IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 8 Issue 1, January 2021
ISSN (Online) 2348 – 7968 | Impact Factor (2020) – 6.72
www.ijiset.com

Augmentation of the Aesthetic Appearance and Quality of Plantation Timber Veneers through Dyeing Technology

Sujatha.D[1]., Mamatha B S[2] & Uday.D.N[3]

Indian Plywood Industries Research and Training Institute (IPIRTI)
P.B.No 2273, Tumkur road, Bangalore-560 022, India
[1]Scientist F, Adhesive technology Division, Bangalore.
E-mail: dsujatha@ipirti.gov.in, sujathad1@gmail.com., Telephone No. 080-30534005
ORCID : 0000-0001-6757-9270
[2]Scientist E , Adhesive technology Division, Bangalore.
[3]Scientist F , Process Development and Engineering Division, Bangalore.

Abstract

The increase in demand for all wood products has created increasing scarcities and high prices for high quality wood particularly hardwood. The requirement for Wood veneers are increasing day to day particularly in the manufacture of panel products for housing and furniture. There is a decreasing trend in the availability of the forest timbers which are highly durable. To overcome the problem of deficit, plantation grown timbers have taken its way in meeting the supply and demand gaps. The colour/appearance and properties of the plantation timbers vary from species to species. The colour variation in the veneers have resulted in search of various colouring techniques to achieve uniform colour of veneers irrespective to the species used and also the colouring of veneers adds aesthetic appearance to the product.

In the research carried out at IPIRTI, the process parameters for achieving through and through penetration of various colours using synthetic dyes which are suitable for wood has been explored. Veneers from Species of *Birch, poplar, silveroak, Beech,, Ubha* and *eucalyptus* of size 2' x 4' with thickness ranging from 1.6 to 1.95 mm were dyed using various colour dyes.

The process parameters viz., the vacuum/steam pressure, temperature and the requisite time to attain uniform distribution of colour with complete penetration of dye solution onto veneers have been optimized for all species. The technology developed yields uniform quality of colour throughout the veneers and improves the aesthetic appearance of the final products made using the coloured veneers. The colored veneers find special applications in high end products like knitting needles, bag handles, wood carving and also for producing face veneers.

Key words: Wood, colour, dyes, products

Introduction

Throughout the world, natural dyes have been used since ancient times until the end of 19th century when they were largely replaced by cheaper synthetic dyes. The ancient dyestuffs were generally organic materials obtained from plants, insects, shellfish and lichens, whereas many of the earliest pigments were inorganic materials obtained from natural ores. Dyes are substances that can be used to colour the materials. Dyes are of two types viz., natural and synthetic and these are present in many substances. Many organic dyes come from plants which are usually difficult to duplicate because of the nature of their sources. Natural dyes are usually not consistent from batch-to-batch. These dyes would not be a good choice for dyeing wood and inlays on a consistent basis. Synthetic dyes, on the other hand, are manufactured in large quantities and offer a wide range of colours and they do not fade or wash out easily as natural dyes. Colours can also be uniformly duplicated from batch-to-batch. Dyes are complex unsaturated aromatic compounds fulfilling characteristics like intense color, solubility and fastness. Dyes can be defined as the coloring particles which differ in each type from the other in chemical composition and are used for coloring fabrics in different colors and shades which are completely soluble in liquid media.

Dyes can be natural or synthesized from benzenoid hydrocarbons obtained from coal tar or petroleum. There are over 7000 different synthetic dyes currently in use in the textile, leather, paper food and cosmetics industries. Dyes are distinguished from pigments in that they are soluble in the application medium, usually water whereas pigments are insoluble. In the present invention a water/alcohol solution has been found preferably as a solvent over water.

Reactive dyes is a class of highly coloured organic substances, primarily utilised for tinting textiles, these kind of dyes bind to their substrates by a chemical reaction that forms a covalent bond between the molecule of dye and that of the fibre. The most preferable dyes for printing the cellulose/cotton are reactive dyes. These dyes have been used for over fifty years on an industrial scale. Rattee and Stephens invented the first reactive dye in 1954 which became commercially available in 1956 (Renfrew, A.H.M. and Taylor, J.A., 1990 and He. Y et al., 2007). Reactive dyes have complicated chemical structures which form covalent bonds between reactive groups of the cellulose and activated functional groups of the dye molecules. Reactive dyes are the most common dyes because of many advantages such as operating under mild conditions, stable structures and bright colors (Wang and Lewis, 2002 and Xie et al., 2008).

The main features of these dyes are to interact chemically with cellulosic fiber as well as maintain quality during washing, last on the fabric for a longer duration and preserve the fixation value. All these features play an important role for the superiority of a reactive dye towards other types of dyes (Timofei, S et al., 1996) and (Al-Degs, Y et al., 2000). The quality of a good dye actually depends on the interaction of the chemically-bound functional groups, e.g., sulfonic, hydroxyl, azo, carbonyl, and chloro groups of the dye with the molecules of cellulose in normal conditions, staying bonded during washing and being resistant to being washed out from the fabric.

Azo dyes is the largest class of dyes used in the textile industry which also finds application in wood colouring. Azo dyes are often used in the colouring process of several textiles and leather products including wood. Some azo dyes contain chemical groups that bind metal ions. Often, the metal ion also unites with the fibre, improving the resistance of the dye to washing and also this bond between the dye and the ion can produce important changes in shade. There are high levels of azo dyes in the environment due to is quite difficult to breakdown this azo bonds (R – N = N – R). They are very stable in acidic and alkaline conditions and resistant to high temperatures and light.

Colors are antistatic part of human life. The best guide to the dyeing performance of a reactive dye can be obtained by considering the compatibility of the dyeing profiles & diffusion behaviour of the dyes selected, similar properties to be identified and used in combination to support right first time production. Dye diffusion exerts a significant influence on dye fixation, ultimate color yield and colorfastness of a dyed fiber. Therefore, dye diffusion should be considered for dye selection and color matching as one of the primary parameters in addition to the nature and chemistry of veneer, chemical structures/functional groups present in wood as well as various bonding types (S. K. Rajput,; Alka Ali, ;Jaya Pandey, 2016). The interaction between dye and veneer is considered to take place with the formation of specific bond between the dye and veneer owing to the covalent bond, hydrogen bond, ionic bond and dipole-dipole interaction. The formation of these bonds is dependent on the type of functional groups present in the dye and the fibre or through Vanderwaals force of attraction between dye and veneer. The hydrophilic/hydrophobic properties of the dye and the wood/veneer will influence the formation of linkages between the dye and wood or the veneer functional group.

With the rise in temperature , the reaction rate of dye onto wood increases, the higher the dyeing rate dye molecules on the wood cellulose results in adsorption and diffusion of at the same time and will lead to hydrolysis when the temperature is more than 80 degree centigrade.

It has always been noticed that when a short time is given for colouring the wood veneers at high temperature, there will be colour absorption only on the surface which indicates that a sufficient time has to be provided for the dye to penetrate completely onto veneers through pressure/diffusion. The pressure provided for impregnation of colours also plays a very dominant role in achieving the dye penetration onto the requisite material thickness. It has been reported and practically proven that a steam pressure of 4-6 kg/cm^2 is very essential to achieve the targeted level of penetration. When the veneers attain to achieve through and through penetration of the colour, the cutting of veneers at any point will also yield the same colours.

MATERIAL AND METHODOLOGY

Method of Dyeing

The veneers of each species to be colored is segregated separately and is immersed in a dye bath in a container. when dyeing hardwoods, better to have a dye with molecule size less than the pore size to permit penetration into the wood. Otherwise the dye will remain only on the surface of the veneer.

Preparationof dye solution:

3-5% of dye was dissolved in hot & cold water (**Fig. 1**.). The quantity of solution was taken in such a way that all the veneers were dipped sufficiently in the dye solution. The concentration of the solution was calculated according to the required quantity of veneers taken for the study. The same solution can be used 2-3 times depending on the dilution of dye. Care should be taken during dye mixing with water such that no lumps remain in the solution. The dye should be completely dispersed in water before pumping into the reaction vessel.

Fig.1 Dye mixed with hot/cold water to make a dye solution

Process of dyeing of veneers:

The veneers size 2' x 4' were kept in a tank and kept inside the pressure impregnation vessel (**Fig 2**). After loading the veneers stacked tank into the pressure vessel, the lid is completely bolted with bolts and nuts to make it airtight and then vacuum pressure of 650 mm/Hg is created. During vaccum pressure application, the airlocks from the veneers get removed. The vacuum pressure was maintained for about one and half hrs. Meanwhile the dye solution is taken in a reservoir fitted to the impregnation plant (**Fig 3.)** which is fitted with a pump to push the dye solution into the pressure impregnation plant. After releasing the vacuum pressure, immediately the dye solution was infused into the pressure vessel. The solution is pumped inside the chamber. Steam pressure of 6Kg/cm^2 is employed to attain temperature of 150^{0}C .The same pressure and temperature is maintained for about 4-5 hours to achieve through and through penetration. It is recommended that the pressure may be adjusted to maintain temperature of 150^0C through the impregnation period. Use of the separate container rather than filling the pressure chamber with the dye directly simplifies the cleaning of the containers after one colour and before repeating the process with another colour dye. After the stipulated time of 4 hours, the pressure is released and the chamber is allowed to attain ambient temperature . The dyed veneers (**Fig.4 & 5**.) are removed for further washing to remove the excess salts deposited on the surface. The solution containing the dye can be reused once or twice depending on the colour with additional solvent added three or four times without affecting the final colour to be obtained.

Care should be exercised at pressures in excess to avoid the integrity of the wood being negatively compromised. The chamber is pressurized until the wood absorbs the amount of colour that is desired. At pressures of 6 kg/cm^2 the time required for penetration is about 4 to 5 hours. Lower pressures will result in slower penetration times. When the colour is absorbed the pressure is released and the veneer is removed and stacked to remove the excess dye solution by way of drain.

Washing of the dyed veneers place important role. Then the veneers need to be washed until the leaching stops if not washed thoroughly, it would affect in the production of the final product. The dyed veneers were washed 2-3 times using Luke warm water / normal water to remove excess dye of the veneer. Washing can be continued until there is no bleeding of colour and then air dried. The veneer is then checked for the level of penetration by visual observation.

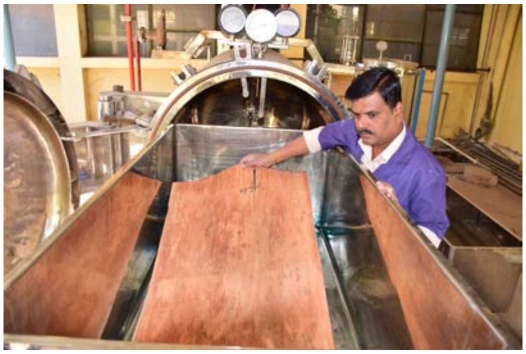

Fig.2. Veneers taken for colouring

Fig. 3. Dye solution added to reservoir for pumping

Fig. 4. Dyed Veneers in tank

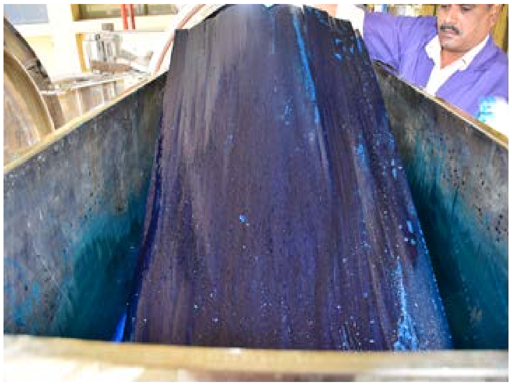

Fig. 5. Veneers after colour impregnation

The resulting veneer has consistent colour such as light blue, ink blue etc. and the dye had penetrated completely through the veneer. The veneer can be sanded, cut etc without damaging or changing the colour avoiding the need to touch up these areas as in conventional methods which are difficult to get colour matches. The dye onto veneers yields wide variety of colours without masking the grain of wood. This adds up to the aesthetic appearance to the wood surface. The final coloured veneers and products made using coloured veneers are shown in **Fig.6.**

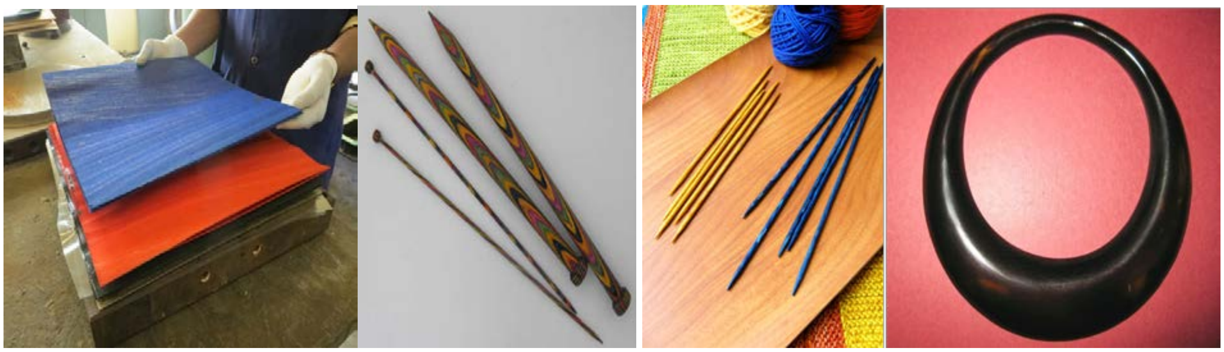

Fig. 6. Coloured veneers and the products made using the coloured veneers

RESULTS AND DISCUSSIONS

The physical properties of these veneer species were initially studied before subjecting for colour impregnation as the infusion of dye depends on the density, pore size and the absorption characteristics of the veneers. The temperature, vacuum pressure, steam pressure and the retention time employed in the pressure vessel for impregnation of dyes onto veneer plays a very significant role. The observations of the experiments with varying temperature and the retention time in the pressure vessel while during the colour impregnation process are highlighted below.

From this research, it has been observed that when the temperature is too high for dyeing, then the reaction becomes very fast and uniform depth of dyeing onto the material will be achieved. However, there will be certain deformation of the veneers. This is mainly due to the destruction of the chemical constituents of the wood at high temperature. When wood veneers are subjected to temperature above 150 - 250^0C , the major changes in the wood components occur by way of degradation and modification. The degradation of lignin is very high at high temperature thereby the integrity of the veneers surface is disturbed resulting in curling of veneers. It has also been noticed that neither the dyeing of veneer carried out at very low temperature yields good result. At a very low temperature and shorter time the surface of the veneer will get colored but through and through penetration of the dye will not be achieved. Increasing the time at low temperature helps in better diffusion and adsorption of dye onto veneers. However long time for coloring will not be a viable technology.

Keeping the above facts observed during the experiments, the process parameters by maintaining the temperature of 150 ±5^{0}C was worked out to achieve the viable technology for commercial implementation. For all experiments initially vacuum pressure of 650 mm/Hg has been maintained for one and half hrs . This was followed by a Steam pressure of 6Kg/cm^2 to attain temperature of 150^{0}C and maintained the same pressure for about 4-5 hours. All the species indicated dye penetration through and through when.

For all the above optimized conditions of pressure, temperature and time, the dye colours were infused through and through onto veneers.

CONCLUSIONS

From the research studies, it was concluded that the veneer of *Birch, poplar, silveroak, Beech, Ubha* and *eucalyptus* species achieved through and through penetration of the colour when pressurized at a pressure of 6 kg/cm2 maintaining a temperature of 140^{0}C- 150^{0}C for about 4-5 hrs and also the dye solution of 3% was quite sufficient to yield the requisite penetration. The solution can be recycled twice without further addition of dye . The veneers can be efficiently coloured for through and through penetration with the requisite dyes without hampering the physical behavior of the veneers. The advantage of dyeing is that the colour cannot be removed or faded by sanding or cutting due to the fact that the veneer gets dyed throughout its entire thickness.

References

1. Al-Degs, Y.; Khraisheh, M.A.M.; Allen, S.J.; Ahmad, M.N. (2000). Effect of carbon surface chemistry on the removal of reactive dyes from textile effluent. Water Res. 34, 927–935.
2. He, Y.; Li, G.; Zhao, J.; Su, H. (2007). Membrane technology: Reactive dyes and cleaner production. Filtr. Separat. 44, 22–24.
3. Renfrew, A.H.M.; Taylor, J.A. (1990). Cellulose reactive dyes: Recent developments and trends. Rev. prog. Color. Relat. Top. 20, 1–9.
4. Timofei, S.; Kurunczi, L.; Schmidt, W.; Simon, Z. (1996). Lipophilicity in dye-cellulose fibre binding. Dyes Pigment. 1996, 32, 25–42
5. S. K. Rajput,; Alka Ali, ;Jaya Pandey (2016). Advanced approach for trichromy formulation in continuous dyeing International journal of engineering sciences & research technology 5(4): April, 2016. ISSN: 2277-9655
6. Wang, H and Lewis, D. M., (2002). Chemical modification of cotton to improve fibre dyeability. Color Technol., 118:159-168
7. Xie,K., Hou, A and Sun, Y., (2008). Chemical graft of cellulose with the ion pair emulsion containing the reactive groups and its dyeing properties. J. Disperse. Sci. Technol., 29: 1385-1390