such problems.

With this background, the authors have begun a program of research to study the feasibility of utilizing laser energy for modifying the surface appearance of wood.

This paper describes the results of basic experiments carried out regarding surface treatment of wood panels and very thin timber sheets using a CO_2 laser.

2. EXPERIMENTAL

2.1Materials

The materials used were SUGI and HINOKI (conifer), and BUNA, SAKURA, NARA, KEYAKI, TAMO, CHEEK (broadleaf).

2.2 Carbonization Equipment

Usually wood surface carbonization is carried out by gas burner. But this method puts restrictions on kind of wood and on thickness,

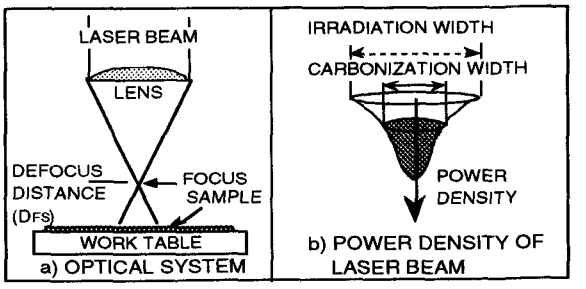

Fig. 1 Schematic Diagram of Laser Irradiation

because it is very difficult to control the energy of the flame.

These problems can be solved if the carbonization is carried out by laser because it is possible to control the laser energy accurately.

Experiments were carried out with a CO_2 laser using beam optics shown in Fig.1. The experimental laser treatment conditions are shown in Table.1

3.RESULTS AND DISCUSSION

3.1 Carbonization condition (panels)

Carbonization experiments were performed by varying the laser treatment conditions (laser power, defocus distance, work travel speed) and the optimum parameters were determined by visual evaluation of the treated surface.

The relation on between laser power and degree of carbonization is shown in Fig.2. Conifer can be carbonized using low energy, but broadleaf trees generally require higher energy. The relation between work travel speed and width of carbonization for SUGI is shown in Fig.3. By visual examination the best laser treatment condition for SUGI was found to be laser power 0.8kW, defocus distance(DFS) 400mm and work travel speed 8m/min. The relation between work travel speed and width of carbonization for BUNA is shown in Fig.4. In this case, best laser treatment condition was found to be laser power 1.2kW, defocus distance(DFS) 350mm and work travel speed 10m/min.

3.2 Characteristics of the Carbon Layer

The depth of carbonization obtained by gas burner treatment and laser treatment is shown in Fig.5. The depth is 454 μ m by burner compared to 235 μ m by laser in the spring wood grain and 198 μ m by burner compared to 52 μ m by laser in the autumn wood grain. In the case of laser treatment, because of the fine control of energy, it is possible to carbonize these types of wood

Table.1 Range of Laser treatment condition

Laser Power	0.3～1.2 kW
Work travel speed	6～15 m/min.
Wavelength	10.6 μm
Lens	plano- convex lens
Defocus distance (DFS)	200～500 mm

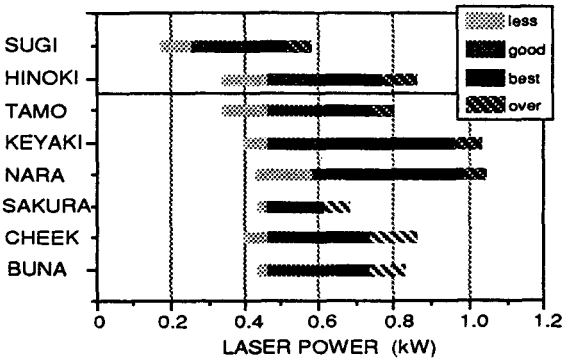

Fig 2. Relation Between Laser Power and degree of Carbonization of Woods

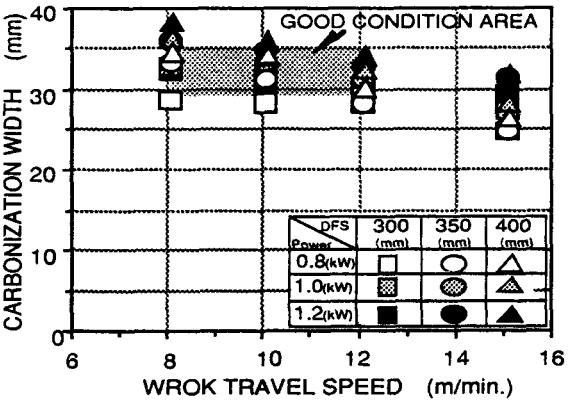

Fig 3. Relation Between Work Travel Speed and Width of Carbonization of SUGI

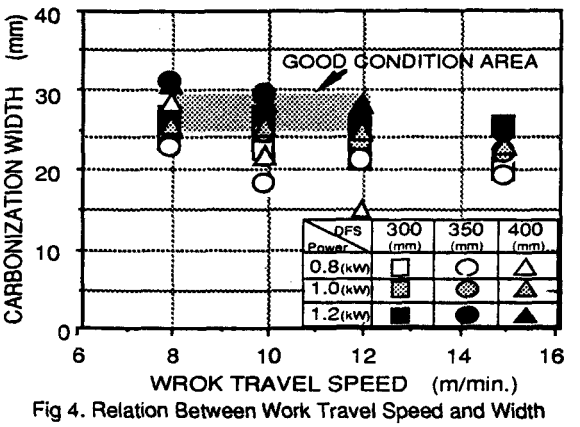

Fig 4. Relation Between Work Travel Speed and Width of Carbonization of BUNA

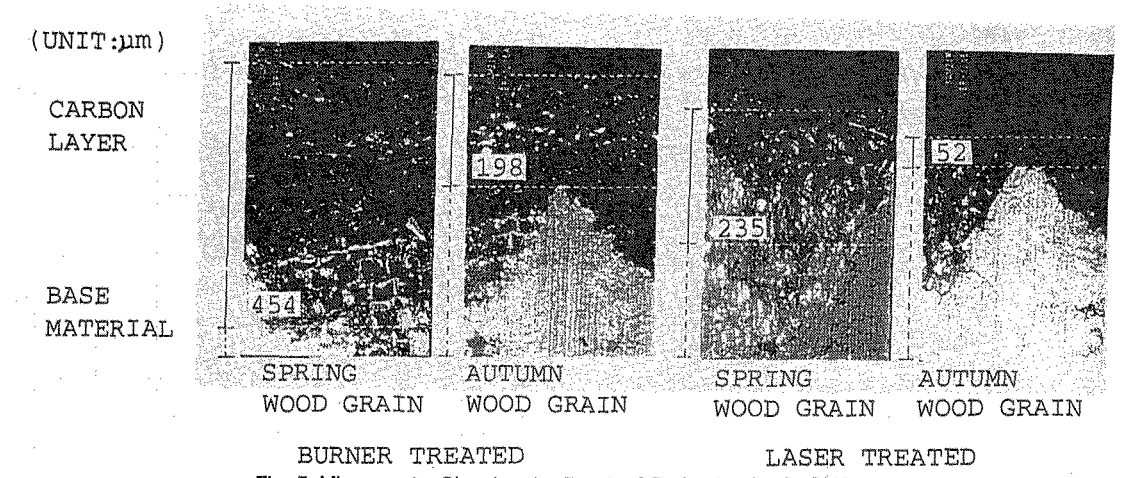

Fig. 5. Micrographs Showing the Depth of Carbonization in SUGI

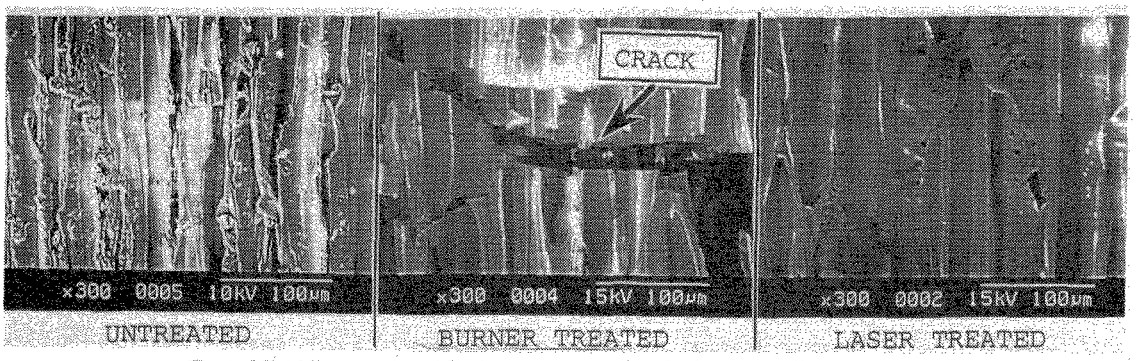

Fig 6. SEM Micrographs of SUGI Before and After CarbonizationTreatment

and still bring out the contrast between the wood grains.

Scanning electron micro graphs of the carbon layer on SUGI is shown in Fig.6. In the case of burner treatment, the wood tissues are damaged and many cracks appear on the surface. Laser treatment does not produce any such damage or defects.

3.3 Work environment

Conventionally, carbonization of wood is carried out using the propane gas (L.P.G.) burner (Fig.7) . In this method, the temperature of the work environment becomes high because of the exposed flame and also CO_2 and CO gas concentration increase. The gas concentrations in the work environment during laser and burner treatment were measured. It was found that the CO and CO_2 gas concentration during laser treatment were less than one-fifth compared of burner treatment. Also, laser treatment does not affect the temperature of the work environment to any significant extent because light is the source of heat. The process on carbon layer formation by laser and burner is compared in Fig.8. In burner treatment, 4 stages of manufacturing are needed, but in the case of laser treatment, this can be reduced to 3 stages.

3.4 Carbonization of very thin timber sheets

In the case of burner treatment, carbonization of very thin timber sheets less than about 1mm thickness is not possible because the sheet catches fire and is burnt . In laser treatment, carbonization of even 0.2mm thick sheets is possible by fine control of the laser energy. The relation between defocus distance and width of carbonization of very thin timber sheet is shown in Fig.9. By visual examination the best laser treatment condition for very thin timber was found

to be, laser power 0.5kW, defocus distance(DFS) 360mm and work travel speed 10m/min.Carbon layer treatment on very thin timber sheet by laser is shown in Fig.10. Laser treatment produces a uniform carbon layer with surface appearance and color equivalent to wood treated by burner. This makes surface carbonization of sliced veneer (thickness 0.2-0.5mm) possible by laser treatment.

4. CONCLUSIONS

Studies were undertaken to assess the feasibility of using laser energy to produce thin carbon layers on the surface of wood. The investigation yielded the following conclusions.

1)The laser beam can be effectively used as an energy source to produce thin carbon layers on the surface of wood. Because of the fact that fine control of the laser energy is possible, many kinds of woods, including those which are impossible to carbonize by gas burner treatment, are amenable to laser treatment. The work environment is also improved in the case of laser treatment.

2)Carbonization of the surface of very thin timber sheets is also possible by laser treatment. Wood rejected because of defect such as knots, blurs, warp etc. can be treated by laser to bring out grain contrast and thus improve its appearance.

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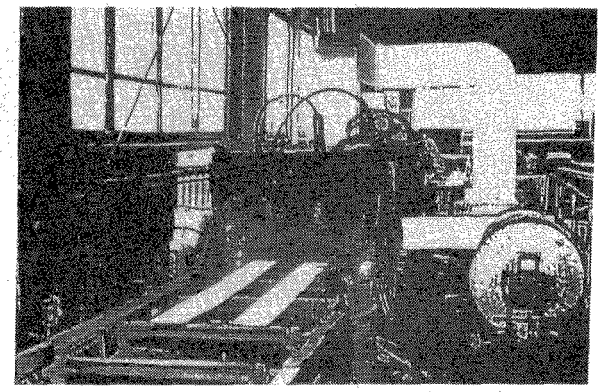

Fig. 7. Conventional Gas Burner Equipment for Carbonization of Wood

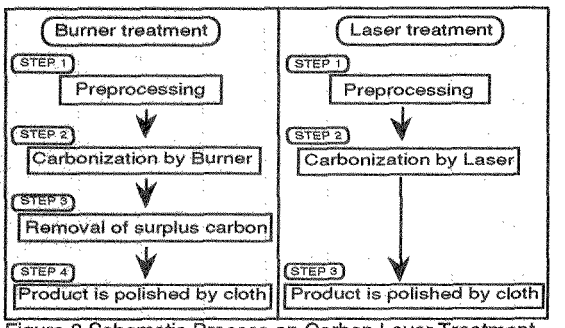

Figure 8 Schematic Process on Carbon Layer Treatment

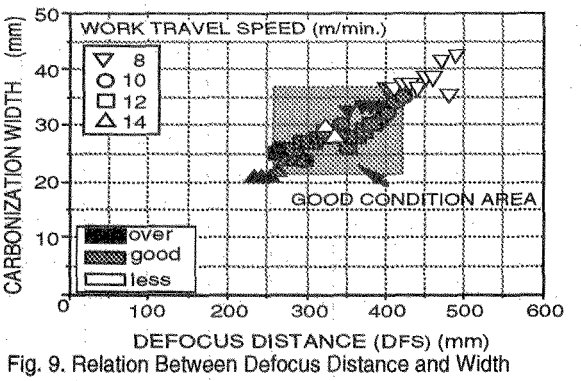

Fig. 9. Relation Between Defocus Distance and Width Carbonization of Very Thin Timber Sheet

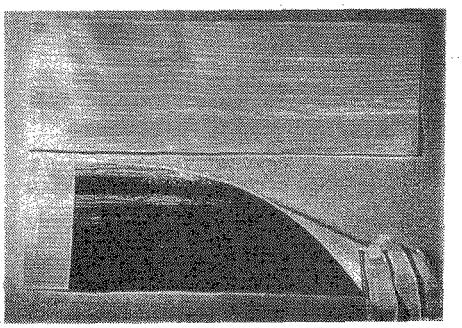

Fig. 10. Carbon Layer Treatment on Very Thin Timber Sheet (SUGI)