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STRENGTHENING THE TECHNICAL AND MANAGERIAL CAPACITIES
OF THE CARPENTRY COOPERATIVES IN MUKALLA AND SEIYUN

SM/PDY/87/005

THE REPUBLIC OF YEMEN

Technical report: Training Manual on Wood, Woodbased products and
other materials used in the production of furniture and joinery.*

Prepared for the Government of the Republic of
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

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INTRODUCTION

This training manual is one of a series prepared by a UNIDO expert while serving as Chief Technical Adviser on a UNDP financed and UNIDO executed project in the Republic of Yemen, to strengthen the Technical and Managerial Capacities of the Carpentry Cooperatives in Mukalla and Seiyun (project No. SM/PDY/87/005).

The entire scope of the training envisaged to be given, with the intended audience for each topic is given in Annex I.

The syllabus, namely the topics, the duration of lectures (theory) and practical work and the level of competence attained after completion of the course on this topic is given in Annex II.

WOOD, WOODBASED PRODUCTS AND OTHER MATERIALS USED IN THE PRODUCTION OF FURNITURE AND JOINERY

In order to select the right materials, utilize better their properties and minimize wastes, persons working in the furniture and joinery industries should be able to recognize all the materials and components used, and know basic facts about their physical, mechanical and aesthetic characteristics. Namely, these characteristics mostly determine: construction of joints, selection of tools, processing methods and correct storage and transport procedures.

This training manual is aimed at training a group of trainees in the basic properties of wood, other woodbased products and auxiliary materials commonly used in the production of furniture and joinery.

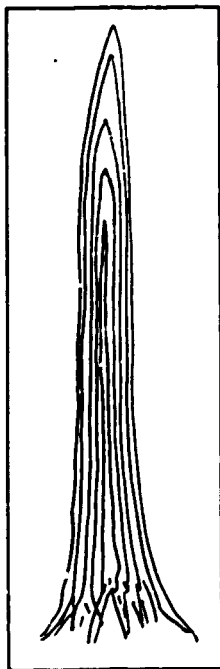


Fig. 1 :
Growth of a
tree.

1. Growth process of a tree and wood anatomy.

Wood is a product of a living nature. Growth of wood occurs as a result of growth and division of special wood cells in the cambium layer, which is the inner part of the wood bark. Every year, cambium cells form an additional cylinder of wood, thus increasing the girth of the tree (see fig. 1).

These layers appear as growth rings. Due to the differences in climate, soil, species of wood etc. there are great variations in wood structure between rings and also within one single ring.

There is a significant difference between early wood, formed during the growing season, and the late wood, formed during the dry season. Early wood contains cells with thin walls and a higher porosity, while late wood consists of cells with thick walls and a lower porosity (see Fig. 2).

The fact that both early and late wood are included in growth rings determines many of the wood's characteristics, such as: density, strength, hardness, shrinkage, etc.

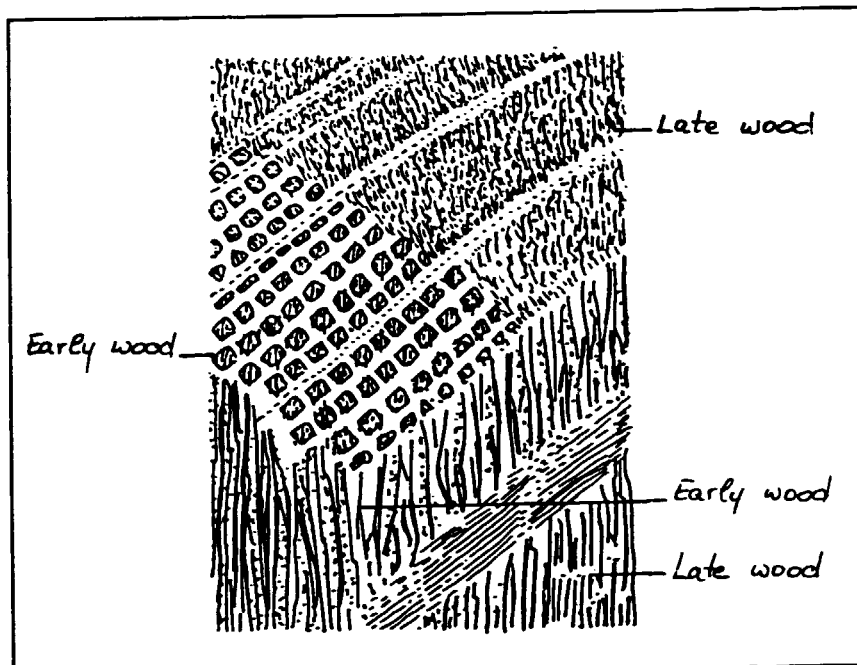


Fig.2: Early and late wood.

2. Classification of species.

There are two major groups of species: softwoods and hardwoods. The anatomical differences between hardwood and softwood caused by differences in the wood's structural elements. Fibres also serve as the major route for movement of sap in softwoods, while hardwoods have additional vessels (pores) through which the sap is distributed in the living tree.

Hardwoods can be ring porous or diffuse porous. The next important characteristic is the difference between sapwood and heartwood. In most growing trees the inner layers of the stem do not contain living cells and sap is no longer present. That heartwood zone is usually darker (often a brown colour) (see Fig. 3).

Most tropical species used by the Carpentry Cooperatives in Mukalla and Seiyun are broadleaved hardwood species.

The terms hardwood and softwood do not necessarily indicate the relative hardness or softness of the wood, although the wood of most hardwood species is harder than that of most softwoods.

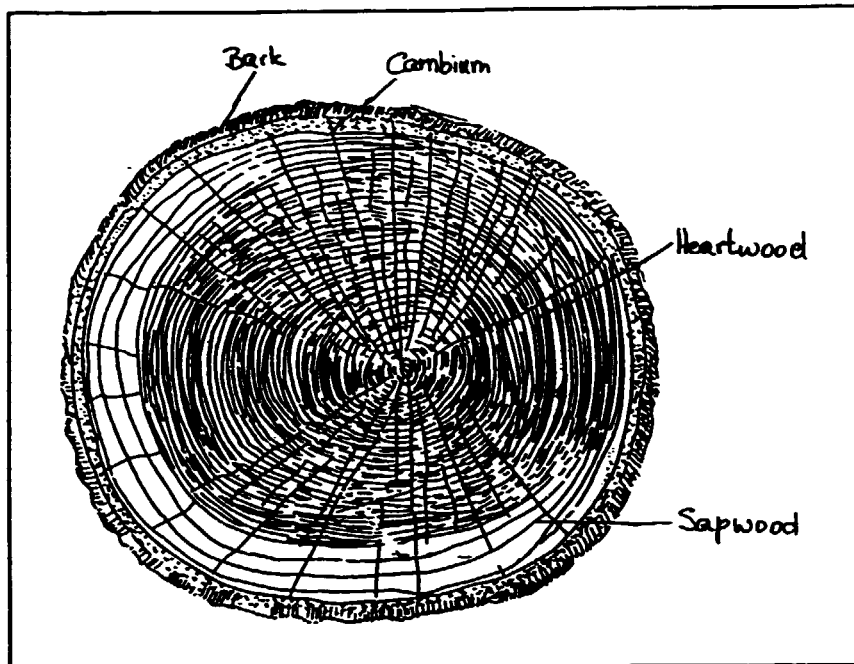


Fig.3: Heartwood and sapwood zones in a tree.

3. Physical and mechanical characteristics.

Wood has different values of physical changes and mechanical strengths in the longitudinal, radial and tangential directions. Also, all data about physical and mechanical properties of wood refer to average values.

From the furniture and joinery production point of view, the important properties of wood are:

- Strength, together with toughness and hardness,
- Grain structure, including homogeneity, colour share and variations,
- Drying properties, such as shrinkage, swelling and twisting,
- Finishing qualities,
- Suitability for gluing,
- Bending qualities,
- Workability,
- Resistance to fungal and insect attack,
- Density.

The properties of each wood species are quite specific, but this dissimilarity may be needed for different products or for different parts of a certain product.

Also, wood characteristics must be taken into consideration when selecting machines, tools, glues, finishing materials and some technical treatments.

4. Moisture content and shrinkage.

Wood is a porous and hygroscopic material giving off or absorbing moisture from the surrounding atmosphere until an equilibrium is reached

between the moisture in the wood and that in the atmosphere. The original moisture in the wood comes from the growing tree. Unseasoned timber usually contains more than 60 percent of moisture. Wood in use is exposed to daily and seasonal changes in the air's relative humidity; it eventually tends to come to stabilize at a level corresponding to the air's relative humidity. The moisture content of wood at this point is called the "equilibrium moisture content" (e.m.c.).

Initially, free water in the cell cavities evaporates and the wood does not shrink at this stage. Shrinkage of the wood begins only when the cell walls begin to dry. This stage is called the "fibre saturation point", which is usually close to 30 percent irrespective of the wood's species.

The wood's moisture content is indicated as a percentage of its dry weight, and can be calculated from the following formula:

$$U = \frac{W_u - W_o}{W_o} \times 100\%$$

where: U is the moisture content (expressed as a percentage)
 W_u is the weight of the undried wood,
 W_o is the weight of the fully dried wood (i.e. the constant weight obtained on repeated drying).

The aim of wood seasoning is to minimize moisture content variations in the wood in use, by drying the wood to the moisture content corresponding to the average atmospheric conditions to which it will be exposed.

When wood absorbs moisture, swelling occurs. This is the opposite phenomenon to that of shrinkage. The shrinkage and swelling of wood gives rise to the following drawbacks

- The dimensions under changes,
- Deformations develop in the cross-section of components because shrinkage is much greater in the tangential than in the radial direction,
- If movement is not allowed to develop freely, harmful internal stresses will occur in components.

In constructing wooden products, one must either make possible free movement or prevent it.

Wood is prone to fungal and insect attack, causing destruction of wood cells, and it becomes unusable as a raw material for furniture and joinery. These attacks occur when its moisture content is between 18 and 30 percent. The most common way of preservation of sawnwood is its seasoning, either by drying it under atmospheric conditions or by artificial drying in a kiln.

Sawnwood which is intended to be used in external applications usually undergo impregnation with chemicals containing fungicide and insecticide. Doors and windows could also be impregnated.

Furniture is usually coated with various finishing materials giving the product a nice look and, at the same time, protection.

5. Sawnwood, its dimensions, quality and use in the secondary wood processing industry.

Sawnwood is produced in a sawmill using either frame saws or bandsaws. The planks obtained are either edged or unedged. They are further processed in the secondary wood processing industry.

Commercially available sawn timber is mostly air dried; additional seasoning is required before it can be used for manufacturing final products.

Sawnwood is mostly produced in standard dimensions and it is subjected to grading. This grading is in accordance with quality standards based on: wood structure, dimensional accuracy and the tolerance of various wood defects. The most common defects caused by irregular drying are:

- Bows: longitudinal curving of the board;
- Cup: transversal bowing of the wood;
- Springs: longitudinal and lateral bowing of the wood;
- Twist: spiral deformation of the board; and
- Honey combing: inner cracks.

Defects caused by irregular drying are shown in figures 4 and 5.

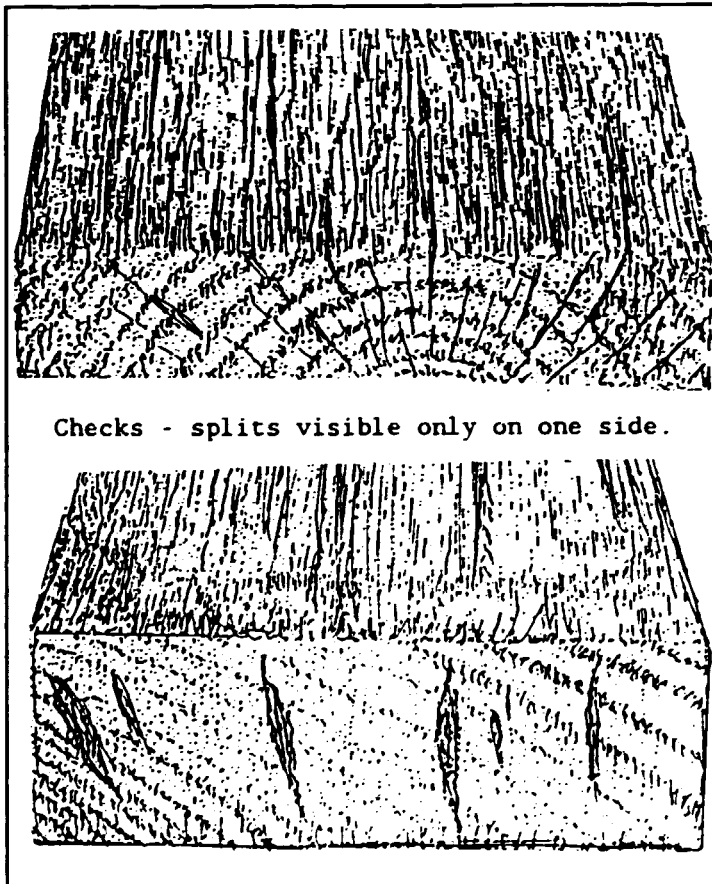
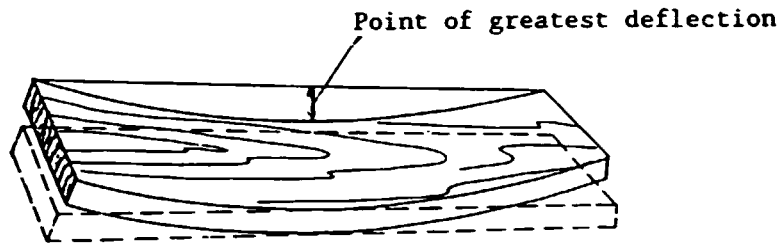


Fig.4: Defects in wood caused by shrinkage.

Bows: longitudinal curving of boards.



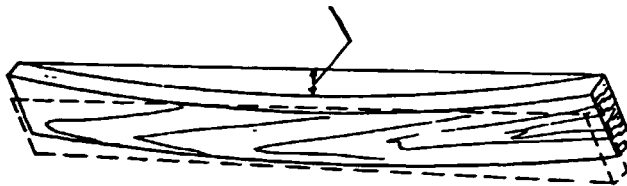
Cup: bowing in the direction of crosscut

Point of greatest deflection

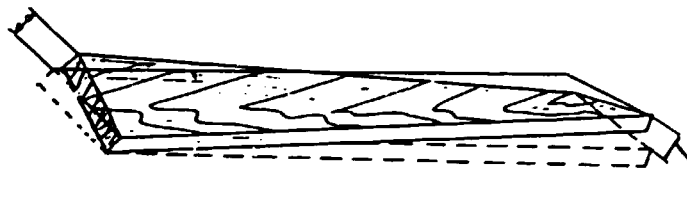


Spring: lateral bowing of wood in the longitudinal direction.

Maximum deflection



Twist: spiral deformation of wood.



Rise of corner.

Fig.5: Defects in wood caused by irregular drying.

There are also other irregularities in wood which are considered as defects, such as: irregular grain, knots, discoloration, decay, insect holes etc. and standards prescribe tolerances for each in each grade of lumber. Since the price is closely related to the quality, it is of utmost importance to ensure an appropriate quality inspection and a quantity control for each shipment of sawwood purchased.

Sawnwood received at the factory site must be properly stacked in order to ensure its appropriate seasoning and to avoid harmful effects of direct exposure to sun and rain.

The expense of stacking sawnwood represents only a small portion of the deterioration which occurs if the wood is not properly handled.

6. Veneer and plastic foils used in furniture production.

Veneers are thin sheets of wood produced by slicing or rotary peeling the logs. The sliced veneer is mainly used as a decorative facing on particle board or other panels, and the peeled veneer is used in the manufacture of plywood, blockboard or special stratified wooden products.

Decorative veneer is produced from the best quality logs and of the certain species with valuable decorative features. Its thickness is usually 0.5 to 1.0 mm. Veneer is delivered to the furniture factory already dried in bundles. The lengths of the bundles are trimmed in decimeters longitudinally, while widths in centimetre increments. They are measured and priced in square meters. The quality grading is in accordance with existing standards on the market, which are based on grain structure, colour and tolerable defects.

Due to the very high price of decorative veneer, it requires skilful and experienced work for its further processing in a furniture factory. This is so as to get a high utilization of veneer and the desirable aesthetic effects on the fact of the furniture.

Paper based decorative plastic laminates are manufactured from paper impregnated with synthetic resins and bound with adhesives. The best known and the most common are decorative laminate boards with melamine resin surface (see fig. 6). There are few modifications of such foils, for example:

- post-forming laminates,
- fireproof laminates,
- low pressure laminates.

Post-forming laminates are manufactured with a modified resin, so that it can be softened in order to make it fit curved edges.

Fireproof laminates are used for table tops. Special substances are added to prevent the board from burning.

Low pressure laminates are used on direct laminated boards. They are made by pressing the decorative foil straight onto the particle board surface and enter the trade as "surface improved particle boards".

The appearance of laminated boards depends on the decorative paper and the surface's finish. The paper can be decorated, printed or monochrome. The most popular is a wood grain imitation. Also, it is possible to obtain various surface finishes, such as glossy, semi-glossy, semi-mat or mat.

If the decorative paper and overlay of the laminate is omitted, the product is an industrial or technical laminate. It is mainly used for the reverse side of table tops or other furniture parts, to give a balanced construction.

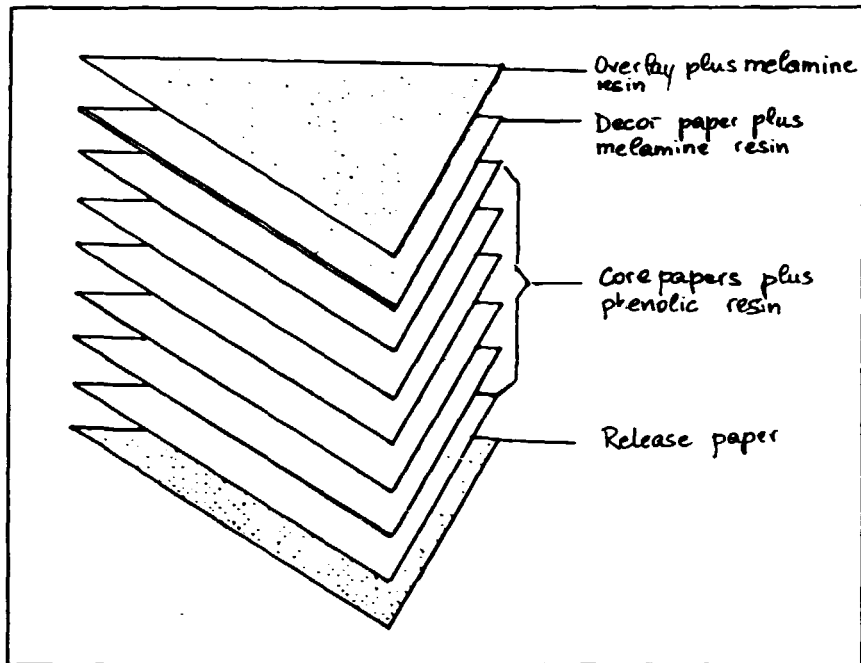


Fig.6: Construction of plastic laminates.

7. Plywood and its use in the production of furniture.

Plywood products are an intermediate product in the transformation of solid wood into modern panel furniture products. Plywood was widely used in the past as one of the main raw materials for the production of furniture. That is because its use is simple and close to the traditional wood processing technology. Nowadays plywood is also used for the furniture manufacturing, although it is mostly substituted by more suitable particle boards and fibreboards.

For the production of carcass furniture plywood has many advantages over solid wood, such as: large sheets, equal strength in both surface directions, lessened shrinkage, non-splitting characteristics, reduced checking, etc.

Plywood products have many uses in the production of furniture: mainly for backs and bottom of carcass furniture, bottoms of drawers and as fillings in the frame construction.

The dimensions and quality grading of plywood are standardized. Thicknesses are 1.5 to 3 mm with increased of 0.5 mm., 3 to 12 mm with increases of 1.0 mm, and 15, 18 and 19 mm. Lengths and widths are standardized, the most common being 2440 x 1520, 2440 x 1220, 2135 x 1520, 1830 x 1220. The quality of plywood is determined separately for the face and for the back side of panels. To select the right quality it is necessary to know how the parts containing plywood will be exposed in the furniture, and whether veneering or laminating is foreseen or not. If additional veneering or laminating is to be done, both sides must be covered to prevent warping. The same applies to the surface finishing.

8. Blockboard and its use in furniture production.

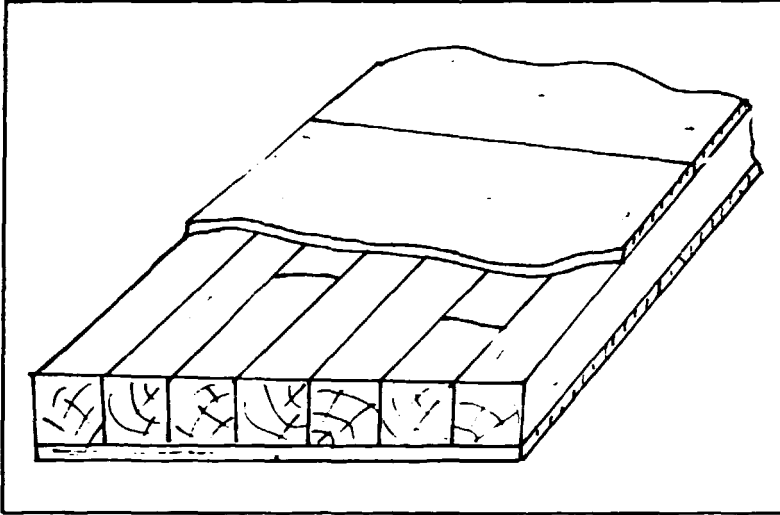


Fig.7: Construction of blockboard.

Blockboard is a product related to plywood. The difference being that the core in blockboard is made of solid wood laths, oriented longitudinally and glued (see fig. 7).

The core is cross-banded with blind veneer. The thickness of blockboard is standardized as follows: 16, 18, 20, 22, 24 and 28 mm, while the lengths and widths are the same as

for plywood. Due to the predominant use of softwood for the construction of the cores, blockboard is light and very suitable for furniture products, especially for doors, shelves and sides of carcass furniture. Furthermore, blockboard is less expensive than plywood of the same thickness. The quality grading is similar to that of plywood.

9. Particle board, its standard properties and use in the production of furniture.

Particle board is a wood based panel manufactured from small pieces (particles) of wood or other lignocellulosic materials, agglomerated under pressure in a heated press using a synthetic resin (usually Urea Formaldehyde) and a catalyst.

The resin plays the key role in achieving the stability of the particle board. A small dose of paraffin is introduced as an anti-swelling agent. Particle board has about the same density as sawnwood of the same species, but it is more homogeneous. Two main disadvantages of particle board are: low rigidity and fairly low resistance to tension perpendicular to the surface of the board. The bending strength is greatly increased by veneering or laminating.

Three layer board is the most common and it is by far the type most preferred by the furniture industry.

The introduction of particle boards into traditional wooden furniture production requires a change-over in manufacturing methods. Not only must methods change, but means of producing precise components must be developed. At least the following production conditions must be attained before a change can be successful:

- Precise cutting to specified sizes.
- Surfacing with veneer or foils.
- Edge lipping.
- Maintenance of carbide tipped cutting tools.

- Assistance in technical design.

Furthermore, appropriate screws, hinges, fasteners and other special hardware must be available.

Particle board can be sawn, routed, planed, profiled and bored.

The rate of feed should be slower than for solid wood, and cutting tools must be kept thoroughly sharp. This is particularly important in the case of laminated board.

10. Fibreboards.

Fibreboards are made of fibrous ligno-cellulosic material from many species of wood, annual plants and can contain a small percentage of tree bark. Resins can be used to impart strength to the board and various agents are also added to make them water resistant.

The classification of fibreboards is based on the method of manufacture, end use and density. With regard to the density, the fibreboards are classified by the International Organization for Standardization (ISO) as follows:

BOARD TYPE	DENSITY (kg/m ³)	Thickness (mm)
Hardboard	800 and up	2 to 8
Medium Density Board (MDF)	350 to 800	6 to 30
Softboard	below 350	9 to 32

The furniture industry uses primarily medium density and hard fibreboard, ranging from 650 to 1200 kg/m³. Hardboard is used for bottoms of drawers, and for backs and base boards of wardrobes, commodes, dressers, etc. Medium density board is used for table tops, and profiled front parts of carcass furniture, because it is a very good substitute for solid wood.

Laminated fibreboards are widely used for the production of kitchen furniture. Hardboard is, also, widely used as a surface material for the production of flush doors used internally in houses.

The surface of the fibreboard is made up of finely ground and well felted fibres, and sands well. Both hardboard and medium board can be sawn, planed, bored and routed.

The strength properties common to hardboard and medium density board are sufficient to meet the needs of the furniture industry.

If products to be used in unstable humid conditions are made of fibreboard, an allowance in the construction should be made to permit shrinkage and swelling of the parts. If boards are laminated a balancing laminate is necessary on the back side.

11. Surface improved boards.

The increasingly difficult problem of obtaining valuable timber has induced the development of methods of upgrading panels made from low cost timbers or from particle board, fibreboard etc. with decorative laminates providing the required appearance of the finished panels.

All types of wood based panels can have their surfaces improved. The post-forming technique has been adopted for the manufacture of table tops, kitchen cabinet tops and doors, office and school desks, as well as other components designed with rounded edges (see fig. 8).

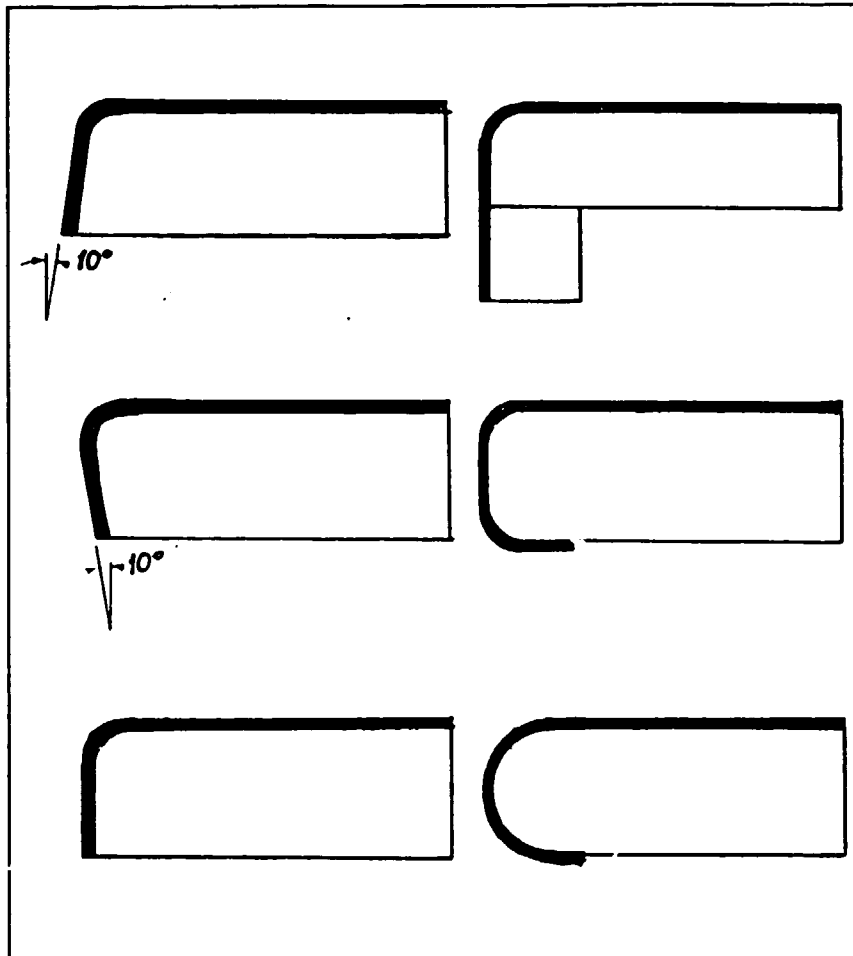


Fig.8: Examples of edges obtainable by using post-forming techniques.

Direct laminated particle board is used for interior panelling and for furniture. It is less durable but much cheaper than the rigid laminates. There are two techniques for gluing laminates on the board surface: hot and cold gluing. Laminate for hot gluing can be prepared in sheets or in rolls, while the cold gluing technique is based on a continuous production using calender rollers. Due to the possibility of producing uniform colour and grain pattern, surface improved boards are very suitable for the production of modular furniture.

12. Glues and glue additives used in the woodworking industry.

The glue using operations in the woodworking industry are numerous. Glue is widely used for the manufacture of furniture, the production of plywood, blockboard, particle board, laminated components and has many other uses. In each case, the transformation of the primary wood material to semi-manufactured products or finished products requires the use of glue.

The glues can be subdivided into groups according to their chemical base and the means of application, as follows:

- Thermosetting adhesives.
- Dispersion adhesives.
- Hot-melting adhesives.
- Solvent adhesives.

Thermosetting adhesives used in the woodwork industry are derived from the process of condensation of formaldehyde with:

- urea to produce urea resins (also known as carbamide glue).
- phenol to produce phenolic resin,
- melamine to produce melamine resins,
- resorcinol to produce resorcinol resins.

Urea formaldehyde is the adhesive most commonly used, it has good properties but only limited resistance to water. Phenol formaldehyde is used for exterior applications where a waterproof bond is important, (eg marine plywood), while melamine and resorcinol glues have far higher bond strengths, they are used only in such applications as glued-laminated beams because of their high costs.

Thermosetting resins are available in the market either as powder or liquid syrups with a non-volatile (solid) content of 50 to 60 percent. Powder products can be either pure or mixed with extenders, fillers or hardeners. Liquid thermoplastic adhesives are colloidal dissolved syrups with an addition of fillers, extenders and hardeners.

Important characteristics of glues are: viscosity, solid content and storage time (shelf life). Application conditions for glue, such as pot life, spreading quantity, open time, pressure and pressing time are prescribed by the glue's manufacturer.

Thermosetting adhesives are widely used for veneering, laminating, the manufacture of plywood, blockboard, particle board, fibreboard and other products.

Vinyl dispersions are primarily materials for the manufacture of dispersion adhesives, which are produced by the addition of fillers, extenders, solvents and plasticisers. Each of these substances and their combination modifies the characteristics required for various applications. Vinyl adhesives belong to the category of thermoplastics because the dry film shows reversible plastic characteristics. The solid content varies from 40 to 60 percent. Application conditions are prescribed by the glue's producer.

Hot-melt adhesives are solid products normally produced by mixing ethylene vinyl acetate copolymers with resins and mineral fillers. In the

manufacture of furniture these glues are used for edge banding, softforming and post-forming operations.

- by heating, the glue is brought to a fluid condition so that it can be applied to the surface to be bound; and at the same time, it wets the surface.
- The surfaces are then quickly put in contact with one another and subjected to sufficient pressure.
- On the cooling, the glue line solidifies and the bond is achieved under pressure during this phase.

The last group of adhesives used by the wood-working industries are mainly polychloroprene-based products. These solvent adhesives are used in the woodworking industry principally as a solution in organic solvents.

The bonding mechanism occurs in the following sequence:

- The adhesive is spread on the two surfaces to be bonded.
- The solvents are allowed to evaporate in order to develop sufficient tackiness to the touch.
- The parts are placed in contact and subjected to a uniform pressure by means of a roller press.

These glues are used for gluing synthetic laminates onto panels and other similar working operations. They are also used for gluing some upholstery materials, like foam. These glues are very expensive and wherever possible should be replaced by some less expensive adhesive.

13. Surface finishing materials.

The purpose of wood finishing is to protect the wood and to improve its aesthetic and commercial values. A rather big choice of finishing materials and methods of surface finishing makes wood products more attractive to customers. By the use of different materials and surface finishing methods, various degrees of gloss can be obtained: glossy, semi-glossy, semi-mat and mat, as well as a big variety of colours. Only the most important products used in finishing furniture and joinery will be mentioned here.

Putties are made of various filling and binding materials which are suitable for repairing surfaces to be lacquered or painted. Usually putties are made of wood powder mixed either with glue or lacquer to form dough-like material. It is recommended to use wood powder from the same species as that of the surface to be repaired

Besides putties made of wood powder, there are also shellac putties.

Wood fillers are used on the surfaces of species with large pores when lacquered or polished surfaces with filled pores are desired. The filler can reduce the number of coatings and speed up finishing work.

Wood fillers may be made of fine wood dust, chalk, gypsum, clay, talc etc. with oil or alkyd varnish as the binding agent. They are usually produced by factories and are available in the shades of various wood species.

Stains are used to give the wood the desired and even colour tone. There are chemical stains, water stains, spirit stains, oil stains, mixed solvent stains etc.

The most common are water based stains. They are water soluble anilin colour, produced by dissolving colour pigments in distilled or rain water at 60 to 80°C. To improve penetration of the cold stain solution some ammonia may be added. Also, the basic solution can be diluted with spirit to improve penetration and adhesion to the wood's surface. This stain is inexpensive and easy to apply.

Oil stains are the most widely used type of stain because of their easy application, excellent penetration and low cost. They are suitable for hardwoods but require a perfect preparation of the surface to be polished.

Mixed solvent stains are becoming increasingly popular because of their good penetration and fast drying properties.

Spirit based lacquers are made of shellac, alcohol as a thinner, and a small amount of other ingredients. They may be applied with a brush or by spraying. They have good filling properties and are suitable for finishing furniture.

Nitrocellulose lacquers are made of cellulose nitrate with in addition softening ingredients, an organic solvent, and thinner which consists of a mixture of organic solvents. The lacquer may be applied by brushing, spraying, curtain coating, dipping and drum lacquering. For spraying a viscosity of 18 to 20 seconds (measured using a Ford No. 4 cup) at 20°C is recommended. Their flammability is class I, with a flash point below 30°C.

The main use of nitrocellulose lacquer is for finishing new wooden products for interior use (furniture and other furnishings). Over 60 percent of all furniture produced is finished with nitrocellulose lacquers.

The main properties are: available as glossy or mat; dries through evaporation, does not fill very well; reasonably water proof, ease of repair of damaged surfaces, fast drying is its main advantage in comparison with other lacquers.

Alkyd-carbamide lacquers are two-component lacquers with alkyd resin, linseed oil and wood or mineral turpentine as a thinner, as main ingredients. Application is by spraying, brushing, dipping, or drum lacquering. Main uses are: interior and exterior lacquering, and relacquering old objects. (They do not dissolve the underlying coating.) Owing to the high solid content (about 45 percent) these lacquers have good filling properties. With the addition of pigments, they are very often used for lacquering joinery products.

Polyester lacquers contain no evaporating ingredients. They have good filling properties. Very high quality glossy lacquered surfaces can be obtained when using mechanical polishing methods. They too are two-component lacquers. A hardener is needed to start the setting reaction.

Polyurethane lacquers set like alkyd-carbamide lacquers. They contain hardeners or these may be added afterwards. The coating obtained is resistant to chemicals and mechanical wear. These lacquers are used in kitchen and

bathroom furniture, boats, etc. They have excellent adhesion, flexibility, water resistance and good gloss. They are used successfully in the clear, glossy, mat or pigmented form.

Other finishing material can also be used in the production of furniture and joinery.

14. Metal components.

A wide range of metal components are used in combination with wood in the construction of furniture and joinery products.

Basically, the following three groups of metal components can be distinguished:

- hardware,
- metal fittings,
- metal jointers-fasteners.

In everyday terminology, hardware includes a wide range of products, such as: handles, hinges, door stops, locks, glides, slides, etc. (see fig. 9). They are more or less exposed to the eyes and must be designed, made and finished in a way that will not destroy but emphasize the aesthetic appearance of wooden products.

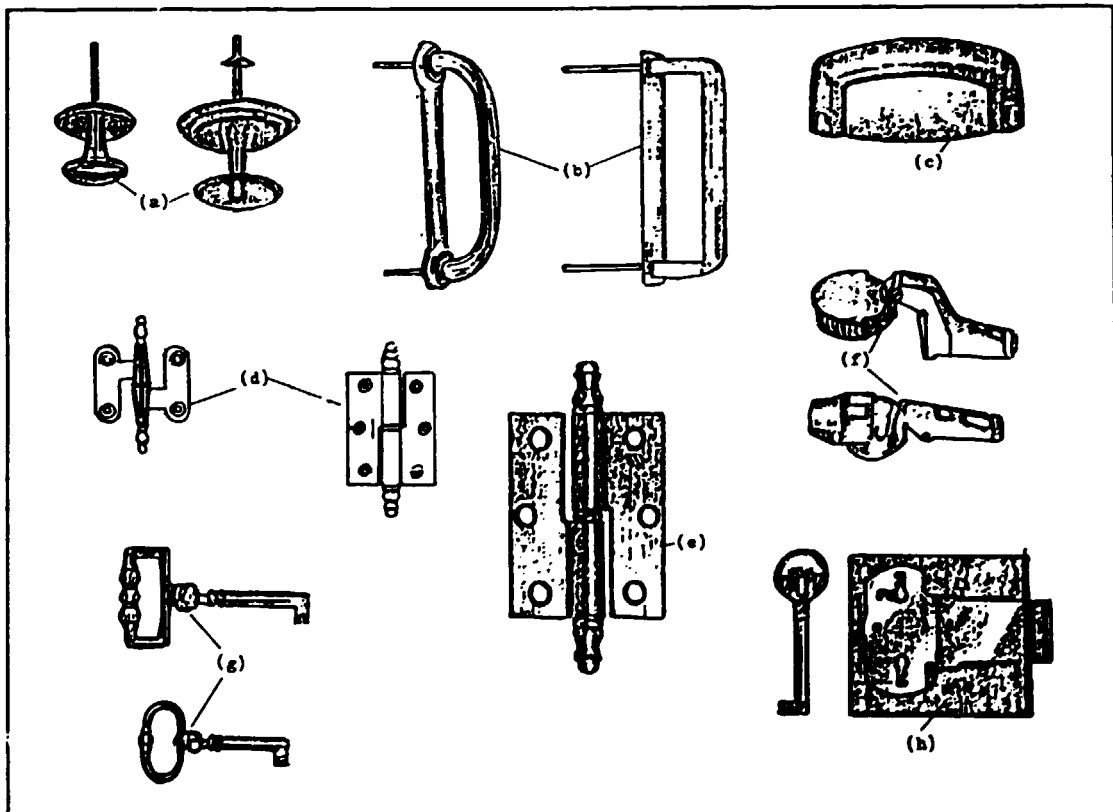


Fig.9: Metal hardware: (a) pulls, (b) and (c) handles, (d), (e) and (f) hinges, (g) keys, (h) lock.

The materials predominantly used in making hardware are: steel, zinc alloys (brass and maxak) and aluminum, either as sheet material, profiles or pressure cast items. Finishing is an essential part of hardware production, because it determines the final appearance and protects the material against corrosion and wear. Finishing is either electrochemical (chromium or nickel plating), chemical (anodizing or oxidizing) or mechanical (painting or polishing).

Metal fittings are items made of metal, such as: metal legs, bed fittings, metal frames for desks and tables, metal parts of chairs, various stands and castors, hangers etc. They are mostly made of tubular, profiled, pressed or cast metals (steel, aluminum or brass). The finish of metal fittings is almost the same as that for hardware.

Metal fasteners are metal products used in the assembling fixed or knock-down furniture (see fig. 10). Such items as screws, nails, staples, bolts and nuts and a very large assortment of jointing components such as angle connectors, eccentric case with dowel jointers etc. belong to this group.

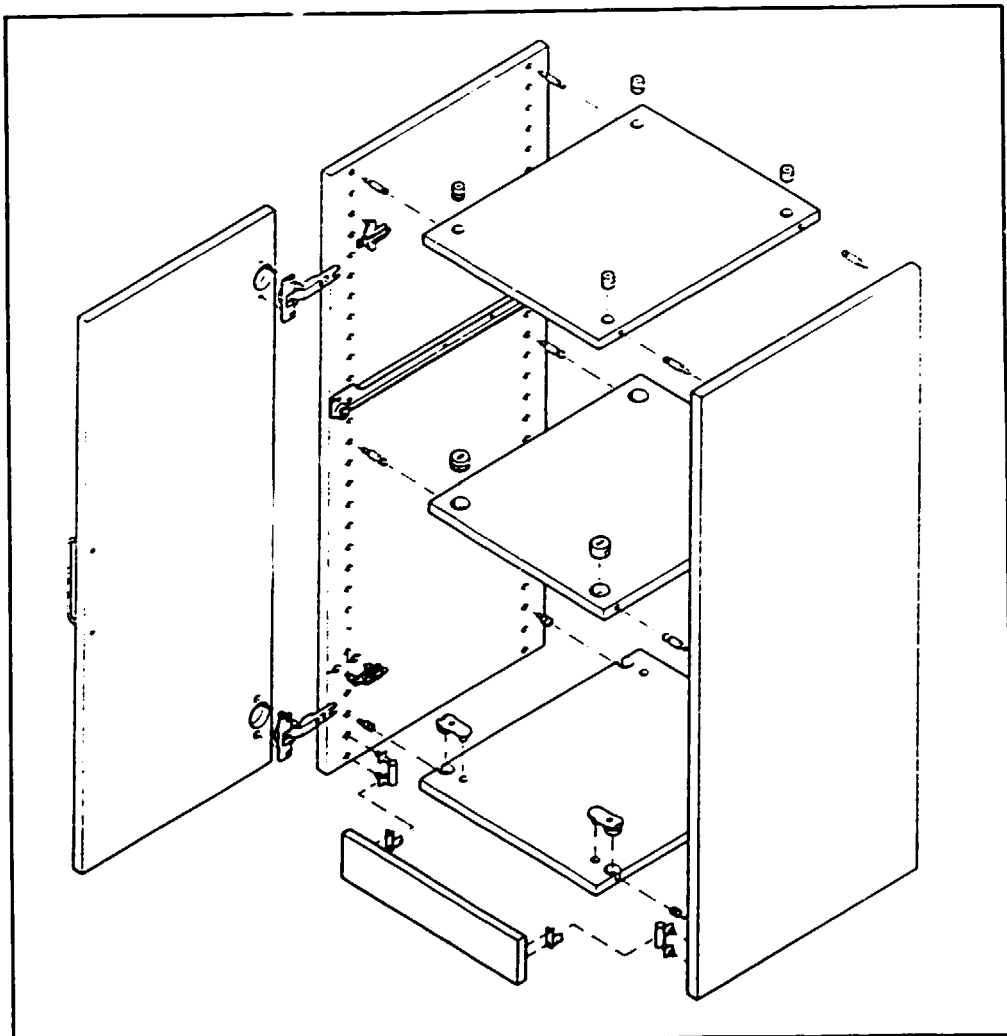


Fig.10: Metal fasteners used in knock-down furniture

An appropriate use of metal components contributes to remarkable possibilities for improving construction and quality of furniture products and for simplifying the production of furniture.

The best way to learn about various metal components is to obtain catalogues of well-known manufacturers of such products.

15. Plastic components and other materials, used in the production of furniture and joinery.

Plastic components have a wide range of use in furniture production. Plastic is a good material because it can be shaped in any form and coloured to match any shade. Some plastic products are used for replacing wood (eg. as imitation of decorative figures or profiled frames); others are used to replace metal hardware (eg. pulls, handles, parts of hinges). Some plastic products are used as joining elements such as corner blocks, plastic dowel nuts. Some of these are a combination of plastics with metals.

Glass is a classical material widely used in carcass furniture products and in windows and doors. Plain glass, 3 to 5 mm thick is used for glass doors or sliding doors. Thicker glass is also used for shelves of cupboards and similar carcass furniture and for doors of wall units, in constructions without wooden frames. Glass can be decorated by mechanical sanding, painted or produced in the desired shade (so-called smoked glass). Plain glass, 3-4 mm thick, is commonly used in windows, while plain or ornamented glass (with its surface shaped in an ornamental form) is used for doors.

Very often, especially for bedroom furniture, glass is sold in the form of mirrors. It is always advisable to use glass with rounded edges.

The glass ordinarily used for furniture products is sometimes replaced by glass fibre, which can be bent or shaped in various forms.

Besides classic materials which are ordinarily used for the production of furniture, such as: glass, marble, lighting fixtures, textile, etc. new materials are constantly tested for use in production of furniture and joinery components.

Nowadays electronic products like radios, alarm clocks etc. are commonly built-in in furniture products.

Innovation is the name of the game in the contemporary industry and the winners are those factories which are ready to play such a game.

ANNEX I

TRAINING PROGRAMME FOR FURNITURE AND JOINERY PRODUCTION

This training programme is designed to achieve the objectives and outputs of the project entitled "Strengthening the Technical and Managerial Capacities of the Carpentry Cooperatives in Mukalla and Seiyun" (project No. SM/PDY/87/005).

After visiting all the production units of these Cooperatives, (the three units of the Coastal Strip Carpentry Cooperative and the four units of the Carpentry Cooperative, Seiyun), and after studying the present state of their production, it has been concluded that a thorough training of operators and managerial staff is a prerequisite for all improvement. Due to this conclusion, the training programme prepared and proposed hereunder is more comprehensive, and the training activities are more numerous than originally planned in the project document. It has been designed to meet the specific requirements of the cooperatives which are on the point of transitting from handicraft to industrial production. The topics for the training courses selected are:

COURSE NUMBER	TITLE OF COURSE	DESIGNED FOR:
1.	Production systems and types of production in the wood processing industry.	Management staff of the Cooperatives and their production units.
2.	Furniture products, classification, standards, design and construction	Production Department staff
3.	Joinery products, classification, standards, design and construction	Production Department staff
4.	Product development in the secondary wood processing industry	Staff of the production and sales departments.
5.	Organization and planning of production.	Production planning staff.
6.	Work allocation and control of production	Production planning staff, supervisors and foremen.
7.	Planning, cost accounting, pricing, cost control and optimization of a product line.	Accountants, salesmen and staff of the production department.
8.	Inventory control and purchasing techniques.	Purchasing unit's staff and staff of the production department concerned with material planning.
9.	Basic elements of marketing	Management, sales and production department staff.
10.	Modern industrial production management	Managerial staff.
11.	Information and documentation systems in the secondary wood processing industry.	Managerial staff, top and middle management of the cooperatives.
12.	Plant layout	Staff of the production department and production supervisors.

COURSE NUMBER	TITLE OF COURSE	DESIGNED FOR:
13.	Wood, affiliated products and other materials used in the production of furniture and joinery	The technical department's staff, supervisors, foremen and operators.
14.	Wood seasoning and preparation	The technical department's staff and people working in the timber yard.
15.	Crosscutting and trimming of sawnwood	Operators of crosscutting and ripping machines, and foremen in the wood cutting area.
16.	Panel sizing.	Operators of panel sizing machines and their foremen.
17.	Veneering and laminating surfaces and edges of wood based panels.	Operators laminating surfaces and edges of panel furniture components.
18.	Surface planing and thicknessing of components	Operators of surface planers/jointers and thicknessers and their foremen.
19.	Tenoning, mortising and drilling	Operators of tenoning, mortising and drilling machines and their foremen.
20.	Moulding and routing	Operators of moulding and routing machines and their foremen.
21.	Sanding and surface finishing.	Operators of sanding and surface finishing machines and their foremen.
22.	Preassembling, assembling and packaging.	Assemblers, packagers and their foremen.
23.	Managing of quality and quality control	Managerial staff at all levels, foremen and quality controllers.
24.	Jigs, templates and fixtures in the secondary wood processing industry.	Production department's staff.
25.	Tool sharpening, maintenance and managing.	Tool sharpeners and persons in charge of ordering tools.
26.	Internal transport, receiving and storage of materials and shipping of products.	Persons working in storage and internal transport services.
27.	Maintenance of equipment	Maintenance personnel.
28.	Safety measures in the secondary wood processing industries.	Foremen and supervisor, in workshops.
29.	Motivation of employees	Managerial staff at all levels.
30.	Innovation and development techniques and methods.	Managerial and production department staff.

PURPOSE AND METHOD OF TRAINING

Training of employees is an integral part of production in modern industrial enterprises. Technical and technological developments offer new technical means and new production methods which make human work easier, safer and more productive. To be able to utilize such advancement, people working in industry have to learn and to train in order to achieve new knowledge and skills necessary for handling modern equipment and processes.

In developing countries, such training has decisive importance for the better utilization of new production techniques and for mastering new technological processes. To avoid unnecessary mistakes and gain indispensable skills, training courses are the most suitable way, because, in a short time, people can learn the best way of performing their duties in production.

The output of these training courses should be knowledge acquired by workers who will increase their abilities for effective production. To achieve this, the training method will rest on three steps as follows:

1. The lecturer will explain a new method.
2. The lecturer will demonstrate the new method.
3. The trainee will perform the new method under the lecturer's supervision.

Short manuals written in a simple language, understandable to the workers, will be prepared by lecturers for each course, translated into Arabic and distributed to the trainees. All graphs, tables and formulas will be adjusted to the level understandable to the people to be trained.

Theoretical teaching will be conducted in a classroom and its duration will be adapted to the minimum of theory which has to be known for a certain job. This part of the training will be performed by the CTA, other experts in the project and by United Nations Volunteers assigned to the project.

The practical part of the training will be organized at the work areas of the respective production operations. This part of the training will be carried out jointly by the experts and the UN Volunteers. The working area must be organized in a proper way, including the prepared production documents, tools, jigs, gauges, protective devices, pallets, materials and everything that is necessary for safe, productive and good quality work. The lectures should explain and show how to check a machine, tools, jigs, and in the case of wrong adjustment, how to correct them and how to prepare correctly all that is needed for the production operation.

The lecturer will show the correct way of performing the operation and supervise the performance of the trainees until he concludes that their work is fully acceptable and that the quality of the products is satisfactory. The counterparts with higher skills and experience will also be engaged to train less qualified labourers and to supervise their practical work.

Most of the training courses conducted for the Coastal Strip Carpentry Cooperative will be repeated for the Carpentry Cooperative in Seiyun, while in some cases the trainees from Seiyun will be invited to come to Mukalla. Persons from the production units outside of Mukalla and Seiyun will be travelling to these two places. Some of the practical training could and should be carried out in the satellite units by the UN volunteers.

SELECTION OF TRAINEES

Trainees will be selected by the counterpart, according to their jobs and to the topics of the training programme. Besides workers who will directly perform particular production operations, all other people concerned with certain aspects of the production, such as: foremen, supervisors, management staff, maintenance personnel, etc. can be included in the training. The list of trainees is an integral part of the training programme and it determines the number of copies of the training manuals to be prepared and distributed for each course.

TIMING OF TRAINING COURSES

The training courses will be prepared and conducted mostly during the experts' missions, and those to be conducted by the volunteers will be scheduled in between those missions. The priority should be given to the courses which are a prerequisite for the better understanding of other topics.

The timetable of all courses is a part of this programme, though the exact schedule can be changed depending on the timing of the future missions by the experts.

Some of the courses are intentionally foreseen for the last mission, hoping that by that time the workshops will be the missing equipment, which is indispensable for a proper training of the operators.

SYLLABI OF COURSES

This programme contains syllabi of all courses planned to be conducted during the project execution. The courses are broken down into topics, and, for each topic, the training duration, both theoretical and practical, and the level of competence to be reached are given.

The selection of topics and the required level of competence is aimed to reach a minimum knowledge needed for successful manufacturing of furniture and joinery products in a medium-scale factory.

Each course has its number and topics are subdivided into a decimal classification following the numbers of the courses.

Once all the training courses are completed the training material can be compiled into a printed handbook to be used throughout the country.

ANNEX II

SYLLABUS OF THE COURSE ON
WOOD, AFFILIATED PRODUCTS AND OTHER MATERIALS USED IN THE PRODUCTION
OF FURNITURE AND JOINERY

This course is foreseen for the staff of the technical department, supervisors, foremen and operators.

STAGE	TOPICS	TRAINING TIME (hours)		LEVEL OF COMPETENCE TO BE REACHED
		THEO- RY	PRAC- TICE	
13-1	Introduction	0.25	--	Understanding the purpose of the course.
13-2	Growth process of a tree and anatomy of wood.	0.25	--	Understanding wood's structure and the properties of wood and wooden products.
13-3	Classification of wood species, hardwood, softwood and major species used for furniture and joinery products.	0.25	--	Being able to recognize major wood species and distinguish hardwoods, softwoods, sapwood and heart wood.
13-4	Physical and mechanical characteristics of wood.	0.25	--	Understanding better the relationship between the properties of wood, the construction of wooden products and the processing methods.
13-5	Moisture content and shrinkage of wood.	0.25	0.25	Understanding the changes occurring in wood during drying and deformities caused by shrinkage and swelling.
13-6	Sawnwood, its sizes, quality and use in the secondary wood processing industry.	0.25	0.25	Being able to select proper sawnwood taking into account quality, dimensions and price.
13-7	Veneers and plastic foils used in furniture production.	0.25	--	Knowing about the main characteristics of veneers and plastic foils.
13-8	Plywood and its use in furniture production.	0.25	--	Knowledge about plywood as a raw material for furniture manufacturing.
13-9	Blockboard and its use in furniture production.	0.25	--	Knowing about blockboard and its processing and use in furniture production.
13-10	Particle board, its standard properties and use in furniture production	0.25	--	Knowing about the properties of particle board which are important for its processing and better utilization in furniture production.
13-11	Fibreboard (elementary information).	0.25	--	Acquiring general knowledge about fibreboard and its use in the manufacture of furniture.

STAGE	TOPICS	TRAINING TIME (hours)		LEVEL OF COMPETENCE TO BE REACHED
		THEO- RY	PRAC- TICE	
13-12	Surface improved boards (elementary information).	0.25	--	Acquiring general knowledge about surface improved boards and the possibilities of their use in the production of furniture.
13-13	Glues and glue additives used in the woodworking industries	0.50	--	Knowing about the basic properties of various kinds of glues used in the woodworking industries.
13-14	Surface finishing materials used for finishing furniture and joinery products	0.5	--	Acquiring general knowledge about various lacquering materials as: thinners, stains, paints, and other materials used for finishing furniture and joinery products.
13-15	Metal components: hardware, fittings, jointers and their use in the production of furniture.	0.50	0.25	Acquiring general knowledge about metal components and their use in the manufacture of furniture and joinery products.
13-16	Plastic components and other materials used in the production of case furniture.	0.25	--	Acquiring general knowledge about the major plastic components and some other products which could be used for the manufacture of furniture and joinery.
	TOTAL	4.5	1	