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16944-E

Distr.
LIMITED

ID/WG.476/6
26 July 1988

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

First Interregional Consultation on the
Food-Processing Industry with Emphasis
on Sugar-Cane Processing

Havana, Cuba, 26-30 September 1988

# REVIEW ON THE BAGASSE PARTICLEBOARD PRODUCTION TECHNOLOGY IN CHINA*

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* The views expressed by the author in this document do not necessarily reflect those of the UNIDO Secretariat. This document has not been edited.

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V.88-27138

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I Development survey

China has begun using bagasse for board making before the eighties, but only for the wet process fiber board manufacture in small output. Since the production of bagasse particleboard by the dry process started in early eighties, the bagasse particleboard industry has developed rapidly. More and more such board factories appeared, with continuous expansion of production capacity and gradual trend towards perfection in processing technique. The product board quality has attained first-class standard of shaving board set by our Ministry of Forestry. The current total annual production capacity of over ten board factories in operation in Guangdong, Guangxi and Sichuan etc. has reached 70,000 - 80,000 $m^3$ (see table attached). As bagasse particleboard could be used widely in the industries of furniture, loud speaker box and building, it is in great demand, and brings good profits to the board factories. It can be said that the newly sprung up bagasse particleboard industry has become an important component of the artificial-board industry in China.

The development of our bagasse particleboard industry has the following characteristics:

1. Production equipment homemade.

From the designing of factory construction, processing technique and equipment manufacture to installation and production, all done by our domestic technical force. The principal machinery and equipments for spreading, forming and hot pressing etc. are all supplied by domestic manufacturers. Continuous improvement in productive capacities, processing technique and new products development are obtained by the combined efforts of the technical forces both in the factories and our Research Institute. Our practice has proved that it is feasible to develop new products by domestic technical resources,

2. Production capacity adaptable to cane crushing capacity of the sugar mill.

The production capacities of most of our bagasse particleboard factories developed in recent years are 3,500 - 5,000$m^3$ a year, with the highest reaching 10,000$m^3$/yr. Comparing with factories abroad, most of which being 30,000$m^3$/yr., our factories are small. Nevertheless, our factory's production capacity is based on domestic situation. First of all, quite a lot of our cane mills' crushing capacity is 2,000 - 3,000t.c./d, and 200,000 - 300,000t.c./yr. Beside supplying the boiler as fuel, about 10,000 - 20,000 tons of bagasse are available for making 5,000 - 10,000$m^3$ particleboard. Secondly, the construction fund. Most of our particleboard factories are self-funded by the sugar mills or received partial loans from the local banks, and so ,not capable of making big investment. A factory with annual production capacity of 10,000$m^3$ board would need 4 to 5 million yuen Renminbi, which would be in keeping with our sugar mills' present financial and material resources.

3. Good economic benefits.

All our bagasse particleboard factories have rather good economic benefits. For example, the bagasse particleboard workshop of the Guangdong Zhujiang Sugar Mill has made a profit of more than ¥600,000 in its first year of trial production. The Guangdong Yatang Sugar Mill's bagasse particleboard workshop was put into operation at the end of 1987. It has planned to make more than¥1,000,000 profits in 1988.

II Varieties and qualities of the bagasse particleboard in China.

Most of the bagasse particleboard produced in China is the Gradual-Type Board. The board dimension of major products is 1.22x2.44m; a few is medium-thickness layer plain board with width 1x2 meter and thickness 8 - 16mm. In recent years, a lot of our board factories produced 3.5 - 6mm thin board by the single press, and the board quality matching that of shavings board, so it is in great demand. But most of them are being used for interior decoration, due to the urea formaldehyde resins used as adhesive, whose waterproof property not as good as the phenol formaldehyde resins. The quality targets of the

bagasse particleboard in China are shown in Table I.

Table I. The quality of bagasse particleboard in China.

| Name of Factory | Sanshui | Zhujiang Sugar Mill | | Standard (Ministry of Forestry) |
|---|---|---|---|---|
| Thickness(m/m) | 19 | 10 | 5 | |
| Density($kg/m^3$) | 580 | 557 | 601 | 450 -750 |
| Modulus of rupture | 259 | 192 | 257 | 180 |
| Internal Bond | 7.3 | 4.01 | 4.2 | 4 |
| Thickness Swelling%(2hr.) | 1.5 | 2.69 | 4.6 | 6 |

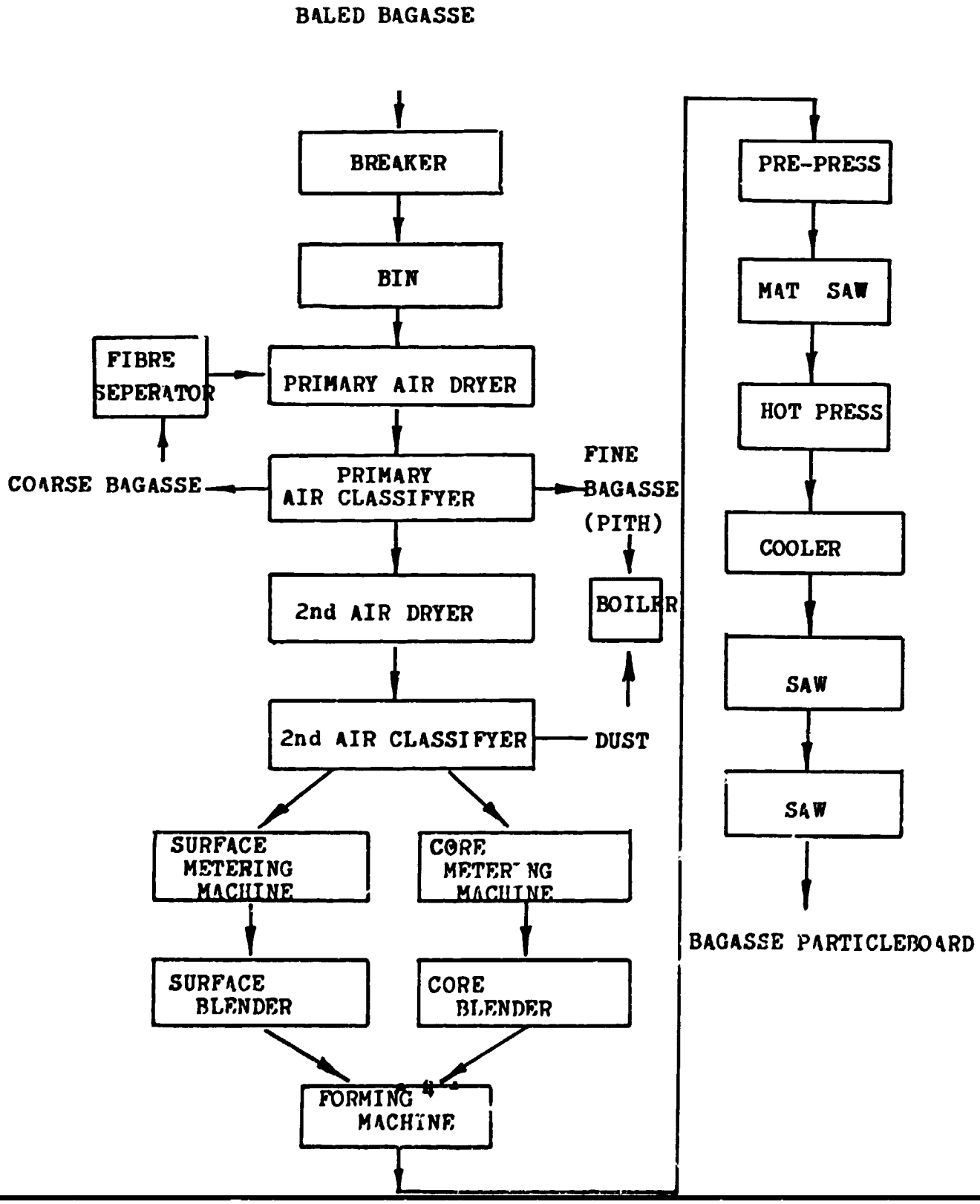
In pace with the changes in market demand, at present there are two principal types of new developing varieties. One is the thin bagasse particle board which is only 3.5 - 5mm thin. It is of good quality, can be substitute for the wood shavings board. The other type is the plastic veneer with fine surface and waterproof. It is an ideal material for furniture making. The Guangdong Sanshui Board Factory is the first complex of bagasse particleboard in China. It produces furniture units made with veneered bagasse particleboards, and have a growing domestic market, part of the products is exported to Hong Kong. From the development point of view, the variety of bagasse particleboard would be more and more, with the quality getting better and better. The development of secondary finishing process would become an important way of getting further improvement in economic benefits and market competition. Some board factories have included the construction of secondary finishing workshop in their development programs.

## III. Equipment and processing technique in bagasse particleboard manufacture.

In the case of processing, our technique in producing bagasse particleboard is more or less similar to that practiced abroad, but in specific processing arrangment and the equipment used, we have our own different characteristics. The most prominent is the treatment of the bagasse. Our success in introducing the "S" type air classifier, evolving our distinctive series of bagasse classification technique. Moreover, the

application of the varying diameter pulse type air drying system with live steam as its heat source, has comply with the requirements of bagasse drying rather well. The characteristics of the principal processing technique and equipment we used are as followed:

1. Production Process



2. Depithing and Storage of Bagasse.

It is wellknown that the sugar mill production is seasonal, so there is the problem of bagasse storage to guarantee the particleboard production for the whole year round. In China, the general practice is dry depithing, bale and pile storage of bagasse, the wet bagasse bulk storage is rarely used. A horizontal rotor depithing machine is being used in the dry process, depithing rate around 15 - 20%. A type of verticle depithing machine with hanging rotor has become popularized in recent years, its depithing rate 20 -30%. The depithed bagasse are baled into 600x450x385 mm bundles, each weighing around 50 - 60kg.

Stacking storage effects the quality of stored bagasse. In the early stage of board production, the quality of certain factory's stored bagasse decreased, thus effecting its normal production, and production costs increased because of the lack of experience and attention in this matter. By now, an excellent storage method for bagasse has been summed up. With this method, each square meter of ground can pile up 1.2 - 1.5 tons of wet bagasse, and the bagasse still possess rather good quality after being stored over 6 months, with the fiber intact, color light, moisture content reduced to around 25 - 30%.

3. Classification of Bagasse

The technique and equipment for cane juice extraction in China is rather advanced, with high recovery in cane crushing, high breakage rate and fine fibre particles in bagasse. About 50% of the particles are suitable for board making directly. The composition of bagasse particles in China is shown in Table 2.

Table 2. Composition of the Bagasse Particles in China and South Africa

| | Bagasse in China | | Bagasse in South Africa | |
|---|---|---|---|---|
| Mesh No. | Dimension (m/m) | Content % | Dimension (m/m) | Content % |
| +6 | over 3.2 | 14.8 | over 2.36 | 22 - 27 |
| -6+12 | 1.6 - 3.2 | 19.4 | 1.4 - 2.36 | 11 - 15 |
| -12+24 | 0.8 - 1.6 | 25.4 | 0.85 -1.4 | 22 - 30 |
| -24+48 | 0.63 - 0.8 | 14.4 | | |
| -28+45 | 0.4 - 0.63 | 13.7 | 0.425 - 0.85 | 27. - 34 |
| -45 | less than 0.4 | 12.3 | less than 0.425 | 2 - 5 |

Table 2 shows that bagasse is different from wood. Bagasse is constituted of different dimesions of particles. If it is used for board making without the process of classifying the different dimensions of particles, the quality of the board produced could not be guaranteed. Especially in China, the bagasse particles are rather fine, with a lot of dust content of less than 0.4 m/m. The removal of such fine dust in the board making process would cut down the amount of adhesive used, and increase the mechanical strength of boards. Coarse bagasse can be of use after going through the crusher. But since the amount not much, some factories just send it to the boiler to save power and equipments. Our experiments have shown that the quality of board varies with different dimensions of bagasse particles ( see Table 3).

Table 3. The Effect of Different Dimentions of Bagasse Particles on Board Quality.

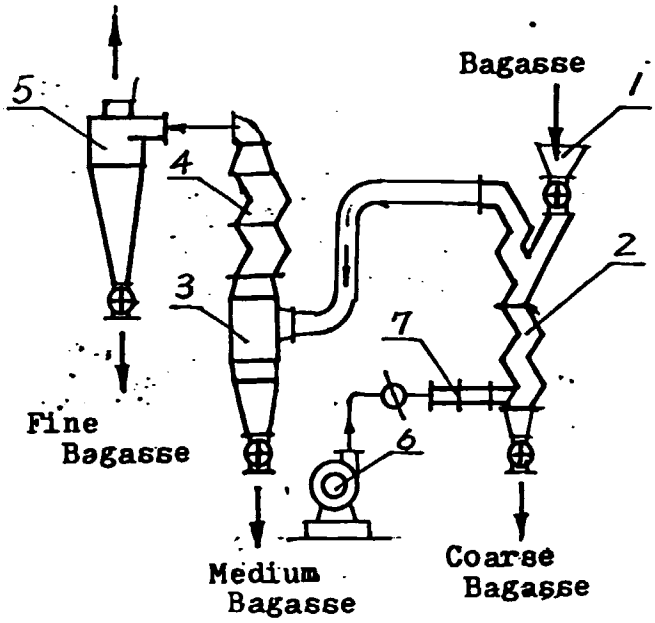
| Classification of Particles / Physical Property of Board | Classified Bagasse | | | | | Whole Bagasse |
|---|---|---|---|---|---|---|
| Dimension | No.1 | No.2 | No.3 | No.4 | No.5 | No. 6 |
| Average length (m/m) | 0.8 | 4.02 | 4.57 | 5.94 | 8.26 | 6.69 |
| Average width (m/m) | 0.2 | 0.31 | 0.32 | 0.32 | 1.15 | 0.48 |
| Board density $kg/m^3$ | 561 | 583 | 719 | 597 | 739 | 734 |
| Modulus of rupture | 146 | 198 | 255 | 238 | 181 | 190 |
| Internal Bond $kg/cm^2$ | 0.3 | 6.3 | 5.2 | 6.9 | 2.9 | 3.9 |
| Thickness Swelling% (2hr.) | 6.6 | 6.7 | 5.4 | 4.9 | 10 | 9.0 |

Table 3 has shown that the quality of boards made with too fine pith dust is the worst, but particles too big is also bad for the board's strength. To get the ideal bagasse particles, we use the 'S' type air classifier. It consists of two S shape channels of certain angle and separates the bagasse into 3 parts: coarse, medium and fine, by different flow speed of air. Such a classifier is easy to manage and control, with wide adaptability to raw material, low noise and low cost. It has become the major equipment in the classification section, and is widely used

in the bagasse particleboard factories in China. Its construction principle is shown in Diagram 1.

Diagram 1.'S'Type Air Classifier

1. Feeder
2. Primary Classification
3. Buffer
4. Final Classification
5. Cyclone
6. Air Fan
7. Ovifice Flow Meter




4. Bagasse Drying

The drying of bagasse is very important in particleboard production. The moisture content of the blended mat must be around 12 % , and so the bagasse's moisture content must be reduced by drying to less than 4 %.

There are many types of drying equipment. In China, the varying diameter pulse type air dryer is used by most factories, a few use the cylinder type rotor dryer. To ensure the drying effect, the air drying system has two steps of drying. The first step is drying to moisture content of 15% and the second step drying to less than 4%. With this drying system, one can easily adjust the necessary processing parameters according to the different moisture content of the raw material used.

Many factories abroad use fuel oil as heat source for the dryer, but the supply of fuel oil or gas in China cannot satisfy the production demand of our board industry. Since most of our sugar mills have medium presure boilers, using steam as heat source, indirectly heating the air to 150°C for the drying

process. In this way, we have solved the drying problem and also can prevent the danger of high temperature causing fire.

In comparison with rotor dryer, the air dryer makes up less space and costs less. An air dryer for factory with 10,000 $m^3$ annual production capacity, costs only ¥110,000 to ¥120,000, while the rotor dryer costs ¥250,000 to ¥260,000.

5. Hot Press Equipment

The hot press is the major equipment in particleboard production, and high manufacture technique is required. We are capable of making a complete production line for an annual board production capacity of 10,000 $m^3$. In the early stage of development, many board factories used multi layer hot press, mainly with 1.22 x 2.44 m dimension, varying from 6 to 10 layers, with simultaneously closing device, whose closing time can be completed within 15 to 30 seconds. There is the tendency towards the use of the single press in recent years. There are two specifications of single press. One is 1.22x4.88m (4x16ft) for factories with annual capacity of 5,000 $m^3$ board; another one is 1.22 x 7.32 m (4 x 24ft) for factories with annual capacity of 8,000 - 10,000 $m^3$ board. Bigger single press with the dimension of 2.44 x 7.32m is not yet in use in China.

Comparing the two types of hot press, production practice has proved that the single press has better guarantee to the board's quality, with little allowable tolerance of the board's thickness; better firmness in the board surface and less heat consumption, and so it is much preferred by the new factories. But at present, factories of big capacities could only use the multi layer press, owing to the non-availability of big sized dimension.

Whether multi layer or single layer, both use steam heating as heat source, rarely employ hot oil or over heated water.

## IV. Economic Benefits

The vitality of each new product depends on the amount of its economic benefits, which is closely related with its production cost and selling price.

The main reasons for our rather low production cost of bagasse particleboard are as followed:

1. Attention to the Storage of Bagasse

Bagasse is the major material in bagasse particleboard manufacture. As we have explained before, its storage is very important. The conditions of the stored bagasse not only concern its utilization ratio, also effect the board's quality. Because our board factories have paid much attention to the improvement of management and technique of bagasse storage, each cubic meter board of bagasse consumption quota has reduced to about 1.8 ton. Well stored bagasse has low moisture content and less power consumption for drying process, thus the production cost is lower.

2. Improvement of Blending Equipment and Adhesives' Quality

The price of urea formaldehyde resins is ratner high. The current situation is, the cost of adhesive used in board making amounts to 1/3 of the total cost, or even more. Thus, the lowering of adhesive amount used is the key to the decrease of production cost. There are two ways in cutting down the amount of adhesive used. One is improvement of the blending homogenity with the high speed circular blender; another is the improvement of adhesive's quality by improving the adhesive prescriptions. In China, there is not yet any factories to produce the adhesives used in board making. Most board factories make the adhesive themselves, and sometime the quality not stable enough. Therefore, they are much interested in the improvement of the adhesive making technique, to ensure the adhesive quality, so as to reduce the ratio of adhesive cost gradually.

3. Strengthen Production Management and Enhance Productivity

Generally speaking, the production cost of the board factory is closely related with its production capacity and management level. Although the capacities of our bagasse particleboard factories are small, the unit product's ratio of non-productive expenses would inevitably be bigger. But because most of our bagasse particleboard factories are affiliated to sugar mills, which posses rather high management level. The supply of steam and electricity, the other management and administrative services all undertake by the sugar mills concerned. Thus making up the unfavourable factors of small production capacity. Many board factories with good management have actual output exceeding their designed capacities, yet with rather low consumption of electricity and steam. The minimum electricity consumption of each cubic meter of board is about 150°, and only 1.5 tons of steam consumption. Table 4 and 5 list out the material consumption and production cost of a bagasse particleboard with annual production capacity of 3,500 $m^3$ board.

Table 4 Material and Power Consumption in Bagasse Particleboard Production

| Item | Unit | Unit Consumption | |
|---|---|---|---|
| | | 8m/m board | 12m/m board |
| 1. Raw material | | | |
| Bagasse (50% water content) | ton | 1.72 | 1.74 |
| Urea formaldehyde resins(solid) | kg | 71.8 | 70.1 |
| NaOH | kg | 0.09 | 0.088 |
| $NH_4Cl$ | kg | 0.05 | 0.05 |
| 2. Power | | | |
| Electricity | kwh | 196 | 181 |
| Coal consumption | ton | 0.35 | 0.32 |

V. Trend of Development

According to our investigation on the trend of domestic market and abroad, together with the sizing up of the current development, we believe that there will be a bigger development for the bagasse artificial board industry in future. The reasons are:1. China is not rich in forestry, the problems of wood supply will last for some time. Devoting major efforts to develop artificial boards production would be an effective measure in solving the problem. According to our Forestry's statistics, although our artificial board industry has made big development since th founding of our People's Republic more than 30 years ago, with an annual board output over 1,400,000 $m^3$, but the average capita consumption is far below the level abroad. To achieve the development target of producing 2,4000,000 $m^3$ board in 1990, the utilization of bagasse for board production accords with the demand of our country.

2. At present, our cane sugar mills are devoting major efforts to develop the utilization of sugarcane, so as to change the phenomenon of producing only one kind of product. The production of bagasse particleboard is a good approach. According to the actual condition in China and informations from abroad, we now compare the several major usages of bagasse : one ton of bagasse as fuel can be substitute for 1/3 ton of coal, which values about ¥40;as for making particleboard would value about ¥100, higher than the value of other bagasse products, more than double the value as fuel,and only second to being used for making writing paper.

The actual figures of our sugar mills show that profits from board production with bagasse of every 10,000 tons of cane crushed is equal to the profit of sugar produced, and so, particleboard production is very big advantage to the sugar mills.

3. A Vast Market

All poorly forested regions are short of wood supply, and

in the plains of east and north China, as well as in the coastal regions of south China, greater amount of timber is needed. These regions will provide a vast market for the bagasse particleboard. Investigation has shown that the board output of the Guangdong Zhujiang Sugar Mill is not sufficient, even for the local market demand, and so, there is no way to satisfy the demand of other provinces. Another bagasse particleboard factory which started operation in 1987, has made sales contracts of over three thousand cubic meters of board with the provinces of Henan, Hebei, Shandong and Xinjiang etc.

Beside the domestic market, our bagasse particleboard has a growing market abroad. Purchase orders are coming from Japan, Singapore and Hong Kong etc. One factory in Guangxi province has concluded transaction of over two thousand cubic meters of bagasse board with Hong Kong, Macao, Thailand and Malaysia. Recently, one foreign trader is preparing to contract for the bagasse board from the Zhujiang Sugar Mill at the price of US$200/$m^3$. A company in Macau is preparing to cooperate with the bagasse particleboard workshop of the Hongqi Sugar Mill and be the sole agent of its product.

4. Rich bagasse resource is a reliable source of material supply for the development of the bagasse particleboard industry. Our annual cane sugar production is more than four million tons, producing 80,0 00 to 90,000 tons bagasse.Beside the use as fuel and as pulp for paper making, there is still a surplus of over one million tons of bagasse. With the continuous improvement of energy saving technique in our sugar mills, there would be more and more surplus bagasse coming. A sugar mill with annual crushing capacity of more than 200,000 tons cane would have surplus bagasse nearly twenty thousand tons, after supplying all the bagasse used by its boiler as fuel. This amount would be sufficient for a board factory with annual capacity of ten thousand cubic meters.

The use of bagasse as particleboard making material has many advantages over other non-xyloid material, such as : centralized availability, needless to purchase, no long distance

transportation, simple processing technique and less expense for equipment and power consumption. All these are favourable conditions for the development of bagasse particleboard industry.

Interest and confidence over further development in the bagasse particleboard industry have increased greatly. In Guangdong Province alone, there are four board factories to begin construction this year. Two of them have an annual capacity of ten thousand cubic meters, and the other two with five thousand cubic meters. Furthermore, there are preparations for the construction of two or three board factories in the provinces of Guangxi, Fujian and etc.

After a few years' efforts, our bagasse particleboard industry developed by domestic resources has reached the developing period. It has achieved certain economic benefits and social benefits, but there are still some distance from the advanced level abroad. The shortcomings are: (1) Variety of product unitary. We should develop high strength thin layer board, highly waterproved board for construction uses and secondary finishing technique to widen the products' usuage; (2) Not enough stability in the product's quality, especially the rather big tolerance in thickness; (3) Insufficient studies on new adhesives development; (4) Rather small dimensions of the hot press equipment, not adaptable to the demand of big board production; (5) Rather low level of production automation, and rather backward in the on-line testing, measuring technique, in medium products and control instruments.

To solve the problems mentioned above, the technical guiding role of the professional research departments must be given full play. The production factories are also required to make continuous improvement in production, to seek more effective ways of solution. We have the following suggestions:: First, with the research units as core, organize professional technical informations interchange within and out of China, comparing the advanced technique and technology abroad and seek out the key problems of the industry. Second, by means of combined capital, import advanced production equipments,

on-line measurement technique, control equipment or technological patents according to plan, so as to avoid repetition of imported items and waste of foreign exchange. Third, digest and absorb the strong points in foreign equipments and processing technique during production, for the development of domestic new equipments to be popularized within the board industry.

## The Bagasse Particleboard Factories In China

| Constr. Date | Name | Location | Capacity ($m^3$/yr.) | Specification(m) | Remarks |
|---|---|---|---|---|---|
| 1984 | Dayi Sugar Mill | Sichuan | 3500 | 1 x 2 | Multi layer |
| 1985 | Dawang S. Mill | Guangdong | 5000 | 1.x 2 | press |
| 1985 | Liangqi S. Mill | Guangxi | 5000 | 1.22x2.44 | " |
| 1986 | Shijing Board Factory | Guangzhou | 7000 | " | " |
| 1986 | Sanshui Board Factory | Guangdong | 7000 | " | With plastic veneer and furniture workshop |
| 1986 | Qianjiang S. Mill | Guangxi | 3500 | " | Multi layer |
| 1986 | Jianshui S. Mill | Yunnan | 3500 | | press |
| 1986 | Zhujian S. Mill | Guangdong | 3500 | 1.22x2.44 | Single press of 1.22x4.88m |
| 1987 | Jinpan S. Mill | Hunan | 5000 | " | Multi layer |
| 1987 | Dayuan S. Mill | Hubei | 10000 | " | press |
| 1987 | Yatang S. Mill | Guangdong | 10000 | " | " |
| 1987 | Hongqi S. Mill | Guangdong | 10000 | " | Single press of 1.22x7.32m |
| 1988 | Beihe S. Mill | Guangdong | 10000 | " | " |
| 1988 | Pingsha S. Mill | Guangdong | 10000 | " | Single press of 1.22x4.88m |
| 1988 | Tiaofeng S. Mill | Guangdong | 5000 | " | |