OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche

08018

Distr.
LIMITED

ID/WG.277/2
19 April 1978

ENGLISH

United Nations Industrial Development Organization

Technical Course on Criteria for the Selection of Woodworking Machinery

Milan, Italy, 8 - 19 May 1978

THE PRODUCTION OF CHAIRS AND OTHER TIMBER COMPONENTS *

by

A. Speranza**

* The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Director of CATAS, San Giovanni al Natisone (UD), Regional Centre of Technical Assistance for Manufacturers of Chairs and Wooden Furniture; Azienda Speciale della Camera di Commercio di Udine.

id.78-2112

CONTENTS

The chair production in Italy is outlined as part of the whole furniture industry. Following the sequence of operation when machining chair components the author describes the production flow and the ancillary material viz: adhesives, coating material and hardware for the chair production.

Comparing the operations on different machines single and multi-purpose equipment has been considered.

Staining and lacquer coating equipment for chair frames including dipping, spray coating, flow coating and coating by means of electro-static systems is mentioned.

The paper covers a machinery and equipment list for a chair production with fifty employees.

1. Introduction

The furniture industry makes use of a variety of raw materials, each one presenting its own is related to different technologic and production problems.

However, a basic distinction can be made between products manufactured from solid timber and those made of timber derivates such as panels.

Production technology and techniques can be considered, in the context of the timber and furniture industry, as a parameter which allows to identify deeply diversified industrial typologies. This report deals with the industrial uses of timber, particularly for the manufacture of chairs.

The machinery and equipment used in the manufacture of chairs do not differ substantially from those required for other timber components and therefore this

report covers all types of timber processing, unless otherwise stated. The subject of this report needs to be dealt with in detail due to the importance assumed by the chair industry, particularly in Italy, and also because modern furniture manufacturers tend to specialise. In fact they are at present increasingly in favour of withdrawing components made of solid timber from their manufacturing cycles. This confirms the complexity of solid timber technology in respect of that required by its various derivates, which are used successfully and in large quantities by today's furniture industry.

2. A few considerations on the Italian chair industry

This particular industrial sector constitutes a major reality in north east Italy, particularly in the Friuli Venezia Giulia area.

Reliable sources quote about 650 firms and 12.000 employees for a turnover of approximately 2 billion Italian lire, mainly from export.

All these firms are located in an area of about 300 km2 around Manzano, San Giovanni al Natisone and Corno di Rosazzo.

This multitude of companies, the first of which were formed at the end of the last century, is due to the particular type of industry; these are in fact "light technology" industries because of the level of investment per employee and the high specialisation in specific jobs which is peculiar to this region. Because of this, also industries with an integral production cycle enjoy a high degree of manufacturing flexibility, since they can make use of sub-suppliers.

Considering the relationship between the products and the market in whioh the chair industry, as a supplier to the furniture industry operates, the following alternatives can be put forward:

a) standardized and consistent models; production for stock; low quality standards; competition merely based on price.

b) sufficiently varied and reasonably consistent models; fairly large mass production (same models for different clients); competition based on price and quality.

c) very large selection of models and timber species; limited mass production; manufacture exclusively by order; competition based on quality of products and service.

Alternative "a" offers the possibility of establishing highly automated and productive manufacturing lines with the creation of special machines; this is also possible for "b", though not to the same extent, because the various models are technically compatible but less repetitive; in the last case, "c", which is probably the most common in the present market situation, the impossibility of adopting the same technical solutions for a wide range of different products, generates the need for the most versatile machinery. This must be capable of performing the same operation for the production of the largest number of models.

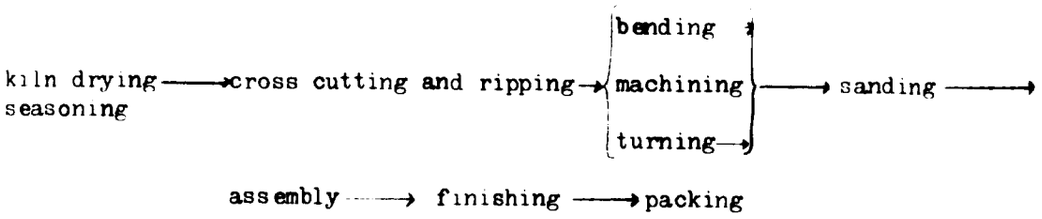
3. Theoretic production cycle

The plant we intend to analyse, so as to identify the various manufacturing operations, and the machinery and equipment capable of performing these, is an "integral cycle" plant for the production of chairs. This means a plant where production starts with the timber boards and ends with a fully finished and packed product. We do not intend to deal here with upholstering of chairs and the bending of timber by steam because these are specialized operations carried out by specialized firms.

The choice of machinery is based first of all on its versatility since this is a major characteristic of this type of plant, which after all supplies sub-components within the furniture industry. We do intend, however, to mention also more sophisticated machinery suitable for mass production.

The major role in the solid timber industry is played by fairly straight forward machinery where the human element is still of great importance and which can be easily adapted for the number of different operations required by rapidly changing models.

We shall attempt to identify a production cycle applicable to most types of chairs and also suitable for other solid timber components. We shall then examine in more detail each production stage and describe the individual woodworking machines.



A few observations:

- kiln drying can be carried out on board material or on rough sawn components;
- machining has been divided into three groups since both bending and turning require special equipment and are often carried out by specialized firms;
- finishing includes all the operations affecting the appearance and the protection of the component against physical, chemical and mechanical agents.

We shall also mention briefly other associated materials used at various stages during the manufacturing process but detailed reports on the specific subjects will be issued in due course.

3.1 Adhesives

The advantages of glued joints as against mechanical joints are several and range from a better appearance to a more uniform distribution of the loads and therefore a better performance in the long term.

Adhesives currently used are based on synthetic resins both because of their improved strength characteristics and their ease of application.
The most widely used adhesive is a PVA-based emulsion (polyvinyl-acetate). This is easy to apply and fairly strong although it has a few disadvantages: Ambient and timber temperature must be not less than 10°C during application, the moisture content of the timber must be not more than 15/16 per cent and finally it is not waterproof.

3.2 Stains and Lacquers.

Both these items are the subject of a separate report and therefore we shall mention them only briefly.

Stains commonly used are either water or organic-solvent based. Special emulsions known as "penetrating stains", in which pigments are diluated with a solvent, are also used: these have the advantage of producing a base coat for subsequent lacquering.

Three types of lacquers are applied for the finishing treatment, in the following order of preference: polyurethanic, nitrocellulose and acid catalist varnishes.

Only the second type is based on a single component and dries out by evaporation of the solvent: this has its well known advantages and disadvantages.

3.3 Other materials

Other materials used in the timber industry include belts and papers for sanding raw and finished components, hardware for jointing, upholstery, paper and cardboard for paokaging.

We shall now examine in detail each stage of production, describing the

machines offered by the industry, from the simple ones to the most sophisticated and, where possible, we shall explain the reasons for our choice.

4. The manufacturing process

4.0 Kiln drying

Timber can either be seasoned in the open air lumber yard or dried in kilns by means of special equipment capable of controlling and decreasing the moisture content of the timber.

This process can be applied both to sawn lumber or rough sawn components prior to their final machining, depending on the individual production requirements. Three kiln drying systems are currently available in our country: the traditional hot air system, the vacuum and the de-humidifying systems.

A specific report deals with the advantages and disadvantages of each system. It is important to stress here, however, that the vacuum system has had considerable success in the chair industry, particularly with certain timber species and components in stick form, due to its simplicity and speed.

4.1 Cross cutting and Ripping

Sawn, kiln dried lumber will be rough sawed by cross cutting and ripping for appropriate component sizes, viz: rails, legs, back posts, splats, stretchers, armrests, etc. First boards are cross cut and then ripped, so obtaining precut sized components ready for subsequent machining.

Cross cutting is usually carried out on a pneumatic or manually operated circular parallel swing-saw giving various outting widths and thicknesses. A width of 60 mm and a thickness of 140 mm are sufficient for our purposes. The simplest alternative to this machine is obviously a hand saw; a standard bandsaw is also frequently used. The latter is used for cutting the rough boards, cross out as previously described, into sticks or into moulded

components, after manual ripping. This machine is indispensable in a factory processing solid timber, is very versatile and its performance relies greatly on the ability of the operator. A multi-rip saw can offer a more productive solution but it is only suitable for parallel cuts: the machine incorporates a number of circular blades spaced on the same shaft at pre-set distances. Several sticks can be obtained simultaneously, all from the same rough sawn board. The use of one or more bandsaws does not eliminate the need for a multi-rip saw which can cope with all types of straight-edged components.
In conclusion, cross cutting and ripping produce rough components in stick form which, in order to achieve the required appearance and final dimensions, will be subjected to further machining (planing, moulding, drilling, etc.).

4.2 Planing

In order to obtain perfectly flat surfaces, rip sawn components must be planed: this operation can be carried out with the old fashioned but still widely used plane; today however this has been replaced by the surface planing and jointing machine and the thicknessing machine.

The first planes two surfaces at right angles to each other and the second planes the other two: these are very basic woodworking machines, very simple to operate and to maintain.

The so called planing and moulding machine constitutes an alternative to these and offers greater possibilities since it allows to carry out several operations at the same time: it incorporates a number of spindles, normally from four to seven, each carrying a cutter-block for planing the four faces (four-cutter); the remaining cutter blocks are used to mould

the piece to the required profile. Timber is fed into the machine at constant speed by rollers or is "pushed" by chain at variable speeds of up to more than 30 m/min. The roller feed must be used with small pieces not perfectly cut to length. The planing and moulding machine has an extremely high capacity and can be equipped with automatic feeding and stacking devices so that it can be operated by one man.

Its setting up is fairly complex and therefore this machine is very profitable for long runs of the same component. It can also be coupled with the multi-blade saw to achieve a mass production line, overseen by a limited number of operators (three). Calibrating wide-belt sanders have been used over the last few years, for particular timber species, to remove by planing thicknesses of a few millimetres. This solution, although in itself expensive, is commercially viable when processing timber species difficult to plane and of high unit price.

The simplest and most versatile machine for planing irregular profiles is the moulding machine: it is well known that its spindle is so designed, that it can be fitted with a number of tools and cutter blocks.

The copy-moulder is certainly a more complex machine but it allows greater productivity and is less dangerous: it consists of two vertical spindles fitted with cutter blocks and a "tracer roll" copying the required profile. The opposite heads reproduce the pre-set profile on the rough components, suitably fixed over the templates. This machine can be equipped with two additional spindles for sanding. It requires one unskilled operator only.

4.3 Shaping

A multitude of contours and profiles can be obtained on the spindle moulder fitted with the appropriate tools. As previously stated, this machine is very versatile, is suitable for various operations, needs only one operator and can be equipped with automatic feed. The maximum spindle speed is 10.000 rpm. The high speed router complements the above mentioned machine: this is suitable to carry out various internal and concave mouldings by using a guide pin located on the table in alignment with the spindle and a template. With this machine, as the tools are of small size, the speed can go up to more than 24.000 rpm giving a very good machine finish. High speed routers became very sophisticated during the last few years and numerically controlled models are available on the market. Obviously the costs are very high and can only be justified in the case of large mass production of, for example, furniture door panels.

4.4 Turning

Rounded components can be obtained by turning timber on a lathe although, as we have seen previously, components of pseudo-circular section can be machined on the moulder or the planer-moulder.

Lathes can range from the ones where the tools is handled by the operator while the piece rotates between centres, to the very complex ones, fully automated and equipped with loader, power feed saddle and finishing tool slides, capable of copying a pre-set profile.

Because of these characteristics there has been a considerable industrial development in the field of timber turning.

4.5 Cutting to length

This is the operation during which the component is cross cut to its final longitudinal dimension. It can be carried out with an adjustable circular saw. A double end cross cutting machine is applied for large production runs: it can cut to length both ends simultaneously.
We can include in this paragraph also a multi purpose machine widely used in this field: it is easy to operate and to set up and it can carry out cutting to length, contour shaping and drilling in automatic sequence.
It is particularly useful for the machining of rectangular section components to be jointed to rounded section components.

4.6 Boring and mortising

These operations are designed to bore round holes or mortises in timber. Drills are sufficient for the former and oscillating mortising machines for the latter although these can also drill round holes. Two or three parallel axis holes are usually required for joints: these can be obtained by using multi-spindles or heads with multi-bits capable of boring various patterns. Multi-spindle boring machines can also have independent boring heads. The same applies to the mortising machines where the different spindles can oscillate on a plane through their axis. A number of very special machines is available for these operations but we do not intend to give here a full list. The following, however, are worth of mention:

- automatic boring machine for seats;
- automatic boring and dowel driving machine: it bores, applies the glue and drives the dowels;
- automatic gang mortising machine: it can drill and mortise contemporarily on different planes and at different angles and it is partioularly suitable for the machining of backposts with non rectilinear profiles.

4.7 Tenoning

Tenons are made at this stage: these can have a rectangular section or, in the case of chair joints, rounded edges. Tenons with rectangular cross section can be machined on a spindle moulder or, for larger production runs, on a single end tenoner, equipped with special cutter heads.

A well established practice however is that of using a tenoning machine with rounding off attachment: this can produce a tenon with tight fit into the mortise, to give a joint with good mechanical strength. Tenoning machines can have one or two tables: therefore they can be very fast, with a production of up to 16 tenons per min. They can machine tenons to various angles and also of circular section, but always perpendicularly to the face which has been processed on the signle end tenoner. The automatic double-head tenoner with rounding-off attachment can achieve an even larger production: the two heads can be moved so as to allow machining of components of different length and can produce two tenons at the same time either identical or of different size and angle. This machine can be supplied with automatic loader and produces more than 1200 tenons per hour.

4.8 Sanding

This operation is carried out to eliminate the cutter marks left by previous machining operations and to obtain the final shape and a smooth timber surface. Abrasive papers or cloths are used for this purpose and the operation can be carried out manually or by special machines where the sanding belt is driven by an electric motor.

Best result on flat surfaces are achieved by using automatic calibrating wide-belt sanders with single or multiple belts. The belts can be positioned above or below the feed table and if both are operated

on the line, two parallel faces are sanded at the same time. These units, to operate satisfactorily, need a ducting system to carry away the sanding dust.

Best results are obtained with twin-belt sanders, where the first belt is coarser than the second.

4.9 Assembly

During assembly, the various components are put together to make up the final product. Very simple tools are required for this operation: cramps and rubber mallets.

A more productive solution is offered by the use of pneumatic cramps which, by means of pistons, assemble very quickly the components of the chair or other products. The cramps are mounted on a sufficiently rigid frame which can be easily modified as required.

4.10 Finishing

This stage includes all the operations for improving the appearance of the timber and providing mechanical, physical and chemical protection. A generally accepted finishing system for timber is based on one coat of primer, two undercoats and, after sanding, one top coat.

Priming is usually carried out by dipping the component in a suitably dimensioned tank containing primer either undiluted or mixed with a low solids-content emulsion.

Finishes can also be applied by more sophisticated methods like manual spray-gun and flow-coating. The use of the gun entails a high material consumption, better quality of finish but a slower prooess.

Flow-coating generates problems of shade variation with time, but the equipment can be installed on a continuous finishing line.

Primed components can be left to dry out naturally in the workshop or fed through heated tunnels on trolleys or hung from a conveyor chain.

Prime coats and top coats are usually applied by spraying: compressed air directed into the material stream atomises it and form into a spray. It is simple to use and to maintain and can be very fast if operated by a well trained operator. The paint can be fed into the system by gravity or from containers under pressure.

This equipment can be improved in respect of material consumption and timing, particularly in the case of components with large cut-outs (chairs, frames, etc.), by using an electrostatic spraying system.

The finish is atomised in an electrostatic field where the gun constitutes one pole and the component to be painted the other. This method decreases spray losses: theoretically all coating material flows to the component surfaces, also on the hidden surfaces. The coating material has to be adjusted to this sytem and the moisture content of the wood has to be balanced. Another possibility, particularly on large surfaces, is given by the use of air-less electrostatic guns. Atomisation of the finishing material is generated by high pressure. The air-less electrostatic gun, equipped with special nozzles, has recently been used for painting chairs with further savings in operation time and material consumption. During the past few years these electrostatic systems have been introduced on automatic finishing plants, solving the coating problems

of continuously automatic painting of chairs.

Independently of the type of application, solvents and spray particles not coating the component must be removed by special exhausts. These form part of the spray booths and are separated from the painting area simply by a metal grill, filter systems or, a water curtain of a special water wash spray booth.

Paints can dry out naturally or in hot air tunnels of the type described for the drying of primers, with the additional precaution that the ends of the component should be kept at a lower temperature than the centre part to allow the curing and cooling of the paint film. Maximum temperature shall not be higher than 50-60°C to prevent problems in the assembled components.

Another system for the finishing treatment of chairs and other similar products worthwhile to mention is the electrostatic disc. This system has found some applications in our field on completely automated production lines, with the additional provision of guns for touching up where the paint film is not sufficient. It consists of a metal disc rotating around its axis and sliding along its length with a traverse approximately equal to the height of the object to be painted. The latter describes around the disc a looped path, presenting its four faces in succession. An electrostatic field is created between the disc and the object so that all the finishing material should reach the component in a succession of film applications of minimum thickness.

Notwithstanding these attempts of automating the finishing process, one operation still needs to be carried out manually, that is

the sanding of the prime. This is normally carried out by hand or, sometimes, with small electric or pneumatic orbital sanders.

In a chair factory this operation requires more than 10 per cent of the labour employed on the entire production line.

4.11 Other operations related to chair production

- the production of dowels: these are made on a machine capable of producing circular section dowels or pins, grooved or plain, of various diameters and of the required length;

- the shaping of the glue blocks (triangular section reinforcements) is carried out on the profile shaper, capable of machining several pieces at the same time and automatically, so preventing that this operation is carried out on the hand-operated spindle moulder, with certain danger for the operator. The same machine can be used for edge profiling solid or framed seats.

- the production of small plywood panels; this is carried out on a press whioh may be a cold or a hot platen press. The combination of a high frequency generator and a press can be adopted for long range production. This system reduces considerably the curing time for the adhesive applied to the veneer sheets of plywood. High frequency heating systems are widely used for the production of panel components and glued up stock and in wood bending. The adhesive applied for HF-curing must be specially formulated.

- maintenance department: this must include a few machine tools for metalwork like a drill press, a grinding machine and an electric welder as well as other maintenance equipment. A tool maintenance room has to include sharpening machine for bits, cutters and saw blades, saw setting equipment and welding machines for bandsaws.

In the case of mass production of only a few models, the chair components can be processed into their final shape, ready for assembly, by a single multi-head machine capable of planing, shaping, boring, sawing tenoning, sanding, etc. Each operation is carried out by a different unit easy to remove and replace. The standards of machining are computer controlled and a single operator is required.

5. Outline of plant equipment

This paper includes a list of machines and equipment required for a ohair production plant with approximately about 50 employees. The machines chosen are particularly suitable for a very diversified production and are simple to operate.

a) Production of straight tenoned components.

1. pneumatic circular swing-saw for cross cutting
2. multi-blade circular saw, 300 mm working width for rip sawing
3. moulding machine, 170 mm working width, with seven cutterheads
4. automatic double-head tenoner with rounding off unit

b) Production of non-contoured components and other operations.

5. 2 bandsaws, 900 mm diameter wheel
6. surfaoe planer, 520 mm working width
7. Thicknessing machine, 630 mm working width
8. 2 spindle moulders, 5 speeds, 10.000 rpm
9. double end sawing machine
10. automatic sawing, boring, shaping machine
11. automatic double-head mortising machine
12. automatic gang mortising machine with three independent units
13. high speed router with floating head

14. automatic lathe with centering device
15. sanding machine with wide belts above feed table, 1100 mm working width
16. 4 horizontal sanders with a 4900 mm belt
17. brush sander with abrasive holder
18. bench sander
19. dust exhaust system for twelve sanders
20. automatic dowel shaping machine
21. automatic shaper for corner blocks and panels

c) Assembly and finishing

22. pneumatic cramps for pre-assembly
23. cramp for assembly
24. electrically heated hydraulic two-platen press, size 2500 x 1300 mm
25. 4 dip tanks
26. 2 water wash spray booth, 4000 x 2200 x 2000 mm
27. 3 electrostatic spray guns
28. 4 airspray guns
29. 3 glue guns and glue containers

d) Pattern and template making department

30. spindle moulder
31. single table mortising machine
32. automatic double table tenoning machine with rounding off unit
33. bandsaw
34. moulding machine with seven cutter heads

e) Maintenance room

35. grinding machine

36. 3 kW portable welders

37. drill press

38. knife sharpener

39. universal tool sharpener

40. bandsaw sharpener with setting attachment

41. bandsaw butt welding machine

f) Power plants

42. chip and dust exhaust system with 2 collectors, 1 silo (capacity 315 m3), 2 electric exhaustors, filter system

43. compressor station consisting of a rotary compressor (capacity 1000 l), air maintenance and cooling system

44. transformer unit and distribution station

45. hydraulic hoist, capacity 4 tons

g) Tools and accessories

46. various tools for the setting up of machines, tool maintenance, assembly and sanding tables, benches and bench supports for components.

On these bases we can calculate the total investment for machines and technologic plants and the specific investment per employee. We refer to prices at the end of 1977. The investment for technical assets could be around 450 million lire (US$ 229.032) and therefore the investment per employee would be approximately 9 million lire (US$ 10.581).
(Exchange rate April 1978: 1 US$ = 850.60 Lire, 1000Lire = US$ 1.17)

C-665

78.11.06