

Characterisation of Surface Finishing Processes in Wood Furniture Manufacturing

by

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Abstract

This paper presents a research project that is currently underway at the Industrial Research Institute Swinburne (IRIS), with funding provided by the Cooperative Research Centre (CRC) for Wood Innovation. This project commenced in June 2002 and is expected to be completed by June 2004. The objective of this research is to investigate the finishing processes and procedures related to wooden components in furniture manufacturing. This would involve the specification of the configuration of the major factors affecting the components finished surface quality. In particular the research will investigate the best process parameters in the sanding operation and develop procedures to achieve the highest quality of surface finish. It is envisaged that the research will lead to a systematic characterisation of the surface qualities for different wood species. The aim of this project is to minimise the requirements for sanding after wood machining operations.

1. Introduction

The purpose of sanding is primarily cosmetic – that is, to remove mill marks, tool marks, other defects and to smooth surfaces [1]. When sanding, sandpaper leaves small grooves relative to the grit size of the paper used. Sanding with progressively finer grits makes these grooves smaller. Once the grooves are small enough so they can not be seen with the naked eye, then the process can end. Wood sanding is also performed to prepare surfaces for treatment such as staining and lacquering. A well prepared wooden surface is one that has been sanded to remove all wood fibres and to open up the grain of the wood. This allows the stain to penetrate the surface ensuring a deep uniform finish. Without proper sanding, wooden surfaces have:

- Poor coating adhesion
- Stain blemishes and imperfections
- Visible milling imperfections.

Wood sanding is an integral processing element for many furniture manufacturers. Its importance is paramount in the finishing quality of the final product.

A thorough sanding is often the factor that separates acceptable results from professional results. The procedure undertaken in the process can also greatly affect the efficiency of the entire production process. It is essential to carefully sand the wood to remove all scratches and create a smooth surface before applying any finish [2]. What makes a precise procedure so onerous is the large number of variables encountered in the procedures. Quality is therefore difficult to achieve. It requires sanding with fine sandpaper before undercoat and all subsequent cutbacks to remove bumps and high spots, especially if a thick coat is to be achieved [3].

A key problem encountered in sanding wood lies with classification of the wood. Each wood is different - different density, hardness, grain orientation, pore size, contrast of young and old wood, and different response to the sanding process and therefore different grades and sequences of sandpaper grits are required for different type of wood.

2. Industrial Implications

Many furniture manufacturers have observed that they have problems in their wood finishing department. The problem in wood sanding is that the material is natural and varies among different species and other environmental conditions. There is little literature that has been uncovered to assist in wood sanding and there is no specific information about the effect of key parameters in the sanding process and their interactions [4][5]. Currently, without any documentation, the industry relies on operator experience and hence ends up with manual control and labour intensive sanding options. Many furniture manufacturers perform the same sanding procedures and processes for all the species of wood they use. Due to its labour intensive operations, sanding is therefore a bottleneck in the whole production. Moreover, the process produces a lot of dust, thereby contaminating the subsequent spraying operations as well.

The interest in wood sanding in the furniture manufacturing industry is due to the information associated with number of variables that are encountered in the sanding process. Differences in machines, tolerance settings, wood types, grits, grit sequences, environmental conditions, sanding procedure, wood storage conditions (e.g. moist wood will react differently to dry wood), etc., may contribute into the differences in the final finish. Therefore, there is a need to guide manufacturers to optimise the performance on the entire process by best configuring the above parameters.

3. Preliminary Literature Review

Much of the literature and practice considers sanding as a most important process in affecting the quality of the finished furniture. From the literature reviewed thus far, the current practice undertaken appears to be fairly general. That is, for example, in hand sanding for preparatory work manufacturers use 80 grit [6]. Table 1 shows a general guide for the proper use of sandpaper, although this may vary for different wood species. This is obviously very unspecific, not taking into account variations in wood types, and environmental conditions. Such allowances may seem minimal but, when one considers the enormous amount of sanding that occurs in a year

in large furniture factory, then small allowances can aggregate to make large operational differences in the economy of the entire process.

Grit	Common Name	Uses
40-60	Coarse	Heavy sanding and stripping, roughing up the surface.
80-120	Medium	Smoothing of the surface, removing smaller imperfections and marks.
150-180	Fine	Final sanding pass before finishing the wood
220-240	Very Fine	Sanding between coats of stain or sealer.
280-320	Extra Fine	Removing dust spots or marks between finish coats
360-600	Super Fine	Fine sanding of the finish to remove some lustre or surface blemishes and scratches.

Table 1 - General guide to the proper uses of sandpaper

The four main types of sandpaper abrasives used in woodworking are Aluminium Oxide, Garnet, Silicon Carbide, and Ceramic. Aluminium Oxide grain abrasives [7] are the most commonly used. These produce long lasting and even cutting sandpaper. Garnet wears out faster, but produces a softer finish on wood, which is particularly useful if the wood is to be stained. Research experiments by Taylor, Carrano and Lemaster [5] showed that Silicon Carbide yielded a better surface than aluminium oxide at the coarsest grit size for all the species. The choice of backing material is as important as the choice of abrasive. For a smooth finish by hand sanding, paper is a good choice, but for a rapid stock removal or other heavy-duty uses, cloth is a better choice. Many sanding belts are made with cloth backing. Therefore it is important to use the correct type and grade for a task.

Diydata [8] recommended that for the best results, sanding should be started by using a medium or course grade paper and change the grade of paper as the job progresses. Lipinski [2] suggested that for pine, for example, to start with a medium-grit (80 to 100) aluminium oxide paper, then progress to finer grits (120 to 150) before smoothing with a 180-grit paper (Some stains require sanding with even finer grits.) and always sand with the grain.

While it is not necessary to progressively sand using every available grit, it is important not to skip too many grit sizes [1][3]. There is a need to use a grit that is just small enough to remove the grooves left by the previous paper. Skipping grits to save time is also not necessarily productive. It often requires sanding for longer periods just

to remove the scratches left by the previous grit. This is more important with harder woods, such as maple, than it is with softer woods like pine. It can also be a waste of time to sand with very fine sandpaper. Sanding maple with 400-grit sandpaper, for example, will tend to seal off the grain and prevent finishes from penetrating [3].

The 3M Corporation [9] suggest that there should be no more than a two-grit jump between roughing and the next grit size (i.e., 36-50 or 40-60) and there should be no more than a one-grit jump between subsequent grits (i.e., 80-100-120-150-180). Conversely, Timesaver [7], the world's largest manufacturer of wide belt sanders suggests that operators should not skip one grid size in a sequence.

For hand sanding, it is important not to use undue pressure as it clogs the paper or causes the paper to wear out unnecessarily quickly [8]. The effect of pressure was significant throughout all grit size levels [4]. When power sanding, very little pressure is necessary, just guiding the tool is normally sufficient. Using a sanding block when hand sanding is useful to reduce pressure spots. Moving sandpaper along the grain of bare timber, (not across) is also important. On a smooth, non-grained surface, sandpaper is moved in small circular motions. A good finishing job requires sanding the entire surface evenly without missing any spots. A common mistake that many manual operators or labourers make is sanding the centre of the surface and neglecting the edges. This creates a dished surface with high spots around the edges. To avoid this, Lipinski [2] recommended that a series of light pencil lines should be drawn across the entire surface, and then sand the lines away. Therefore when some lines disappear while others remain; it is an indication that the operators are not sanding evenly.

Regardless of the type of sanding technique used, there are some basic rules to follow. Many texts and articles tell the reader never to sand against the grain. This is not always true. Initially sanding against the grain will remove stock much quicker and remove mill marks and level the surface quicker [1]. Once mill marks are removed and the surface has been levelled, the process can finish up by sanding with the grain before moving up to a finer grit. Also there are some cases where sanding against the grain is enforced. One such case is at a joint line where two pieces of wood meet at an angle. In this case it is preferred to sand against the two pieces, and finish by sanding with the grain up to the joint line.

Wood and sandpaper storage conditions are also important. For wood storage conditions, the 3M Corporation [9] recommended that, ideally, after coming out of the presses, particleboard should be stored to allow it to come to ambient temperatures, 15-27°C. If the board goes directly to a planer and is sanded at temperatures of 37-93 °C, serious degradation of belt life and machine operation may result. High temperatures tend to soften resin on the belt, and material tends to build up on machine parts, interfering with good operation. Sandpapers should be stored carefully in a cool dry area [8]. Except for papers made using waterproof adhesive and backing material, any dampness may cause the adhesive or backing to fail or weaken and grains will become detached. If the paper becomes clogged after a short time of use, look at the surface being sanded, the timber may be damp - allow time for it to dry out.

In terms of machining, rotary machining is extensively used for planing and moulding operations within the woodworking industry [10]. Although the surface form produced by this machining method is acceptable, the rotary machining action generates cutter marks on the wood surface so that further finishing operations, such as sanding, are often required to produce a product of acceptable standard. It has been suggested by Brown and Parkin [10] that the surface finish of planed and moulded timber products may be improved by oscillation of the cutter block in either a vertical or horizontal plane. They use rapid surface simulation algorithm to predict surface finish and computer simulations to model cutter block oscillation. The result is a tool for effective design and optimization of a hydraulic oscillation system in order to improve surface form.

4. Research Aims and Objectives

The objective of this research was to investigate the factors affecting the finishing properties of wooden components in furniture manufacturing. This would involve the specification of the configuration of the major factors affecting the finishing qualities. In particular the research will investigate the best sanding process and procedures to achieve highest quality of surface finish for commonly used furniture timber. It will include investigations of different parameters that may contribute to the difference in final finish, such as differences in machines, tolerance settings, wood types, grit sizes, environmental conditions, sanding procedures and wood storage conditions. It is envisaged that the research will lead to a systematic characterisation of finished wood. The aim is to minimise the requirements for sanding after the wood machining operations. This may imply changes in the machining processes.

The outcomes of this research will be a systematic characterisation of finished wood for the furniture manufacturer to be used as guidance for furniture manufacturers to optimise the performance of the finishing process and to achieve the highest quality of surface finish by best configuring the sanding process and procedures.

5. Summation

The literature review highlighted some factors affecting the finishing of a wooden component. Many of the recommendations that were highlighted were commercially motivated. There were several other variables affecting the sanding process such as machines, tolerance settings, wood types, grits sequence, environmental conditions, sanding procedure, and wood storage conditions, etc. Preliminary investigations show that there is little scientific information available to assist the industry with their wood sanding process and the machine set up. It is envisaged that the research will lead to a production of a systematic characterisation of the wood sanding method for the furniture manufacturer to be used as guidance to optimise their finishing operations performance by best configuring the above parameters. It is envisaged that, as a result of this research, furniture manufacturers, machine makers and researchers will benefit from this research.

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