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NATIONAL CANE SUGAR INDUSTRY RESEARCH CENTRE

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THE PEOPLE'S REPUBLIC OF CHINA

China.

Technical report: Research and development for the production of panels from bagasse*

Prepared for the Government of the People's Republic of China
by the United Nations Industrial Development Organization,
acting as Executing Agency for the United Nations Development Programme

Based on the work of M. Mueller, Expert in the production of bagasse particle board

United Nations Industrial Development Organization
Vienna

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ABSTRACT

According to the duties entrusted by UNIDO, Vienna to Mr. Miroslav Mueller from the State Forest Products Research Institite (SFPRI) in Bratislava, Czechoslovakia as expert in the industrial technique of bagasse particle board manufacture (post No. DP/CPR/82/005/11-09/31.7.C.), the above mentioned expert left Bratislava on 11 June 1985, visited UNIDO and arrived in Beijing on 13 June: on 14 June he visited the National Cane Sugar Industry Research Centre in Guangzhou, then he left Guangzhou on 4 July, and after having accomplished his mission he left Beijing on 8 July, arrived in Vienna on 9 July and returned to Bratislava on 10 July 1985.

The purpose of the project was to provide, by utilizing by-products, a better foundation for the establishment of a National Cane Sugar Industry Research Centre.

The aims of the activity in question were:

- to provide information on the world development of bagasse particle board production, the latest processing technology and machinery, the top quality of products, etc.
- to give lectures in the domain of bagasse particle board manufacturing technology on selected technological aspects, on the equipment used, and on the surface finishing.
- to provide the expert's evaluation of and consultations on the line selected for bagasse particle board manufacture in order to improve the quality of production.

The following activities were also carried out:

- finding the state-of-art in the domain of particle board and fibreboard research and development at the National Cane Sugar Industry Research Centre in Guangzhou;
- stating the actual situation in the field of bagasse conversion into particle board, and possibilities of further development in this industrial branch;
- delivering lectures and panel discussions about bagasse particle board and bagasse fibreboard manufacturing for the Guandong Society of Cane Sugar Technologists;
- visiting the Research Institute of Wood Industry and the Chinese Academy of Forestry in Beijing.

ABBREVIATIONS AND GLOSSARY

SIRI	Sugar Cane Industry Research Institute, Guangzhou, People's Republic of China
SFPRI	State Forest Products Research Institute, Bratislava, Czechoslovakia
ICIDCA	Instituto Cubano de Investigaciones de los Derivados de la Cana de Azúcar, La Habana, Cuba
CSN	Czechoslovak Standard (Ceskoslovenská norma)
DIN	Industrial Standard of the Federal Republic of Germany (Deutsche Industrienorm)
Density	Weight per unit volume expressed in g/cm^3 or kg/m^3
Internal bond	Tensile strength perpendicularly to the surface of the board
MDF	Medium density fibreboard (made by the dry process)
ME 10 ZEIS	Roughness of surface measuring device
Modulus of rupture	Bending strength
MPa; N/mm^2	Tension units
Perforating method	Method for measuring the amount of free formaldehyde in a board.
Pith	Paronchymatical cells with one part of short fibre after separation from bagasse
Swelling	The increase of thickness after 2 or 24 hours of immersion in water at 20°C, expressed in percent.

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INTRODUCTION

After a briefing on 6 June 1985 by Mr. Antoine V. Bassili, Senior Industrial Development Officer of UNIDO, the expert left Bratislava on June 11 for UNIDO in Vienna where he received some background materials, and afterwards on 12 June he continued his travel and arrived at Beijing on 13 June where he was informed in details about the situation concerning his mission by Mr. A. W. Sissingh, Senior Industrial Development Field Adviser at UNDP. Then the expert left Beijing for Guangzhou in order to visit the Cane Sugar Research Institute and the National Cane Sugar Industry Research Centre of the Ministry of Light Industry.

The aim and goal of the mission was to strengthen the capabilities of the Cane Sugar Industry Research Institute in the field of sugar processing, utilization of by-products and the abatement of pollution in order to provide a better foundation for the establishment of a National Cane Sugar Industry Research Centre as well as to visit some bagasse particle board factories (see job description in Annex I). According to a further requirement - the letter of the Deputy Director of the Sugar Cane Research Institute (see Annex II) - the expert's activity was extended to also cover bagasse fibreboard manufacturing.

At the Sugar Cane Industry Research Institute, the expert was acquainted with the objectives and activities of this Institute in the sphere conversion of bagasse into particle boards and fibreboards, and on this occasion the expert gave a concise information on the activities of SFPRI in Bratislava. He handed likewise over 30 specimens of bagasse particle boards and fibrebards manufactured by the dry process, specially prepared by SFPRI Bratislava for this purpose.

In conformity with the job description and the detailed schedule (see Annex III), the expert left Guangzhou in order to carry out his field activities, and between 16 and 24 June 1985 he visited two bagasse board manufacturing plants in the country and one wood processing industrial complex.

While visiting manufacturing plants the expert's interest was oriented mainly at the production technology, the technological equipment and machinery as well as at the checking of the technological processing.

After reviewing all the production sections in the plants visited, and having obtained the necessary information on the actual state, discussion were held with leading officers and members of the technical staff on the major problems concerning the present state of production technology, the quality of the products manufactured, the manufacturing equipment and existing difficulties.

On the basis of findings, some proposals were immediately made and ready-made solutions were found for improving the actual state of bagasse particle board manufacturing.

After having finished these field activities, the expert provided SIRI with detailed information concerning the conversion of bagasse into bagasse particle boards and partly into bagasse fibreboards while giving lectures on the latest processing technology, the up-to-date machinery and equipment, the subsequent imrpovements, and the most advantageous fields for the practical utilization of bagasse particle boards and fibreboards.

Then, on 2 July 1985, he lectured and provided thorough information about the latest development of bagasse particle board and fibreboard industry all over the world in the frame of a meeting, organized by the Guangdong Society of Cane Sugar Technologists in the Guangdong Scientific Hall.

At the National Cane Sugar Industry Research Centre, finally, the overall situation was evaluated with due conclusions relating to his mission and to the preparation of his report.

On 4 July the expert arrived in Beijing where he visited the Research Institute of Wood Industry, and then he shortly informed Mr. A. W. Sissingh, at UNDP, about the most important conclusions of his mission. On 8 July he left Beijing for UNIDO, Vienna where he was debriefed by Mr. A. V. Bassili, and on 10 July the expert returned to Bratislava.

BASIC INFORMATION

Information and lectures

1. Informing activity

At the National Cane Sugar Research Centre (Ministry of Light Industry) in Guangzhou the expert provided information on the development of bagasse particle board production in the world (Annex IV), the latest processing technology including flow diagrams of bagasse particle board production lines (in Cuba), and all important and detailed parameters of the machinery and equipment concerned.

Further, the quality of bagasse particle board produced was compared with wood particle board according to the DIN Standard (Federal Republic of Germany) (See Annex V, table 1) and the CSN Standard (Czechoslovakia) from the point of view of its physical and mechanical properties, quality of surface. and of free formaldehyde content (see Annex V, tables 2 and 3).

In conformity with the quality of the bagasse particle board manufactured, the possibilities of its adequate uses - mainly for decorative appliations in furniture, for building industry purposes as well as for new utilizations, eg. for moulded products - were discussed.

2. Samples of bagasse board brought to China

The expert brought with him 30 different samples of bagasse particle board for SIRI which had been specially prepared in SFPRI Bratislava. These samples demonstrated the advantageous possibilities of industrial manufacture of various up-to-date and highly progressive surface finishing for the furniture industry and other decorative purposes.

Further conforming to the letter of the Deputy Director of SIRI, dated 4 May 1985, the staff of SFPRI Bratislava had prepared eight samples of bagasse hard fibreboards manufactured by the dry process, both with resin as well as without resin.

Phenol-formaldehyde resin was used as bonding agent, the quantity added being about 1.5 percent of bone dry board. Due to shortness of time no paraffin was applied as hydrophobic agent to the samples prepared.

The list of samples taken to SIRI is given in Annex VI.

3. Lectures

The expert gave lectures from the point of view of the latest state of the art all over the world on research and development work already done in the field of technology and machinery development for converting bagasse into particle board.

These lectures contained not only important facts and results, but also many hints at mutual correlations and dependencies of the main technological parameters as well as of parameters, concerning machinery and equipmnt.

The lectures were always followed by discussions and immediate answer of all questions. In conformity with the job description, the following themes were analysed:

3.1 Lecture on 'storage of bagasse'

Three different storing methods of bagasse, compressed into bales and stored in pyramids, were compared, namely:

- the depithed and predried bagasse (humidity 18 to 25 percent);
- the depithed and non-predried bagasse (humidity 90 to 100 percent);
- the non-depithed and non-predried bagasse (humidity 90 to 100 percent).

The comparison was carried out from the point of view of humidity, temperature, weight losses and the resulting quality of the bagasse stored (cellulose, hemicellulose and lignin content, overall look, etc.).

The predried bagasse gives the best quality; it conserves its original colour and quality, the weight losses after 120 days of storage is about 6 percent. The heat consumption for predrying is 2.9 to 4.5 MJ per kg of evaporated water.

The predrying can be advantageous where the waste (flue) gases from cane sugar mills can be exploited.

The worst results and losses up to 28 to 30 percent are obtained from non-depithed and non-predried bagasse.

On this occasion, a detailed information (including parameters) was given on the Bison Type ADM flash vertical predrier as well as on the bale compressing machine of Messrs. Lindemann.

3.2 Lecture on 'depithing'

In this lecture, the influence of pith on mechanical and physical properties of bagasse particle boards was thoroughly analysed and documented with graphs and this namely at various contents of pith ranging from 0 up to 35 percent. An overall negative influence of pith on all mechanical properties can be stated. This negative influence is not evident on swelling. A detailed information (including technical parameters) on the depithing machine Pallmann PMS-12-1200 was also given.

3.3 Lecutre on 'drying'

The subject of this lecture was different methods of bagasse drying with a description of machinery and equipment used. The main decisive technological parameters influencing the drying process have been elucidated, eg. inlet and outlet humidity of dried material, uniformity of size and shape of dried particles, temperature of drying medium, evenness of motion of dried material and the temperature distribution in the drier and modes and ways of control of drier.

A special part of the lecture was reserved for causes of fire and explosions, and for respective precautions which have necessarily to be taken into account.

3.4 Lecture on 'sorting' (separating bagasse particles)

This lecture was dedicated to a detailed analysis of: methods of screening and air-classifying particles, their function and applicability in production lines for manufacture of bagasse particle boards, screen apreture dimensions used for different types of particles - cores, surfaces and dust.

Various sorting devices and machinery and equipment in use for bagasse classification have been described and the difficulties occurring in this process were pointed out.

3.5 Lecture on 'spreading resin adhesive'

In this lecture, the two methods of spreading synthetic resin adhesive were described in detail and evaluated from a technological point of view, namely the old conventional method of using the long retention-time blender (DRAIS) which works by spraying resin through air nozzles, and the newer method of applying the short retention-time blender as, for example, the DRAIS TURBOPLAN, because both systems are still in use in production lines for manufacturing bagasse particle boards.

Some interrelations, for example the one between the size of bagasse particles, their specific surface and the percentual portion of resin adhesive retention according to fractions available, have been explained both from the theoretical as well as the practical standpoints.

Particular information and the main technical parameters of both types of machines and the air nozzles for resin adhesive spreading were given.

This lecture, owing to the demand, was extended and also covered parameters of resin adhesives applied in particle board, and methods of preparation and dosing adhesives into blenders respectively.

Due to local difficulties with evaluating the resin adhesives quality, a methodology for evaluating the adhesive power of urea formaldehyde and phenol formaldehyde resins was handed over (Annex VII).

As far as the utilization of paraffin emulsion as a hydrophobic agent is concerned, some troubles with its stability (namely the paraffin's separation from the emulsion) have been stated. On account of this, the formulation for preparing paraffin emulsion was also handed over (annex VIII).

As far as the determination of free formaldehyde directly in the cured adhesive is concerned, this test is not being carried out at SIRI due to the lack of adequate testing devices and methodology.

In view of this, the specifications of the necessary equipment together with the methodology for determining free formaldehyde was handed over (see Annex IX).

The problem of free formaldehyde escaping directly from the already pressed and stored boards - and the proper methodology of its determination - was also discussed (Annex X).

3.6 Lecture on 'secondary surface finishing

In this lecture the expert provided detailed information on secondary surface finishing (surface treatment) technology and equipment as follows:

3.6.1 Surface finishing of bagasse particle board by the application of paints (painting materials) - wet surface finishing;

- filling of particle board surface;
- drying of polyester paints by UV radiation;
- UV lamps used for curing purposes: low pressure and high pressure radiators;
- curing by ultraviolet impulse radiation;
- curing by infra red radiation;
- curing by emission of electrons.

Equipment for w·· surface finishing by appliation of coating materials:

- applyi.. fillers;
- surface painting.

3.6.2 Surface finishing of bagasse particle board by veneering foils (by overlaying of foils):

- various types of foils, technological parameters required while applying foils onto particle board.

3.6.3 Surface finishing of particle board by foils through a continuous process.

3.6.4 Surface finishing of particle board by laminating - the short cycle process: papers, technology, equipment.

4. Various other lectures, information and discussions

During the expert's stay in China, many problems touching the fields of technology, special devices and machinery and equipment were discussed and explained mostly as a result of direct enquiries. Only the major ones are mentioned hereunder:

- mat forming machine, quality and evaluation of forming process, graduated layer board, etc.;
- pressing process, pressing plots and effects of pressing parameters on the quality of boards;
- structural inner composition of partile board, particle size requirements for surface and core layers, mass relation between layers, etc.;
- fundamental information on possibilities of manufacturing bagasse hard fibreboard by the dry process without adding resin adhesive or with a reduced content of resin adhesive;
- due attention was systematically paid to the main sources of up to date theoretical and practical information, to specialized publications as well as to wood industry periodicals from leading industrial countries (see Annex XI).

5. Seminars and panel discussions

Seminars and panel disucssions on bagase particle board and bagasse fibreboard manufacturing n the world were given (see Annex XII).

PARTICLE BOARD PLANTS

Two plants for manufacturing particle board from bagasse, i.e. the Shijing Man-made Board Factory and the Sanshui Man-made Board Factory as well as the wood industry complex Yuzhu Wood Processing Factory, all situated in the province of Guangdong, have been visited.

Both plants purchase non-depithed bagasse from sugar mills located close to them during the crushing period; the bagasse acquired is compressed into bales and stored in pyramids. This bagasse earmarked for manufacturing particle boards is not depithed. From the point of view of particle size, it is very heterogeneous owing to the utilization of different surfaces on the crushing rollers in roll at the sugar mills during the production of sugar.

SHIJING MAN-MADE BOARD FACTORY

This factory was designed by the Sugarcane Industry Research Institute, Ministry of Light Industry, Guangzhou, in 1982. Trial running of the line began in 1984. The production line was put into operation in February 1985.

Designed plant capacity: 5,000 m^3 per annum.

Actual production capacity: 4,600 - 4,900 m^3 per annum.

Size of boards: 1220 x 2400 mm.

Thickness: 9 - 12 mm.

Density: 650 kg/m^3.

Graded density board.

Production days: 280 per annum.

Three shifts per day.

Labour employed: 20 workers and 1 chief per shift.

All equipment and machinery installed in the plant were made in the People's Republic of China. Its flow diagram is given in Fig. 1.

Raw material, present state

Green, non-depithed, bagasse of absolute humidity about 100 percent is the raw material. The bagasse, after leaving the sugar milling tandem is compressed into bales and transported about 4 km to the particle board factory. The crushing season at the cane sugar mill is about 90 to 120 working days per year.

Result: Because of the 30 to 35 percent pith content in the raw material, a considerably higher volume of bagasse has to be transported thereby increasing raw material costs.

Recommendation: The bagasse should be depithed after leaving the sugar milling tandem.

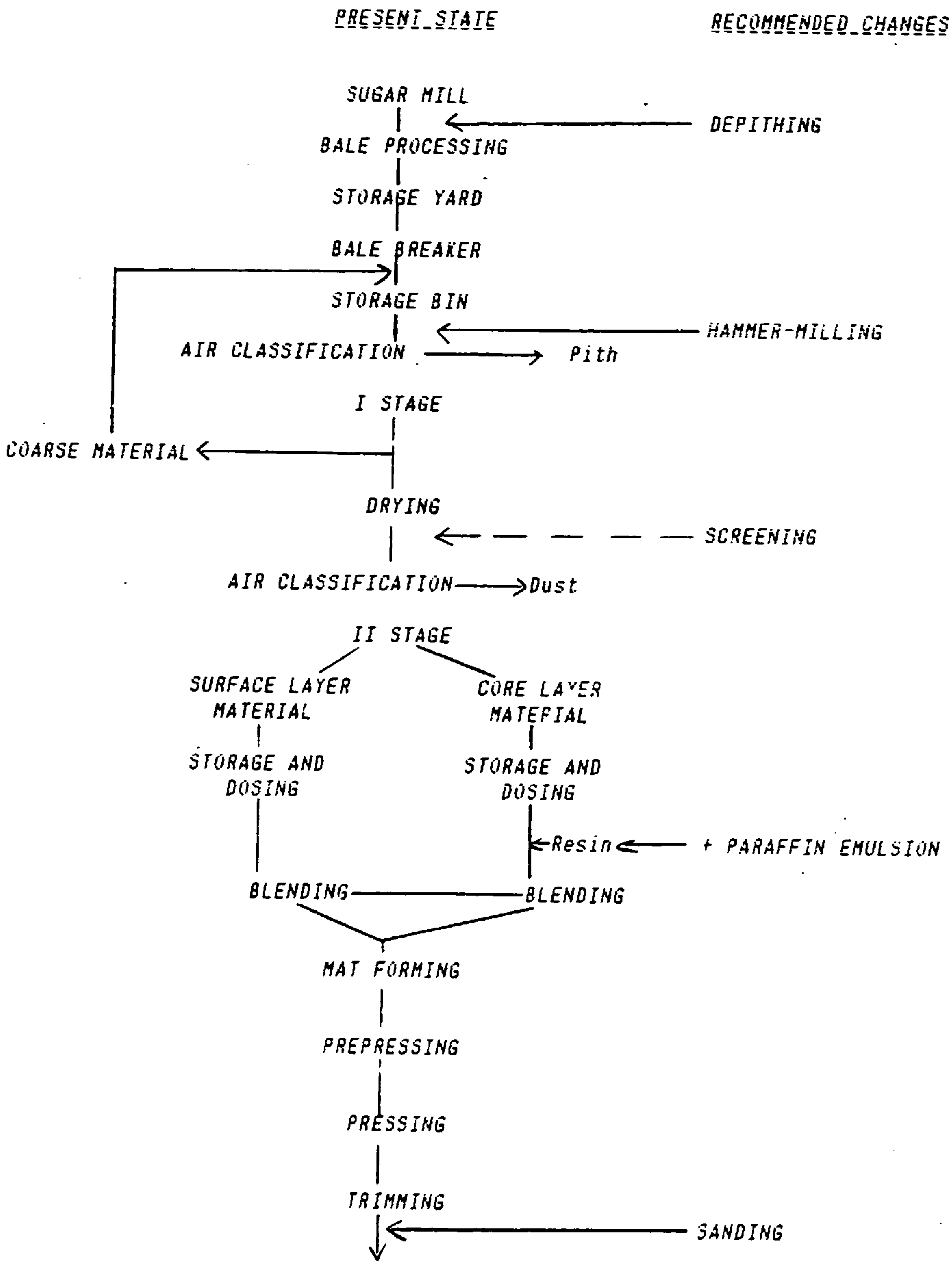

Fig. 1: Flow Diagram of the Shijing Man-made Board Factory.

Bagasse storage

The bagasse is compressed into bales and stored at the storing yard in piles (pyramids). The piles are covered with sugar cane leaves.

Size of bales: 30 x 30 x 100 cm.

Initial relative humidity: approx. 50 percent; humidity after storage: 22 to 35 percent depending on season.

Result: the quantity of bagasse stored is approximately 30 percent higher in comparison with depithed bagasse. The pith contains 1.5 to 2 percent of residual sugars after extraction showing certain sensitivity to fermentation. Water content of pith is higher than that of fibre.

Recommendation: Only depithed bagasse should be stored.

Transport from storage yard to production line

Transport is assured by small cars, loaded, pushed and unloaded manually.

Bales breaking

Breaking of bales is partly manual, partly mechanized (by a bale breaker). There are two small bale breakers installed in the line. Bagasse is fed into the bale breakers manually.

Result: uneven quantity of raw material supplied into the line.

Recommendation: Two screw-feeders are to be set behind the bale breakers (at the bottom part) or belt conveyer feeding devices are to be installed before the bale breakers.

Pneumatic transport

Bagasse is transported from the bale breakers by hot air (at 160°C) directly into the storage bin.

Bagasse storage

A horizontal bin with a bottom belt transporter, driven by a variable speed electric motor, is used. The bin is equipped with a discharge head serving as a dosing device. The bin's storage volume is 6 m^3.

Bagasse predrying

A small tube flash predrier with combined horizontal and vertical drying tubes is used.

Tube diameter: 450 cm.

Air quantity: 5,980 m^3/hour.

Heat exchanger (steam-air heated) tube surface: 60 m^2.

Inlet temperature of air: 90°C (present state).

Moisture content of particles before predrying: 22 to 35 percent.

The predrier has no possibility to regulate automatically the inlet temperature of the drying air according to the outlet moisture content and quantity of dried material.

The equipment mentioned was not able to meet the full scope of the requirements.

Result: High humidity of predried particles (18-30 percent); high fluctuation of moisture content of predried material depending on particles' inlet humidity; settling down of excessive volume and of heavy particles in the horizontal part of the predrier tube.

Recommendation: increase the air inlet temperature as foreseen by the project to 140°C. Increase the inlet air quantity by about 50 percent over the projected capacity.

In this way, it is only possible to decrease the moisture content of dried material, but not to eliminate the moisture content outlet fluctuation of the predried material. In order to have a better uniformity of average moisture content of predried material, the predrying process has to be automatically regulated. The situation described affects negatively on the following technological operations:

- particle classification (high moisture content),
- drying (high fluctuation of moisture content.).

Particle classification - First stage

The air classifying of particles is done by zigzag channel classifiers. The first classifyer separates excessively large particles which leave the equipment in its bottom part. The rest of the material enters the second classificator, where the dust is separated, and suitable particles are discharged by the rotary air lock cells and enter the drier.

The air velocity can be adjusted within the range of 2 to 5 m/s. The hot air from the predrier is used for the classification.

Recommendation: excessively large particles are to be returned to the bin or directed towards the hammer mill which is to be installed behind the particles bin or behind the first grade of air separation of the hammer mill, in order to improve the particle size distribution.

Drying

A single tube flash drier with horizontal and vertical combination of drying tubes is used.

Horizontal length of drying tube: 4000 mm.

Diameter of tube: 550 mm.

Vertical part of drier: length 12000 mm.

Diameter of tube: 750 mm.

Diameter of cyclone: 1200 mm.

Heat exchanger (steam air): 2 x 60 m^2

Air inlet temperature: 85°C (present state).

Air quantity: 8375 m^3/minute.

Input power of ventilator: 10 kW.

Air pressure: 134 mm H_2O.

Moisture content of particles after drying: 8 to 12 percent.

Result: High and uneven moisture content of dried material; impossibility to regulate the air temperature and the outlet moisture content of particles; outlet moisture content depends on inlet moisture content of particles: settling of excessively large and heavy particles in the horizontal drier tube.

The equipment mentioned was not able to meet all the requirements - to maintain the adjusted moisture content of outlet particles in the range of 2.5 plus or minus 1.5 percent.

The state described affects negatively on the following technological operations: pressing parameters (longer), pressing temperature (lower), pressing time (longer), pressing diagram (longer). The quality of the boards is also influenced negatively, namely by warping.

Recommendation: increase the air inlet temperature to 140°C as foreseen in the project's original design: increase the inlet air quantity by about 50 percent of the projected capacity: maintain the heat exchanger (clean the inner part). If the results obtained are not satisfactory, the vertical part of the drier has to be extended or a second drier installed, resulting in two stage drying.

Note: It is thus possible to improve the technological function of the drier and to increase its capacity as well, but the required accuracy of mositure content in dried particles will not be achieved.

Particle_classification_-_Second_stage

The second classification of particles takes place at the zigzag channels classifyers.

The first of two air classifyers separates the core layer particles which pass through discharge rotary air lock (rotary pocket discharger), and fall directly into the small feeding bin.

The second air classifyer separates the dust which leaves the equipment at its upper part, and is separated from the air in a cyclone.

The particles for surface layers leave the classifyer the same way as those for the core layer and fall into the small feeding bin.

The air velocity can be adjusted in the range of 2 to 5 m/sec.

Resin_adhesives_application

Two blenders are used, one type for core particles and another type for surface particles.

Blenders_for_core_particles

For core particles a long retention time blender (DRAIS system) with horizontal shaft equipped with shovels is used. Only two spraying nozzles are used for applying resin adhesive.

The outlet opening is located at the bottom just at the end of the blender. The capacity of the blender is insufficient, resulting in the machine being overloaded.

The feeding of particles into the blender is volumetric, by a small operational bin equipped with a live bottom (rubber belt conveyor) driven by a variable speed electric motor. There is no automatic control in relation to the resin adhesive feeding pump. Amounts of adhesive and particles are adjusted only by hand (according to subjective experience). The spraying nozzle ends are inserted directly into the blender.

The equipment in question does not work as foreseen in the project because only two spraying nozzles are used.

Result: Impossibility to control the functioning of the spraying nozzles; resulting in an uneven distribution of resin adhesive on the particles surfaces.

Recommendation: According to the project twelve spraying nozzles are to be used; the spraying nozzles must be adjusted in such a way that the spraying end of the nozzles will be 1 cm above the blenders' case (visual control of adhesive spraying); the outlet opening has to be situated in the upper half of the machine, about 5 cm above the shaft level.

Blenders for surface particles

The vertical blender is used for applying resin adhesive on the particles that will form part of the surface layers.

The blender consists of a vertical cylinder of 1200 mm in diameter which, in its bottom part, changes into a conical form. The five air spraying nozzles are situated in this conical part, but only two are used for applying resin adhesive. The amount of resin applied is 11-12 percent. The particles enter the upper part of the equipment and pass through the resin adhesive mist being created by the air spraying nozzles, and leave the equipment in its bottom part.

Result: The fact that the fine parts of particles are settling and sticking on the inner walls of the blender is a disadvantage, since the equipment must be cleaned frequently.

Recommendation: use the five air spraying nozzles as foreseen in the project in order to improve the quality distribution of resin adhesive on the particles.

Paraffin application

Paraffin is used only sporadically, and it is applied in the form of a water emulsion in the blender by a separate air spraying nozzle. The paraffin emulsion prepared in the factory is unstable.

Recommendation: prepare the paraffin emulsion according to the description given in Annex VIII; add it to the urea formaldehyde resin in an amount of 0.25 - 0.75 percent (ratio of solid weight to dry weight of particles), and apply this mixture onto the particles.

Delivery of resin into the blenders

The locally made urea formaldehyde resin is delivered at a concentration of 48-50 percent from the storage tank by two gear pumps. The delivering capacity is too high, and does not correspond to the resin consumption of the blender. This cannot be changed although a certain part of resin could be returned to the storage tank by a valve. This valve is to be adjusted manually by the operator. There is no automatic regulation between the amount of particles flowing and the resin adhesive introduced.

Result: nobody knows what is the real ratio between the amount of particles and the amount of resin adhesive.

Recommendation: change the electric motor driving the gear pump and install there a variable speed electric motor, or variator; adjust the gear pump at different outputs and find out in graphic form the correlation between amount of resin delivered and the revolutions per minute of gear pump, electric motor or variator.

Mat forming and formers

It was foreseen in the project that an air-classifying forming machine be installed in order to secure that the particle sizing would be graduated from coarse material in the mat centre towards the finest material on the surface. This was done automatically regardless of the material being fed into the forming machine.

This original concept was changed by the owner of the production line, and a former with mechanical classifying effect was installed.

Result: lack of uniformity in specific gravity distribution, and broad density variation of the furnish mat; lack of material on edges of the board: high tendency of the pressed board to wrap.

Recommendation: install the original former as foreseen in the project; improve the function of the small size particle bin, and its performance in distributing evenly particles across the mat formed.

Prepressing, cross cutting and mat transportation

A single continuous rubber belt prepress is used for mat prepressing. The mat entering the prepress is continually pressed by a system of prepressing rolls, and by two pairs of nip rolls. A travelling cut-off saw is used for cross cutting.

The mat transportation works well.

Recommendation: install the cleaning brush equipment to clean the upper rubber belt of the prepress; keep the rubber belt clean, and use sometimes a separator, eg. silicon oil that does not stick to particles on the surface of the belt; install an exhaust for the saw-dust after the saw.

Hot pressing and press

For pressing a 15-opening hydraulic press without simultaneous closing equipment is used.

Dimensions of press platens: 2650 x 1480 x 70 mm

Daylight openings: 100 mm

Maximum specific pressing pressure 3.8 MPa

Maximum temperature: 180°C.

The press is steam heated.

The mat transportation into the press as well as the pressing proper are carried out on caul plates. The closing of the press is slow, the time needed for reaching the necessary pressing pressure is 2 min., the pressing temperature is 150°C, and the humidity of pressed mats is in the range of 15 to 20 percent.

The press discharging device (for pulling out the caul plates) does not work reliably.

Result: a very long pressing time: for 9mm boards upto 14 min.; long pressing cycle: more than 17 min.; big operational time losses: feeding, closing, opening and discharging of press.

Recommendation: increase the pressing temperature upto 170-175^{o}C; reduce the press closing time (recalculate the hydraulics, and increase the performance, i.e. to raise the number of pumps); reduce the press opening time, and improve the reliability of the device pulling out the caul plates: provide the press with a simultaneous opening and closing device.

The production quality is unstable with big fluctuations in all parameters checked. The rprssed boards are unstable as far as their shape is concerned, and show deformation tendencies in all directions. The surface quality is bad and non-homogeneous. The quantity of first grade products attains only about 50 percent of total production (on the basis of local evaluation criteria).

The plant does not have a laboratory for testing board quality nor a check of the technological process.

The urea formaldehyde adhesive is being produced by the plant.

Three board samples have been taken directly form the manufacturing process for analysis purposes at SIRI. The test pieces were not seasoned (conditioned). The average values measured are shown in the following table:

Property	Board No. 1	2	3	Chinese standard
Thickness (mm)	9.2	8.6	9.14	--
Density g/cm^3	0.72	0.66	0.62	0.45 - 0.75
Internal bond MPa	0.39	0.65	0.62	0.45 minimum
Modulus of rupture MPa	18	17	14	18 minimum
Swelling after 2 h (%)	3.2	4.0	2.8	4 maximum
Humidity (percent)	7	6	9.2	9

Sanshui Man-made Board Factory

This plant was also designed by SIRI, and was put in full operation in October 1983. The designed capacity of the production line is 7000 m^3/year for boards with dimensions of 1220 x 2400 x 19 mm, based on 300 working days and 3 shift operation. The actual production capacity attains 6000 m^3/year while manufacturing graded density boards.

The design of the plant is similar to the Shijing Man-made Board Fatory with the following differences:

The quality of the bagasse is the same as in the above-mentioned plant: but the size of particles are smaller. The initial part of the production line in the section breaking the bales, predrying, drying, classifying and resin adhesive spreading is designed with parallel lines for the core layer and for the surface layers. After the resin adhesive has been spread the particles are mixed together, and the production line is further conceived as for one-layer board similar to the above mentioned plant.

As far as the machinery and equipment is concerned, the changes are in the resin adhesive spreading where two short-retention-time blenders are used, namely one for core particles, and one for surface particles. The mat forming machine is a mechanical one with graduated forming effect (two forming machines type BP 3213).

The seven-opening press is provided with a simultaneous closing device, and the press closing time to reach full pressure is up to 1 min. A board turner and cooler is placed behind the press. An edge trimming and chipping saw is used for size cutting.

The quality of boards manufactured is better than in the foregoing plant, and the boards show no tendency to warp. Average properties (tested in the factory):

Thickness: 14-19 mm

Density: 0.72 g/cm^3

Internal bond: 0.4 MPa

Modulus of rupture: 20.3 MPa

Swelling 2 and 24 h: 6 and 11 percent.

The consumption of resin adhesive for the core layer and for the surface layers is 10 and 12 percent respectively. The consumption should be lowered to a level of 9 percent for the core, and 10-11 percent for the surface layers.

The production line has some problems with particle humidity (after drying they are still at 8-10 percent) in the same manner as in the previously described plant.

The pressing cycle for boards of 16 mm thickness fluctuates to a large extent, namely from 10 to 20 min. depending on the humidity of the particles. This should be the case for other thicknesses too.

The production line has some capacity reserve, and after solving the problems of drying and the pressing parameters there exists a potential possibility of raising the production capacity by up to 50 percent.

This plant can test the mechanical and physical properties of finished boards as well as of resin adhesives parameters.

This plant has installed a Bürkle (Federal Republic of Germany) continuous foils veneering line. They have also tried overlaying particle boards with a paper foil, but without success. The real cause of this failure is to be found partly in the resin adhesive used. They do not have the necessary experience, and they are currently veneering high-quality plywood with foils. They seem to have lost interest in the direct surface finishing of particle boards for the time being.

The plant in question also manufactures multi-layer pressed papers impregnated with phenol formaldehyde and melamine resins. This product is used for surfacing bagasse particle boards. Direct surface finishing by one or two layers of impregnated paper laminates is not carried out. Such a technology of surface finishing by direct lamination has, to the best of our knowledge, hitherto not been introduced in China.

RECOMMENDATIONS FOR FACTORIES DESIGNED BY SIRI
(Improving particle board quality and increasing capacity)

1. Raw material

1.1 Only depithed bagasse is to be used for manufacturing particle board.

1.2 A bagasse depithing device for production lines of up to a capacity of 10,000 tons per year is to be developed.

The bagasse must be depithed immediately after the sugar extraction through the sugar roll mills at the bagasse's original humidity of 40 to 50 percent.

The major part (20-30%) of parenchyma cells must be eliminated. During depithing, a part of short fibre portion is also separated together with parenchyma. This mixture is mentioned in literature as pith, and represents 25 to 35 percent.

During the process of depithing, a partical refinement of particle size structure occurs accompanied by a reduction of humidity.

A good experience was gained in Cuba with depithing devices having the depithing rotor mounted vertically. These devices have a capacity of about 11 tons of depithed bagasse per hour.

2. Bagasse storage

2.1 The depithed bagasse must be stored at its original humidity of 40 to 50 percent or at 20 to 25 percent if it is to be stored as predried bagasse.

2.2 A bale breaker for production lines with capacity up to 10,000 m^3/year must be developed.

By storing depithed bagasse at its original humidity the intensity of the fermentation process is subdued, and thereby also the losses of total weight reach about only 22 percent as against about 28 to 30 percent for non-depithed bagasse.

The smallest weight losses are obtained from depithed and predried bagasse, with a humidity of 20-22 percent. They attain only 6 percent after 120 days of storage, and this assures the best quality bagasse. The predrying, however, demands further investment costs (e.g. for a flash tube drier), and the heat consumption moves in the range of 2.9 - 4.5 MJ/kg of evaporated water. These costs of predrying could be considerably reduced when utilizing chimney waste gases from the sugar cane mill's boiler house.

3. Particle preparation

3.1 An adequate and suitable structure of particle size for particle board manufacture with a fine surface, ready for subsequent surface finishing by up to date methods (mainly for furniture industry purposes) must be necessarily assured.

In manufacturing particle board with a smooth surface it is essential to have a sufficiently thick surface layer of fine particles. The weight ratio of the various layers is as follows: the core layer should not exceed 60 percent, and the surface layers be at least 40 percent. Using this ratio, and with a good functioning of the forming machine as well as with a press giving acceptable tolerances (the sanding allowance being about 0.8 mm), the core layer should not appear as a result of sanding operations.

For the core layer particles which pass through screen openings of 6x6mm, and for the surface layer particles that pass through the screen openings of 1.2 x 1.2 to 3.6 mm or 1.0x1.0 to 3.6 mm, and are caught on the screen with openings of 0.2x0.2 mm are suitable. The most important dimension here is the thickness of the particles.

All particles which pass through a screen with openings of 0.2x0.2 mm are considered as dust and must be eliminated from the manufacturing process.

The composition of particle sizes can be assured by introducing milling devices in the production line; hammer mills are considered the most appropriate. Usually they are only placed after the drier. In this case (for non-depithed bagasse and using air classifying), it is better to place the hammer mill at the very beginning, behind the first bagasse bin. Because of a higher humidity of milled material it is necessary to take into account the installation of a hammer mill with about 50 to 100 percent higher capacity than for a mill placed after the drier.

The maximum screen size of hammer mill is 10x40mm, depending on the fineness of particles and on the type of hammer.

4. Particle drying

4.1 The drier capacity must be such so as to assure that the particles' mean humidity after drying will not exceed 4 percent.

The particles' humidity after drying is currently in the range of 8 to 10 percent as against the required 2 to 4 percent. The increase *in humidity has a negative influence on the drying processing, on prolonging the pressing cycle in some cases (at 16 mm thickness of boards) up to 16 min. as well as on the deterioration of the boards' quality, e.g. the boards warping after being pressed.*

A higher drying capacity can be obtained by raising the quantity of drying air and by extending the length of the drier a considerable performance improvement is not to be expected.

Another possibility is the installation of a further drier, i.e. having a two-stage drying process.

Drum rotary (single- or three-pass) driers, heated by waste gases or hot air are more suitable for particle drying than contact drum rotary driers with heated tubes, since the latter offer a higher danger of fire.

These driers can be suitably combined with vertical tube driers for first stage drying.

By ensuring a sufficient drying capacity, the production capacity of the lines could be raised by upto 50 percent over the present ones.

5. Particle classification

5.1 *Adequate conditions for classifying particle size by mechanical screening have to be created on production lines for manufacturing particle board with high quality surfaces.*

A suitable size of particles can be secured by screening particles according to their envisaged use in boards as well as by following the preset ratio of layers weight.

The determining factor for good surface quality (maximum 120mm) is, first of all, the thickness of surface particles. For the sake of surface homogeneity, the length and breadth of particles is of importance too.

The classification by mechanical screening should be incorporated into the line only after drying the particles, thus eliminating the remaining dust portion.

In the actual lines of bagasse particle board manufacturing designed by SIRI only air separating (according to the particles' weight) is used.

In applying the graduated mat forming (pneumatic or mechanic forming) systems, again only the classification by weight occurs. It means that flat large particles are getting into the surface layers resulting in a non-homogeneous surface.

It would be convenient to introduce also mechanical screening classification into a selected line, and to consider it also when further new lines are envisaged.

For bagasse a simple flat classifying device, rectangular in shape with gyratory movement has proven to be suitable.

6. <u>*Spreading resin adhesive*</u>

6.1 *The homogeneity of the resin adhesive spread on the particle surfaces must be improved.*

6.2 *The possibility of setting, dosing and the subsequent checking of the requried quantity of resin adhesive, added into the blender corresponding to the weight of particles must be assured.*

For spreading resin adhesives on particles new up to date high-duty short-time-retention blenders give a better resin adhesive distribution on particles than the old glue spreaders and hence should be the only ones used. It therefore seems justified to abstain from developing other methods of spreading resin adhesives locally. The utilization of this equipment gives a good opportunity to drop the resin adhesives consumption from the present high level.

A modified type of such a resin adhe   blender was produced in China, and is being presently used by the S   l Man-made Board Factory.

In the meantime, the setting of the optimum amount of resin adhesive to be spread on particles is carried out only on the basis of the operator's experience, without any possibility to check the real quantity added. Undesirable changes in the amount of resin adhesive coated onto the particles influence the quality and properties of boards to a high degree.

The setting has to be assured by utilizing a variable speed electric motor or a variator on the resin adhesive dosing gear pump. the proper checking of quantity can only be done by using a flow indicator.

It is necessary to draw up a graph showing the inter-dependence of quantity of resin adhesive used on the amount of particles dosed and on the set velocity of the particle dosing conveyor into the resin adhesive blender. All this should be carried out in the frame of on line measurements. This correlation should be determined for different percentages of resin adhesive.

7. Mat forming

7.1 *The homogeneity of mat weight and density distribution in the forming machines used has to be improved.*

7.2 *The possibility of manufacturing multilayer bagasse particle boards with a fine and smooth surface must be secured.*

Transversal and longitudinal measurements of mat weight distribution in boards have to be carried out by cutting the board into samples of 100x100mm. and by statistical evaluation of the results of tests. The coefficient of variability in any board should not be higher than 8 percent.

An improvement should be achieved mainly by ensuring a homogenous dosing of particles into the forming machine bin (throughout its breadth) as well as by a homogeneous removal of particles from the bin. After determining the real transversal profile of the mat weight, in case of permanent , shortcomings can be compensated by adjusting the shape of the last scraper roller. This applies both for the mechanic as well as the pneumatic forming process. Plausible results can however only be got through a thorough knowledge and experience in this field of operation.

A locally produced forming machine (type BP3213) can be utilized for manufacturing multilayer bagasse particle boards. One forming head is designed for the core layer, and two forming heads for the surface layers (they can also be replaced by air forming systems).

8. Mat pressing

8.1 The duration of the pressing time proper as well as the pressing cycle have to be shortened.

8.2 Only presses with simultaneous closing have to be used.

Some production lines still show long pressing times. The pressing time for boards of 19 mm thickness should not exceed, under normal conditions 8 minutes, and the pressing cycle should be in the range of 9-9.5 minutes.

The shortening of pressing time can be achieved by reducing the humidity of the particles and by raising the pressing temperature to 160-175°C.

The shortening of pressing cycle in some cases can be achieved by a quicker press closing and opening. The closing time for a press up to the point when the press platens touch the top mat surface should not exceed 30 seconds, and the attainment of full pressing pressure should not exceed 60 seconds from the start of the closing The closing speed influences the transverse profile of the board density as well as the quality of surfaces, other variables being: humidity of surface particles, temperature of platens and size of surface and core particles.

9. Surface finishing of boards

9.1 The sanding of boards should be taken into account in the design of production lines.

Sanding is an imperative operation from the point of view of reaching the thickness tolerances of plus or minus 0.2 to 0.3 mm as well as of eliminating, in some cases, the thin non-homogeneous surface layer. Although drum sanders exist, the most suitable machines are the wide-belt two sided two- or four-head sanders.

10. Operational checking

10.1 It is necessary to create conditions for introducing the checking of the technological process as well as the product quality on all production lines, including the introduction of uniform record-keeping.

The main reason for this checking is to take the necessary steps to maintain the standard quality and the final classification and grading of products on the basis of the measurements and the product's properties at various points in the production flow.

Its importance is accentuated mainly in production lines with little automation for maintaining the technological parameters. The possibility of checking the board's mechanical and physical properties must be assured on production lines. Further the properties of the resin adhesives viscosity using a minimum Ford cup with a hole of diameter of 5 mm, and the gel time at 100°C must also be checked regularly. Standardized recording of results is necessary to evaluate and compare the results obtained and utilize these results for research and development purposes.

COMMENTARY ON THE STATE-OF-ART OF RESEARCH AND DEVELOPMENT IN THE FIELD OF BAGASSE CONVERSION INTO AGGLOMERATED MATERIALS ABROAD AND SPECIALLY IN CHINA

It is reasonable to say that the worldwide research work in the field of conversion of bagasse into particle board and fibreboard is insufficient.

The research work performed by SIRI has been mainly concentrated in the area of the problems of the existing particle board factories. Knowledge and experience obtained in the world about the conversion of bagasse into agglomerated materials is published very rarely, and only in general terms. Therefore the possibility of applying these results by the People's Republic of China is limited. If more success is to be expected in the field of conversion of bagasse into agglomorated materials, it is necessary to reinforce the research and development activities in China.

In the People's Republic of China research work has to be conducted in solving problems, such as e.g. increase of capacity of production using the same installation, improvement of surface quality and reduction of production losses.

Additional research projects should be undertaken, such as problems concerning the modernization of the production technology, the optimalization of processing, the introduction of highly efficient technique for further processing, the development of now, more economic and higher quality products which can be used directly by customers.

Moreover, fundamental problems such as storage and depithing of bagasse, preparation of particles, drying, adhesive spreading and mat formation, which are also essential for the progress of the industry, especially in the development of special products should also be addressed. Automation should also be included in research programs.

All these basic problems are closely connected with the modernization or reconstruction of old factories, eventually with the construction of new production lines incorporating the latest developments.

In spite of the rather meagre facilities existing for research and development work in particle board, the research group of the Sugarcane Industry Research Institute in Guangzhou has made considerable achievements in the field of industrial conversion of bagasse into particle board.

As a result of a research project, twelve new particle board factories, ranging from 1000 to 7000 m^3/annum, have been put into operation between 1981 and 1985, based on their proper design.

The research activity of SIRI in the conversion of bagasse into particle board is concentrated mainly in solving the fundamental problems closely connected with particle board production in some factories. It also intends to complete its own particle board laboratory and pilot plant.

On the basis of experiences in the field of research and development, it is reasonable to say that the successful performance of the task of conversion of bagasse into particle board and fibreboard is especially dependant on a broad research programme. This can be fulfilled only by the SIRI and the UNIDO/UNDP assisted Research Center, which possess the nature of a National Institution.

Non-centralized and non-coordinated research activity often leads to unsuccessful results with financial loss and to delays in development. However, on the other hand, research and development activity must be closely connected with production enterprises, otherwise it may not be a service to the industry.

On the basis of the situation already mentioned, as well as of further perspectives and trends in research and development in the field conversion of bagasse into particle board and fibreboard, the Sugar Cane Industry Research Institute should orient its activities in the following directions:

1. Activities in the field of fundamental and applied technological research of agglomerated materials: bagasse storage and depithing, pith influences on physical and mechanical properties, effect of pith

on quality surface, particle preparation and screening, drying, dosage of resin, pressing parameters and other pressing conditions in order to improve the q :lity of products and the capacity of production.

2. Activities in the field of research and development of subsequent surface finishing of boards: technological conditions for short-cycle lamination with melamine impregnated paper, urea formaldehyde impregnated paper, foils in rolls and wet surface finishing.

3. Activities in the field of development of new products including their direct use in practice: boards for the furniture industry, construction panels for the building industry, boards for shuttering, moulded products.

4. Activities in the field of development of technological equipment both for research work and for the factories: forming machines, depithing machines, bale breakers and different devices for automation and mechanization of the technological processes.

Additional activities that should be performed by this Research Institute and by the UNIDO/UNDP assisted Research Centre are:

- Cooperation with other institutions in the field of developing and supplying more complex production lines and more advanced machines and equipment, as well as providing consultancy services for imported equipment;
- Activities in the selection of more efficient equipment for further development of this industry and its economy;
- Cooperative activities in the field of production of auxiliary products, such as resins, lacquers, coated papers, etc.
- Cooperative activities in the field of development of other industrial branches, using agglomerated materials for the production of furniture, low cost wooden constructions and houses, etc.;
- Activities in establishing standards and testing methods and evaluatin of agglomerated materials;
- Advisory and engineering activities in the designing and construction of new factories and reconstruction of old ones;
- Educational activity: education of research and production workers.

RECOMMENDATIONS

1. To support and to strengthen the position of the Department of Agglomerated Materials in the framework of SIRI under the Ministry of Light Industry and to pay greater attention to the development of the laboratory and pilot plant for the conversion of bagasse into particle board and fibreboard, and to increase the effectiveness of research and development.

At present, this department concentrates its efforts on problems of bagasse particle board, it has only seven co-workers and this makes it impossible for it to give even the most urgently needed assistance to the plants. Research on bagasse particle board will start after the erection of the laboratories and the pilot plant will be finished. This currently has a high priority.

There is practically no research being undertaken in fields related to hard fibreboard and MDF, nor is there the necessary equipment.

The dynamic development of processing bagasse into agglomerated materials will lay high claims on the equipment for research and on the qualifications of the co-workers, and also on the unified and coordinated development activities of the Ministry of Light Industry.

The present state and the working team at SIRI is to serve as a nucleus of the research basis, which has to be developed dynamically so as to be able to fulfill the broad requirements given in this report.

2. To consider a possible application to the Government for it to increase its financial support so as to equip the laboratory and the pilot plant.

The basic assumption for research activities and the achievement of their results is the building of a research and development facility having an internationally accepted level. For this purpose devices and equipment not tested as to their function and reliability should not be used.

Research laboratories normally test panels whose dimensions are 500x500mm and the results achieved are then reproduced using a pilot plant that manufactures boards of at least 300x1000mm.

This research facility, which is to be considered only as a first step is not yet completed and the following equipment has to be imported:

- hammer mills for the laboratory and pilot plant,
- resin blenders for the laboratory and pilot plant,
- wire screens for the laboratory and pilot plant,
- pilot plant wide belt sanding machine, width 900 to 1200mm.
- an ME10 testing instrument produced by Zeiss Jena (German Democratic Republic) for the testing of surface quality.

Pilot plant equipment should have an output of about 200 to 600 kg. bone dry bagasse per hour. A detailed specification of various types of possible equipment will be sent to SIRI by UNIDO before the end of 1985.

3. To collaborate closely with the Forest Products Research Institute of the Wood Industry of the Chinese Academy of Forestry in Beijing in the field of particle board and fibreboard technology and machinery development, and with other research institutes in the country and abroad.

In research and development the collaboration of different institutions is extremely important to ensure an exchange of information and possible common research work, to avoid duplication.

Although bagasse is certainly a specific raw material different in certain respects from wood that has to be considered as such; the Forest Products Research Institute of the Wood Industry in Beijing is well equipped and has a rich experience. A narrow collaboration in the following technical and technological fields is therefore strongly recommended:

- particle drying;
- particle sorting;
- development of glues and resins;
- resin spreading;
- mat formation;
- pressing;
- surface finishing of the board.

4. To secure the advisory and consulting services by foreign experts and organize visits of Chinese experts abroad, already at the preparatory phase of planning research and development, in the fields of technology and machinery and for the preparation of detailed future research and development plants.

It would be advisable to get acquainted more closely with the following large scale production conditions of the newest Cuban bagasse particle board lines and with the Cuban research institute ICIDCA:

- Camilo Cienfuegos, Santa Cruz del Norte, la Habana (multi opening press);
- Jesus Menendèz, Tunas (single opening press);
- Jesus Menendèz, Tunas (Mende-system production line for thin boards);
- Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (ICIDCA), la Habana.

As to the immediate programme of investigation it should be focused on research of the basic problems intended to improve the production of bagasse particle board:

- bagasse storage, bagasse depithing and the effect of pith on the mechanical properties and on the surface of the board produced;
- inner composition of the board and the effect of particle size on its properties;
- mat forming;
- effect of resin content and pressing conditions on board properties;
- development of special board grades for the production of furniture and in the civil engineering branch;
- protection of the board against mildew, decay and biological damage.

FURTHER PERSPECTIVE DEVELOPMENTS IN THE CONVERSION OF BAGASSE INTO AGGLOMERATED MATERIALS

The cane sugar industry sector in Guandong as well as in other parts of China shows an ever increasing rate of development. Globally, the widest utilization of bagasse is as a fuel to generate heat in the cane sugar industry. Unlike in other states, China due to its considerable local stocks of coal (which is used together with bagasse as a fuel) can release a part of the bagasse for other end uses. By planning the replacment of old boilers for heat production by new heavy-duty ones more coal could be used as fuel than at present, thus releasing additional bagasse for other end uses.

The utilization of bagasse for producing agglomerated materials represents a higher level in its exploitation than using it only as a fuel only, and in China it can become the second most important raw material source after wood for this industrial branch.

A number of small pulp mills were erected that utilize this raw material. Due to water pollution problems, there is an increased tendency of using bagasse for the particle board industry (since it is a dry process) and by this way to eliminate very complicated pollution problems.

In the meantime, China also utilizes part of its bagasse as raw material for manufacturing particle board. The annual production of particle board from bagasse attains some 50,000 m^3 but the plants have small production capacity (in the range of 3,000 to 7,000 m^3/year) a low level of automation and the quality of the products does not correspond to the requirements expected of wood-based particle board.

In view of the planned rapid development of China's economy, an intensive investment activity in the field of agglomerated materials is foreseen in the near future.

In order to participate in the alleviation of the wood shortage, more attention should be paid to, and more efforts made in, establishing and improving China's own technological research and development base as well as its own bagasse particle board manufacturing technology.

CONCLUSIONS

1. As far as bagasse is concerned, it is a good material for manufacturing particle board, hard fibreboard and medium density fibreboard. It can be considered as a material equivalent to wood, especially in China where the demand for wood is colossal, but the forest resources are relatively limited.

2. The quality of particle board and hard fibreboard produced from bagasse by the wet process is equivalent to that of particle board and fibreboard made from wood.

3. The end uses for particle board from bagasse and from wood are quite similar: e.g. furniture, building industry, decorative panelling, ceilings, etc.

4. In case of three-layer or graduated density (boards with a high surface layer quality) boards a broad range of furniture surface finishing possibilities, e.g. by laminating with melamine impregnated paper using short cycles and with foils using the continuous process, exist for use by the furniture industry. It is also possible to apply highly efficient processes of wet surface finishing, e.g. by coating with fillers and transparent lacquers, where curing is carried out by ultra-violet radiation, impulse ultra-violet radiation, infrared radiation, etc. can be used.

The high pigmented lacquers (of different colours) such as polyester, polyurethane or acid cured lacquers can also be used for surface finishing.

5. As far as bagasse particle board is concerned, the technology, machines and other equipment have been developed for a wide range of plant capacities (from 3,000 to 50,000 m^3/year), but these have to be adapted to the local conditions.

As far as hard fibreboard (produced by the dry process) and medium density fibreboard are concerned, the respective technology has not yet been fully developed.

6. The coarse particle board is an intermediate product. The production of boards for commercial uses has to be correlated with processing industries, i.e. with furniture manufacturing, the wood construction industry, etc.

RECOMMENDATIONS

1. Particle board production lines having an annual capacity of up to 10000 m^3 can be established using exclusively locally developed and constructed equipment while using the latest achievments in research and development.

For particle board lines with annual capacities of over 15,000 m^3 the following most important pieces of the production line should be imported: depithing machines, hammer mills, air and screen classifiers, resin adhesive blenders with auxiliary devices, formers, presses, sanders and measuring and control equipment.

All other equipment such as air and mechanical transport systems, electric motors and gear boxes, driers, bins, boilers, etc. should be produced locally.

2. All equipment for secondary surface finishing by laminating, continuous foil veneering and wet surface finishing (filling, painting) should also be imported.

ANNEX I

JOB DESCRIPTION
DP/CPR/82/005/11-09/31.7.C.

Post title:	Expert in the industrial technique of bagasse particle board manufacture.
Duration	One month.
Date required:	April 1985.
Duty station:	Guangzhou, with travel to related factories.
Purpose of project:	To strengthen the capabilities of the Cane Sugar Industry Research Institute in the field of sugar processing, utilization of by-products, and the abatement of pollution, in order to provide a better foundation for the establishment of a National Cane Sugar Industry Research Centre.
Duties:	The expert will specifically be expected to:

1. Provide information on the world development of bagasse particle board production, the latest processing technology, equipment, the quality of products, with regard to both technical and economic aspects. Evaluate the production and economic value of bagasse particle board and compare it with wood shaving board.
2. Give lectures mainly on the techniques and characteristics of storing, screening, depithing, drying and blending the bagasse in the process of particle board manufacture, and of the equipment used.

3. Introduce the diffrrent uses of bagasse particle board and the developing trend of new products.
4. Provide detailed information on decorative sheet and ther secondary processing technology and equipment.
5. Give lectures on the on-line measurement techniue in processing.
6. Assess and recommend the techniques used by the bagasse particle board factories in the country.

The expert will also be expected to prepare a final report, setting out the findings of the mission and recommendations to the Government on further action which might be taken.

Qualifications: Expert with extensive knowledge of, and experience in, the research work and production of bagasse particle board.

Language: English.

Background Information: The country has in recent years made considerable progress in research work and the production of bagasse particle board. The Sugar Cane Industry Research Institute, Ministry of Light Industry, in Guangzhou, has been working on this project for several years, and has made certain achievements. There are several bagasse particle board factories in the province of Guangdong, Guangxi and Sichuan, etc. each with an annual capacity of 3,500 - 7,000 m^3. In these factories, all the equipment and technology of screening, drying and blending are locally produced, and, on the whole, the quality of their products has attained the same level as that of wood shaving board. However, productivity is still comparatively low, and only a few of these factories are using secondary processing technology.

ANNEX II

轻工业部甘蔗糖业科学研究所

Sugarcane Industry Research Institute

MINISTRY OF LIGHT INDUSTRY

Mr. Miroslav Muller
Haburská 3, 821 01
Bratislava
Czechoslovakia

May 4, 1985

<u>DP/CPR/82/005/11-09</u>

Dear Mr. Muller:

I learned from the UNDP in Beijing that you will arrive in China on June 11, 1985. I take the liberty to express my pleasure of greeting you for coming to Guangzhou as our honourable guest, and wishing for the success of your mission.

I believe you already have the JOB DESCRIPTION of bagasse particle board on hand. But I would like to present here a few supplementary materials which I trust would be useful.

As a matter of fact, China is lacking wood supply. Bagasse particleboard is a very ideal substitute for wood in making furnitures and other domestic equipments, which are now being urgently purchased in the local market, due to the rapid increase of income of inhabitants. According to the national plan of development, before the end of this century, we will probably have 4 times the production capacity as 1980. This leads to an annual yield of more than 6 million tons of sugar from cane. If there were enough coal as fuel for the sugar mills, then we shall have about 6 millions tons of bagasse (in dry base) as raw material for industries including the fibre board industry. Therefore it is exceedingly essential to have a stronger technical foundation of making fibre board.

Our Research Institute has been undertaking the research project of particleboard manufacture for some years, and a number of particleboard plants have been built up and put into production, with annual capacities

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MINISTRY OF LIGHT INDUSTRY

of 3.5 to 7 thousand M^3 each. Two of them are not far from Guangzhou, so I suggest that you'll stay in one of them with our engineers to have a detailed investigation of the processing facilities for several days. You might have sufficient time for interview with the technicians in the factories. I suppose this should be a realistic way of making consultation.

For the time being, the first thing we would like to improve is the quality. Although the products have met the requirements of the National Standards of wood shaving board, still they are inferior than the imported products from the more advanced manufacturers. Some of the existing problems are: 1/ even distribution of material during molding. 2/ even application of resin. 3/ optimalization of conditions used in thermalpressing. While most of the factories prepare their own resins, urea or phenol formaldehyde, they expect to have means in improving the quality of resin, and the technique of identification of quality. We recognize that these might have some influence to the quality of the fibre board.

Several of our sugar mills are proceeding to cooperate with some foreign companies to import bagasse fibre board plants of 30 to 40 thousand M^3 annual capacity. They are now facing the decision of choosing which kind of product they should produce; e.i. the bagasse particleboard or the bagasse medium density fibre board. Could you please give advices in this field?

Recently, there are quite a number of newly developed technologies of the manufacture of bagasse fibre board. We would appreciate very much if we could be informed in detail and be advised; e.g.

1/ Dr. Shen's Process in Canada to make bagasse fibre board without using resins. It was claimed that 25 to 30% cost saving can be achieved, and the quality met the requirement specified by Canadian National Standard for poplar waferboard.

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2/ Processing of bagasse fibre board, making use of the waste liquor from paper mills.

3/ Tilby Separation Process of cane. The rind of cane is stripped off the cane, washed and dried; and then made into fibre board and lumber capable for use in building construction. Amount of resin used is claimed to be below 5% only.

Most of your lectures will be given in our research institute, to attendants specified in the field of fibre board industry; together with one or two days' meeting organized by the Guangdong Society of Canesugar Technologists, to give informations of the development of bagasse fibre board industry in the world.

In case you have any enquiries or suggestions, please don't hesitate to let me know.

Looking forward of meeting you, and all best regards.

Yours sincerely,

Bao Guoyu

(Bao Guo-Yu)
Deputy Director
Sugarcane Research Institute

cc:

Mr. M. Kulessa
Resident Representative
UNDP in Beijing

Mr. Liu Guang-Lo
Bureau of Foreign Affairs
Ministry of Light Industry

ANNEX III

National Cane Sugar Industry Research Centre

MINSITRY OF LIGHT INDUSTRY

Schedule for Mr. M. Mueller's visit to Guangdong
14 June to 5 July 1985

Friday, 14 June:	Arrival Guangzhou.
Saturday, 15 June	Visit the Sugar Cane Industry Research Institute (SIRI).
Sunday, 16 June	Sightseeing in Guangzhou.
Monday, 17 June	Visit to the Sanshui Man-made Board Factory.
Tuesday, 18 June	Visit the Yuzhu Wood Processing Factory.
Wednesday, 19 June	Visit the Shijing Man-made Board Factory: General Production Inspection.
Thursday, 20 June	Symposium: Blending Technology and Equipment (in Shijing).
Friday, 21 June	Symposium: Problems on spreading machine (in Shijing).
Saturday, 22 June	Symposium: Suggestions and measures to improve the product's quality (in Shijing).
Sunday, 23 June	Sight-seeing in Zhaoqing.
Monday, 24 June	Lecture: Separation and drying of bagasse (in SIRI).
Tuesday, 24 June	Lecture: The contemporary state of the production of particle boards from bagasse in the world: The quality and uses of bagasse particle boards.
Wednesday, 26 June	Lecture: Storage and depithing of bagasse (at SIRI).
Thursday, 27 June	Lecture: Resin making technology, resin application and blending equipment (at SIRI).
Friday, 28 June	Lecture: Mat formation, spreading machine, conditions of hot pressing technology (at SIRI).

Saturday, 29 June	*Symposium: Trends of bagasse particle board devgelopment. Programme of the research and development work at S.I.R.C. for the near future (at SIRI).*
Sunday, 30 June	*Sight seeing in Guangdong.*
Monday, 1 July	*Lecture: secondary finishing technology for bagasse particle board (at SIRI).*
Tuesday, 2 July	*a.m.: Lecture in the Guandong Scientific Hall (presided by the Guangdong Society of Sugar Cane Technologists).* *p.m.: Symposium.*
Wednesday, 3 July	*Evaluation and discussion of experience gained. Main conclusions and recommendations.*
Thursday, 4 July	*Travel Guangzhou/Beijing.*
Friday, 5 July	*Visit to the UNDP Office and the Research Institute of Wood Industry, the Chinese Academy of Forestry, Beijing.*
Saturday, 6 July	*Sight-seeing, the Great Wall.*
Sunday, 7 July	*Free day.*
Monday, 8 July	*Visit of the UNDP office and departure from Beijing.*

ANNEX IV

Bagasse particle board plants all over the world

Name of factory	Location	Production capacity ton/year
1. Tablopan, S.A.	San Mateo Aragua, Venezuela	24,000
2. PROCUBA	Cruses, Cienfuegos, Cuba	22,500
3. Maderas Tècnicas	La Salud, Habana, Cuba	12,000
4. Camilo Cienfuegos	Santa Cruz del Norte, Habana Cuba	36,000
5. Iro de Enero	Ciego de Avilao, Cuba	36,000
6. Jesùs Menèndez	Tunas, Cuba	36,000
7. Jesùs Menèndez (Mende Process)	Tunas, Cuba	28,000
8. Usines de Beauport, S.A.	Port Louis, Guadelupe	9,000
9. Standard Building Products	Spanish Town, Jamaica	36,000
10. Central Igualdad	Puerto Rico	36,000
11. Trinidad Bagasse Corp.	Trinidad	15,000
12. National Bagasse Prod.	Vacherie, LA, USA	30,000
13. Cia. Azucarera Tucuman	Tucuman, Argentina	39,000
14. Taglosa	Costa Rica	24,000
15. Tableros Peruanos	Zaredo, Perù	21,000
16. Okinawa	Japan	18,000
17. Sucreries de Bourbon	La Mare, La Reunion	12,000
18. Universal Board	Mauritius	3,000
19. Taiwan Sugar Corp.	Kachsing, Province of Taiwan	16,500
20. Golagokarnath (U.P.)	India	12,000
21. Crescent Sugar Mill	Lyallpur, Pakistan	12,000
22. Hulsakane	Zululand, South Africa	36,000
23. Afcol 4	Johannesburg, South Africa	30,000
24. Kom Ombo	Egypt	24,000
25. Productos Agro Industriales S.A. do C.V.	El Salvador	15,000

Source: INIDCA Cuba 1980

ANNEX V

Table I

Physical and mechanical properties of commonly produced particle boards

Parameter	Unit	Particle boards made from			
		hardwood		softwood	bagasse[1/]
Thickness	mm	19	19	19	19
Density	kg/m^3	788	742	688	635
Swelling 2 hours	%	4	3,2	3,4	7,6/11,7 [2/]
Internal bond	MPa	0,58	0,45	0,54	0,46
Modulus of rupture	MPa	21	23	19	21
Roughness of surface ME 10 ZEISS	m	102	98	88	130
Free formaldehyde	mg/100g	20	22	20	58
Moisture content	%	8	8	8	8

1/ Produced in Cuba in 1980.
2/ 11.7 refers to a 24 hour cycle.

Table 2

Technical requirements of particle board according to DIN

Parameter	Unit	DIN 68761 part 4 Flat pressed board for general purpose FPO - boards 1/	DIN 68761 part 1 Flat pressed board for general purpose FPY - boards 2/
Density	kg/m3	--	--
Swelling 2 hr. (max.)	%	8	8
Internal bond (min.) thickness mm	N/mm^2		
13		0,4	0,4
13 - 20		0,35	0,35
20 - 25		0,3	0,3
25 - 32		0,24	0,24
32 - 40		0,2	0,2
40 - 50		0,2	0,2
Modulus of rupture thickness mm.	N/mm^2		
13		16	18
13 - 20		15	16
20 - 25		14	14
25 - 32		12	12
32 - 40		10	10
40 - 50		8	8
Tensile strength ⊥ to the upper surface layer	N/mm^2	1,0	--
Free formaldehyde 3/ max.	mg/100g	30	30
Moisture content	%	5 - 11	5 - 11
Thickness tolerance	mm	0.2 0.3	0.3

1/ Particle boards with defined requirements on fine surface particles (for direct surface finishing by painting, laminating, etc.)
2/ Flat pressed boards for general purpose (furniture, equipment, packaging, etc.)
3/ Free formaldehyde measured as type test by the PERFORATING method for the following types of boards: one layer boards, multi-layer boards, graduated density boards.

Table 7

Technical requirements of particle boards according to CSN

Parameter	Unit	Special CSN 42 2606		for general purposes one-layer grade		multi-layer grade	
		type L	type S	I	II	I	II
Density max.	kg/m^3	850	850	750	750	750	750
Swelling 2/24 hr. max.	%	6/n.a.	6/n.a.	6/15	16/25	6/15	16/25
Internal bond min. thickness mm	MPa	1/	1/	2/	2/	2/	2/
1/ 6-13 2/ 6-13		0,4	0,4	0,392	0,343	0,392	0,343
16-20 13-18		0,35	0,35	0,343	0,294	0,343	0,294
22-25 18-25		-	0,30	0,294	0,245	0,294	0,245
Modulus of rupture min. thickness mm	MPa	1/	1/	2/	2/	2/	2/
1/ 6-13 2/ 6-13		19,5	19,5	17,65	14,22	19,61	16,18
16-20 13-18		17,5	17,5	15,69	12,75	17,65	14,71
22-25 18-25		-	14,5	12,75	10,30	14,71	12,26
Roughness of surface max. apparatus	μm						
ME 10 ZEISS		120	120	-	-	-	-
TSG 3		85	85	-	-	-	-
Tensile strength ⊥ to the upper surfice layer min.	MPa	1,8	-	-	-	-	-
Free formaldehyde 3/ max.	mg/100g	30	30	-	-	-	-
Moisture content	%	7 ± 2	8 ± 2	8 ± 3	8 ± 3	8 ± 3	8 ± 3

Type L - particle boards with defined requirements on fine surface particles (for surface finishing by laminating, foils, etc.).

Type S - Particle boards with fine surface particles (for furniture decorative sheeting sliced and peeled veneer sheets).

3/ Free formaldehyde measured as type test by the perforating method.

ANNEX VI

Samples of bagasse particle board and fibreboard taken to SIRI

Two samples of bagasse particle board, size 130 x 300 x 20 mm each, with the following characteristics:

- without surface treatment;
- with a base paper foil, finished with an acid cured pigmented lacquer (mat);
- with a base paper foil, finished with an acid cured pigmented lacquer (glossy);
- base coat polyester lacquer, finished with a pigmented nitrocellulose lacquer;
- base coat polyester lacquer, finished with an acid cured pigmented lacquer (mat);
- base coat polyester lacquer, finished with an acid cured pigmented lacquer (glossy);
- with the surface prefinished with a polyester lacquer;
- veneered and surface finished with a nitrocellulose lacquer;
- veneered and surface finished with an acid cured lacquer;
- with only the base paper foil for further painting;
- laminated with melamine formaldehyde impregnated paper - short cycle pressing;
- with the base paper foil and a polyester lacquer finished with an acid cured pigmented lacquer (mat);
- with the base paper foil and a polyester lacquer finished with an acid cured pigmented lacquer (glossy);
- with the base paper foild and a polyester lacquer finished with a nitrocellulose lacquer.

Bagasse fibreboard made by the dry process, thickness 3.3 and 5 mm

Two samples each of:

- hard fibreboard produced wihtout resin;
- hard fibreboard produced with a phenol formaldehyde resin content of 1.5%.

ANNEX VII

Testing adhesive power

The adhesive power of synthetic resins can be tested in the following way:

Preparation of test pieces:

A plywood is to be pressed from three hard veneers of dimensions 30x30cm, coated with the resin to be tested.

Thickness of veneers	1.2 - 1.8 mm
Humidity of veneers before pressing	5 - 8 %

Spread of resin to be tested:

Urea formaldehyde (UF)	180-200 g/m^2
Phenol formaldehyde (PF)	160-180 g/m^2

Preparation of resins for the proper bonding:

Phenol formaldehyde resin is not modified;

Urea formaldehyde resin is modified as follows:

Add to 100 parts by weight of resin 20 parts by weight of technical flour and 20 parts by weight of curing agent 15 percent NH_4Cl.

Pressing conditions:

		UF	PF
Specific pressing pressure	MPa	1.8	1.8
Pressing temperature	°C	105-110	150
Pressing time	min.	5	5

Test pieces are prepared from the pressed plywood having the shape and size shown in fig. 1.

The dimensions of the shearing surface are measured with an accuracy of plus or minus 0.1 mm.

For testing UF resins the test IW-20 to CSN 49 0173 parts 1 & 2, and for testing PF resins the test E-100 to DIN 53255 are used.

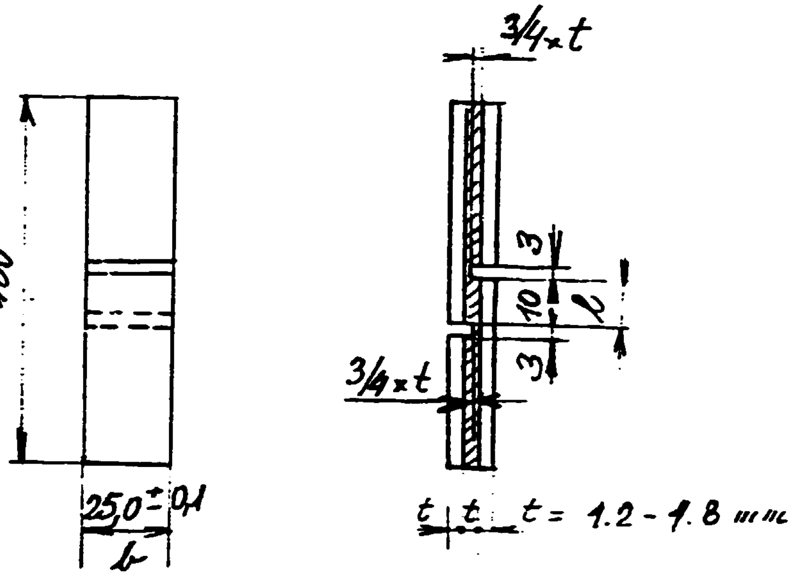


Fig. 1

Test IW-20	temperature of water	20 ± 2°C
	immersion time	24 h
Test E-100	temperature of water	100°C
	immersion time	6 h

Course of exposure testing:

- The test pieces are immersed into a water vessel in such a manner that every test piece must be perfectly wetted by water on its entire surface.
- After having finished the test, the samples are taken out from the vessel and put on filter paper.
- The testing of adhesive power is carried out on the test piece, within 30 minutes of its removal from the water.

Test procedures:

The test pieces are clamped after the exposure testing into the jaws of the testing jig so that the ends of jaws should be positioned at least 10 mm from the indents of the test piece.

- The test piece is submitted to tensile strength testing (shearing stress) in such a way that the failure is incited during 60 ± 30 seconds.
- The strength F_{max}, at which the test piece failure set in, is measured with an accuracy to within 5 N.

Shear strength:

The shear strength (t) is given by the relation

$$t = \frac{F_{max}}{b.l}$$

where

F_{max} = loading at the test piece failure in N

b = width of shearing area in mm

l = length of shearing area in mm.

ANNEX VIII

Paraffin emulsion

Composition by weight:		Concentration: 10%	20%
Paraffin having a melting point of 50-52°C	kg	9.00	18.00
Elain (Oleic Acid)	kg	1.00	2.00
Water (tap)	kg	89.50	79.00
Ammonia	kg	0.50	1.00
Total		100.00	100.00

Preparation:

Melt the paraffin with the elain at 75°C. Warm half the quantity of water up to 54°C, and add the ammonia. While stirring intensively add, pouring slowly, the melted mixture of paraffin and elain into the warmed water containing ammonia.

Stir for 15 minutes.

Add the second half of cold water.

Stir again for 15 minutes.

N.B. When using paraffin with a melting point of 60 to 62°C, raise the temperature of the melt up to 80°C, and that of the water up to 65°C.

Oleic acid (technical quality known as elain)

Oleic acid is produced from beef fat or bone fat by distillation. Elain ($CH_3.(CH_2)7.CH=CH.(CH_2)7.COOH$) has a light yellow colour. The saponification number ranges between 195 and 200. If the saponification number is higher than 200 the product contains coco-acid, and if it is lower than 185 it also contains mineral or vegetable oil.

ANNEX IX

Determination of free formaldehyde in cured resin

The formaldehyde released at higher temperatures from a sample of cured urea formaldehyde resin is absorbed in iced water and the quantity is determined by acidimetric titration.

(a) Sample preparation:

20 g of the sample are weighed and put into a 100 ml beaker, 2ml of a 15 percent ammonium chloride solution are added and the mixture is cured 5 minutes in a boiling water bath. After curing the beaker is lifted from the water bath, covered, and is left standing 24 hours at ambient temperature (about 20°C). The cured sample is ground in a mill or in a coffee grinder with a cutter knife. For the determination, the fraction used has a coarseness of 0.2 mm to 0.5 mm.

(b) Absorption of formaldehyde:

The formaldehyde content is expelled from the ground sample of the cured resin in a glass washing bottle by a stream of air at a constant velocity, at the temperature of 100°C of the water bath. The formaldehyde displaced is absorbed into water.

(c) Equipment:

This is shown in the figure on page 54.

(d) The function of the absorption device:

The float flow meter (1)[1/] and the gasometer (2) are measuring the flow rate and the volume of the air. Known devices are used, enabling to maintain a flow rate of 1 liter per minute. The washing bottle is filled with a 20 percent solution of NaOH (3) (or with a 37 percent solution of H_2SO_4) captures the air moisture. The washing bottle, filled with a 10 percent solution of Na_2SO_3 (4), absorbes the formaldehyde eventually present in the air. The cotton wool filter (6) captures the mechanical impurities of the air and prevents little sample particles to enter the absorption vessel. The sample is put into the washing bottle (5) with a sintered disk type S-1.

1/ Numbers refer to the figure on page 54.

The absorption vessel (7) is a washing bottle with a sintered absorption head type 81 S, with a volume of 100 ml. The air flow rate needed is controlled by a vacuum pump. The connection between the washing bottle (5) and the absorption vessel (7) is made by an adapter with a ground joint and a silicone hose. For the remaining connections rubber hoses are used. The water bath (8) consists of boiling water, the cooling bath (1) is water containing pieces of ice. The heater (9) is an electric hot plate with power input of 1200W. All the air entering the measuring device is going through the air filter (11).

(e) Displacement and absorption of formaldehyde:

70 ml of distilled water are put into the absorption vessel (7). 10g of the cured resin with 0.2mm to 0.5 mm coarseness are weighed and put into the washing bottle (5) on a sintered disk. The temperature of the distilled water is kept below $5^{o}C$ before starting the absorpiton. The bottles are connected according to the figure on page 54 and submerged into the respective heating (8) or cooling (10) baths. The vacuum pump starts working and the flow rate of the air is adjusted to the value of 1 liter per minute. After 50 liters of air have flown through the apparatus, the displacement of the formaldehyde from the sample is completed, the bottles are disconnected, lifted from the bath and separated. The content of the absorption vessel (7) is the sample for the analytical determination of the free formaldehyde.

During the displacement and absorption a constant through flow of air and the prescribed temperatures of the heating and cooling bath must be maintained.

(f) Determination of formaldehyde in the absorption liquor:

(f.1) Chemicals:

Sulphuric acid (H_2SO_4), 0.1 N solution

Sodium hydroxide (NaOH), 0.1 N solution

Sodium sulphite (Na_2SO_3), freshly prepared neutral solution.

Preparation:

25.2 g of crystalline sodium sulphite ($Na_2SO_3.7H_2O$) is weighed into a 100 ml graduated vessel, dissolved in water and filled up to the mark with water. After careful mixing the pH value is adjusted to 9.4 by drops of 0.1 N H_2SO_4 using thymolphtalein as indicator.

Preparation of thymolphtalein:

0.1 g of thymolphtalein is dissolved in 50 ml of 96 vol. percent ethyl alcohol.

(f.2) Testing procedure:

The contends of the absorption vessel with the formaldehyde are transferred into a titration flask with a volume of 250 ml, 5 drops of the thymolphtalein indicator are added and the pH of the sample is adjusted by 0.1 N NaOH solution to a weak blue tint. After this adjustment, 6 ml of the sodium sulphite solution are added to the sample, stirred and after a rest of 5 minutes the titration is made wiht 0.1 N H_2SO_4 to the weak blue tint.

(f.3) Calculation:

The content of free formaldehyde (x) in mg per 1 g of urea formaldehyde resin is calculated by the following equation:

$$x = \frac{a \cdot 3}{b}$$

where a = consumption of the 0.1 N H_2SO_4 solution 1/

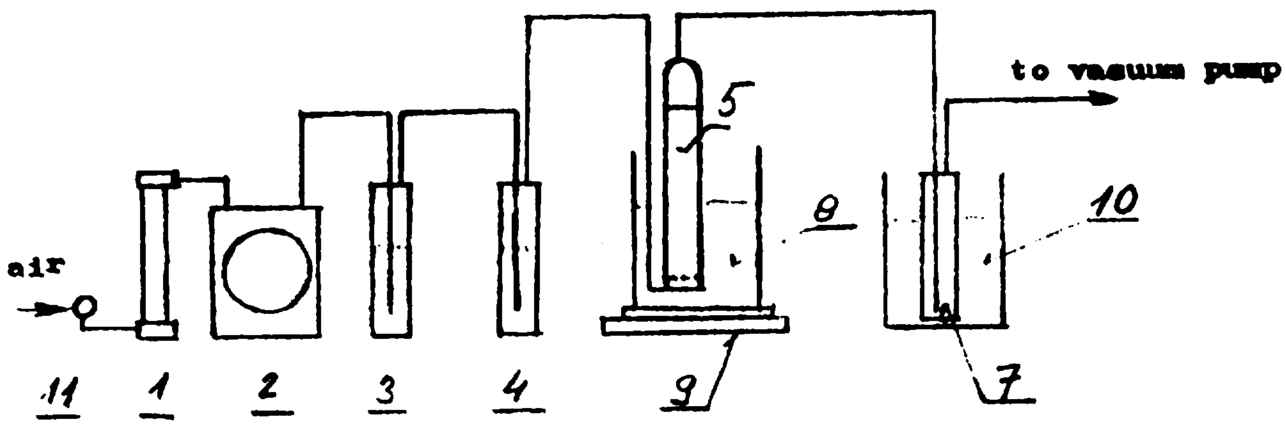
b = sample weight in grams

(f.4) Accuracy of determination:

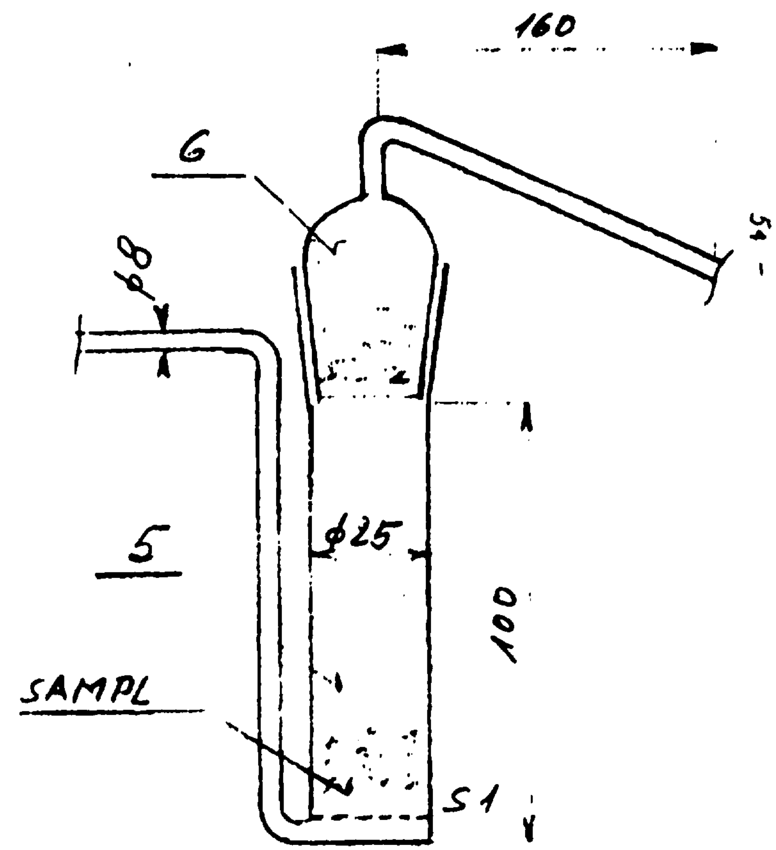
The difference between the determinations by two laboratories can be a maximum of 20 percent of the value determined..

1/ 1 ml 0.1 N H_2SO_4 corresponds to 3 mg of formaldehyde.

Equipment for Determination of Free Formaldehyde in Cured Resin



- Float flow meter (1)
- Measuring device for the volume of air flow /for instance a gasometer (2)
- Washing bottle with a 20 % NaOH solution or 37 % of H_2SO_4 (3)
- Washing bottle with a 10 % Na_2SO_3 solution (4)
- Washing bottle with a sintered disk (5)
- Cotton-wool filter (6)
- Absorption vessel (7)
- Water bath (8)
- Heater (9)
- Cooling bath (10)
- Air filter (11)



ANNEX X

Determination of the free formaldehyde content in the agglomerated materials

The FESYP- perforate (DIN EN 120) method has been applied for the analysis of the free formaldehyde content. The method has been accepted by producers of particle boards in Western Europe as the most decisive in the board quality evaluation with respect to the free formaldehyde content. Boards were divided into three emission classes determining the range of formaldehyde in milligrams liberated per 100 g of absolute dry sample tested.

Emission class	E_1	0 - 10 mg/100 g
	E_2	10 - 30 mg/100 g
	E_3	over 30 mg/100 g

Boards in the E_1 emission class can be used, according to the specifications valid in Western Europe, for furniture production and wood constructions to the full extent without any other alterations.

Boards in the E_2 class can be used in furniture production with some alterations, as for example by cementing edges, lamination or coating with various painting systems, etc.

Boards in the E_3 emission class can be used after such alterations, which, by their influence, change the class to the previous ones.

The principle of the method lies in the extraction by toluene of formaldehyde from the samples tested into distilled water. The content of acqueous solution of formaldehyde thus obtained is then determined by the iodine test.

The samples tested

Dimensions: 25 x 25 mm taken at least 500 mm from the front edge of the board.

Number of tested samples: minimum 3.

According to the method given, the samples tested should be cut off from boards immediately after their cooling behind the press. They should be stored under the exclusion of atmospheric air and analyzed within 24 h of their withdrawal.

Determination of moisture content

The determination of moisture content is performed by weighing samples after drying at 103 ± 2°C till a constant weight is attained. The latter is considered to be a value which does not change after 4 h and does not comprise a higher change than 0.1 percent of the weight of the sample. The precision of sample weighing should be plus or minus 0.001 g.

Apparatus

The testing apparatus is depicted in the figure at the end of this annex and consists of the following parts:

1. Cooler according to Dimroth, length 400 mm
2. Connector
3. Built-in filter with a frit of porosity No. 1 and funnel diameter of 60mm.
4. Perforated head, length 1000 mm with an outlet cock;
5. Distilling flask 1000 ml.
6. Connecting equipment for gas absorption - a tube with two bulbs, length 380 mm, outer diameter 10 mm, bulb diameter 50 mm, the first bulb is situated 200 mm from the tube's end, and the second 50 mm fro the first one.
7. Receiver - Erlenmayer flask 300 ml.
8. Heating equipment - heating nest with a fine control of heating rate.

All equipment parts are connected through ground glass joints. Routine laboratory equipment is used for titration.

Test performance

Approximately 100 g of samples weighed with a precision of 0.1 g are added to the 1000 ml boiling flask. 600 ml of toluene are then added. The perforated head is put on the flask in the heating nest and fixed. The toluene used must be free of water.

Distilled water (1000 ml) is poured into the head in such a way that its level is about 2 cm below the trough's mouth. Both cooler and absorption equipment are then connected. Everything is fixed well to the stand and the distilled water (100 ml) is poured into receiver in order to absorb the volatile formaldehyde.

The heating is then switched on to a such intensity that the toluene recycling starts after 20-30 minutes, which corresponds to a distillation rate of 30 l/min. The beginning of perforation is measured from the first toluene recycling. It is necessary to keep the toluene recycling constant during the perforation. Water must not enter the recycling flask.

After two hours of perforation, the heating is switched off and the receiver is put aside. After cooling at 20°C, the water from perforator is discharged through the cock to a 2000 ml volumetric flask and separated from the toluene. The apparatus is washed twice with distrilled water (200 ml), which, combined with water from the receiver, is added to the volumetric flask. The latter is filled with distilled water to 2000 ml. Thus, the solution of formaldehyde is prepared for chemical analysis.

It is necessary to perform a blanc test, i.e. to use pure toluene to test unglued particles.

Determination of formaldehyde content

Formaldehyde is oxidized in an alkaline medium with an excess of iodine to formic acid. The iodine that has not been consumed is titrated with sodium thiosulphate. Compounds oxidized with iodine must not be present (ethanol, acetone, etc.).

Procedure:

From the volumetric flask (200 ml), 100 ml of sample are pipetted to the Erlenmayer flask (300 ml). A 0.01 N solution of iodine (50 ml) and 1 M NaOH (20 ml) are added and the solution is allowed to stand in dark for 15 minutes, 10 ml of H_2SO_4 (1:1) are then added with the liberation of unreacted iodine, which is titrated with 0.01 N Na_2SO_3 using starch as the indicator.

In the same way the blanc determination is performed, but instead of a sample, 100 ml of distilled water are applied.

The perforator value is determined in percent with respect tot he weight of absolute dry board and can be calculated using the following equation:

$$P = \frac{0.003\ (b-a)\ .\ (100 + v)}{E_v}\ (\%)$$

E_v = weight of sample tested before the test (g)

b = consumption of 0.01 N Na_2SO_3 for blanc determination (ml)

a = consumption of 0.01 N Na_2SO_3 for the estimation (ml)

v = sample moisture (%)

The sample moisture can be calculated from the equation:

$$v = \frac{G_v - G_0\ .\ 100}{G_0}\ (\%)$$

G_v = weight of undried sample (g)

G_0 = weight of dried sample (g)

Note: One determination is sufficient for the routine inner tests. The individual values in two fold determination may differ from one another absolutely by 0.005 percent. Results should not deviate by more than 10 percent with respect to the higher value, otherwise a thrid determination is necessary.

ANNEX XI

Periodicals recommended for the library of SIRI

1. Holz als Roh- und Werkstoff
   (a) Springer-Verlag, Heidelberger Platz 3
       D-1000 Berlin 33, Federal Republic of Germany
       Tel.: 030/8207-1, Telex: 183319
   (b) mb Media Brains Inc.
       Nakagin Bldg, 1-5-18, Meguro
       Meguro-ku, Tokyo 153, Japan
       Cable Address: MEDBRA JAPAN
       Tel.: 03/493p5871, Telex: 2466049

2. Holz-Forschung
   Verlag Walter de Gruyter & Co., Genthiner Strasse 13
   D-1000 Berlin 30, Federal Republic of Germany
   Tel.: 030/260050, Telex: 184027

3. HOB - Die Holzbearbeitung
   A.G.T. Verlag Thum G.m.b.H., Tinacher Strasse 34
   Postfach 109, D-7140 Ludwigsburg/Wuertt., Federal Republic of Germany
   Tel: (07141) 33046-33047; Telex: 7264853

4. Wood and Wood Products
   (a) Digo Hong
       Hong Industrial Co. Ltd.
       3 Fl., No. 77 Ai-Kua East Road.
       P.O.Box 2-240
       Taipei, Province of Taiwan
       Tel.: (02) 3212324, 3944189
       Cable address: HONG Taipei
       Telex: 27357 FARFAR attn DIGO
   (b) Japan
       Hiruki Hireyama
       EMS. Inc.
       Sagami Bldg.
       4-2-21, Shinjuku
       Shinjuku-ku, Tokyo 160
       Japan
       Telex: 2322520 EM SINC
       Tel: (03) 3505666

5. World Wood
   Miller Freeman Publications
   500 Howard Street
   San Francisco, California 94105
   U. S. A.

6. Holz-Forschung und Holz-Verwertung
   Oesterreichischer Agrarverlag
   Druck- und Verlagsgesellschaft m.b.H.
   Bankgasse 1-3, A-1014 Wien, Austria

7. *Forest Products Journal*
Forest Products Research Society
2801 Marshall Court
Madison, Wisconsin 53705
U. S. A.

8. *Wood Science and Technology*
Springer-Verlag G.m.b.H. & Co. KG.
D-1000 Berlin 33
Federal Republic of Germany

9. *Mokuzai Gakkaishi*
Journal of the Japan Wood Research Society
The Japan Wood Research Society
21-4-407, Hongo 6 chomo, Bunkyo-ku
Tokyo 113, Japan

10. *Bauen & Fertighaus*
Partner Presse Vertrieb G.m.b.H.
D-7000 Stuttgart 80
Federal Republic of Germany

11. *Holz-Zentralblatt*
DRW-Verlag Weinbrenner-KG,
Fasanenweg 18
D-7022 Leinfelden - Echterdingen
Federal Republic of Germany
Tel.: (0711) 7989-1, Telex: 7255609 drw.

ANNEX XII

Seminar

The seminar in question was organized by SIRI and the Guandong Society of Cane Sugar Technologists.

Programme

a.m. The lecture covered the world's state-of-the-art in the field of productin and development of particle board and fibreboard from bagasse, the manufacturing quality in comparison with usual particle board, standards being applied, optimum domains of utilization and methods of evaluating particle board and fibreboard production from the point of view of up-to-date technology and machinery and equipment. Further detailed information was given concerning the particular methods of manufacturing particle board in multi-opening presses, in continual processing thin particle boards by the Mende system, and finally on the production of MDF.

p.m. - Panel discussion referring to all the sphere of production of agglomerated materials.

Some of the main questions analyzed were:

- Methods of bagasse storage, and possibilities of protecting the piles against weathering;
- Possibilities of depithing by the wet process;
- Influence of pith on particle boards and fibreboards;
- Methods of dosing and metering the quantity of resin in manufacturing particle board from bagasse;
- Fermentation process during storage, and its influence on the stored bagasse;
- Possibilities of manufacturing particle board with non conventional binders (in view of particular patents and information);
- Possibility of eliminating bagasse leaking from the upper feeder screw of the defibrator in manufacturing fibreboards by the wet process;

- *Causes of sharp fibre milling in manufacturing fibreboards by the wet processing;*
- *Possibilities of manufacturing MDF from bagasse and potential fields of its utilization;*
- *Humidity of particles after drying in manufacturing particle boards from bagasse.*