Explosion pulp of eucalyptus [Hawaii] : A comparison with CMP and CTMP.

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ABSTRACT

Eucalyptus, a hardwood species, is a promising raw material for pulping. Ultra-high-yield pulp of eucalyptus obtained by using CTMP, CMP and explosion pulping processes shows paper of good quality. However, the explosion process shows advantage in terms of paper properties over the conventional CMP and CTMP when the pretreatment solution contains 2% or less NaOH in addition to Na_2SO_3. Mechanical properties of unbleached eucalyptus explosion pulp is comparable or equivalent to those of bleached eucalyptus kraft pulp although the properties of pulp increase after bleaching. Brightness of eucalyptus explosion pulp can be raised to a level of 83% from its initial level of 56% by applying 4% H_2O_2 in a single-stage process.

Keywords : Eucalyptus, Explosion pulp, CMP, CTMP, Impregnation, Mechanical properties, brightness and bleaching.

Introduction

The various sub-species of eucalyptus are the most common hardwood available in Australia and other tropical and sub-tropical regions of the world. Many of the Australian species have been tried for plantation development in other parts of the world, especially in South America, South Africa. and the Mediterranean (1).The most extensively used species are eucalyptus saligna, grandis and globulus. Eucalyptus saligna is fast-growing in hot and humid areas where its production rate is 10-15 t/ha. The normal rotation period is about 8 years. Due to the fast-growing characteristics and since it is well-suited to pulping, such plantations are expected to be a good way of solving future wood supply problems in tropical and sub-tropical areas where a complex mixture of indigenous hardwood is available The eucalyptus studied in this paper was procured from such a plantation in Hawaii.

The explosion pulping process (2-4), including the chemical impregnation of chips with sodium sulfite and sodium hydroxide, short duration (4 min) saturated steam cooking at 190°C, explosive pressure release, refining and bleaching has been studied for eucalyptus from Hawaii.

For hardwood, the explosion pulping process produces pulp of excellent strength while the relative specific refining energy is less than that of conventional CMP or CTMP (5,6). It was recently reported (7) that, at similar freeness and yield levels, all explosion and conventional aspen pulps exhibited similar paper properties but the relative specific refining energy of explosion pulps was 20% to 30% lower than that of conventional CMP cooked at 170°C. The objectives of this work are to study the explosion pulping of eucal-

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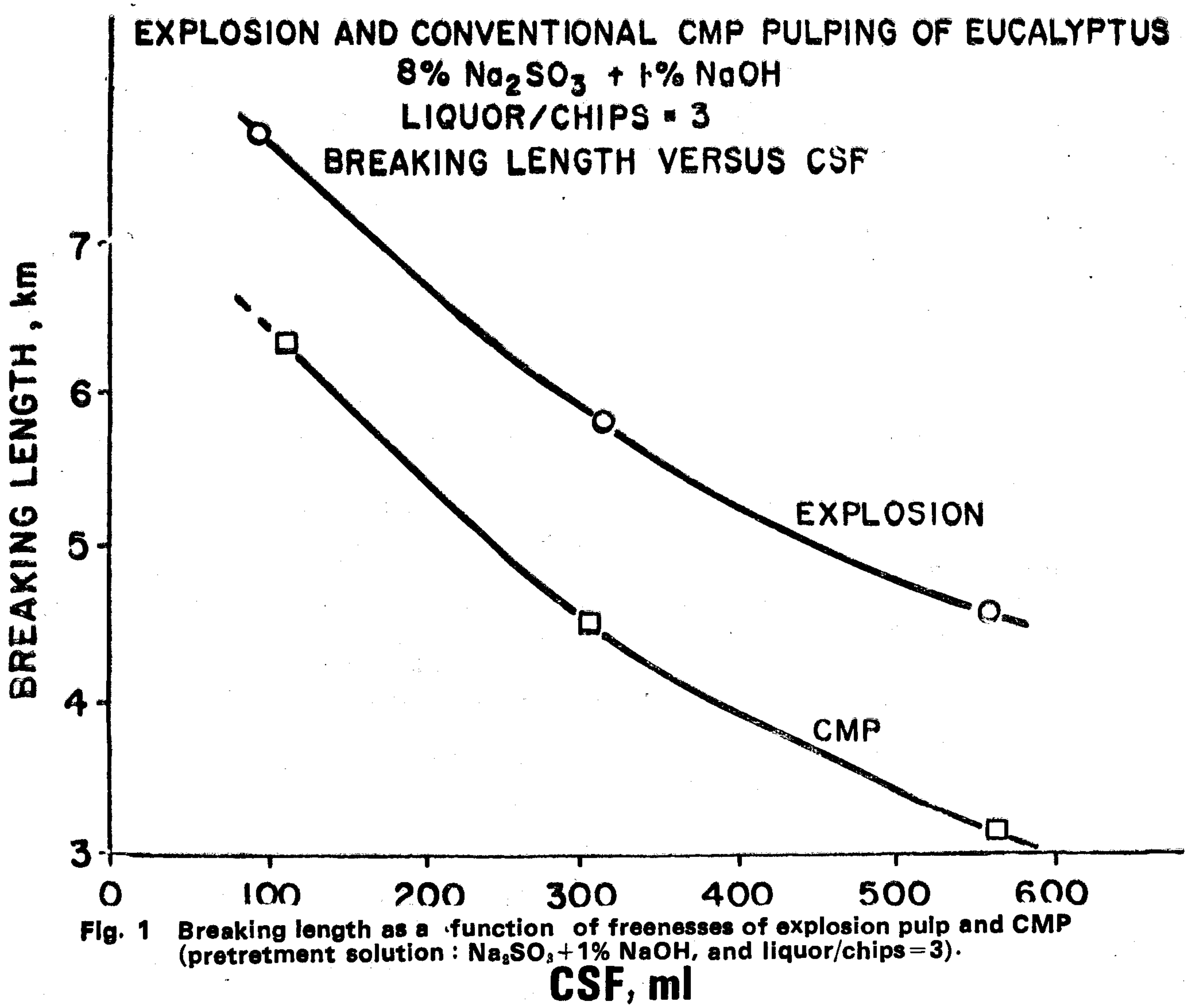


Fig. 1 Breaking length as a function of freenesses of explosion pulp and CMP (pretretment solution : Na_2SO_3+1% NaOH, and liquor/chips=3).

yptus (Hawaii) and to compare the pulp properties with that of CMP and CTMP of the same speeies.

EXPERIMENTAL

Materials : Eucalyptus supplied in log form was debarked, chipped and screened at "la Station Forestiere Duchesnay"Quebec. Average chip size, after screening, was as follows : length 2-5 to 3.75 cm, width 1 to 2 cm, thickness 1 to 9 mm.

Impregnation of chips : 177 g of chips with a moisture content of 58% were mixed in a plastic bag with 177 g of a solution. Solutions were prepared either with 8% Na_2SO_3 + 6% NaOH, 8% Na_2SO_3+4% NaOH, 8% Na_2SO_3+ 2%NaOH or 8% Na_2SO_3+1% NaOH. Impregnation time was 24 hours at 60°C.

Steam Cooking : Cooking was conducted at 190°C for 4 minutes in a laboratory-scale batch reactor designed and manufactured by Stake Technology Limited. Cooking was preceded by one minute of steam flushing at atmospheric pressure. After Cooking, the pressure was suddenly released, and the chips which exploded into the release vessel were washed and cooled with one litre of tap water and, subsequently, refined after being stored in a cold room. Cooking conditions, i,e. temperature 190°C and time 4 minutes were Selected according to previous studies (5,8). In the case of CTMP, Cooking temperature was 128°C and cooking time 10 minutes. As for CMP, cooking temperature was 150°C and cooking time 30 minutes. Yield was measured after the exploded fibers were defibrated for 3 minutes in a laboratory blender

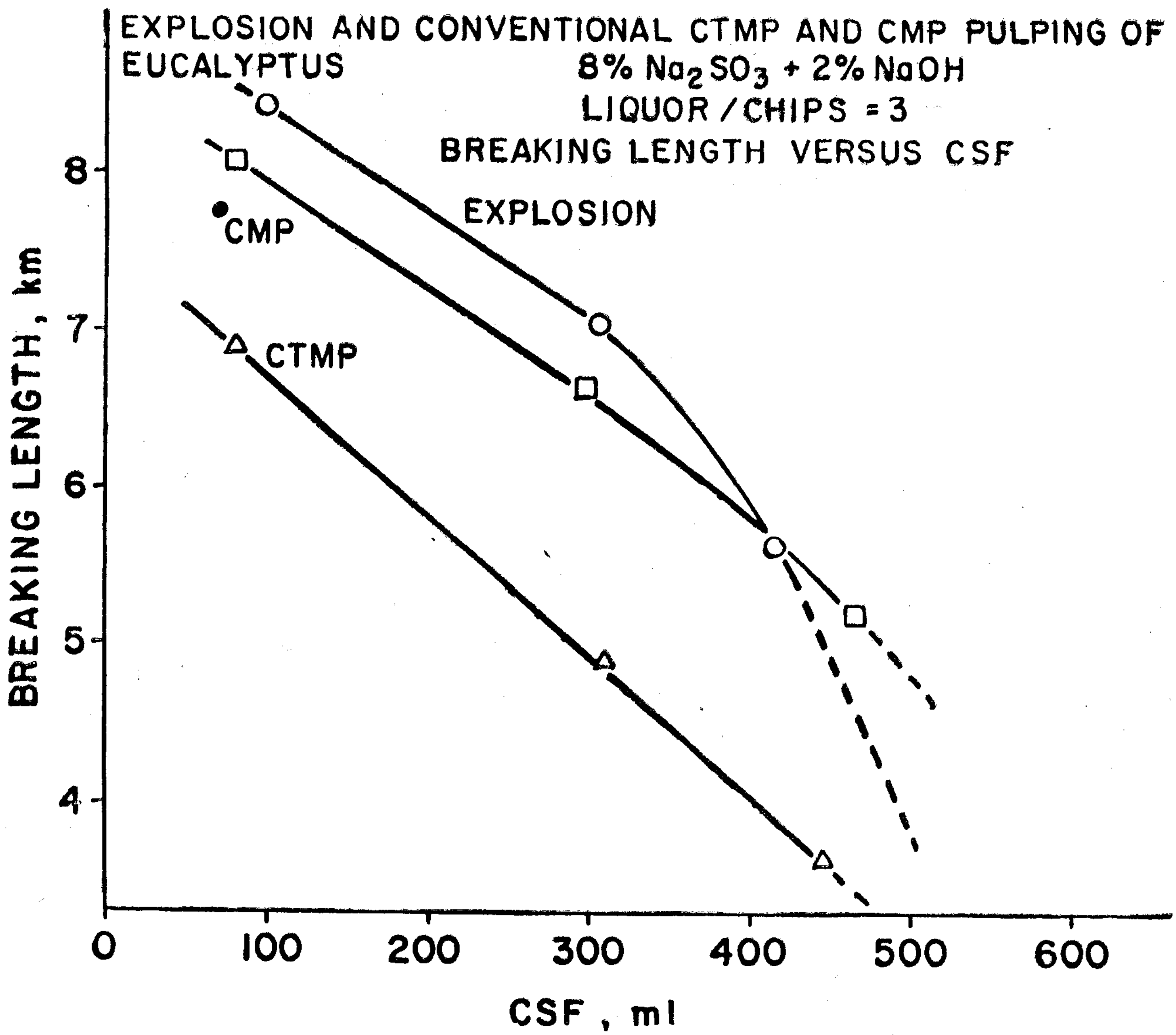


Fig. 2 Breaking length as a function of freeness of explosion pulp, CMP (pretreatment solution : 8% Na_2SO_3+2%NaOH, and liquor/chips=3)

at a 2% consistency level. The oven-dried weight of thoroughly washed pulps was related to the initial oven-dried weight of chips.

Refining : Defibration and refining of the exploded chips were performed with a domestic blender Osterizer B 8614 at a 2% consistency level. Total refining and blending energy were measured by using a HIOKI model 3181-01 wattmeter. Relative specific refining energy was calculated by subtracting the blending energy. of water-beaten fiber suspension from total refining energy. It was shown that the paper properties obtained by blender refining of mechanical (9) and explosion (5) pulps correspond well to those of pulps refined industrially or semi-industrially.

Bleaching : Explosion pulps produced from wood chips impregnated either with 8% Na_2SO_3 and 2% NaOH or with8%Na_2So_3 and6%NaOHwere chosen for the bleaching experiment. For the preparation of the samples, exploded chips were refined to 250-300 ml CSF. The pulp was then washed, filtered and pressed between two blotters to remove water in order to reach a 30% to 35% level of siccity. Finally, the pulp was separated into small pieces before bleaching chemicals were added. Eucalyptus explosion pulps were bleached by using a single-stage hydrogen peroxide bleaching process. The bleaching conditions and procedures used for CTMP (10,11) and aspen explosion pulp (11) were applied in thiscase.

Property evaluation : paper sheets were made and tested according to CPPA standard methods. The brightness (Elrepho)

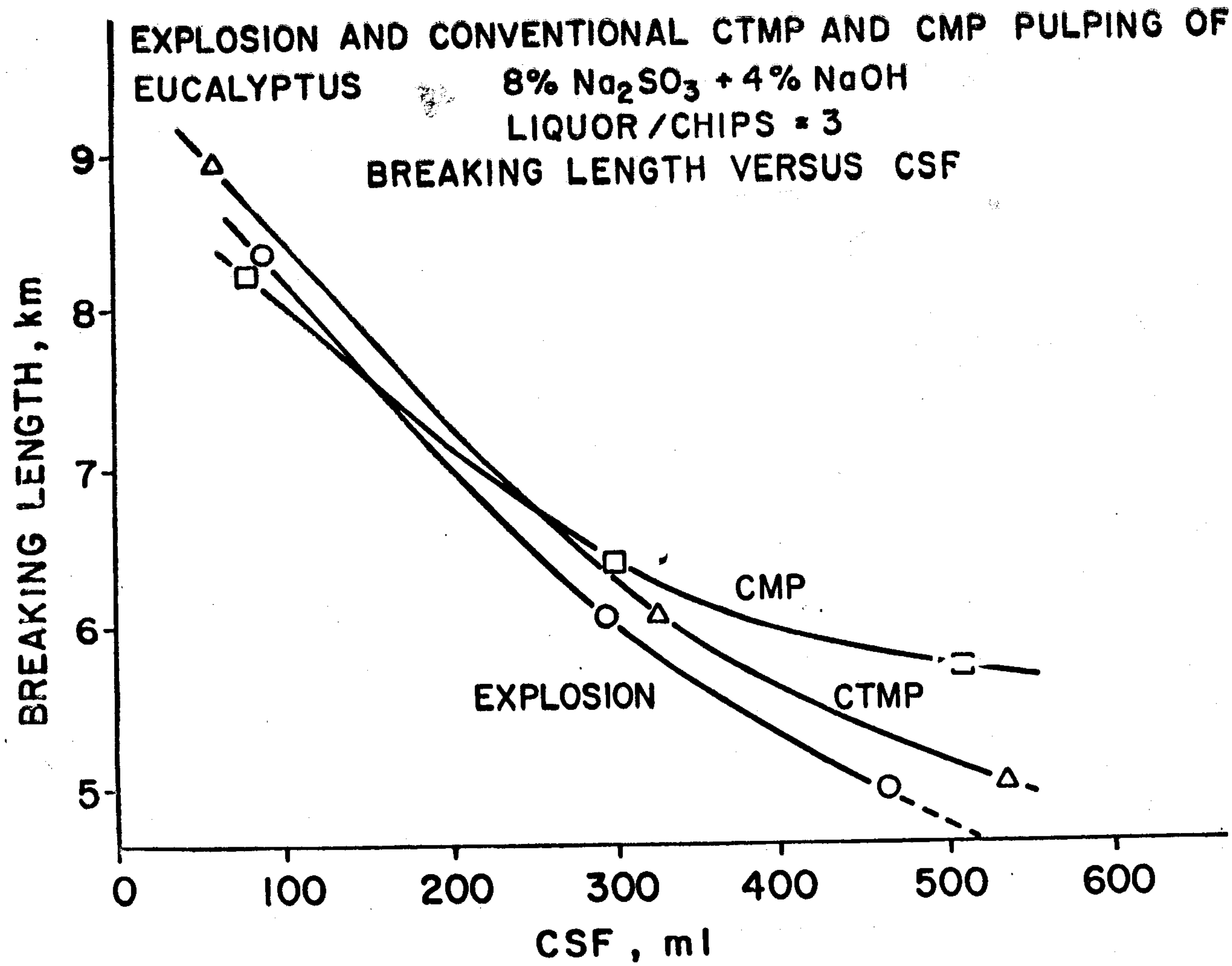


Fig. 3. Breaking length as a function of freeness of explosion pulp, CMP and CTMP (pretreatment solution : 8% Na_2SO_3+4% NaOH, and liquor/chips=3)

was measured on 1.2 g or 3 g sheets prepared with demineralized water.

RESULTS AND DISCUSSION

In Figures 1, 2 and 3 breaking length is plotted as a function of freeness for pulps obtained with the following impregnation solutions : 8% Na_2SO_3 plus 1% NaOH, 8% Na_2SO_3 plus 2% NaOH and 8% Na_2SO_3 plus 4% NaOH.

Explosion pulp provides the strongest paper for the whole range of CSF when the impregnation solution contains 8% Na_2So_3 and 1% NaOH. The difference in absolute value for breaking length among explosion pulp, CMP and CTMP decreases with an increased NaOH concentration in the impregnation.Solution All three types of pulps corresponding with an Impregnation solution of 8% Na_2SO_3 and 4% NaOH provide paper of similar breaking length for similar CSF values. Among the disadvantages of using a high concentration of caustic during impregnation are low pulp yield and brightness. In the presence of more caustic in chips, the higher pH of the cooking media cannot be reduced to the appropriate level with liberated acid during cooking. This causes severe degradation during cooking and results in low pulp yield and brightness. Figure 4 shows that property such as breaking length of ultra-high-yield pulp is not totally controlled by pulp yield. In yield range between 80 to 90%, mechanical properties of pulp are seemed to be more dependant on total ionic content, specific surfacs area and cellulose cristallanity of the pulp rather than pulp yield.

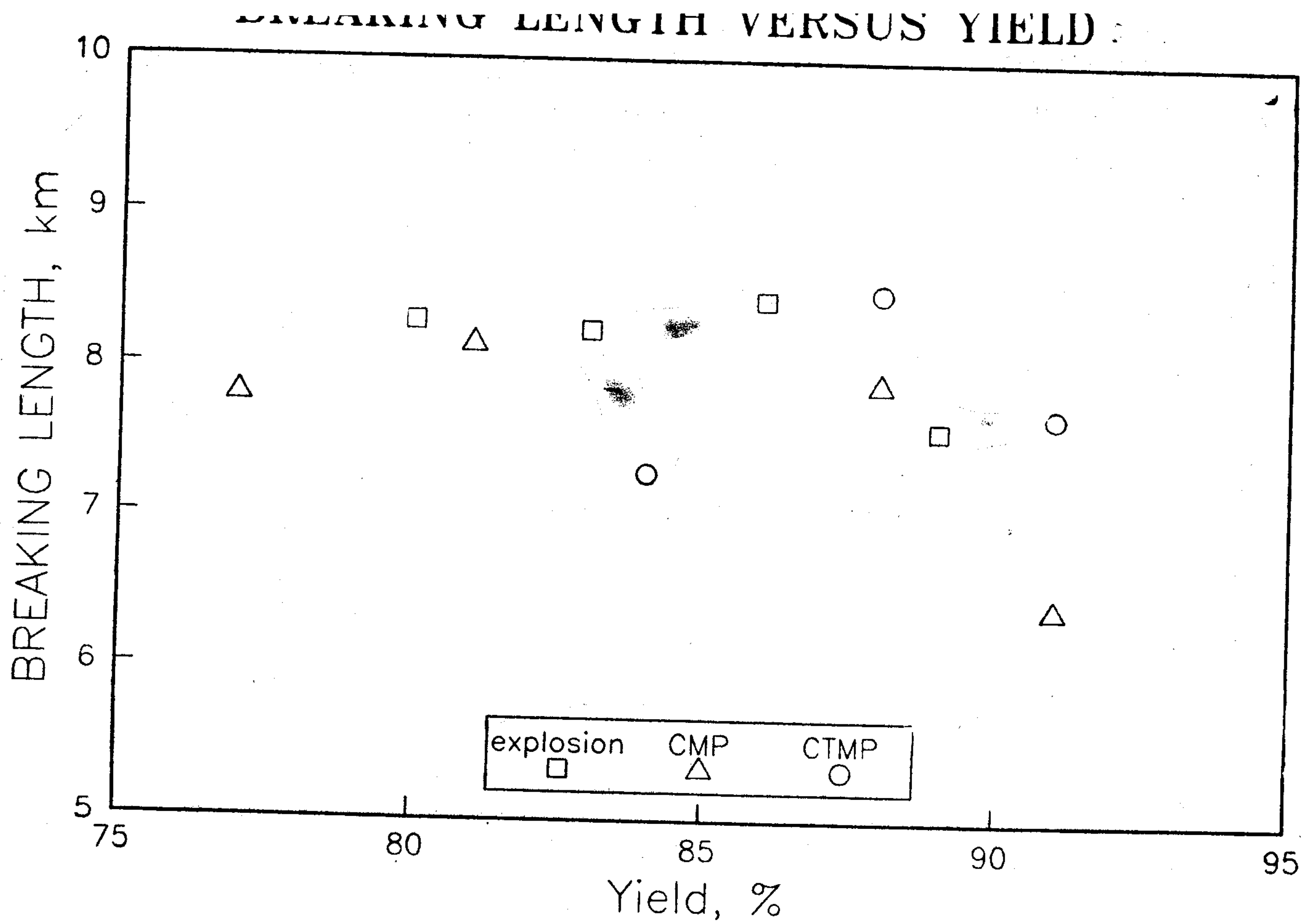


Fig. 4. Influence of pulp yield on breaking length.

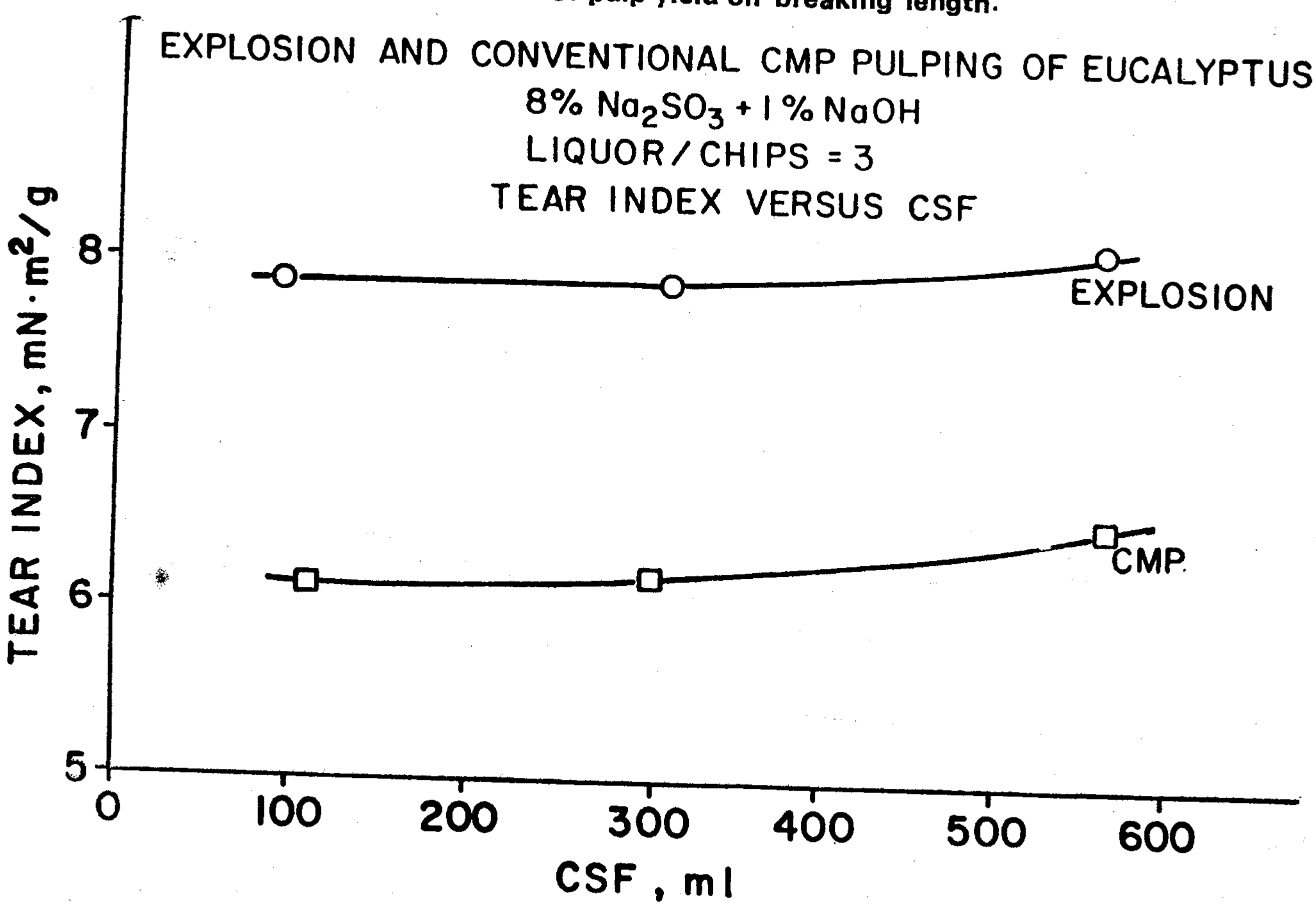


Fig. 5. Tear index as a function of freeness of explosion pulp and CMP (pretreatment solution : 8% Na_2SO_3 + 1% NaOH and liquor/chips = 3).

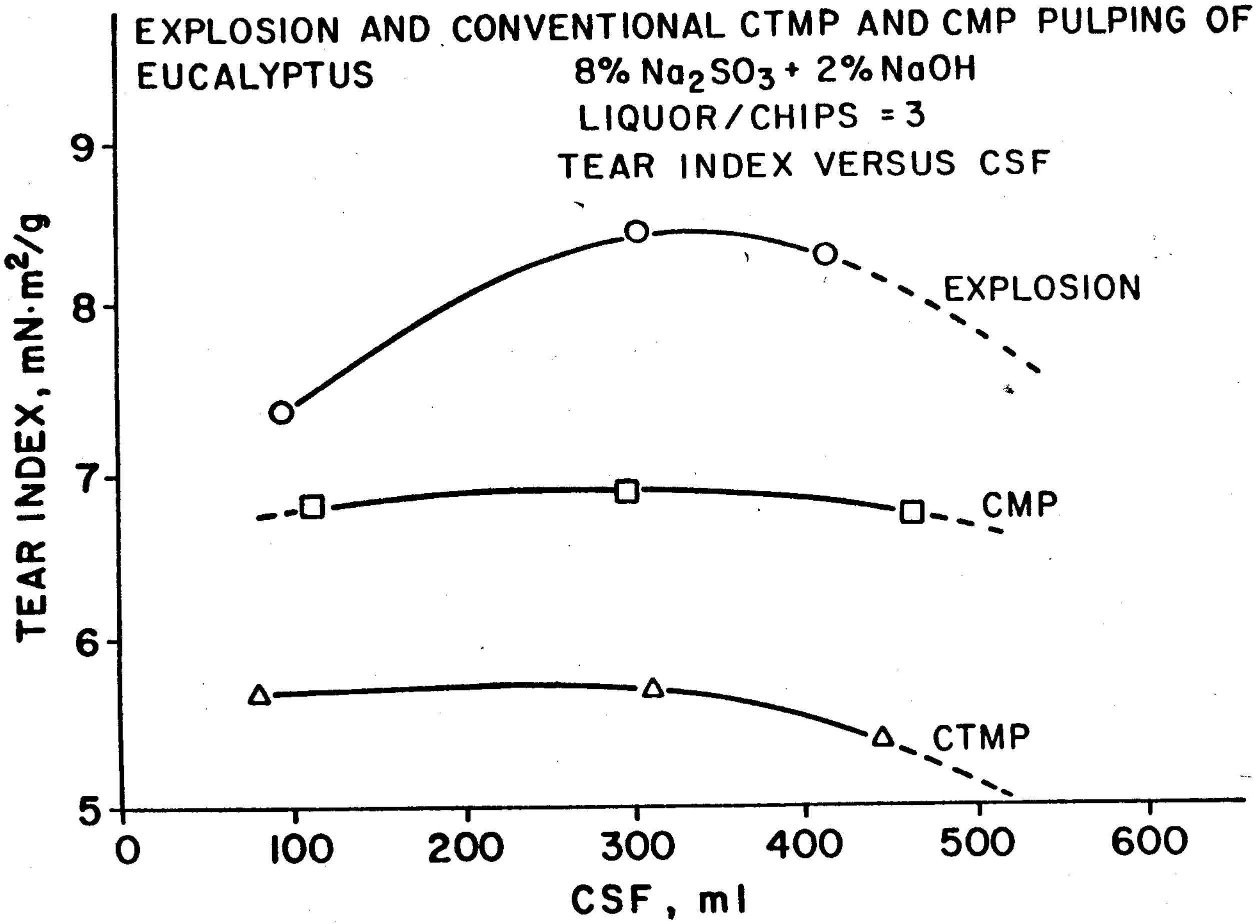
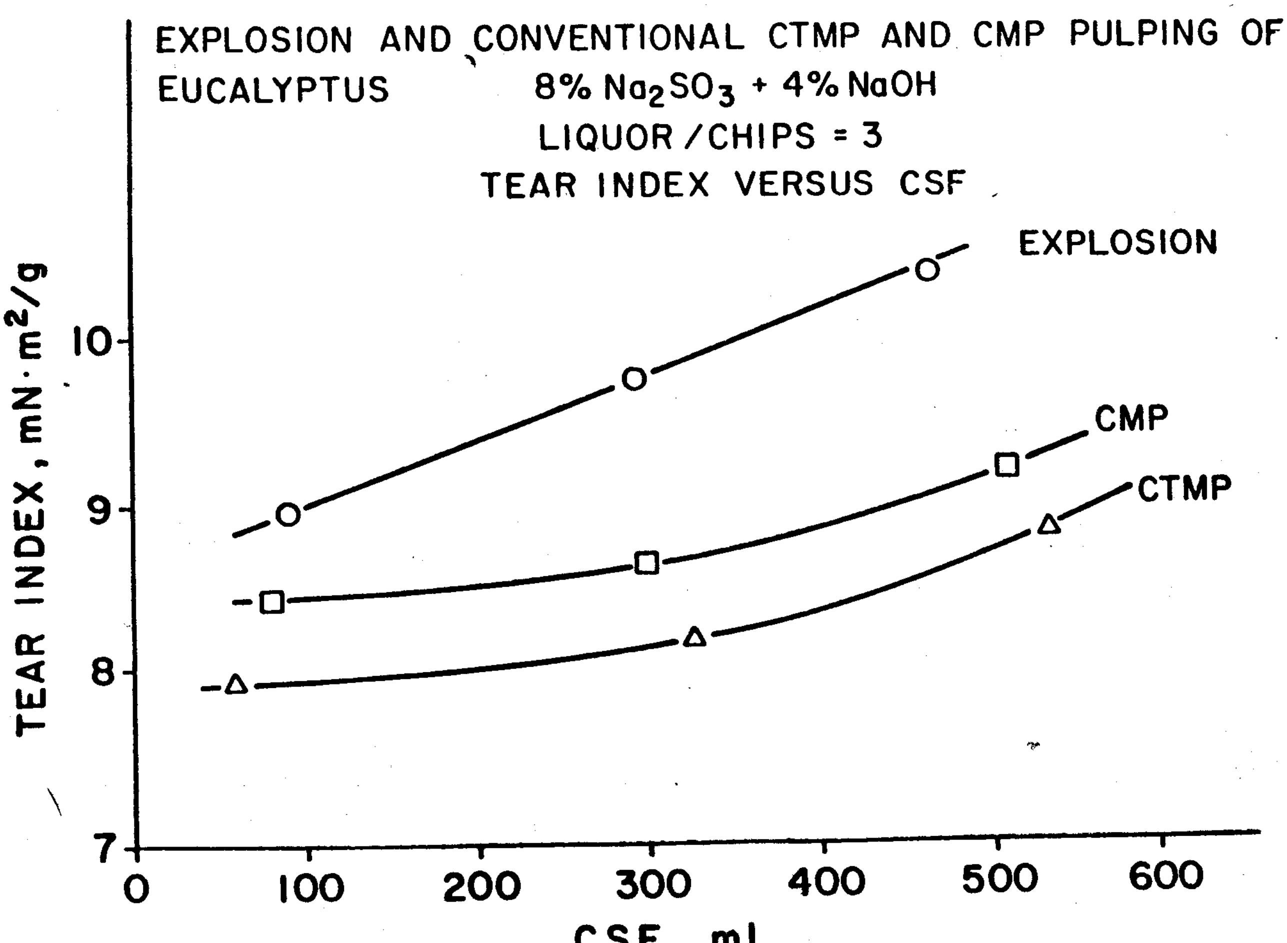


Fig 6. Tear index as a function of freeness of explosion pulp, CMP and CTMP (pretreatment solution : 8% Na_2SO_3 +2% NaOH, and liquor/chips =3).



Fig, 7. Tear index as a function of freeness of explosion pulp, CMP and CTMP (pretreatment solution : 8% Na_2SO_3 + 4% NaOH, and liquor/chips =3).

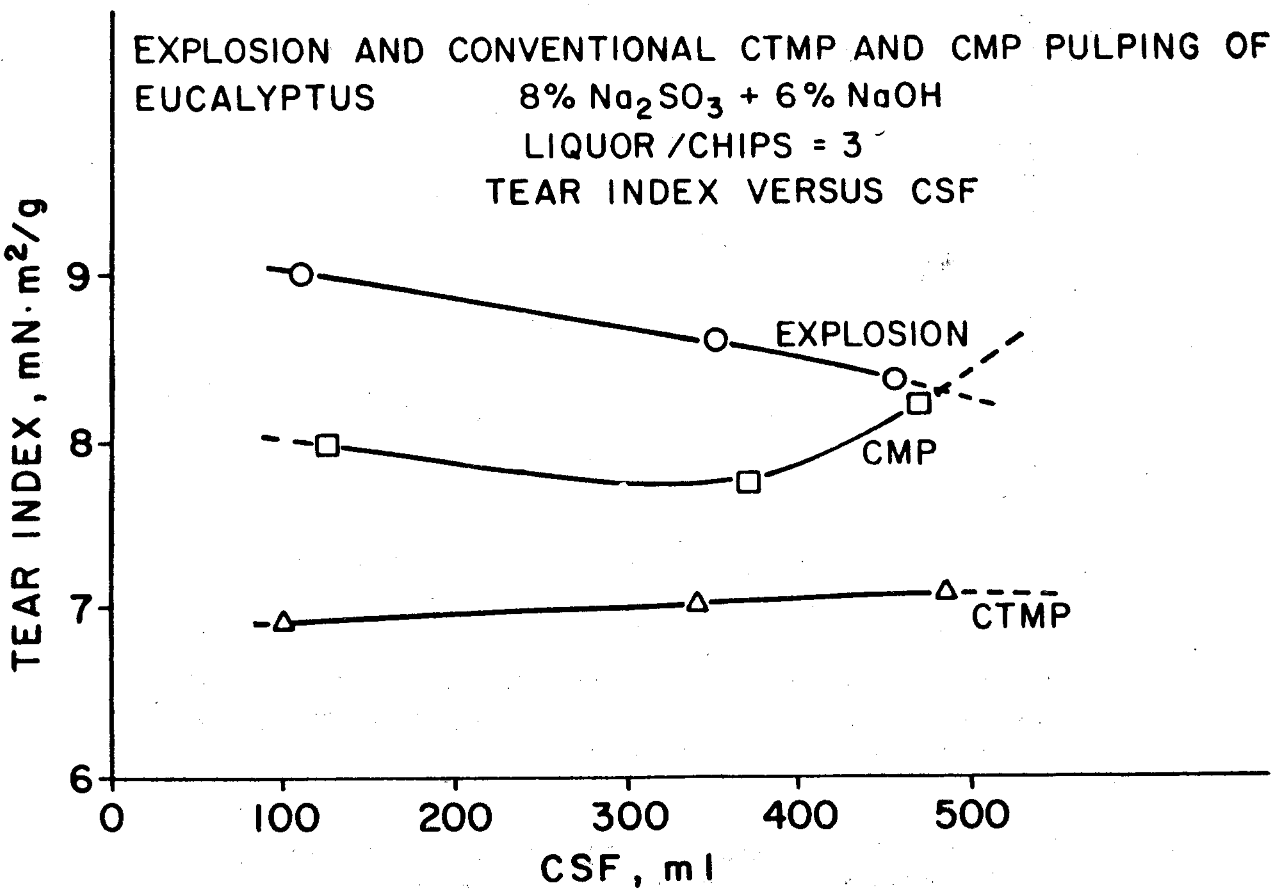


Fig. 8 Tear index as a function of freeness of explosion pulp, CMP and CTMP (Pretreatment solution : 8% Na_2SO_3+6% NaOH, and liquor/chips=3).

In Figures 5, 6, 7, and 8, tear index is plotted as a function of freeness for pulp obtained with different concentrations of NaOH in the impregnation solution. Explosion pulps show the highest tear values in all cases when compared to equivalent CMP.orCTMP. At 100 ml CSF level the absolute tear values of explosion pulp is approximately, 7.75 and that of CMP is roughly 6.1m N. m2/g, when the impregnation solution contains 1% NaOH.

Specific refining energy is plotted in Figures 9, 10 11 and 12 as a function of CSF of ,he pulp obtained from eucalyptus pretreated with an impregnation solution containing various quantities of NaOH. All three types of pulps require similar specific refining energy to reach similar CSF values. In a Previous study (13), it was observed that explosion pulp has a tremendous advantage over CMP or CTMP in specific refining energy requirements when the impregnaton solution contains only Na_2SO_3. This advantage diminishes with the increase of the NaOH proportion in the impregnation solution.

The correlations between tear index and breaking length of explosion pulp, CMP and CTMP obtained with an impregnation solution containing different amount of NaOH are presented in Figures 13, 14, 15 and 16. It is observed from these figures that explosion pulp has higher tear values than those of CMP and CTMP at similar breaking length. The difference in tear values for similar breaking length among explosion pulp, CMP and CTMP reduces with the climb in the proportion of NaOH in the solution used for the pretreatment of chips. The explosion process provides superior pulp properties e.g. breaking length and tear values compared to CMP and CTMP by consuming less chemicals during impregnation.

Specific refining energies are plotted in Figures 17, 18, 19 and 20 as a function of breaking length of explosion pulp, CTMP and CMP obtained with an impregnation solution containing various quantities of

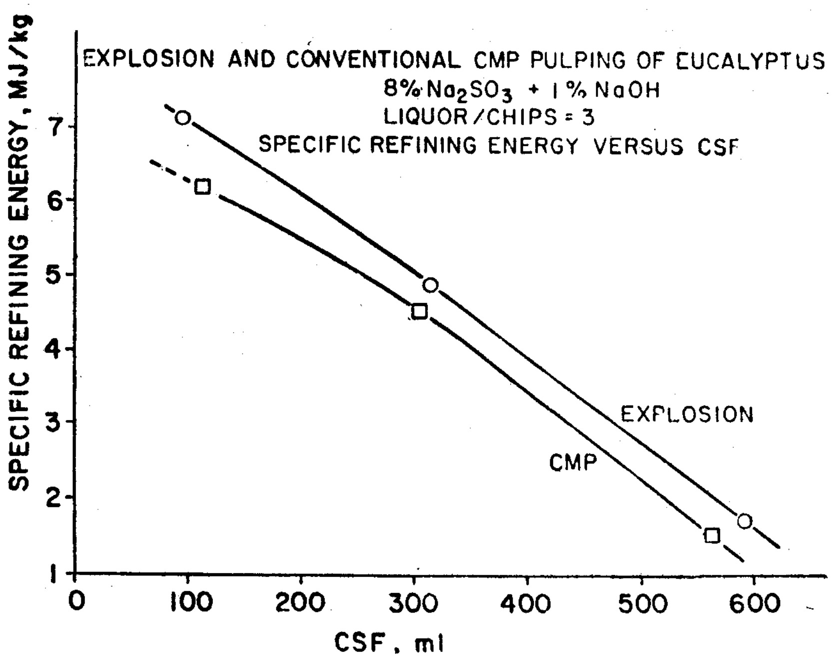


Fig. 9 Specific refining energy as a function of freeness of explosion pulp, and CMP (pretreatment solution : 8% Na_2So_3 + 1% NaOH, and liquor/chips =3).

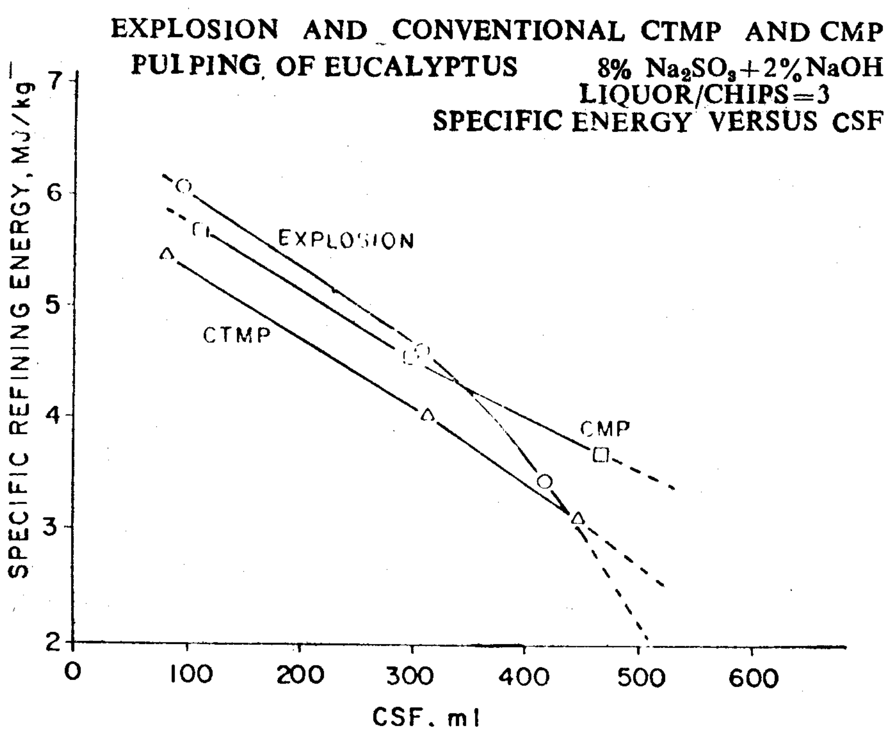


Fig. 10. Specific refining energy as a function of freeness of explosion pulp, CTMP and CMP (pretreatment solution : 8% Na_2SO_3 + 2% NaOH, and liquor/chips =3).

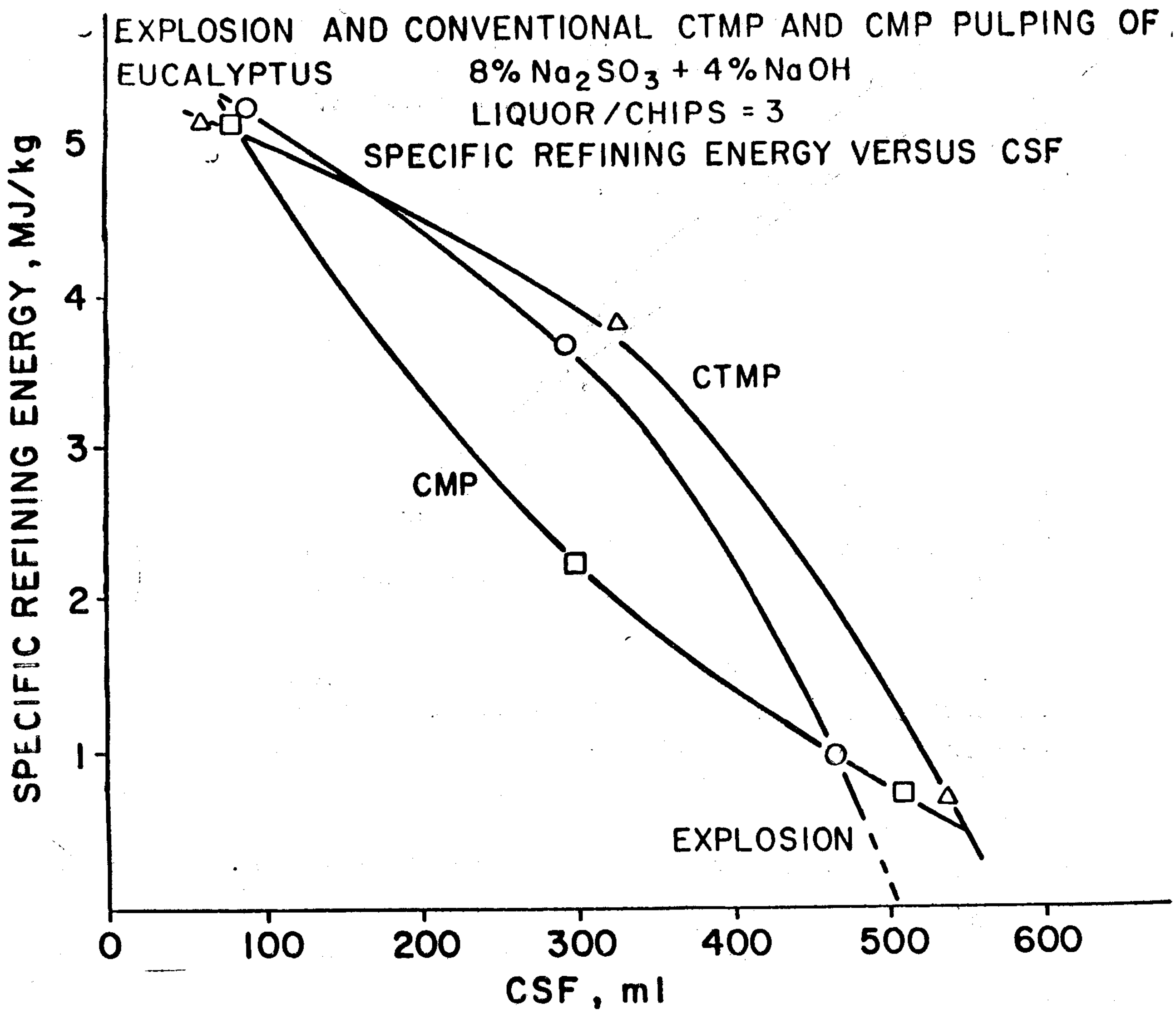


Fig. 11 Specific refining energy as a function of freeness of explosion pulp, CTMP end CMP (pretreatment solution : 8% Na_2SO_3+4% NaOH, and liquor/chips=3).

NaOH. It is clear that explosion pulp requires the lowest refining energy to achieve comparable breaking length when the impregnation solution contains 2% or less NaOH. The advantage of explosion pulp over CMP or CTMP disappears when the impregnation solution contains a high percentage of NaOH e.g. 4% or 6 %

The properties of unbleached eucalyptus explosion pulp obtained with 1% NaOH in an impregnation solution can be compared with bleached low-yield eucalyptus kraft pulp (Table 1). The unbleached eucalyptus explosion pulp has a breaking length of 6 km and tear inax of 7.a mN. m²/g at a 300 CSF level

Table 1

Comparison of eucalyptus explosion pulp with eucalyptus kraft pulp.

Properties	Euclyptus Kraft Pulp (bleached) (1)	EucalyptusExpl. pulp pulp (unbleached)
CSF	400	315
Breaking length (Km)	4	5.82
Tear Index (mN,m²/g)	5.2	7.86
Brightness (%)	81.5	62.0
Opacity (%)	86.5	94.9

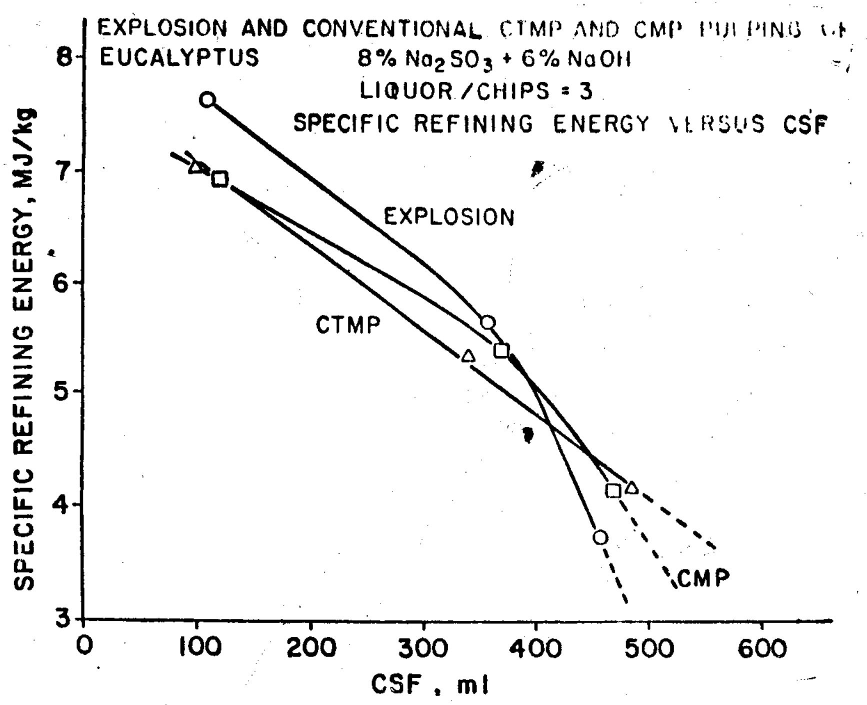


Fig. 12. Specific refining energy as a function of freeness of explosion pulp, CTMP and CMP (pretreatment solution : 8% Na_2SO_3 + 6% NaOH, and liquor/chips =3).

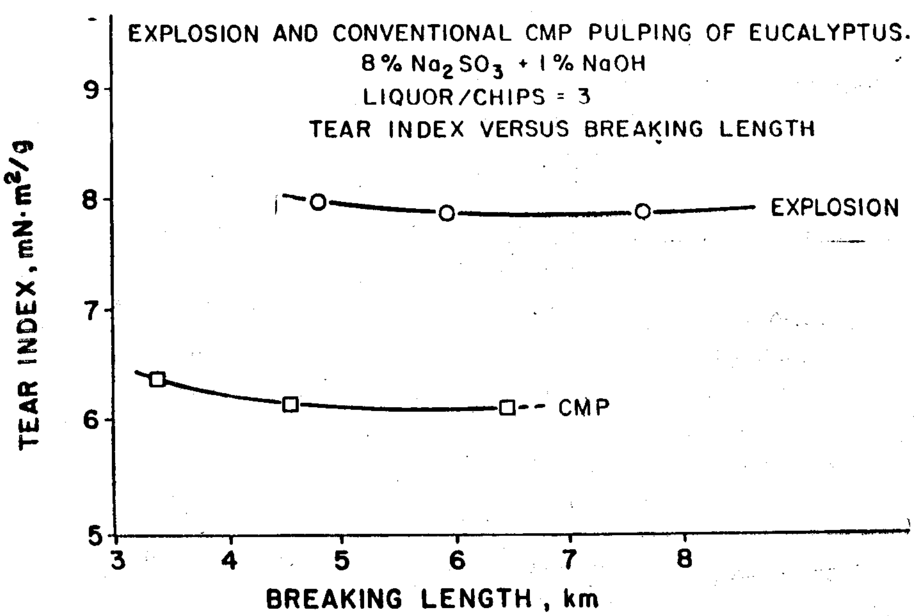


Fig. 13. Tear index as a function of breaking length of explosion pulp, and CMP (pretreatment solution : 8% Na_2SO_3 + 1% NaOH, and liquor/chips =3).

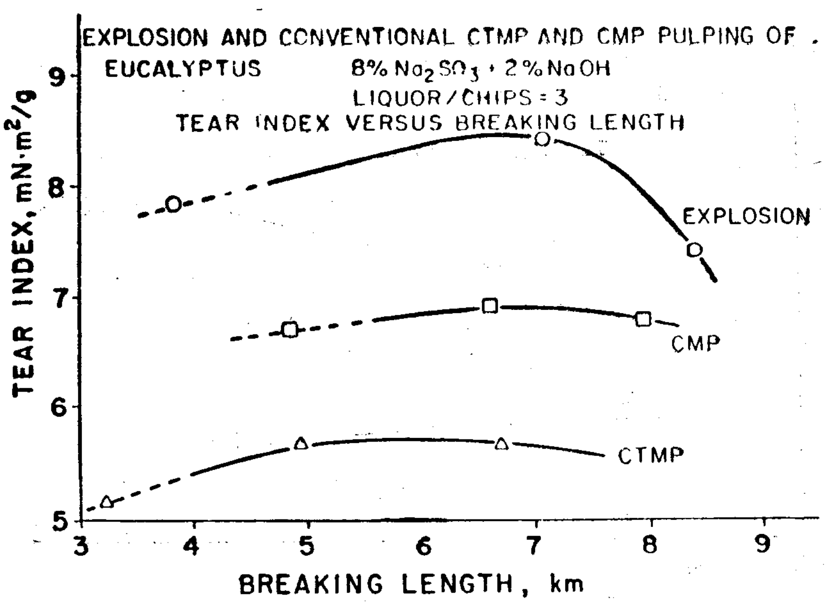


Fig. 14 Tear index as a function of breaking length of explosion pulp, CTMP and CMP (pretreatment solution : 8% Na_2SO_3 +2% NaOH, and liquor/chips = 3).

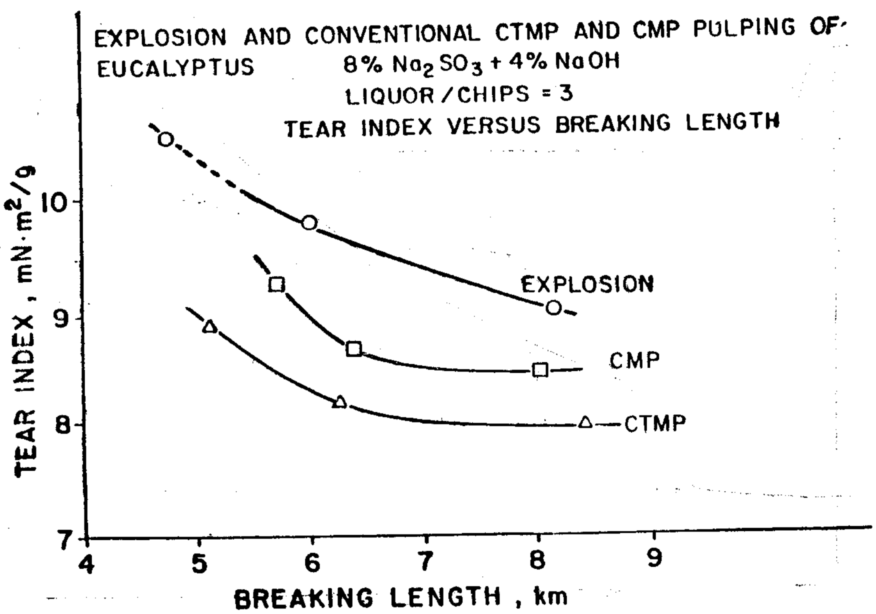


Fig. 15. Tear index as a function of breaking length of explosion pulp, CTMP and CMP (pretreatment solution : 8% Na_2SO_3 + 4% NaOH, and liquor/chips =3).

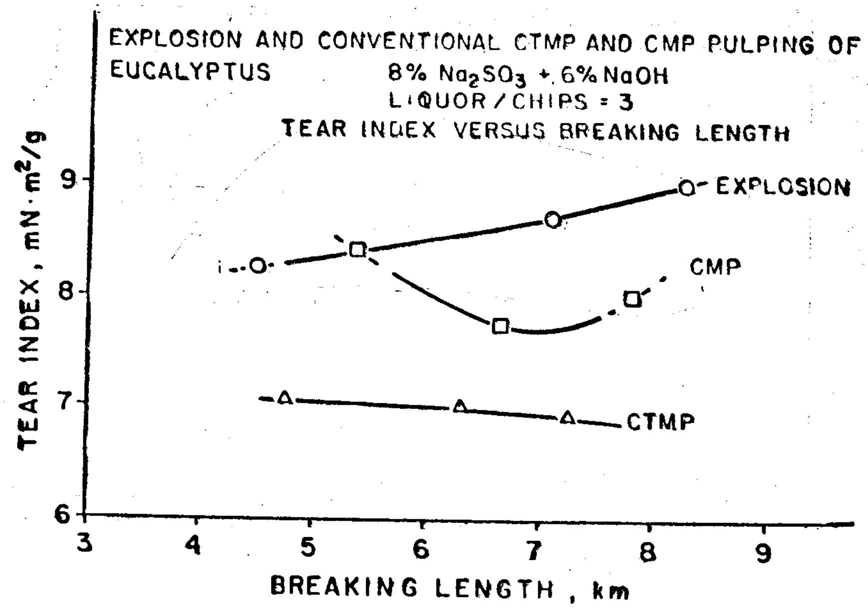


Fig. 16. Tear index as a function of breaking length of explosion pulp, CTMP and CMP (pretreatment solution : 8% Na_2SO_3 + 6% NaOH, and liquor/chips =3).

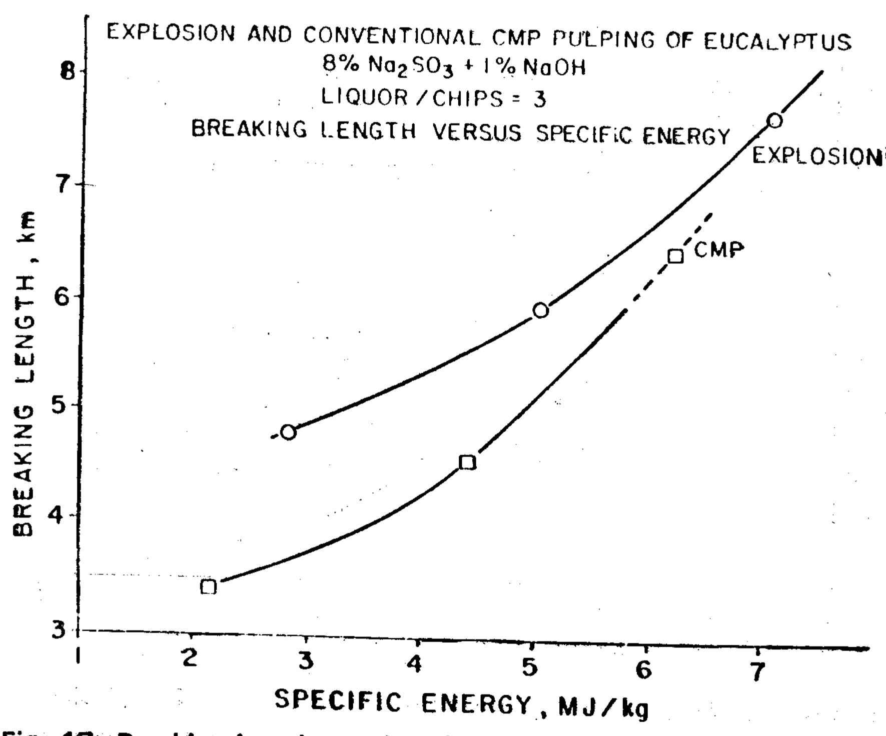


Fig. 17. Breaking length as a function of specific refining energy of explosion pulp and CMP (pretreatment solution : 8% Na_2SO_3 + 1% NaOH, liquor/chips =3).

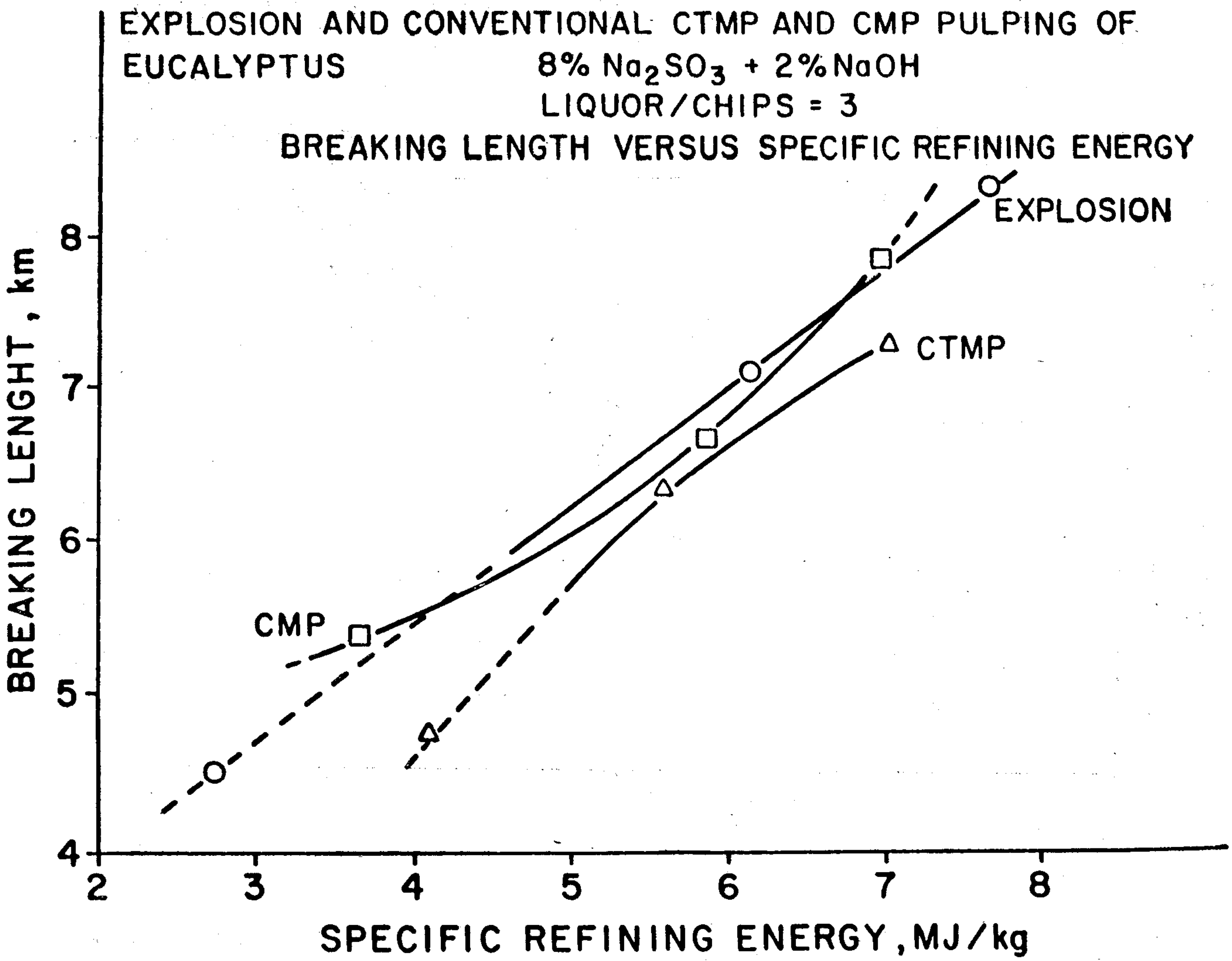


Fig 18 Breaking length as a function of specific refining energy of explosion pulp, CTMP and CMP (pretreatment solution : 8% Na_2SO_3+2% NaOH, and liquor/chips=3).

whereas the bleched eucalyptus kraft pulp exhibits a breaking length of 4 km and tear index of 5.2 mN m2./g. The bleaching process generally increases the physical properties of the pulp by 15% to 20%. The brightness of bleached eucalyptus kraft pulp (81% after reversion) and that of bleached eucalyptus explosion pulp (80% after reversion) is also comparable.

In Figures 21, 22, aod 23 long fiber fractions R14 + R28 ± R48 as well as short fiber fractions R200 + p200 were plotted against breaking length These figures offer a strong indication that paper strength can be related to the presence of long fiber as well as short fiber fractions.

Yield values of explosion pulp CMP and CTMP drop with the increase of the caustic concentration in the impregnation solution. It falls more rapidly in the case of CMP compared to explosion and CTMP with the increase of the caustic concentration in the pretreatment solution.

CTMP exhibits the most brightness in comparison with explosion pulp and CMP. Explosion pulp and CMP both show similar brightness when the chips are pretreated with the same chemical solution. The brightness drops drastically with the rise in the caustic concentration in the solution.

H_2O_2 bleaching conditions described in reference

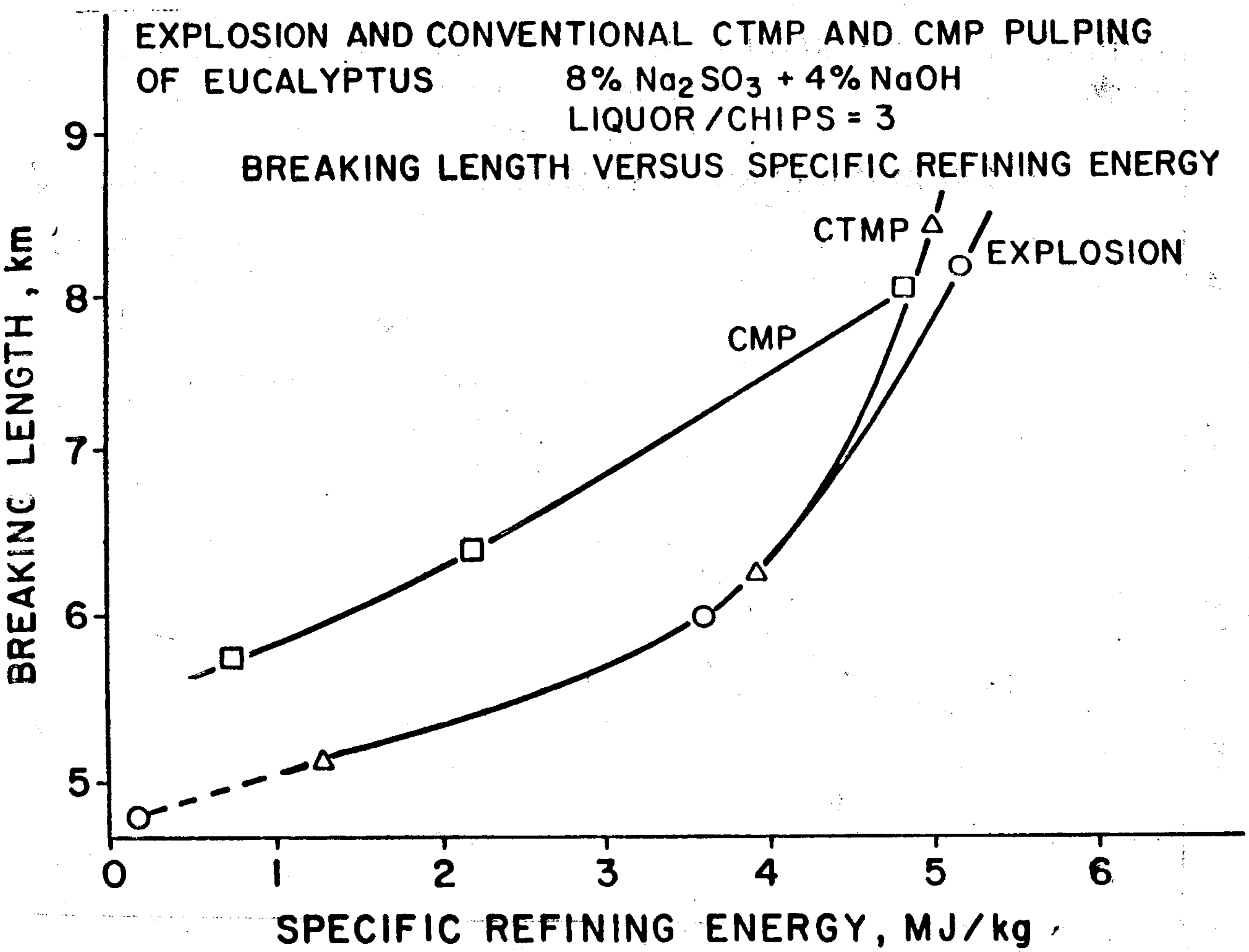


Fig. 19 Breaking length as a function of specific refining energy of explosion pulp, CTMP and CMP (pretreatment solution : 8% Na_2SO_3+4% NaOH, and liquor Chips=3).

(12) were applied. Brightness and brightness stability of explosion pulp are presented in Table 2. It is clear that a one-stage brightenning of explosion pulp with 4% H_2O_2 can bring the brightness level from its initial level of 56% to 81%. However, this brightness of the bleached pulp drops to 80% after brightness reversion at 105°C for 60 minutes. Preliminary results- indicate that the brightness of explosion pulp having a low initial level of brightness (42% to 46%) can be raised further by 18 to 24 points by varying the concentration of H_2O_2 and NaOH.

CONCLUSION

Explosion pulping of eucalyptus results in excellent paper properties Explosion pulping has revealed itself to have a tremendous advantage over conventional CMP&CTMP when the impregnation solution contains 2% or less NaOH. It is necessary to optimize the alkali concentation of the impregnation solution to provide the explosion pulping process with a real advantage. Breaking length and tear index of unbleached eucalyptus explosion pulp is comparable or equivalent to those of bleached eucalyptus kraft pulp, although the properties of pulp increase by 15%-20% after bleaching. Resulting yield of eucalyptus explosion pulp is expected to rise further in industrial production where higher temperature (195°C to 200°C) and shorter time spans (60 to 45 sec) prevail. It is also expected that an unbleached brightness level of 57% would increase in industrial production by nearly 60% and bleached brightness would rise to a 80% to 83% level with 3.5-4.5% H_2O_2 applied.

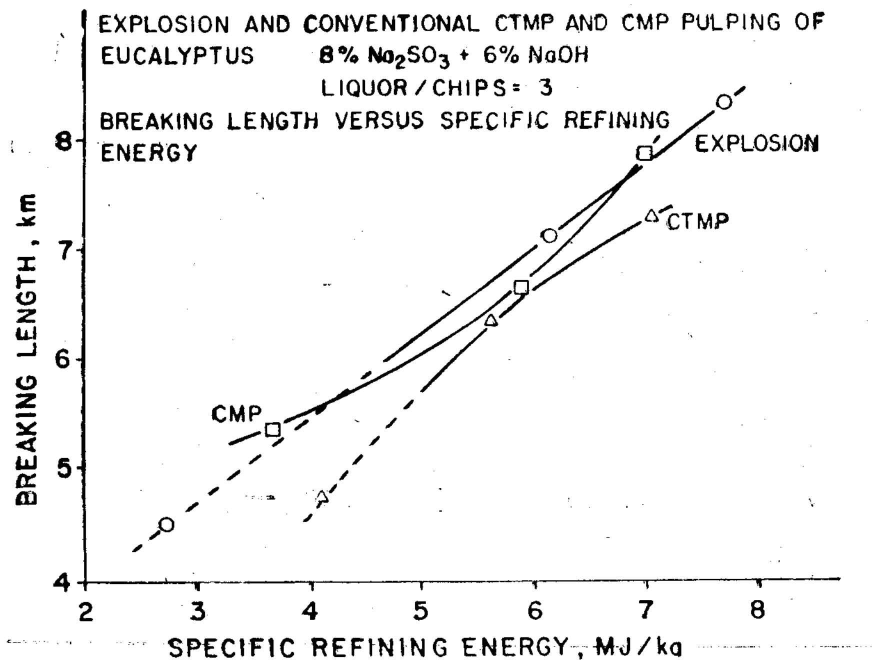


Fig.20—Breaking length as a function of specific refining energy of explosion pulp. CTMP and CMP (pretreatment solution: 8% Na_2SO_3 +6% NaOH, and liquor/chips=3)

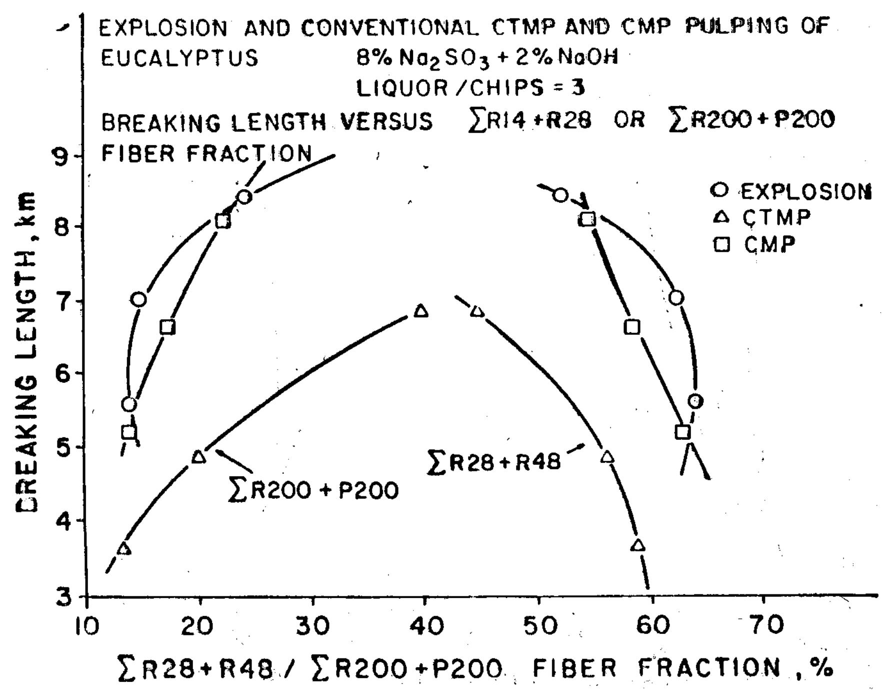


Fig. 21 Effects of fiber fraction (R28+R48 or R200+P200) on the breaking length of explosion pulp, CTMP and CMP (pretreatment solution: 8% Na_2SO_3 + 2% NaOH and liquor/chips = 3).

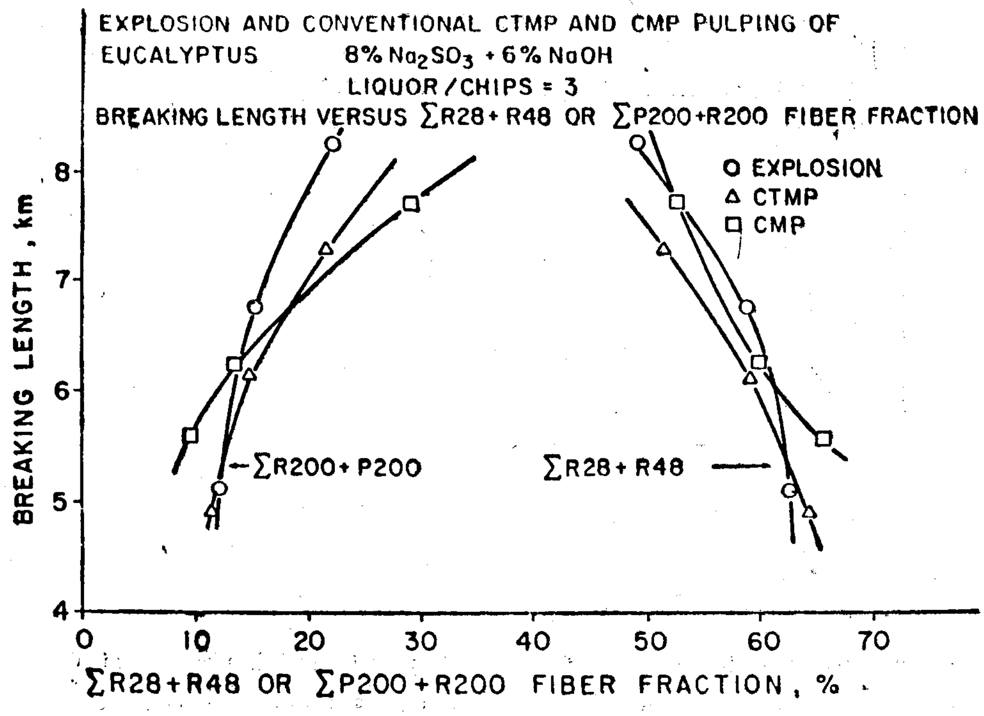


Fig. 22 Effects of fiber fraction (R28+R48 or R200+P200) on the breaking length of explosion pulp, CTMP and CMP (pretreatment solution : 8% Na_2SO_3 + 4% NaOH, and liquor/chips =3).

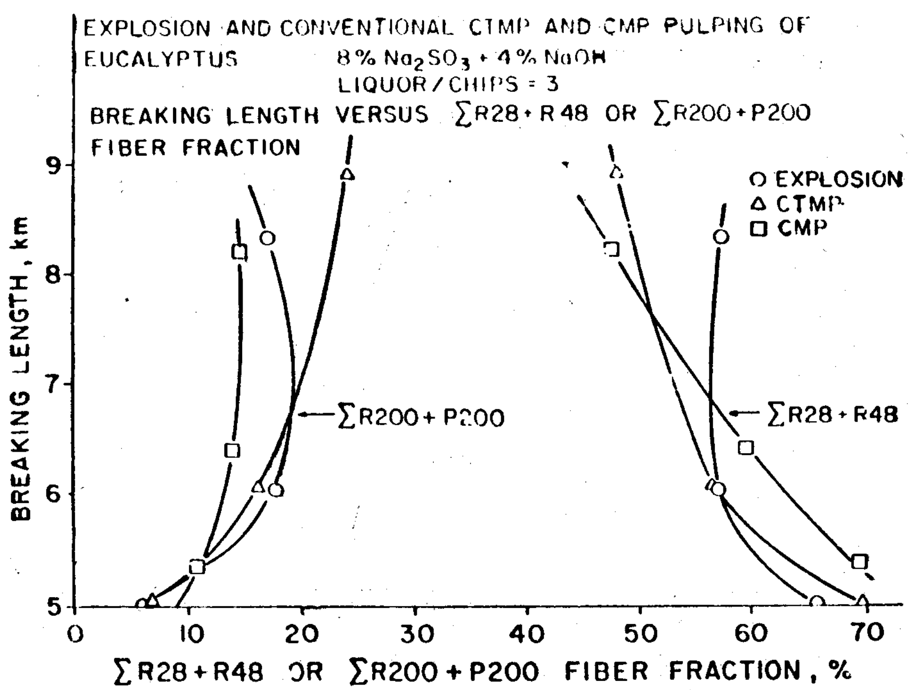


Fig. 23. Effects of fiber fraction (R28+R48 or R200+P200)on the breaking length of explosion pulp, CTMP and CMP(pretreatment solution : 8% Na_2SO_3 + 6% NaOH, and liquor/chip s=3.)

TABLE 2

Hydrogen peroxide bleaching of explosion pulp prepared from eucalyptus pretreated with 8% Na_2SO_3 and 6% NaOH.

	Explosion (1)		Explosion (2)	
DTPA (%)	0.5	0 5	0.5	0.5
$MgSO_4$ (%)	0.05	0.05	0.05	0 05
Na_2SiO_3 (%)	5-0	5.0	5.0	5 0
NaOH (%)	0.5	1.0	1.0	2 0
H_2O_2 (%)	4.0	6.0	4.0	6 0
Temperature, °C	80	80	80	80
Time, min	240	240	240	240
pH initial	9.8	10.1	10.3	10.4
pH final	8 6	8.8	9 0	9 3
Residual H_2O_2(%)	2.02	2.6	1.47	1.55
pulp CSF, ml	355	355	305	305
Original brightness(%) (1.2 g sheet)	39.9	39.9	54.2	54.2
Original brightness(%) (3 g sheet)	42.3	42.3	56.8	56.8
Bleaching brightness(%) (1 2 g sheet)	57.5	60.8	78.9	76.2
Bleaching brightness(% (3 g sheet)	59.2	62.8	81.3	77,9
Reverted brightness(%)	59 3	62.6	80.4	77.4
Original opacity (%	98.5	98.5	92.7	92.7
Opacity (%) (after bleaching)	89.3	87.5	80.5	82 4
Light Scatt. Coef. (%	578	578	437	437
Light Scatt. Coef. (%) (after bleaching)	452	446	407	437
Bleaching yield (%)	92.1	94.1	95.2	93.3

Explosion (1) : impregnation solution 8% Na_2SO_3 and 6% NaOH

Explosion (2) : impregnation solution 8% Na_2SO_3 and 2% NaOH

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