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PARTICLE BOARDS FROM COCONUT PALM TIMBER*

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INTRODUCTION

During the proposed reorganisation of the copra industry in the Gilbert and Ellice Islands it is estimated that about six million coconut palm trees will be felled in the initial stages and thereafter a significant felling of trees will take place annually.

At the request of the Assistant Resident Commissioner, the Tropical Products Institute examined samples of this timber to determine the feasibility of using this otherwise waste material in the manufacture of particle board.

In general, the process consists of converting the green timber into flakes, the dimensions of which largely determine the physical characteristics of the particle board. After flaking, the particles are dried to a moisture content of between 5 and 8 per cent and then sprayed with a synthetic resin binder, usually a urea-formaldehyde/hardener mixture, the generally accepted quantity being 8.0 per cent by weight of the finished board. The sprayed particles are then compressed at an elevated temperature and pressure for about 15 minutes in a hydraulic press. to produce boards 8 feet by 4 feet and either $\frac{1}{2}$, $\frac{3}{4}$ or 1 inch thick. This product, with slight differences in surface finish caused by variations in particle dimensions and multi-layer board, in which the outer layers are made from fine particles and the core of coarse particles, represents the normal chipboard or particle board produced commercially.

SAMPLE DESCRIPTION

The preliminary stages of the investigation were carried out on a first consignment consisting of eleven logs of kiln dried timber in lengths of approximately 2 feet 6 inches and 8 inches in diameter. All the logs had a soft, pith-like core about 4 inches in diameter, and a visual examination showed the structure of the logs to be very different from that of the conventional timbers usually used in particle board manufacture. The difference, in fact, was so great it was thought unlikely that particles of a flake-like form could be produced from this material when processed in a wood-flaking machine specially designed to produce flakes of different lenghts and thicknesses. This difference in structure was clearly observed during the initial experiments when the particles produced were more accurately described as splinters, rather than flakes and this term is used throughout the remainder of this report.

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The second consignment, delivered some considerable time after the first, consisted of eight logs each 4 feet in length and about 10 inches in diameter. The exposed cross-sections of these logs revealed, differences in structure from the timber previously used. In this case the logs were not kiln dried and the pith-like core was much harder and considerably less in quantity than in the previous sample.

PREPARATION OF SAMPLES

To reduce the logs to a suitable size for flaking, they were cut into lengths of 10 inches with a chainsaw and then longitudinally on a diameter by a bandsaw. Because the first consignment of timber was very dry and produced excessive quantities of fines during flaking, the logs were submerged in fresh water for seven days before treatment. The second consignment was also soaked in water before flaking because, although the moisture content on delivery was 40 per cent this was reduced to about 20 per cent during the time the logs were in store.

MACHINERY

The flaking machine used at TPI consists of a circular disc, 3 feet 6 inches in diameter which rotates at 500 r.p.m. and is driven by a belt and pulley coupled to a 10 h.p. motor. The disc carries four radial knives, each 10 inches long, arranged at an angle of 90° to each other and these are preceded by scoring bars of the same length and fitted with vee-shaped cutting tools. Knives and scoring bars can be adjusted to enable the flakes produced to be varied in length from 15 to 120 mm. and in thickness from 0.2 to 2.0 mm. When the machine is set up in this way it produces normal flakes from deciduous and coniferous timbers, but, as has been previously mentioned, difficulty was experienced with this material and only splinter-like particles could be produced.

DRYING

The moisture content of the splinters leaving the flaking machine was about 45 per cent. To avoid the danger of delamination of the board caused by the formation of steam in the mat during pressing, it was necessary to reduce the moisture content of the splinters to between 5 and 8 per cent before spraying with resin. This was done, with the first set of samples by drying the splinters in an oven at a temperature of 103°C and the fines (i.e. those particles passing through a No. 22 B.S. Sieve) were removed by hand-screening.

With the second set of samples, however, the drying took place in a multiple tray drier and, after drying, the fines were removed by passing the splinters over a motor driven oscillating screen.

During this process it was found that prepared and dried splinters of coconut palm timber are rather hygroscopic and when exposed to high humidity conditions, the rate of absorption of moisture from the atmosphere is quite rapid. This means that if the dried splinters are to be stored for any length of time before pressing, they should be protected in covered containers.

BOARDMAKING

A weighed quantity of splinters was sprayed in a rotary mixer with a measured amount of urea-formaldehyde liquid resin, to which had been added a suitable hardener. After spraying, the splinters were removed from the mixer and placed in a rectangular metal mould for cold prepressing. The mould was then removed and the mat hot-pressed for 15 minutes between the platens of a single-daylight hydraulic press at a temperature of 140° C to produce particle boards 14½ inches square and ⅜ inch thick with a nominal density of 40 lbs./c.ft. These boards were later cut into smaller pieces for testing to, British Standard Specification No. 2604 : 1963.

EXPERIMENTAL

Because of the high proportion of fines produced during flaking it was decided to assess the production of fines under different conditions of splinter preparation, before proceeding with the physical tests to determine the strength of the boards. Accordingly, splinters of constant thickness 1.0 mm. and lengths of 15, 30, 45 and 60 mm. were prepared in sufficient quantities to determine the amount of fines produced and also to make particle boards from which test pieces could be cut for the determination of the Modulus of Rupture. Similar tests were done with splinters 30 mm. long, and at thicknesses of ¼, ½ and 1.0 mm.

Finally splinters were prepared 45 mm. long and ½ mm. thick, from which it was thought particle boards could be made which would combine maximum strength with minimum production of fines when using resin contents of 10.0 per cent.

These tests showed that a strong and attractive looking board could be made from coconut palm timber when using 10.0 per cent of resin without the production of excessive fines and it then became necessary to extend the investigation, in an effort to reduce the quantity of resin used. The second consignment of coconut palm timber was therefore obtained and prepared for boardmaking following, as closely as possible the methods previously adopted.

During the second series of tests a constant splinter length of 30 mm. was used and the splinter thickness and the resin content were varied. Particle thickness of 0.4, 0.6 and 0.8 mm. with resin contents of 7.0, 8.0 and 9.0 per cent were tried. Also, as the strength of particle boards containing resin contents of 7.0 per cent was found to comply with British Standards strength requirements, the screening operation was dicontinued to enable the performance of boards containing 20.0 per cent of fines to be examined.

Throughout these tests excessive dimensional changes due to water absorption were encountered and further tests were carried out using 8.0 per cent of resin to which was added proportions of 0.5, 1.0 and 1.5 per cent (by weight) of a proprietary wax emulsion known as 'Mobilcer 67' in an effort to correct this high water absorption.

TABLE 1

Condition	Resin Content per cent	Splinters Length mm.	Splinters Thickness mm.	Fines per cent	Density lbs./c.ft.	Modulus of rupture p.s.i.	Tensile stress perpendicular to plane p.s.i.	Screw holding lbs.	Water absorption per cent	Thickness swelling per cent
Screened ..	10	15	1.0	14	44.3	1910	—	—	—	—
„ ..	10	30	1.0	10	39.8	1338	Not determined	Not determined	Not determined	—
„ ..	10	45	1.0	16	43.8	2158				—
„ ..	10	60	1.0	15	44.5	2690	—	—	—	—
„ ..	10	30	0.25	22	43.7	3210	Not determined	Not determined	Not determined	—
„ ..	10	30	0.50	18	43.4	2290				—
„ ..	10	30	1.0	10	39.8	1338	—	—	—	—
„ ..	10	45	0.50	—	42.8	2230	66	129	39	—
B.S. 2604: 1963	—	—	—	—	—	2000	50	80	75	—

TABLE 2

Screened ..	9.0	30	0.4	—	40.5	2836	91	164	60	17.7
„ ..	9.0	30	0·6	—	41.3	2930	112	166	37	13.9
„ ..	9·0	30	0.8	—	40.3	2294	86	178	63	22.0
Unscreened ..	9.0	30	0.6	—	41.1	2345	135	156	26	7.5
Screened ..	8·0	30	0.4	—	41·9	2579	70	163	66	19.3
„ ..	8.0	30	0·6	—	41·1	2744	107	180	57	17.8
„ ..	8.0	30	0.8	—	40.5	2366	84	173	50	16.6
Unscreened ..	8.0	30	0.6	—	40.8	2351	92	180	36	15.8
Screened ..	7·0	30	0.4	—	40.4	2589	54	138	76	26.6
„ ..	7.0	30	0·6	—	41.4	2593	97	173	57	21.7
„ ..	7.0	30	0.8	—	40·7	2114	76	168	71	24·0
Unscreened ..	7·0	30	0.6	—	40.7	2265	79	166	37	18.2
B.S. 2604 : 1963	—	—	—	—	—	2000	50	80	75	12.0

TABLE 3

Condition	Resin Content per cent	Wax Content per cent	Splinters Length mm.	Splinters Thickness mm.	Density lbs./c.ft.	Modulus of rupture p.s.i.	Water absorption per cent	Thickness swelling per cent
Screened	8.0	0.5	30	0.6	41.9	2813	23	12.3
„	8.0	1.0	30	0.6	41.5	2600	22	6.8
„	8.0	1.5	30	0.6	42.2	3020	5	1.7

RESULTS

Table 1 shows the result of the exploratory tests carried out on particle boards made from the first sample of coconut palm timber. It will be seen that when allowance is made for differences in density the strength of the board, indicated by Modulus of Rupture, remains practically unchanged for different lengths of splinter when the thickness and resin content are kept constant. The exception is the results shown for boards made with splinters 60 mm. long. In this case special techniques were used during spraying because of the interlocking of the splinters in the rotary mixer and the results are probably not representative. The amount of fines produced when preparing splinters of different length is somewhat varied but appears to be least when the length is 30 mm. The scatter in the results of screening this material is due to the splinter like shape of the particles some of which are able to pass through the holes of the mechanical screen longitudinally. When, however, only the thickness is varied, the length and resin content remaining constant at 30 mm. and 10 per cent respectively, then as the thickness is decreased, strength of the board and the quantity of fines is increased. When 10.0 per cent of resin is used as a binder, with splinters 45 mm. long and 0.5 mm. thick, then an attractive looking particle board is produced which slightly exceeds the minimum requirements specified for resin-bonded chipboards.

Table 2 shows the test results on sample boards made from the second consignment of coconut palm timber without addition of wax emulsion. It will be seen that even when the resin content is reduced to 7.0 per cent by weight, the physical strength of the boards remains above B.S. requirements. With each of the resin concentrations considered maximum strength occurs in those boards from which the fines have been removed and when the thickness of the splinter is 0.6 mm.

When splinters 30 mm. long and 0.6 mm. thick are prepared and the fines (20 per cent) allowed to remain in the processed material (i.e. unscreened) then although the strength of the final particle board is reduced by some 15 per cent, it still conforms to B.S. strength requirements. The tensile strength in a plane perpendicular to the length or plane of the board is acceptable in each case and is greatest when the splinter thickness is 0.6 mm. but this strength is diminished slightly as the proportion of resin is reduced.

The screw-holding property of the boards does not appear to be affected by a decrease in resin content or by the presence of fines and is in all cases above British Standard requirements.

In general, however, the water absorption results are unsatisfactory except when unscreened material is used, and the thickness swelling results are still less satisfactory. Only one sample meets the requirements of the British Standards and this occurs with unscreened material containing 9.0 per cent of resin.

Finally, in Table 3, we have the results of the tests in which different proportions of wax emulsion have been used. These show that 0.5 per cent of wax added to the particles with 8.0 per cent of resin: reduces the thickness swelling to a level only slightly greater than required by the British Standard, the addition of 1.0 per cent on the other hand, is more than adequate.

CONCLUSIONS

The two samples of coconut palm timber used during the investigation were markedly different from each other in a number of respects, which resulted in considerable differences in performance from the particle boards made from them.

With 8.0 per cent of urea-formaldehyde resin binder, and between 0.5 and 1.0 per cent of wax additive mixed with splinters 30 mm. long and 0.6 mm. thick, particle boards of nominal density 40 lbs./c.ft. which meet all requirements of the British Standards can be made from coconut palm timber using normal commercial procedures.

As mentioned above, the hygroscopic properties of this timber must be taken into account when considering the industrial utilisation of the material. The protection of the dried splinters from exposure to high humidity conditions by providing covered containers or bunkers should not prove very difficult but must be planned for in terms of cost and of design of the hardware involved.

An economic assessment of the process is being worked out in detail and will form the subject of a related report.