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

FAIR USE POLICY

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

RESTRICTED

DP/ID/SER.A/1718
12 April 1995
ORIGINAL: ENGLISH

ASSISTANCE IN THE ESTABLISHMENT OF A PILOT FURNITURE PLANT

DP/DRK/86/011

THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

Technical report: Training manual on wood, affiliated products and other materials used in the production of case furniture*

Prepared for the Government of the Democratic People's Republic of Korea
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Radmilo Malis
expert in furniture production

Backstopping officer: Antoine V. Bassili,
Agro-based Industries Branch

United Nations Industrial Development Organization
Vienna

* This document has not been edited

V.95-53014

TABLE OF CONTENTS

		Page
	PREFACE	iii
1.	Introduction	1
2.	Growth process of a tree and wood anatomy	1
3.	Classification of wood species	2
4.	Physical and mechanical characteristics of wood	3
5.	Moisture content and shrinkage of wood	4
6.	Wood preservation	5
7.	Sawnwood	7
8.	Veneer	8
9.	Plywood	9
10.	Blockboard	9
11.	Particle board	9
12.	Fibreboard	10
13.	Surface improved boards	11
14.	Glues	13
15.	Finishing materials	15
16.	Metal components	17
17.	Plastic components and other products used in the manufacture of case furniture	18
	FIGURES	
1.	Growth of a tree	1
2.	Early and late wood	1
3.	Porosity of wood	2
4.	Heartwood and Sapwood zones in a tree	3
5.	Bow - longitudinal curving of boards	6
6.	Cup - bowing in the width of the board	6
7.	Spring - lateral bowing of the wood in the directions of its length	6
8.	Twist - spiral deformation of wood	7
9.	Checks - splits visible only on one side	7
10.	Honeycombing - inner cracks	8
11.	The construction of laminated board	12
12.	Example of gluing which can be obtained by the postforming technique	13
ANNEX I		20
ANNEX II		24

PREFACE

This training manual is one of a series prepared by a UNIDO Furniture Production Expert, Radmilo Malis, while serving as Chief Technical Adviser of a UNDP financed and UNIDO executed project in the People's Democratic Republic of Korea, to assist in the establishment of a Pilot Furniture Plant in Pyongyang (Project DP/DRK/86/011).

This manual deals with wood, its affiliated products and other materials used in the production of furniture.

The manuals were written to achieve two major goals, first: to give trainees a broader view of an industrial system and second: to serve as a practical guide to machine operators and assemblers, thus enabling them to better perform their duties.

A particular attention has been devoted to materials and their proper utilization, to the design and quality of products, to the organization of the work areas and to safety measures.

The description of the machines is based on those bought for the Pilot Furniture Plant.

With respect to the organization of production, an attempt has been made to incorporate the organization of the Pilot Furniture Plant into the organizational structure of the Pyongyang Wood Processing Complex, bearing in mind the specific internal organization of the Pilot Furniture Plant.

These manuals have been written in such a way that they can also apply to other similar factories.

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.

1. Introduction

The aim of this training manual is to acquaint a selected group of trainees who will perform key operations in the Pilot Furniture Plant, with basic wood properties, other affiliated products and auxiliary materials usually used for the production of case furniture. People working in furniture production must be able to recognize all processes, materials and components used. They must also know basic facts about their physical, mechanical and aesthetic characteristics. These characteristics mostly determine the construction of joints, the processing methods, the selection of tools, the internal transport used and the complete handing during the manufacturing process.

2. Growth process of a tree and wood anatomy

Wood lives. Wood grows as a result of the growth and division of special cells in the cambium layer which is the inner part of the wood bark. Cambium cells divide and form an additional wood cylinder every year, thus increasing the girth of the tree (fig. 1). A new layer is formed every growing season between the bark and the stem of the tree. These layers appear as growth rings. Due to differences in climate, soil, species, etc. there are great variations in wood structure between the rings and even in one single ring. There is a significant difference between early wood (formed during the growing season) and late wood (formed during summer or dry season). Early wood contains cells with thin walls and has a higher porosity, whereas late wood consists of cells with thick walls and has a lower porosity (fig. 2). Early and late wood growth rings influence many characteristics of wood, such as its density, its strength, its hardness, its shrinkage, etc.

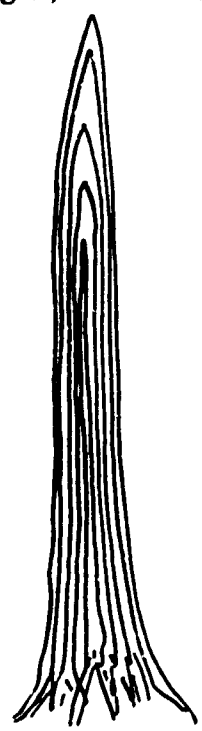

Fig. 1: Growth of a tree

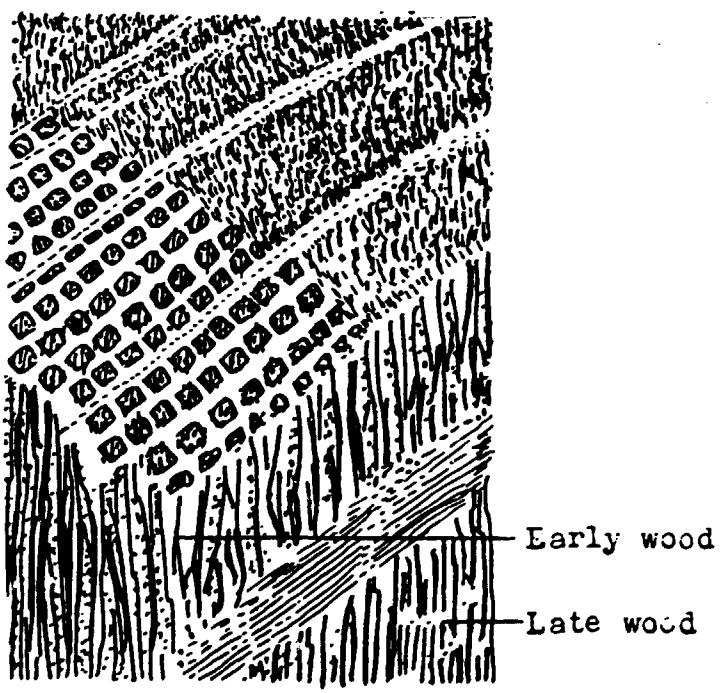

Fig.2: Early and late wood

3. Classification of wood species

Two major groups of wood species exist: softwoods and hardwoods. The main anatomical difference between these two groups is due to differences in the structural elements of the wood. Fibre is the basic structural element of wood. Fibres are also the major translocation route for sap in softwoods, while hardwoods have additional vessels (pores) through which the sap is distributed in the living tree.

Hardwoods are again divided in two major subgroups, namely ring porous hardwoods and diffuse porous hardwoods (fig. 3).

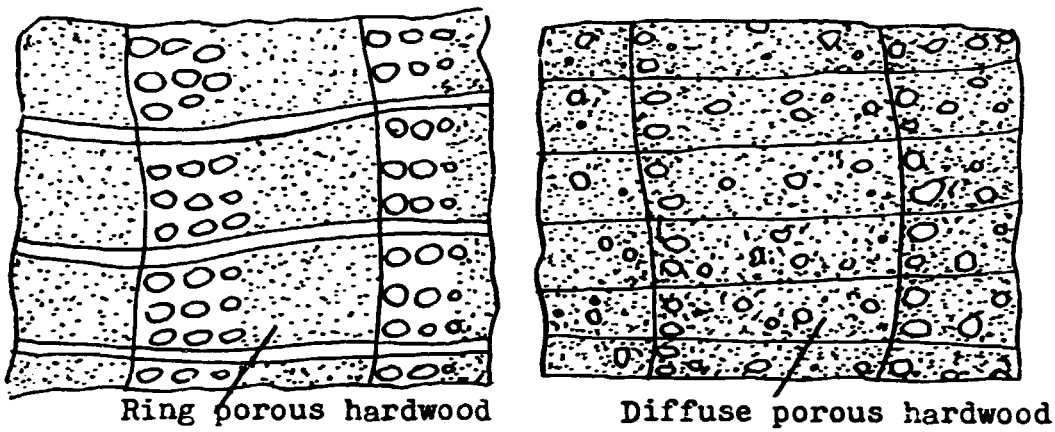

Fig. 3: Porosity of wood

Another important characteristic by which to differentiate the quality of wood is the difference between sapwood and heartwood. Sapwood is the outer layer of the wood. This layer contains living cells translocating or storing sap in the living tree. The storage of material in the sapwood makes it prone to fungal and insect attack. The amount of sapwood in a tree varies considerably. The width of sapwood in a cross-section is not uniform. In most growing trees, there is no sap in the inner layer of the stem which does not have any living cells. This heartwood zone contains a higher amount of extractives than sapwood and its composition is generally different. Heartwood is usually darker with a tendency to brown colouring (fig. 4).

Hardwood and softwood are divided into many wood species which are botanically more or less different. Pine, larch, spruce, fir, etc. are conifers, known commercially as softwood species. Deciducus (broad-leaved) trees are known commercially as hardwood species. Some of those species are: oak, birch, ash, elm, beech, etc. Many tropical species also belong to this type.

The terms hardwood and softwood do not always apply directly to the hardness or softness of the wood, although most hardwood species have harder wood than softwoods. Some of the broad-leaved species such as poplar are rather soft. From a technological point of view, these could be considered a separate group.

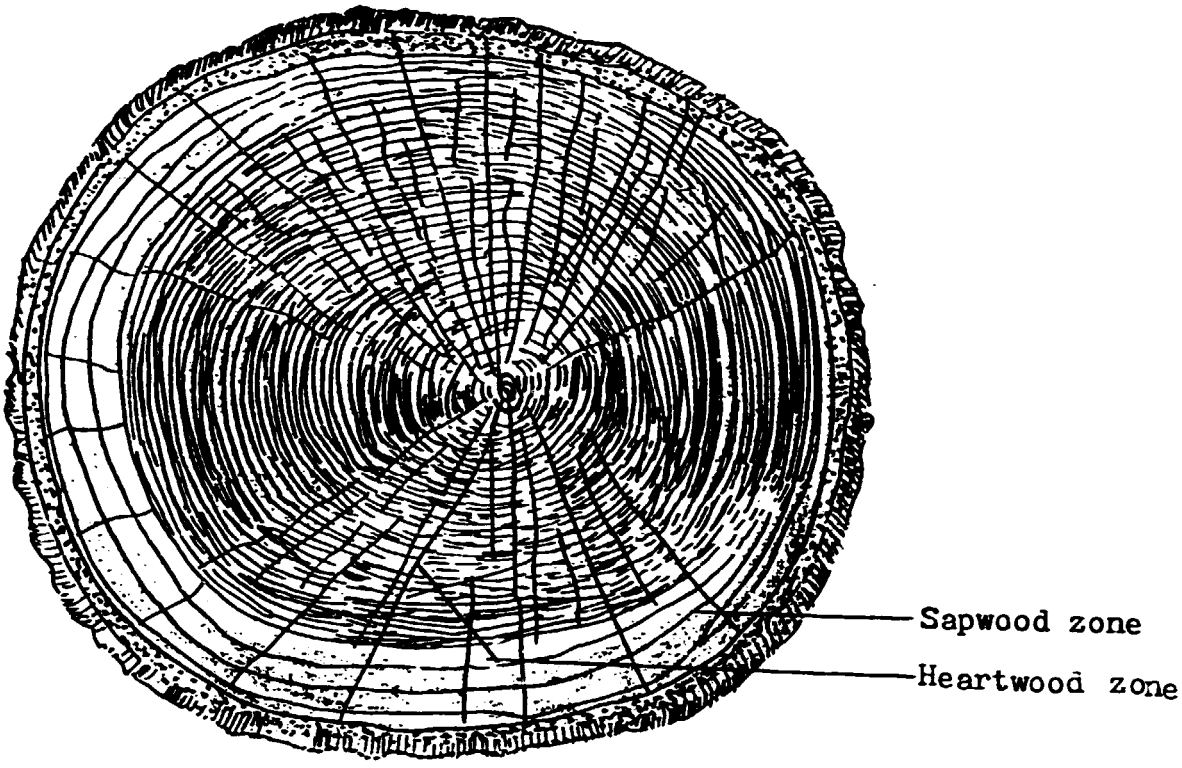

Fig. 4: Heartwood and sapwood zones in a tree

4. Physical and mechanical characteristics of wood

Wood, as a living product, is not an isotropic material since it has different values of physical changes and mechanical strengths in the longitudinal, radial and tangential directions. All data about the physical and mechanical properties of wood refer to the average values pertinent to the species considered.

Those wood properties which are important for the production of furniture and for the choice of the appropriate raw material is of interest to the project. From this point of view, the following properties should be taken into consideration:

- strength, together with toughness, rigidity and hardness;
- grain structure, with homogeneity, color and their variations;
- drying properties which will influence shrinkage, swelling and deformation;
- surface finishing qualities;
- suitability for gluing;
- bending qualities;
- workability;
- resistance to fungal and insect attack·
- density;
- rate of growth.

Each wood species has specific properties. This lack of similarity is needed for different products or for different parts of a given product. Wood characteristics also have to be taken into consideration when selecting machines, tools, glues, finishing materials and some technological treatments. Table 1 hereunder shows some properties of the major wood species processed in the Democratic People's Republic of Korea.

Table 1: Some properties of the major wood species used in the Democratic People's Republic of Korea.

Species	Rate of growth rings/cm	Spec. gravity kg/m³	Shrinkage (percent) Rad.	Tang.	Bending strength MPa	Hardness tang. N/mm²	Modulus of elasticity Gpa
Birch	5.5	616	0.27	0.32	98.6		32.414.2
Oak	5.5	703	0.20	0.30	105.0		54.5n.a.
Ash	6.7	653	0.20	0.32	108.0		n.a.13.7
Poplar	2.9	416	0.12	0.23	59.7		18.2 8.3
Aspen	5.4	486	0.20	0.32	77.4		19.912.4
Pine	7.0	446	0.13	0.28	70.2		16.6 9.3
Larch	7.4	645	0.18	0.38	111.0		n.a.15.3
Spruce	4.2	356	0.12	0.36	64.0		n.a. 9.2

5. Moisture content and shrinkage of wood

Wood is a hygroscopic material adjusting its moisture content to that of the atmosphere. Originally, moisture in wood comes from a growing tree. Sapwood has a higher whereas heartwood has a lower moisture content. Unseasoned timber usually has a moisture content of over 60 percent, but it could be higher or lower, depending on many factors.

Wood is exposed to daily and seasonal changes in the relative humidity of the air. This causes slight changes in its moisture content since wood balances its own moisture content to the humidity of the ambient air. At this point, wood's moisture content is called the 'equilibrium moisture content'.

The free water in the cell cavities evaporates first. There is no shrinkage of the wood at this stage. When the cell walls dry out, wood begins to shrink. This stage is called the 'fibre saturation point'. It is usually around 30 per cent irrespective of the kind of wood.

Moisture content of wood is defined as the weight of water as a percentage of its dry weight and can be calculated as follows:

$$u = \frac{Wu - Wo}{Wo} \times 100$$

whereby u = moisture content (%)
Wu = green weight
Wo = oven dried weight

Thus, the rate of wood seasoning can be controlled. The aim of correct seasoning is to minimize moisture content variations after processing in wood used. The aim is that its moisture content should correspond to the average atmospheric conditions to which it will be exposed.

Wood swells when it absorbs moisture. When wood releases moisture, it shrinks. Shrinkage and swelling result in the following drawbacks:

- The dimensions of the wood elements change.
- Deformations occur in the cross-section of elements because wood shrinks more in the tangential than in the radial direction.
- When deformations do not develop freely, internal stresses occur that might cause damage.

Furniture pieces should be built in such a way that: either to allow free deformations, or all means should be used to prevent them.

6. Wood preservation

Wood, especially sapwood, is easily attacked by fungi and insects. This causes the destruction of wood cells. The consequence is that such wood cannot be used as a raw material in the wood processing industry. These attacks occur when the moisture content is below the saturation point, but above 15 percent.

Sawn logs are usually protected by spraying with water, the moisture content in the wood is thus kept above the saturation point. Logs can also be treated chemically with various fungicides and/or insecticides.

The most common way of preserving sawnwood is by seasoning, either by air drying or by kiln drying. Sawnwood which is air dried is usually impregnated with chemicals containing fungicides and insecticides. The final wooden product (for interior furnishings or for household furnishing) is usually coated with various finishing materials. These give the product an aesthetic look and protects it at the same time.

7. Sawnwood

Sawnwood used for furniture production is produced in a sawmill on both frame saws and bandsaws. The planks are either edged or unedged. Unedged sawnwood allows a better utilization of the wood and a higher productivity. This timber is usually air dried. The first operation in furniture production is usually kiln drying. Sawnwood is produced in standard sizes and is subject to a quality grading. Quality grading is based on standards resulting from the wood structure, the defects and the accuracy of processing.

Lumber often shows defects caused by irregular drying. Some of the most common defects are:

- Bow — longitudinal curving of the board;
- Cup — bowing of wood in its width;
- Spring — lateral bowing of wood lengthwise;

- Twist — spiral deformation of the board
- Checks — split along cells visible only on one side of the board;
- Honeycombing — inner cracks.

Defects caused by irregular drying are shown in figs. 5 to 10 hereunder.

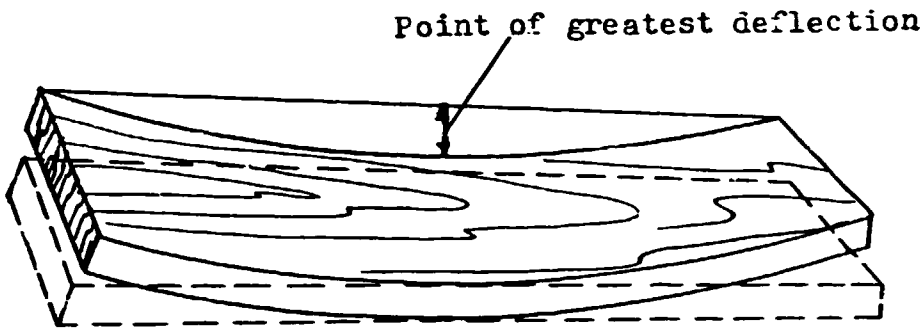

Fig. 5: Bow - longitudinal curving of boards

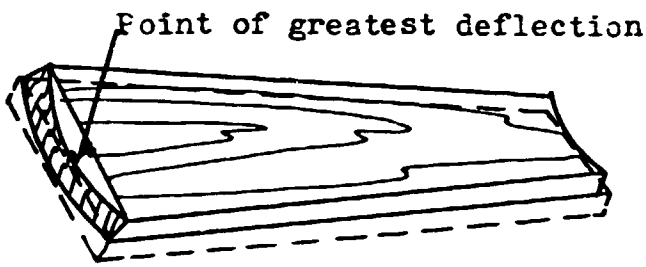

Fig. 6: Cup - bowing in the width of the board

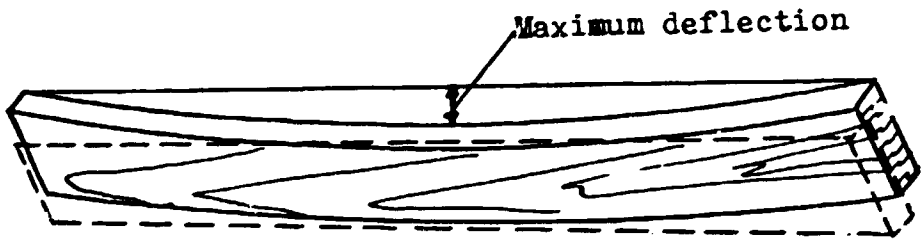

Fig. 7: Spring - lateral bowing of the wood in the direction of its length

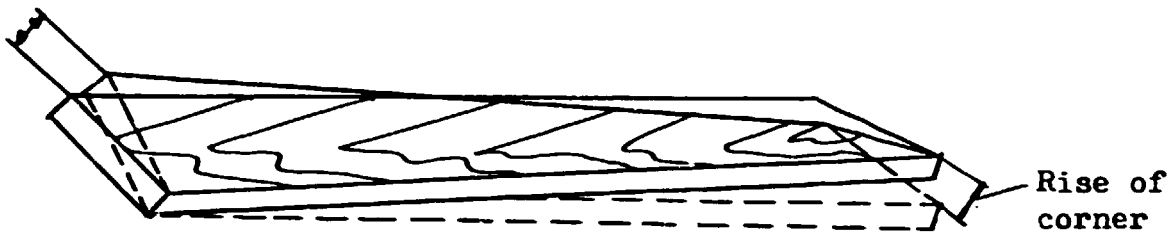

Fig. 8: Twist - spiral deformation of wood

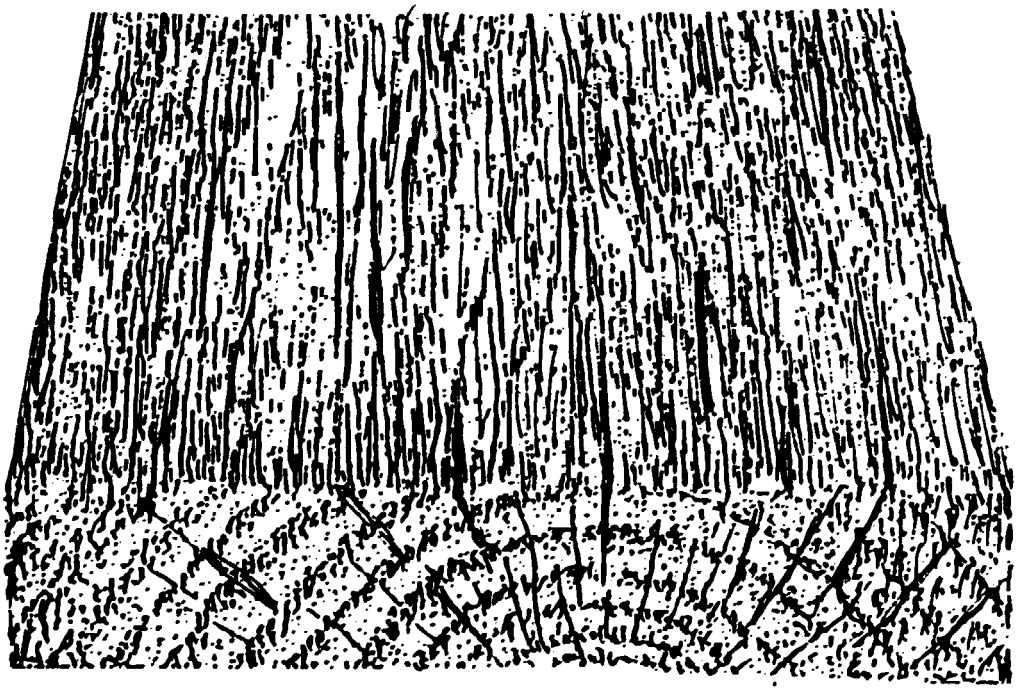

Fig. 9: Checks - splits visible only on one side

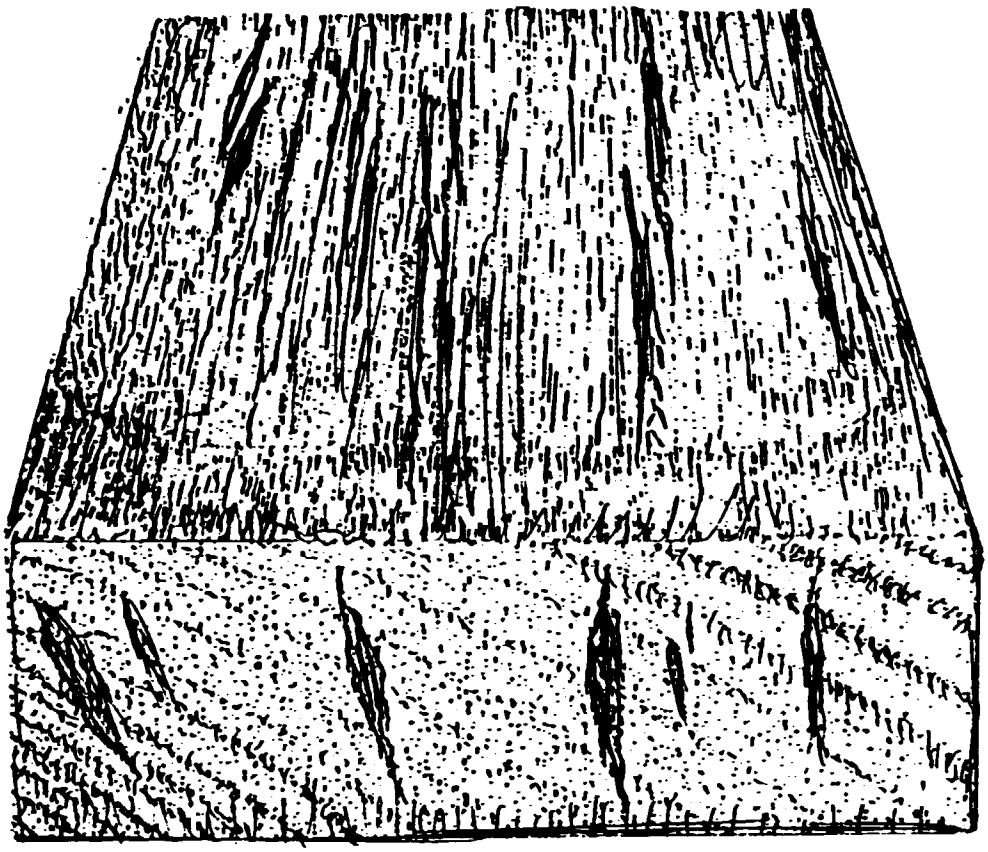

Fig. 10: Honeycombing - inner cracks

There are also other irregularities in wood which are considered defects. Some examples are: irregular grain, knots, discolourations, decay, insect borings, etc.. Standards prescribe their tolerance for each grade of sawnwood. Higher quality wood is used for the production of exposed parts, and lower quality for less exposed or concealed parts.

8. Veneer

Veneers are thin sheets of wood produced by either slicing or rotary peeling. Sliced veneer is mainly used as a decorative facing of particle board or other panels. Peeled veneer is used for plywood, blockboard or special stratified wooden products.

Decorative veneer is produced from the best quality logs of certain species with valuable decorative features. It is usually between 0,5 and 1 mm thick. Veneer is delivered to the furniture factory dried, edged and bound into bundles. Lengths of bundles are multiples of decimeters and widths increase by centimeters. Bundles are measured in square meters. The quality of grading is in accordance with existing standards, basically based on grain structure, colour and tolerable defects. Due to the high price of decorative veneer, skillful and experienced work for its further processing in a furniture factory is required

in order to get a high utilization of veneer and to get the desirable aesthetic effects on the furniture surface.

9. Plywood

Plywood is the oldest wood based panel. It is the intermediate stage in the transformation from solid wood to modern panel products. In the past, plywood was one of the main raw materials used in furniture production. This was due to its simple use and because its machining is the closest to that used in solid wood processing. Today, plywood is still used in furniture production, although more suitable panels (particle boards and fibreboards) are more often used. Plywood is produced by gluing three or more sheets of peeled veneer together with the grain of sheets at right angles. (A product similar to plywood, but with parallel grain, is laminated wood.) The construction of plywood is always symetric and balanced, which, together with the crossed direction of the veneer, results in equal strength in the plane, lesser shrinkage and swelling. This is explained by the fact that wood shrinks and swells very little in the direction of the grain and that the strongest tension and compression is parallel to the grain.

Plywood has many advantages compared to solid wood. These are: large sheets, equal strength in all directions at right angles and less shrinkage, non-splitting properties, reduced checking, greater log yield, etc. There are many uses for plywood in furniture production, but it is most often used for backs and bottoms of case furniture, bottoms of drawers and as infills of frame constructions. Plywood sizes and grades are standardized. Thicknesses are 1,5 to 3,0 mm with increases of 0,5 mm; 3 to 12 mm with increases of 1 mm; and 15, 18 and 19 mm. Lengths and widths of plywood are standardized as follows: 2440 x 1520 mm; 2440 x 1220 mm; 2135 x 1525 mm; 1830 x 1220 mm, etc.

Plywood quality is determined by the face and reverse side of the panel. In order to select the right quality plywood, the exposure in a furniture piece must be known in order to determine whether to use decorative veneer or not. If additional veneering is foreseen, both sides must be veneered. The same applies to finishing. If this is not done, warped plywood parts will result.

10. Blockboard

Blockboard is a product related to plywood, the main difference being that the core is made of solid wood laths oriented lengthwise and glued. The core is cross-banded with blind veneer. Blockboard thicknesses are: 16, 18, 20, 22, 24 and 28 mm, while its 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 suitable for furniture products, especially for doors, shelves and sides of furniture. When good quality particle board is not available, blockboard is the best suited raw material for furniture production.

11. Particle board

Particle board is a wood-based panel produced from small pieces (particles) of wood or other ligno-cellulosic materials, agglomerated by using glue as a binder, together with a catalyst, heat and pressure.

There are two main sources of raw materials for particle board production. These are: Small dimension logs, branches, etc. from forestry operations and timber waste (offcuts, edge rippings, planer shavings or chippings) obtained from further processing.

The quality of the binder (adhesive) determines the stability of particle board. The most common binders are synthetic resins, which are thermo-setting and cure rapidly and irreversibly by heat. Paraffin is introduced in small proportions as an anti-swelling agent.

Particle board is more homogeneous than, and has the same density as, sawnwood of the same species. Longitudinal swelling due to moisture is equal in both directions thus it is somewhat lower than solid wood. The same applies to thickness swelling. (In very humid conditions, edges must be protected to limit thickness swelling which may cause decomposition.)

Particle boards have two main disadvantages. These are a low rigidity and a fairly low resistance to perpendicular tension to the surface of the board. Bending strength is greatly increased by veneering or laminating.

Particle boards are produced either as single layer, three-layer or multi-layer boards. The most common particle board has three layers and is the one preferred by the furniture industry. It is produced using a platen press.

The density, as well as other properties of particle boards depend on many factors. Some of these are: the type of chips, the type of glue, the chip spreading method, the pressure applied, etc.

To introduce particle board in traditional wooden furniture production, a change in the plant's manufacturing methods is required. Not only must the methods change, but a precise component production method must be developed. The following conditions are imperative for a good quality production:

- Precision cutting to specified sizes;
- Surfacing with veneer or foils;
- Edge lipping;
- Carbide tipped cutting tools must be used and their maintenance assured;
- Technical product design must be appropriate (initially assistance may be needed).

Appropriate screws, hinges, fasteners and other special hardware must also be available. Particle board is used predominantly in the production of case furniture. It can be sawn, routed, spindle-moulded, planed or bored. The feed rate should generally be slower than for solid wood and the cutting tools must be very sharp. This is especially important for laminated boards.

12. Fibreboard

Fibreboards are produced from fibres of wood, annual plants and tree bark. Resins can be used to strengthen the board and various agents can make

them water resistant. Fibreboards are classified according to their production method, use and density. These are produced by either the wet or dry process. There are three kinds of fibreboards: compressed (hard), medium density and non-compressed (soft) boards. The International Standardization Organization classifies fibreboards (with respect to their density) as follows:

Board type	Density (kg/m³)	Thickness (mm)
Hardboard	800 <	2 to 8
Medium density board	350 - 800	6 to 30
Softboard	< 300	9 to 32

Medium density and hard fibreboard ranging from 650 to 1200 kg/m³ are used by the furniture industry, whereas softboard is used in the building industry as a decorative and insulating material. Hardboard is used for the bottoms of drawers, backs and baseboards of wardrobes, commodes, dressers, etc. Medium density board is used for table tops and profiled front parts of case furniture since it is a very good substitute to solid wood. Laminated fibreboards are widely used for the production of kitchen furniture. Hard fibreboard should also be used as a face material for internal flush doors.

Fibreboard surfaces are made of finely ground wood fibres with good sanding qualities. Both hardboard and medium density board can be worked easily. These can be sawn, planed, bored, perforated and milled. They do not crack or split when worked on with TCT cutters under normal conditions. The strength properties - which are common to both hardboard and medium density board - are satisfactory for furniture production. When boards are covered with hard overlays, a balancing film must be added on the opposite side of the board. Should fibreboard products be used under unstable humidity conditions, shrinkage and swelling of parts must be calculated in their construction. Boards which are produced at a temperature above 200°C have a good stability under conditions where moisture varies.

13. Surface improved boards

Since it is increasingly difficult to obtain valuable timbers, manufacturers were led to seek methods of decorating and upgrading panels produced from low cost timbers or particle board, fibreboard, etc. with synthetic products giving the required appearance to the finished panel. All types of wood based panels can become surface improved boards. These are laminated boards coated with various plastic materials.

The decorative plastic laminates are manufactured from paper and synthetic resins with adhesives. The most common and best known board is the decorative laminated board with a melamine resin surface (fig. 11). Some modifications to laminated boards exist, such as post-forming laminates, fire-proof laminates and low pressure laminates.

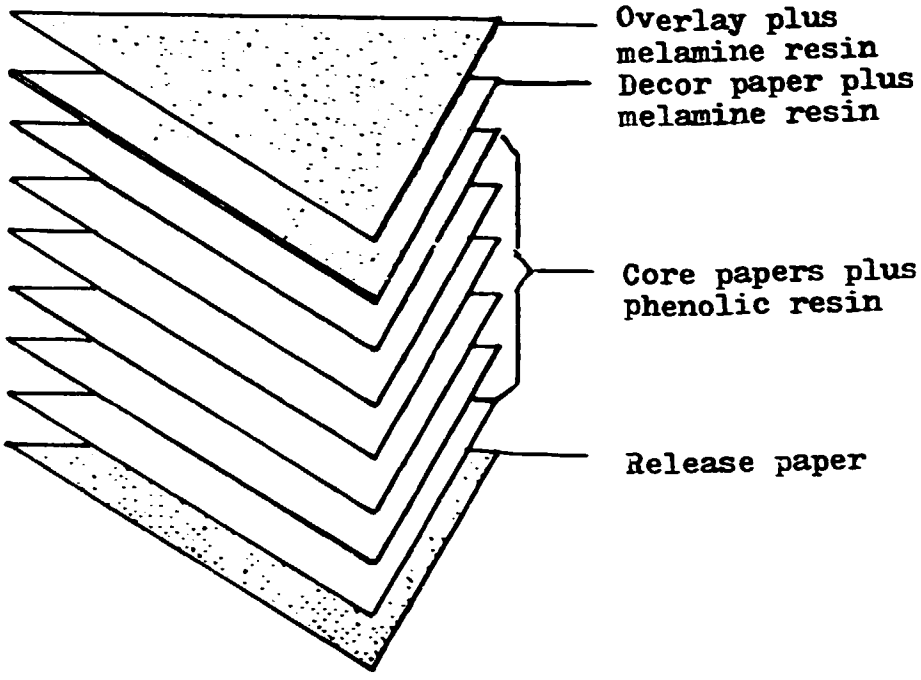

Fig. 11 The construction of laminate board

The only difference in the manufacturing process of post-forming laminates compared to normal laminated board is the modified resin used. It is then possible to soften it once more and thus to bend the board for the production of curved corners. The adhesive used for this type of board is a polyvinyl acetate dispersion specifically formulated and applied by the heat reactivation system used on special machines called post-formers.

The post-forming technique has been adopted for the production of table tops, kitchen cabinet doors, desks and other components designed with rounded edges (fig. 12).

Fireproof boards are used for ship construction, and occasionally for special table tops. Special substances are added to the resin or paper which prevent the board from burning.

Low pressure laminates are used for direct laminated boards. Decorative paper is pressed straight onto the particle board surface. A pressure of only 15 kp/cm^2 must be used to avoid compressing the particle board. Direct laminated particle board is used for interior panelling and furniture. It is less durable, but much cheaper than laminated boards.

The appearance of a laminated board depends on the decorative paper and on the surface finishing. The paper can be decorated, printed or one-coloured.

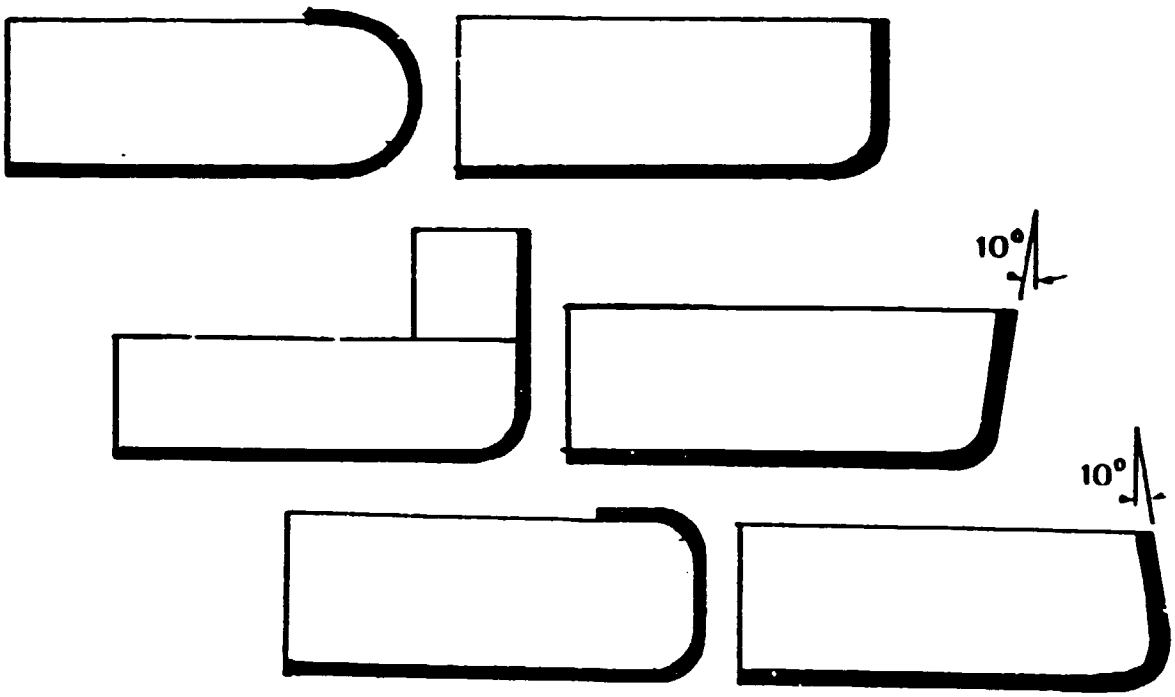

Fig. 12: Examples of gluing which can be obtained by the postforming technique.

The most popular is the wood grain imitation with a porous finish which looks more like wood. It is also possible to finish the surfaces in various ways: glossy, semi-glossy, semi-mat or mat. If the decorative paper and overlay of the laminate is omitted, the product is called industrial or technical laminate. This is mainly used in furniture on the bottom side of table tops to give a balanced construction. There are two techniques for gluing laminates on the board surface, the hot and the cold method. The laminates for hot gluing can be prepared in sheets or in rolls, while for cold gluing, continuous equipment with calender rollers is necessary. Since a uniform colour and grain pattern can be manufactured, surface improved boards are very suitable for modular furniture production.

14. Glues

Glues used in conjunction with wood are described hereunder. Gluing operations in the woodworking industry are numerous. Glues are used in furniture manufacturing, plywood, blockboard, particle board, fibreboard production, in the production of laminated components and many others. In each case, glue is required to transform the product from its primary state to semi-manufactured or manufactured products. Glues can be subdivided into homogeneous groups due to their chemical base and their application, as follows: thermo-setting adhesives, dispersion adhesives, hot-melting (thermo-plastic) adhesives and solvent adhesives.

The thermo-setting adhesives used in the woodworking industry are obtained through the process of condensation of formaldehyde with urea to produce urea resins; with melamine to produce melamine resins; with phenol to produce phenol resins; and with resorcinol to produce resorcinol resins. Condensation is a process of polimerization eliminating water. A clearly defined point must be reached in order to produce adhesives. The last stage of condensation takes place during gluing. This occurs by adding an appropriate catalyst with the relevant heat.

Thermo-setting resins are available on the market, in either powder or liquid form, with a non-volatile content of 50 to 60 percent. Powders can either be pure or mixed with extenders, fillers or hardeners. Liquid thermoplastic adhesives are collodial-dissolved fillers, extenders and hardeners are added. Each resin - depending on its formula - has its own reactivity on which depends its speed to react under given conditions during the gluing phase, i.e. as it solidifies and thus reaches an irreversible condition.

Important characteristics of glues are: viscosity, non-volatile content, free formaldehyde and storage time (shelf-life). The producer determines the glue mixes and application conditions, such as quantity, open time spreaded, pressure and pressing time. Thermo-setting adhesives are widely used for veneering in the furniture industry. These are also used for the production of plywood, blockboard, particle board, dry process fibreboard, laminated boards, etc.

Dispersion adhesives are based on vinyl acetate homopolymers and copolymers. They are of interest to all sectors of the industry (for construction and furniture assembly, in the production of various panels by cold pressing, blockboard manufacture, joinery production, etc.).

Vinyl dispersions are primary materials for producing finished adhesives by adding fillers, extenders, solvents and plasticizers. These substances and their combination modify the characteristics required for various applications. Vinyl adhesives fall in the category of thermo-plastics since the dry film has plastic reversible characteristics. The non-volatile content varies from 40 to 60 percent. The viscosity is usually measured using a rotational viscometer and is determined for different speeds of rotation and storing temperature. All conditions for their application are prescribed by the glue producer.

Hot-melt adhesives are solid products manufactured by mixing ethylene vinyl acetate copolymers with resins and mineral fillers. In furniture production, these glues are used for edge banding, soft-forming and post-forming operations. Gluing with a hot-melt glue is as follows:

- The glue is liquefied by heat so as to apply it on the surface to be bound and thus wet it.
- The surfaces are then quickly coupled and pressed adequately.
- On the cooling line, the glue solidifies and the bond is achieved under pressure.

Viscosity is tested at a temperature between 120 and 140°C with a rotary viscometer.

One last group of adhesives worth mentioning for the woodworking industry are polychloroprene based products. These solvent adhesives are mainly used in the woodworking industry as a solution in organic solvents. The bonding occurs as follows:

- The adhesive is spread on the two surfaces which are to be glued.
- The solvents are allowed to evaporate and thus develop sufficient sticking properties to the touch.
- The parts and placed in contact and pressed uniformly using a roll press.

Important characteristics of these adhesives are their viscosity, solid content, open time, resistance to heat and bond strength. These adhesives are used for gluing synthetic laminates on panels and in all other similar woodworking operations.

15. Finishing materials

Finishing protects the wood and improves its aesthetic and commercial value. By using different materials and methods of surface finishing, gloss degrees vary considerably. One can obtain glossy, semi-glossy, semi-matt, and matt surfaces as well as a great variety of colours. This big choice of finishing materials and surface finishing methods makes wood more attractive and appeals more to the end user.

In this paragraph, the most important finishing materials for the furniture industry will be described.

Putties are made of various filling and binding materials. These are suitable for preparing surfaces for lacquer or paint. Putties are usually produced from wood powder mixed either with glue or lacquer to form a dough-like material. It is recommended to use the same wood species as the surface to be repaired. Apart from putties made of wood power, shellac putties are also available on the market.

Wood fillers are used on wood with large pores which should be lacquered or polished. The filler reduces the number of coatings and speeds up the finishing phase. Filling powder may be fine wood sawdust, chalk, gypsum, clay, talcum, etc. The binding agents are oil or alkyd varnish. Wood fillers are usually produced by factories and are available in the shades of the various wood species.

Stains are used to give the wood a desired and equalized colour tone. There are chemical stains, water stains, spirit stains, oil stains, mixed solvent stains, as well as non-grain-raising stains. The most common water based stain is water-soluble anilin colour. It is produced by dissolving colour pigments in distilled or rain water at 60 to 80°C. To improve the penetration of the cold stain solution some ammonia may be added. The basic solution can be diluted by adding a spirit which improves the penetration and adhesion of the stain to the

wood surface. This kind of stain is inexpensive and its application is easy. Due to its limited penetration, it produces an even colour.

Oil stains are the most commonly used type of stains because they are easy to apply and because they are not expensive. They have excellent penetration properties and are suitable for hardwoods of even texture, but they require a perfect preparation of the surface to be finished.

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

Non-grain-raising stains are similar to mixed solvent stains. Their properties are: resistance to fading, non-grain-raising, good penetration and fast drying. They are relatively expensive.

Spirit-based lacquers are made of shellac, alcohol as a thinner and a small amount of other ingredients. It can be applied with a brush or by spraying. It has good filling properties and a satisfactory resistance to solvents (turpentine or benzene). Its water-proof and has satisfactory wear resistance properties. It is suited for finishing furniture and music instruments such as violins and guitars.

Nitrocellulose lacquers are made of cellulose nitrate with softening ingredients, an organic solvent and a thinner which consists of a mixture of organic solvents. Lacquer can be applied by brushing, spraying, curtain coating, dipping or drum lacquering. A viscosity of 18 to 20 seconds (cup size 4mm at 20°C) is recommended for spraying. Flammability is class I, the flash point is below 30°C. Nitrocellulose lacquer is used for lacquering new wooden products for interior use. Over 60 percent of all furniture produced is finished with nitrocellulose lacquers. They dry fast and this is their main advantage when compared to other lacquers. Their other main properties are that:

- they exist in both glossy and matt;
- they dry through evaporation;
- they do not fill very well;
- they have satisfactory water-proof characteristics.

Alkyd-carbamide lacquers are two-component lacquers with alkyd resin, linseed oil and wood or mineral turpentine as a thinner, which is its main ingredient. They are applied by spraying, brushing, dipping or drum lacquering. They are mostly used for interior and exterior lacquering and relacquering old objects. They do not dissolve the underlying coating. Since they are composed of 45 per cent of solid ingredients, these lacquers have good filling properties.

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

Polyurethane lacquers set like alkyd-carbamide lacquers. They contain a hardener which can also be mixed at the time of spraying (two component lacquers). The coating obtained is resistant to chemical and mechanical wear.

These lacquers are used for kitchen and bathroom furniture, outdoor furniture, boats, etc. They have excellent adhesion, flexibility, water resistance and a good gloss. They are used successfully in their clear glossy, matt or pigmented form.

There are other finishing materials than the ones indicated above that can be used in furniture finishing.

16. Metal components

Different metal components are used in combination with wood in furniture production. There are three groups of metal components: hardware, metal fittings and metal jointers-fasteners. Hardware includes a wide range of products such as handles, hinges, door stops, locks, glides, slides, etc. (see fig. 13). They are more or less exposed and must thus be designed, produced and finished to improve the aesthetic appearance of furniture. Steel, zinc alloys (brass and mazak) and aluminum are the materials most commonly used for producing hardware, either as sheet material or profiles and pressure die castings. Finishing is an essential part of hardware production, since it determines the final appearance and protects against corrosion and wear. Finishing is either electro-chemical (chromium and nickel plating), chemical (anodizing and oxidizing) or mechanical (painting and polishing).

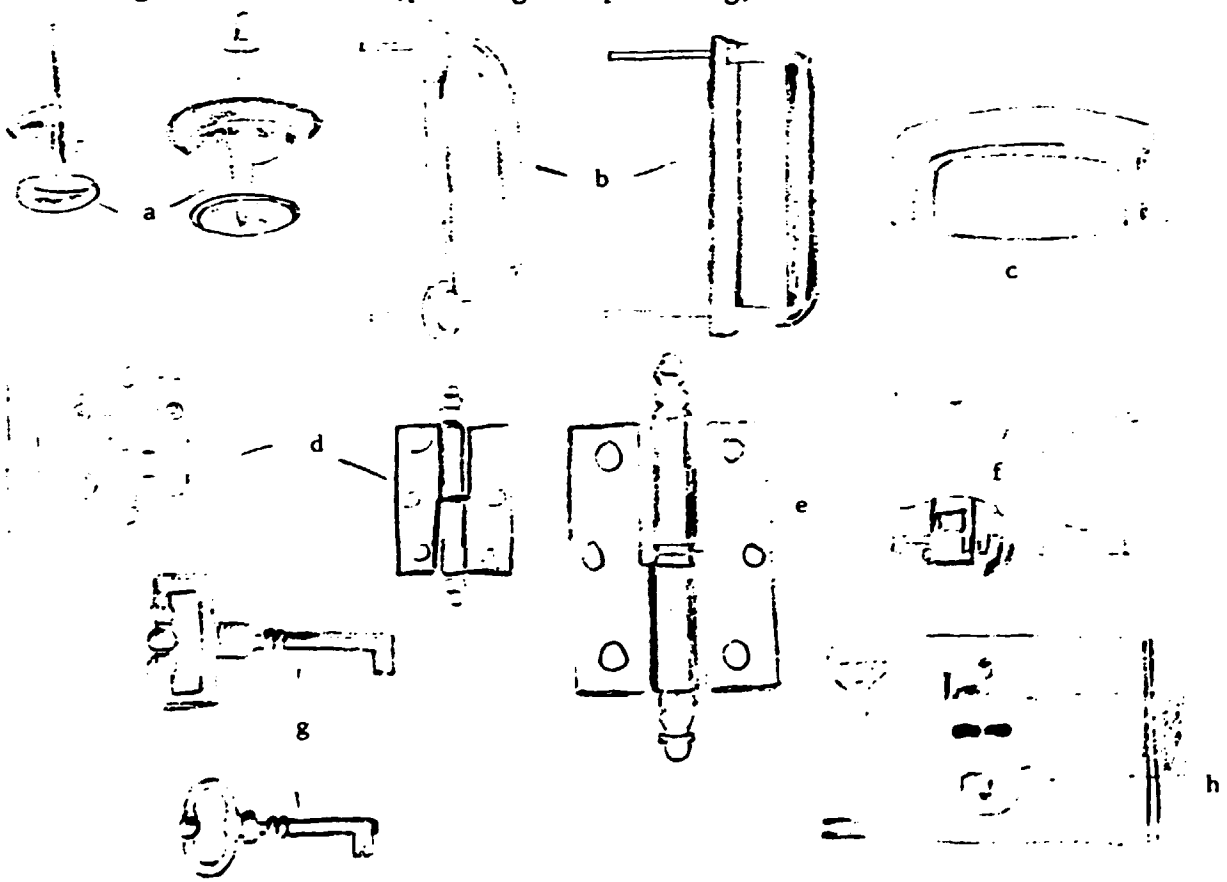

Fig. 13: Metal hardware: (a) pulls, (b) and (c) handles, (d) (e) and (f) hinges, (g) keys and (h) lock.

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

Metal connectors and fasteners are metal products used in assembling fixed or knock-down furniture. These are screws, nails, staples, bolts and nuts, as well as a large assortment of joining components such as angle connectors, eccentric case with dowel jointers, etc. (fig. 14).

Using appropriate metal components simplifies production and contributes to improving the construction and the quality of the furniture piece.

17. Plastic components and other products used in the manufacture of case furniture

Plastic components can be widely used in furniture production. Plastic is a material which is easy to shape and which can be coloured in any shade. Plastic products are used for replacing wood as an imitation of decorative figures or for profile frames. Others are used to replace metal hardware, such as pulls, handles, parts of hinges, etc. Some plastic components are used as joining elements of fittings, sometimes even in combination with metal. Glass in furniture is sometimes replaced by fibreglass which can be bent and shaped into various forms. Apart from classic materials normally used in furniture production, such as glass, marble, lighting fixtures, textile, etc., new materials are constantly being tested for the production of furniture components. Innovation is the name of the game, and the winners are those factories which are willing to play such a game.

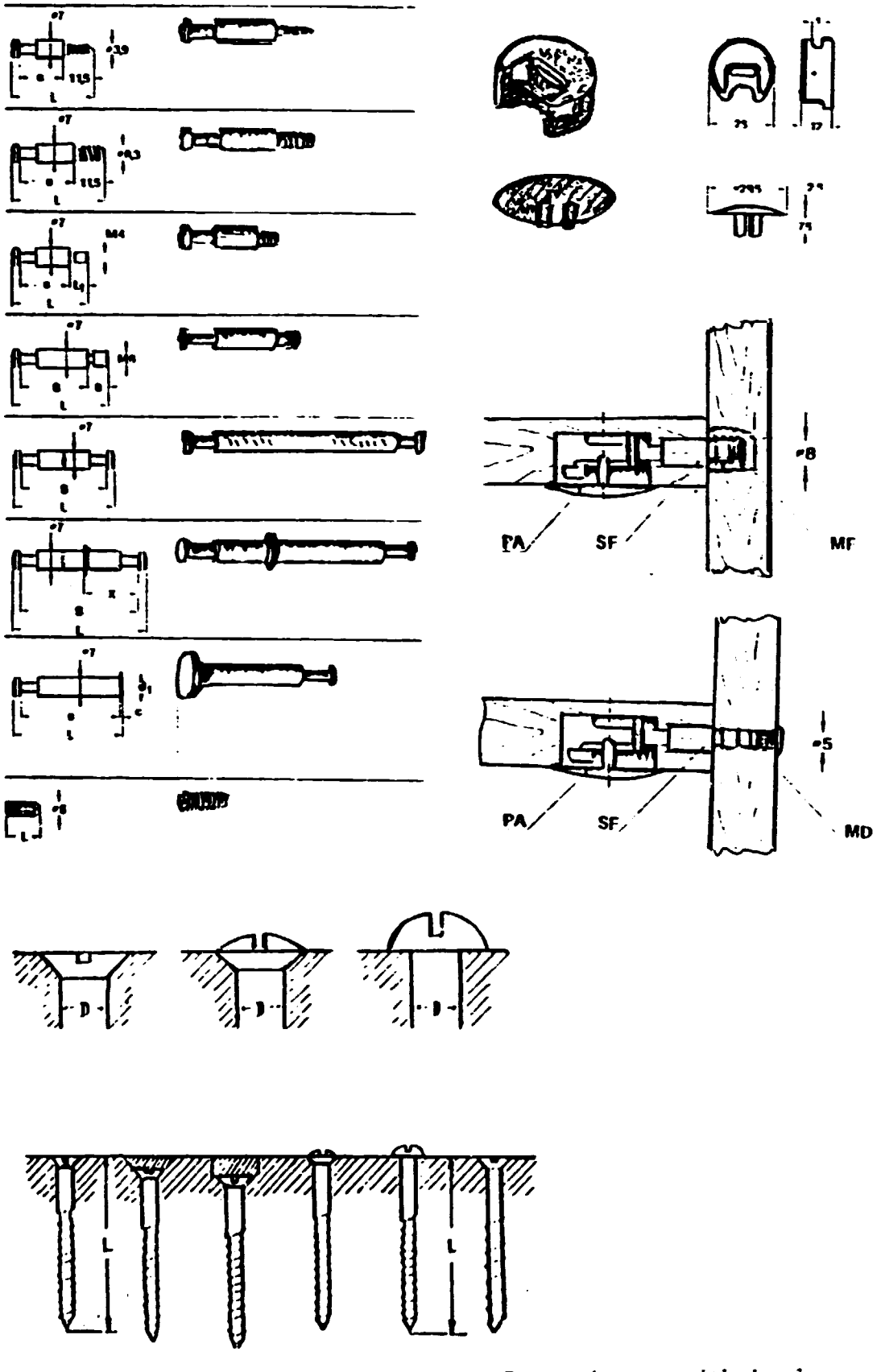

Fig. 14: Eccentric connector, Eccentric case with dowel jointers (above) and various screws (left).

ANNEX I

TRAINING PROGRAMME FOR FURNITURE MANUFACTURING

1. Introduction

This training programme is designed to accomplish the objective and outputs foreseen in the project "Assistance in the Establishment of a Pilot Furniture Plant" (DP/DRK/86/011).

Referring to the project document, the immediate objective is to "train wood technicians and machine operators in the efficient operation of all the machinery and maintenance of tools, so as to manufacture furniture of medium quality", and also to "train managerial staff in overall management techniques including introduction to the marketing of furniture products".

This objective will be achieved through the accomplishment of outputs Nos. 6, 8 and 10.

Output No. 6 states: "20 wood machinists, 10 assemblers and four team leaders trained in the efficient use of the available manufacturing equipment, able to manufacture furniture of medium quality acceptable for export."

Output No. 8 states: "Two wood technicians trained to design and make the required production fixtures aimed at attaining accurate machining of components parts."

And output No. 10 states: "Design of overall factory organization, with established work preparation, cost accounting and management procedures, with managerial staff trained in (a) factory management based on modern industrial production methods and in (b) the basic elements of marketing."

The planned activities of the quoted outputs are:

For output No. 6:

6.1 Prepare a training programme for furniture manufacturing.

6.2 Prepare a training manual for each of the major production operations.

6.3 Train 20 machine operators, 10 assemblers and four team leaders to manufacture furniture of acceptable quality.

For output No. 8:

8.1 Train two wood technicians to design, produce and maintain jigs and other furniture production fixtures.

For output No. 10:

10.3 Train factory management in modern industrial production methods.

10.4 Acquaint the managerial staff with the basic elements of export marketing.

Training labourers is an integral part of production in modern industrial enterprises. Technical and technological developments are offering, practically on a daily basis new products and methods which make human work easier, safer and more productive. To follow such advances, people working in industry have to learn and to train in order to acquire new knowledge and skills necessary for the handling of modern equipment and processes.

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

2. Training programme for the Pilot Furniture Plant

This training programme is designed to meet the specific requirements of the Pilot Furniture Plant. The main topics covered in the programme are:

1. Wood, affiliated products and other materials used in the production of case furniture;
2. Furniture products: design, construction and quality standards;
3. Production organization and work preparation;
4. Panel sizing;
5. Veneer trimming and joining;
6. Veneering;
7. Processing of veneered furniture parts: trimming, tenoning edge banding and drilling;
8. Moulding and routing;
9. Sanding;
10. Finishing;
11. Preassembling, assembling and packaging;
12. Tools, jigs and measuring instruments;
13. Quality control;
14. Safety measures in the furniture production;
15. Management based on modern industrial production methods;
16. Basic elements of marketing.

The main goals of this training are to enable workers, not only to learn how to perform their jobs, but also to understand the industrial production system as a whole.

Courses numbers 1, 2, 3, 12, 13 and 14 are foreseen to be attended by all workers to be trained, while the other courses are intended only for the workers who will perform the respective production operations.

All these courses are independent from one another, but in their totality they represent an integral training programme for the production of casegoods furniture in a medium size factory.

3. Methodology of training

There is an old Chinese wisdom which says "What I hear I will forget, what I see I will remember, and what I have done I will know." The output of this training should be knowledge learned by workers who will increase their ability for effective production. To achieve this, the training method will rest on three steps as follows:

1. Explain (to hear),
2. Demonstrate (to see), and
3. Try (to do).

Short manuals, written in a simple language, understandable to the workers, will be prepared for each course, translated into Korean and distributed to the trainees. All graphs, tables and formulae will be adjusted to the level of understanding of the people to be trained.

Theoretical teaching will take place 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 teaching will be performed by the expert (CTA) and the Chief of the Technical Department in the Pyongyang Wood Processing Complex (PWPC).

The practical part of the training will be organized at work areas for the respective work operations. For that purpose, the work areas must be organized correctly, including production documents, materials, tools, jigs, gauges, pallets, protective devices and everything that is necessary for productive, safe and good quality work. The expert will explain and show how to check a machine, tools, jigs and, in the case of wrong adjustments, how to correct them and prepare the equipment for correct use. The expert will show the correct way of performing operations and continue to supervise these operations until he concludes that proper work is fully accepted and that the quality of production is satisfactory.

The Chief of the Technical Department and other engineers who have undertaken training abroad will also collaborate in performing this practical training. Some practical experience of the trainees will help in the practical part of training.

Course No. 12 (tools, jigs and measuring instruments) should be conducted by the Tool Maintenance Expert.

Course No. 13 (Quality control). The manual prepared during the CTA's first mission can be used.

Courses Nos. 15 and 16 ("Management based on the modern industrial production methods" and "Basic elements of marketing") are foreseen for the managerial staff and will be conducted in a way to initiate discussion and an active participation of the trainees.

4. Selection of trainees

The persons to be trained will be selected by the counterpart, according to their duties 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, members of the management, maintenance personnel etc. could be included in the training.

It is recommended that in selecting the trainees attention should be paid that their physical and psychological abilities be in accordance with the requirements of the pertinent jobs.

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 every course.

5. Training programme

TITLE	TRAINING HOURS	
	Theoretical	Practical
1. Wood, affiliated products and other materials used in the production of case furniture	4.5	1.25
2. Furniture products: design, construction and quality standards.	2.75	0.5
3. Production organization and work preparation	4.75	2
4. Panel sizing operation	2.75	3.5
5. Veneer trimming and joining	2.75	4.5
6. Veneering	5	4.5
7. Processing of veneered furniture parts: trimming, tenoning, edge banding and drilling	4.5	9.25
8. Moulding and routing	2.75	4.75
9. Sanding	0.25	4.75
10. Finishing	4.25	6.75
11. Preassembling, assembling and packaging	4.5	8.5
12. Tools, jigs and measuring instruments	5.75	4
13. Quality control	5	2.5
14. Safety measures and work protection in the furniture industry	5.5	1.25
15. Management of production in a modern industrial factory	10.25	4
16. Basic elements of marketing	5.25	-
GRAND TOTAL	70.50	62.00

Detailed syllabi for each topic are given in Annex II.

ANNEX II

DETAILED SYLLABI FOR THE PROPOSED TRAINING COURSE

Topic 1: Wood, affiliated products and other materials used in the production of casegoods furniture

ITEM	TOPICS	TRAINING TIME (in hours)		LEVEL OF COMPETENCE TO BE REACHED
		Theoretical	Practical	
1.1	Introduction	0.25	--	Understanding the purpose of the course
1.2	Growth process of a tree and anatomy of wood	0.25	--	Understanding wood structure and properties of wood and wooden products
1.3	Classification of wood by species, hardwoodS, softwoodS and major species used for furniture production in the country	0.25	0.5	Ability to recognize the most common wood species and to distinguish hardwoods, softwoods, sapwood and heartwood of any species.
1.4	Physical and mechanical characteristics of wood with emphasis on the properties of domestic species	0.25	--	Better understanding wood as a raw material and relationship between properties of wood and processing methods.
1.5	Moisture content and shrinkage of wood, including shrinkage data for domestic species	0.25	--	Understanding changes occurring in wood during its drying process, like deformation and other defects caused by shrinkage and swelling of wood.
1.6	Wood destructors and wood preservation, including drying and finishing of wooden products	0.25	--	Understanding requirements for correct handling and storing of wood and wooden products.
1.7	Sawnwood, its dimensions, quality grading and utilization in secondary wood processing	0.25	0.5	Ability to better utilize sawnwood both quantitatively and qualitatively.
1.8	Veneer used in furniture production and its properties	0.25	0.25	Better understanding of the veneering process and ability to distinguish the most common species and quality grades.
1.9	Plywood, its properties and use in furniture production	0.25	--	Knowledge of its basic properties, sizes and quality grades important for furniture production.
1.10	Blockboard, its properties and use in furniture production	--	0.25	Knowledge of blockboard important for processing in furniture production

ITEM	TOPICS	TRAINING TIME (in hours)		LEVEL OF COMPETENCE TO BE REACHED
1.11	Particle board. its standard properties and usad in furniture production	0.25	0.25	Knowledge of mechanical and other characteristics of the particle board which are important for processing and its better utilization in furniture production.
1.12	Fibreboard (basic information	0.25	--	General knowledge of fibreboard and its use in the manufacture of furniture.
1.13	Surface improved boards (basic information).	0.25	--	General knowledge of surface improved boards and possibility of their use for the manufacture of furniture.
1.14	Glues and glue additives, their classification, major properties and use in furniture production	0.5	--	Better understanding of the gluing process and ability to select the correct glues and gluing parameters.
1.15	Finishing materials: lacquers, fillers, putties, thinners, stains etc. their classification, basic properties and use in furniture production	0.5	--	General knowledge of finishing materials, their role, properties and technological requirements for the correct finishing of furniture products.
1.16	Metal components: hardware, fittings, metal products for joining and fastening and their use in furniture production	0.25	--	General knowledge of metal components, possibilities and advantages of their use in furniture production.
1.17	Plastic components and other materials used in the production of casegoods furniture	0.25	--	General knowledge of the most common plastic components and other products which could be used in the Pilot Furniture Plant.
	TOTAL	4.50	1.75	