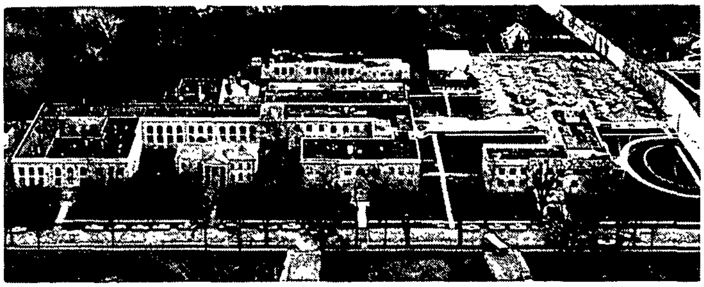

THE INSTITUTE OF PAPER CHEMISTRY, APPLETON, WISCONSIN

# PULPING CHARACTERISTICS OF POPULUS TRISTIS WHOLE-TREE CHIPS

## PULPING & BLEACHING PROPERTIES

Project 3364

Report Four

A Progress Report

to

MEMBERS OF THE INSTITUTE OF PAPER CHEMISTRY

and

THE UNITED STATES FOREST SERVICE

December 28, 1981

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

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## PULPING & BLEACHING PROPERTIES


### SUMMARY

This report describes the results of kraft pulping to kappa No. 17 of whole-tree chips, as such, and after separation into fractions labeled accepts, rejects, and fines, respectively. The separation was accomplished in a vacuum airlift segregator (VAS). Included in the pulping evaluation was a 50/50 mixture of jack pine and accepts. The cooked pulps were evaluated in terms of yield, reject levels, and handsheet strength properties after beating in a PFI mill. In addition, the pulps were also bleached using a CEHD sequence to determine their response with respect to shive (or dirt) removal and brightness.

In general, all pulps except the fines cooked at the same rate and gave similar yields and reject levels. The fines cooked at a much slower rate and gave a significantly lower yield. No further evaluation of the fines material was made. Both the physical properties and the bleach response of pulps prepared from the segregated materials were similar to those of pulps from the whole-tree chips. Thus, using unfractionated whole-tree chips offer the best means of utilizing this resource.

## INTRODUCTION

The pulping and bleaching study described in this report was an investigation of the utilization of _Populus tristis_ whole-tree and segregated whole-tree chips as a papermaking pulp. The separation of whole-tree chips into fractions was accomplished using a vacuum airlift segregator that gives three fractions: accepts, a fraction that has higher wood and lower branch and bark composition than the original whole-tree chip mixture; rejects, consisting of some wood, but higher bark and branch content; and fines, material that passed through the belt screen.

The objective and experimental design are described in a memo from D. Einspahr to T. McDonough dated September 3, 1980. A series of kraft cooks to kappa No. 17 were done and the pulp quality determined by measuring handsheet strength properties. A standard CEHD bleach sequence was used to evaluate the bleachability of the pulp.

## EXPERIMENTAL

### CHIP PREPARATION

Frozen chips labeled whole tree, VAS accepts, VAS rejects and VAS fines were supplied by the Forest Biology Section. The frozen chips were thawed and then air dried for storage.

### PULPING

The IPC multiunit digester was used to establish the appropriate cooking conditions (Table I) to achieve a target kappa number of 17, and the large-scale cooks (Table II) were done in a 2-cu ft recirculating digester. The description of the pulping for both the multiunit digester and the 2-cu ft digester are described in earlier reports (Project 3409).

Pulp from the large-scale cooks was screened over a 0.006-inch-cut valley flat screen and the reject level determined as the oven-dried material left on the screen. The fiber was partially thickened on a muslin-covered wash box, then transferred to a bag of finely woven nylon cloth where some water was removed by centrifugation. The pulp cake was broken up mechanically and the wet crumbs packed in polyethylene bags for storage. Representative samples taken at this time were weighed, oven dried and reweighed to allow calculation of yields.

The physical properties (Table III) of the pulps were determined according to Tappi Standard Methods after beating in a PFI mill at 10% consistency.

EXPLORATORY

TABLE I PULPING DATA (MULTIUNIT DIGESTER)

| | H Factor | Kappa No. | Yield, % |
|---|---|---|---|
| | 1000 | 26.0 | 49.8 |
| | 1100 | 22.4 | 53.8 |
| | 1200 | 22.5 | 49.4 |
| VAS Accepts | 1400 | 20.1 | 50.1 |
| | 1600 | 18.1 | 49.6 |
| | 1800 | 16.7 | 50.2 |
| | 2000 | 17.4 | 46.2 |
| VAS Rejects | 1800 | 17.8 | 50.4 |
| | 2200 | 18.1 | 49.1 |
| VAS Fines | 1800 | 34.7 | 32.5 |
| | 2400 | 34.4 | 32.0 |
| Whole Tree | 1800 | 17.8 | 49.3 |
| | 2400 | 16.4 | 50.2 |

| Conditions: | | |
|---|---|---|
| | Wood Charge | 60 |
| | L/W | 4/1 |
| | E.A., % | 13.5 |
| | S , % | 20 |
| | Temp., °C | 172 |
| | Time to temp, min. | 90 |

BLEACHING

The bleaching conditions and charges for a CEHD sequence are shown in Table IV. Each bleaching run was done in heat-sealable, polyester bags. The required amount of crumbed pulp was placed in a suitably sized polyester bag, and a specified amount of bleach solution, diluted with deionized water to give the final bleach consistency, was added. The contents of the bag were heat sealed and the bag kneaded to disperse the bleach chemical. The bags were then maintained at the temperature specified in a constant temperature bath for the required time. Upon

TABLE II PULPING DATA FROM 2-CU. FT. DIGESTER

| | Effective Alkali, % | Sulfidity, % | Kappa No. | H Factor | Screened Yield, % | Rejects, % | End pH |
|---|---|---|---|---|---|---|---|
| | 13.5 | 20 | 23.3 | 1854 | 51.0 | 1.35 | 12.6 |
| VAS Accepts | 13.5 | 20 | 22.2 | 2200 | 52.7 | -- | 12.1 |
| | 16.0 | 25 | 18.4 | 2000 | 47.9 | 0.40 | 13.1 |
| VAS Rejects | 16.0 | 25 | 17.7 | 2000 | 44.5 | 0.61 | 13.1 |
| Whole Tree | 16.0 | 25 | 17.8 | 2000 | 47.8 | 0.40 | 13.1 |
| 50% VAS Acc.+ 50% VAS Rej. | 16.0 | 25 | 18.6 | 2000 | 46.2 | 0.32 | 13.1 |

Conditions:

| | |
|---|---|
| Wood Charge, kg | 40 |
| L/W | 4/1 |
| Temp., °C | 172 |
| Time to temp., min | 90 |

TABLE III PHYSICAL PROPERTIES OF UNBLEACHED PULPS

| Pulp Sample | Kappa No. | Nos. of Revs. | C.S.F., mL | Density, g/cc | Burst Factor | Tear Factor | Breaking Length, km | TEA kg. m/m² | 2s-Breaking Length, km | Stretch, % | Shives, M² |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Whole Tree | 17.8 | 0 | 485 | 0.628 | 30.9 | 62.4 | 6.32 | 1.81 | 18.06 | 1.41 | 5600 |
| | | 250 | 420 | 0.675 | 41.6 | 61.9 | 7.19 | 2.37 | 19.09 | 1.59 | 3700 |
| | | 750 | 360 | 0.694 | 49.4 | 61.3 | 8.30 | 3.73 | 18.87 | 2.13 | 2900 |
| | | 2000 | 290 | 0.720 | 56.9 | 62.5 | 8.98 | 4.79 | 19.12 | 2.44 | 1900 |
| | | 4250 | 220 | 0.742 | 61.8 | 63.5 | 8.92 | 4.87 | 19.22 | 2.52 | 1900 |
| VAS Accepts | 18.4 | 0 | 480 | 0.667 | 31.9 | 55.1 | 6.84 | 2.18 | 18.12 | 1.53 | 600 |
| | | 250 | 425 | 0.694 | 43.2 | 58.1 | 7.77 | 2.96 | - | 1.82 | 200 |
| | | 750 | 375 | 0.713 | 52.9 | 60.2 | 8.49 | 3.81 | 19.78 | 2.12 | - |
| | | 2000 | 290 | 0.744 | 58.4 | 62.2 | 9.56 | 5.73 | 19.49 | 2.80 | 200 |
| | | 4250 | 235 | 0.763 | 63.1 | 62.6 | 8.85 | 4.63 | 19.70 | 2.42 | 100 |
| VAS Rejects | 17.7 | 0 | 465 | 0.590 | 28.0 | 52.7 | 6.07 | 1.99 | 16.90 | 1.56 | 4400 |
| | | 250 | 380 | 0.621 | 38.2 | 54.8 | 7.26 | 3.15 | 17.93 | 2.00 | 2900 |
| | | 750 | 330 | 0.638 | 43.2 | 57.1 | 7.78 | 4.22 | 17.23 | 2.47 | 2600 |
| | | 2000 | 275 | 0.653 | 49.3 | 65.2 | 8.30 | 4.62 | 17.82 | 2.56 | 3100 |
| | | 4250 | 220 | 0.670 | 54.0 | 65.6 | 8.26 | 5.18 | 18.00 | 2.66 | 700 |
| VAS Rejects + VAS Accepts (50:50 wt/wt) | 18.6 | 0 | 485 | 0.633 | 32.2 | 54.1 | 6.63 | 2.26 | 17.78 | 1.63 | 3300 |
| | | 250 | 420 | 0.656 | 41.3 | 54.9 | 7.26 | 2.84 | 18.30 | 1.83 | 2200 |
| | | 750 | 370 | 0.676 | 49.8 | 58.9 | 8.53 | 4.08 | 19.12 | 2.26 | 1400 |
| | | 2000 | 295 | 0.698 | 55.4 | 60.2 | 8.59 | 4.79 | 19.05 | 2.55 | 1400 |
| | | 4250 | 235 | 0.727 | 61.0 | 62.5 | 8.72 | 4.85 | 18.83 | 2.56 | 800 |
| Jack Pine + VAS Accepts (50:50, wt/wt) | | 0 | 600 | 0.603 | 45.4 | 119.3 | 7.08 | 3.64 | 19.00 | 2.34 | 600 |
| | | 1250 | 480 | 0.685 | 69.9 | 105.7 | 9.80 | 6.30 | 19.83 | 3.00 | 200 |
| | | 2500 | 400 | 0.725 | 75.8 | 92.4 | 10.00 | 6.07 | 19.07 | 2.85 | 300 |
| | | 4000 | 310 | 0.749 | 82.1 | 87.4 | 9.98 | 5.88 | 19.44 | 2.73 | - |
| | | 5750 | 210 | 0.762 | 85.7 | 87.0 | 10.64 | 6.72 | 19.70 | 2.96 | - |

## TABLE IV. BLEACHING CONDITIONS AND RESULTS

| | Unbleached Kappa No. | $\%Cl_2$, on OD Pulp Added | $\%Cl_2$, on OD Pulp Consumed | NaOH % on OD Pulp | End pH | CE K No. | NaOCl % on OD Pulp Added | NaOCl % on OD Pulp Consumed | $ClO_2$ % on OD Pulp Added | $ClO_2$ % on OD Pulp Consumed | Br.,% | Dirt, ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Whole Tree | 17.8 | 3.95 | 3.44 | 2.18 | 11.1 | 3.3 | 1.0 | 0.95 | 0.8 | 0.66 | 86 | 1.8 |
| | | | | | | | | | 0.5 | 0.48 | 84 | 3.6 |
| Accepts | 18.4 | 4.10 | 3.77 | 2.25 | 11.2 | 3.2 | 1.0 | 0.96 | 0.8 | 0.66 | 86 | 1.8 |
| | | | | | | | | | 0.5 | 0.48 | 84 | 2.3 |
| Rejects | 17.7 | 3.95 | 3.52 | 2.18 | 11.2 | 4.2 | 1.0 | 0.98 | 0.8 | 0.78 | 87 | 4.2 |
| | | | | | | | | | 0.5 | 0.48 | 86 | 5.0 |
| Accepts/Rejects (50/50) | 18.6 | 4.13 | 3.82 | 2.27 | 11.0 | 3.2 | 1.0 | 0.94 | 0.8 | 0.73 | 86 | 2.1 |
| | | | | | | | | | 0.5 | 0.48 | 84 | 2.5 |

NOTES: Pulp wt. o.d. - 50g
$\%Cl_2$ - 0.22 X unbleached kappa number
%NaOH - % $Cl_2/2 + 0.2$

completion of the bleaching time the bag was opened, the pH and bleach chemical residual measured, and the pulp thoroughly washed. The brightness and dirt count were determined according to Tappi Standard Methods.

## RESULTS AND DISCUSSION

The data (Table I, Fig. 1) from multiunit digester runs indicated that the whole tree chips, VAS accepts and VAS rejects cooked at similar rates and gave comparable yields for similar pulping conditions. However, the VAS fines cooked at a much slower rate and gave a significantly lower yield.

On the basis of the above cooks, it was decided that the large-scale cooks and bleaching evaluations would be done on the whole tree chips, the accepts, rejects, and a 50/50 mixture by weight of accepts and rejects. When cooking conditions similar to the multiunit digester cooks were employed, the target kappa No. 17 was not attainable. Increasing the effective alkali and sulfidity to 16% and 25%, respectively, gave pulp in the range of 17-18 kappa. The whole-tree accepts and the mixture of accepts and rejects pulped at the same rate and gave comparable yields with similar rejects levels. Although the rejects pulped to the same degree, there was a significantly lower yield and slightly higher rejects level.

The anomalies seen between the multiunit digester cooks and the large-scale cooks are due to the effect of sampling size. The sample size for the multiunit digester is small, approximately 50 grams, and would therefore not be a representative sample, particularly when chips, twigs, bark fragment, and dirt are the major components. A large sample (4000 g) would eliminate any such bias.

The handsheet strength properties of the pulps investigated are shown in Table III and in Fig. 2 to 7. Pulps having 50% jack pine and 50% accepts as well as 100% jack pine are also included for comparison.

Both the tear-breaking length and burst-breaking length relationship (Fig. 2 and 3) illustrate that the strength properties of the fractions are similar to

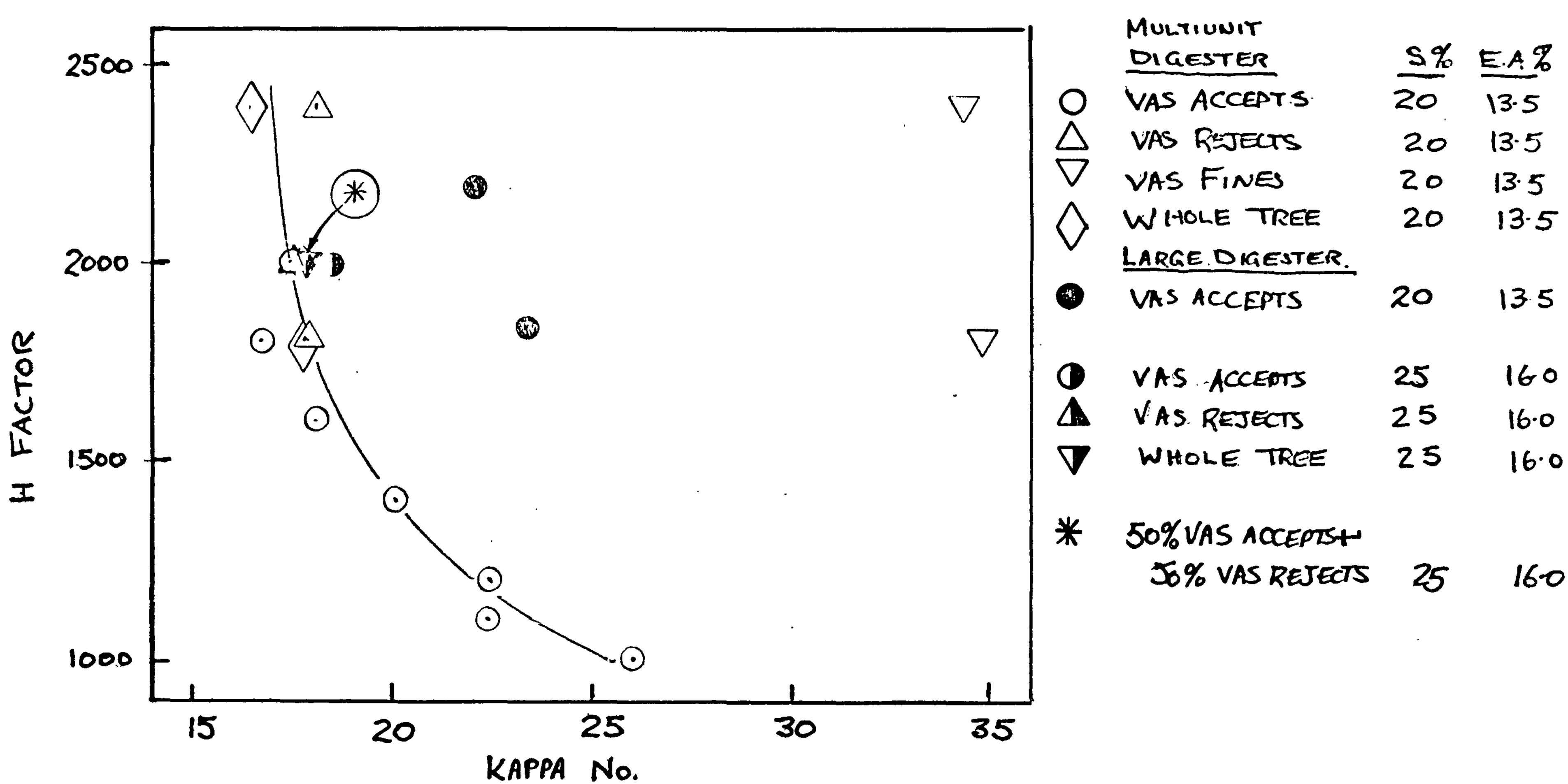


Fig. 1 H FACTOR VS. KAPPA NO. FOR MULTIUNIT DIGESTER AND 2 Cu.ft DIGESTER.

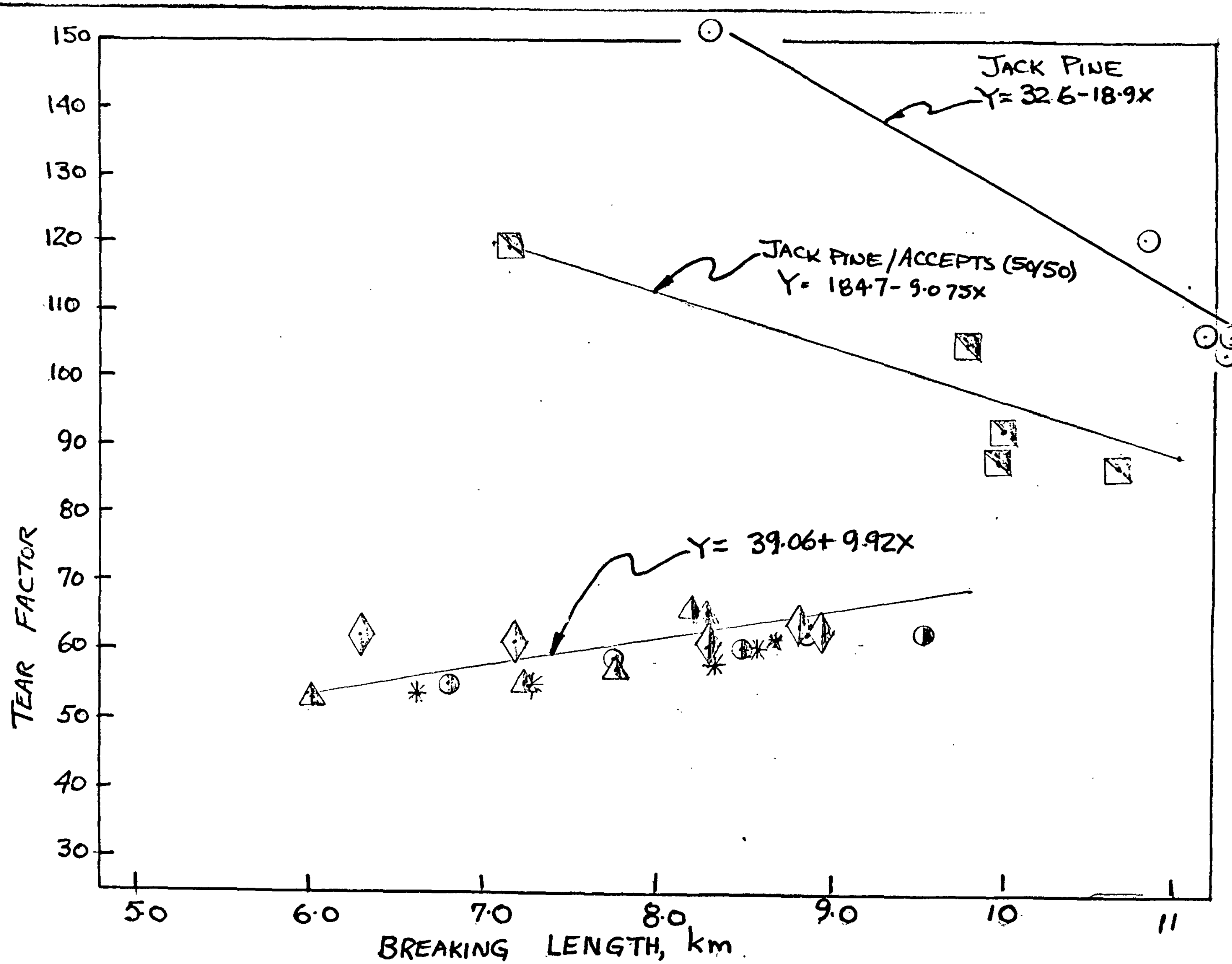


Fig. 2 TEAR FACTOR VS. BREAKING LENGTH

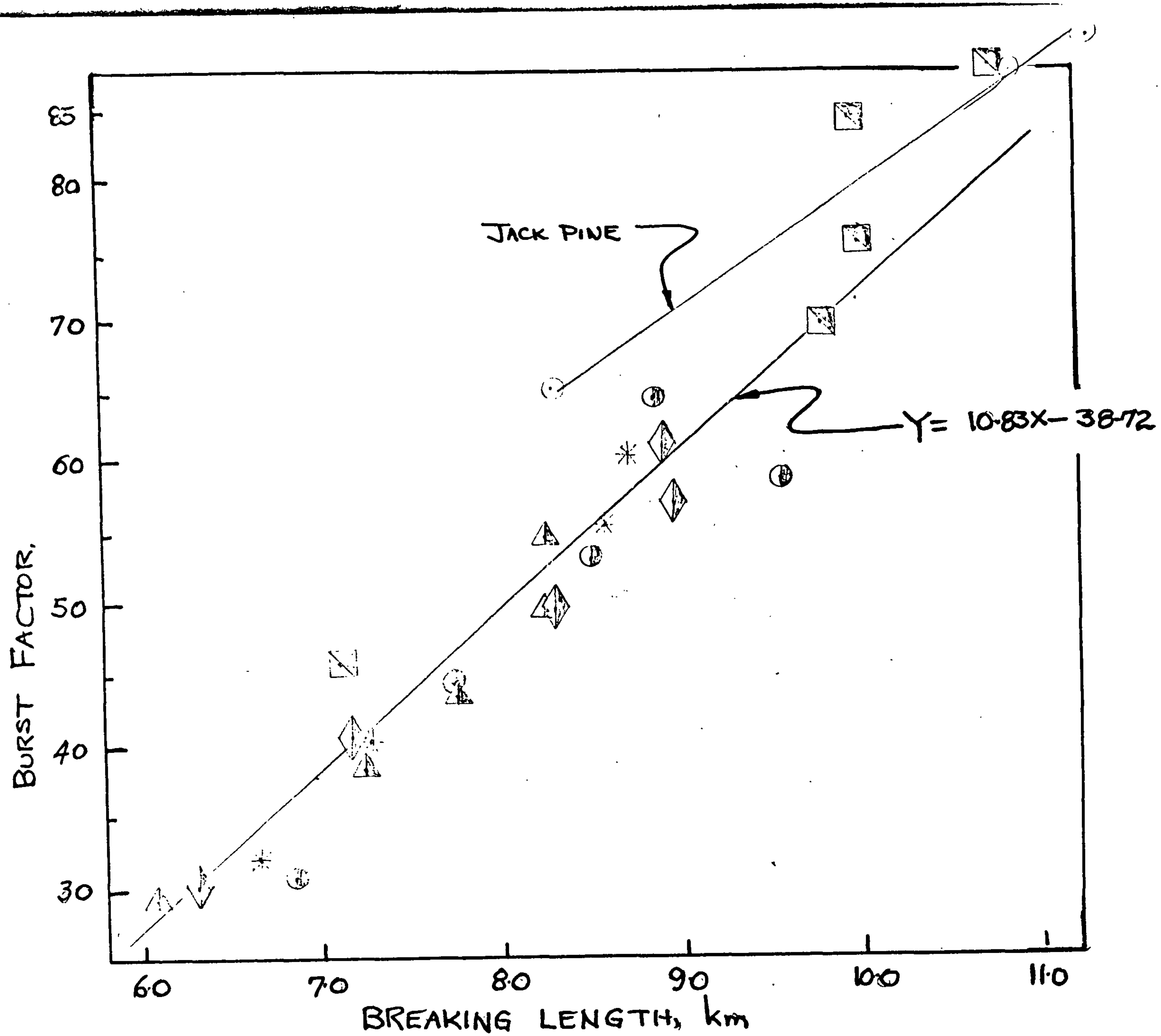


Fig 3. BURST FACTOR VS. BREAKING LENGTH

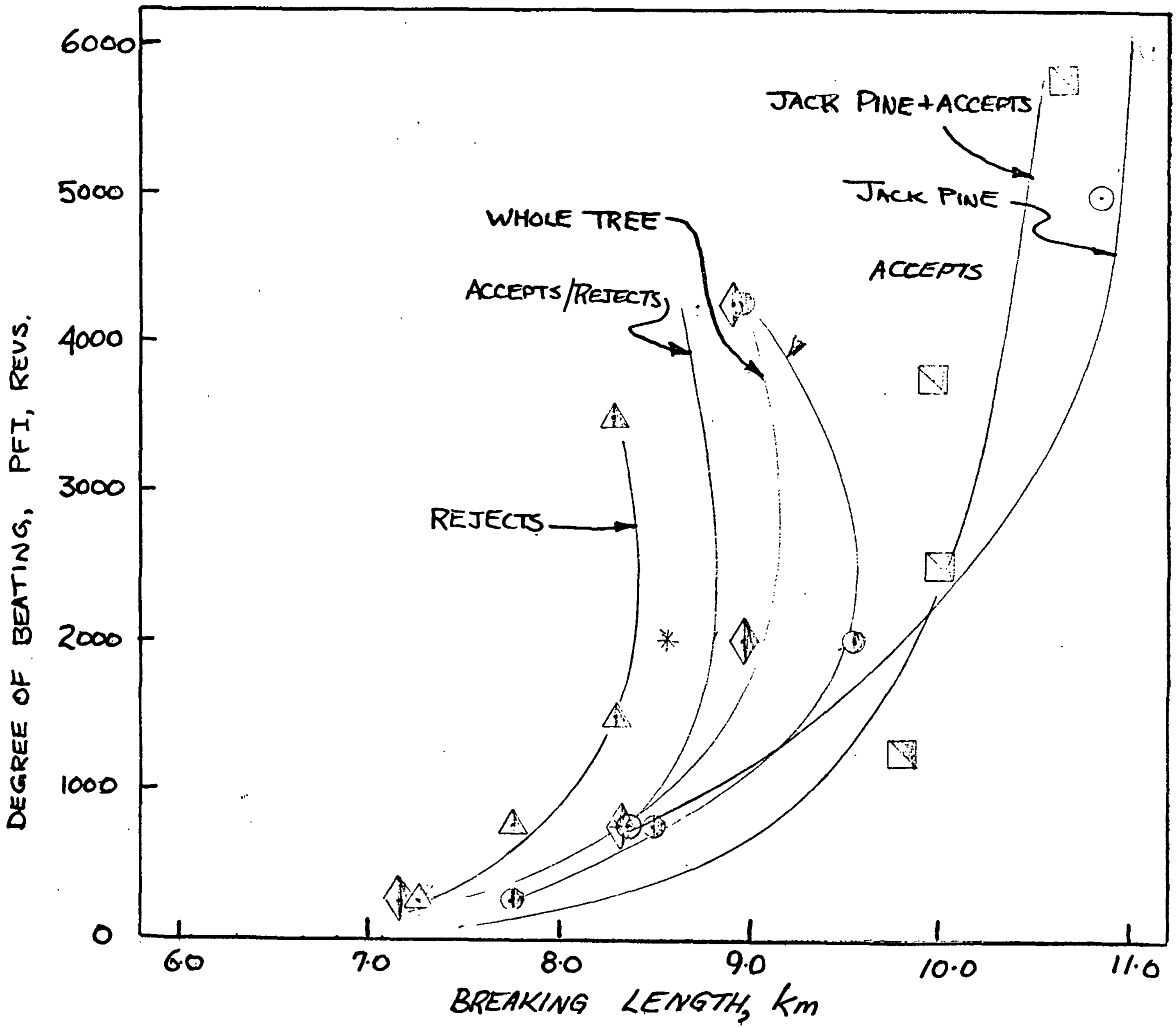


Fig 4. DEGREE OF BEATING VS. BREAKING LENGTH

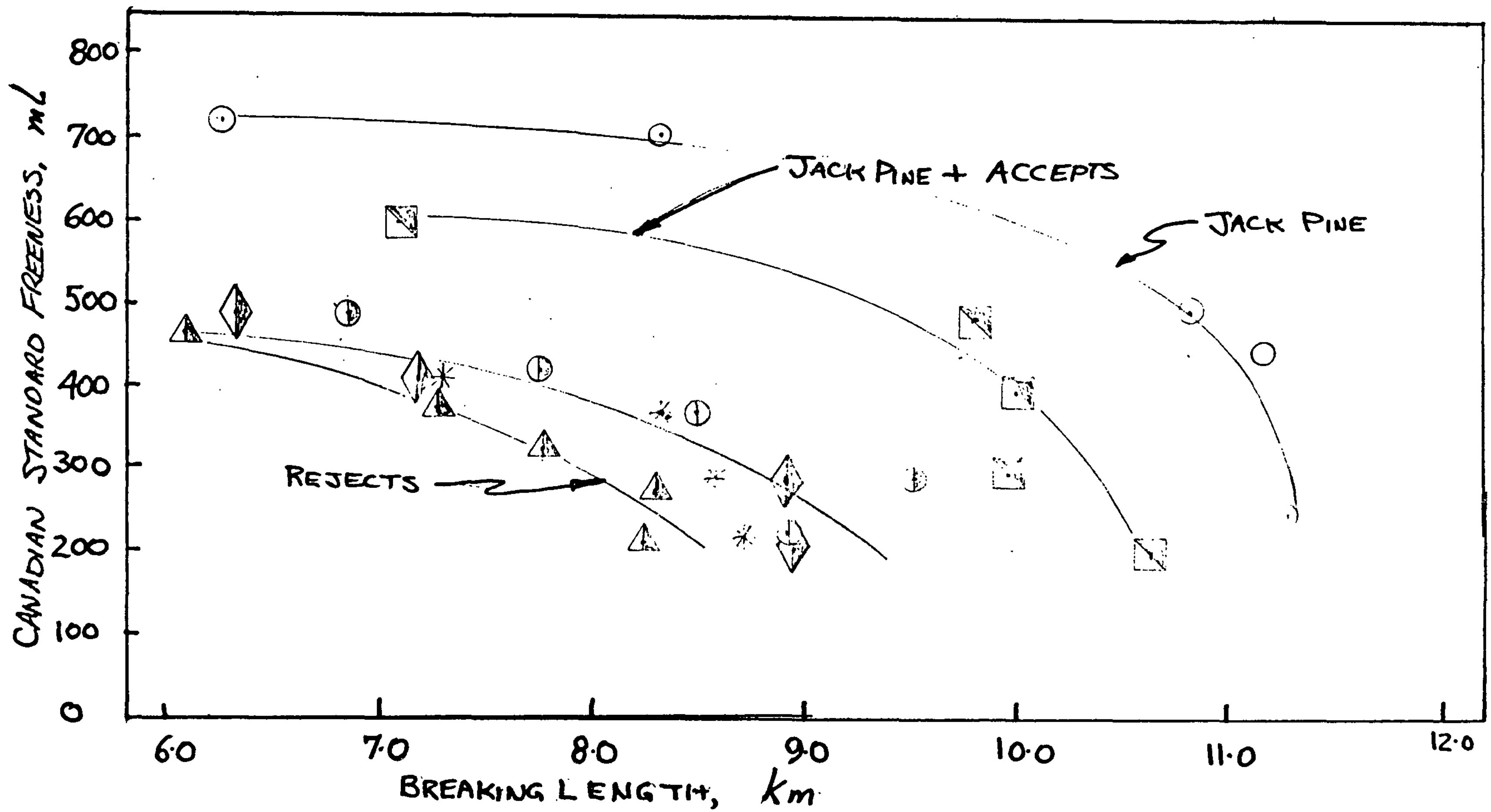


Fig. 5. CANADIAN STANDARD FREENESS VS. BREAKING LENGTH.

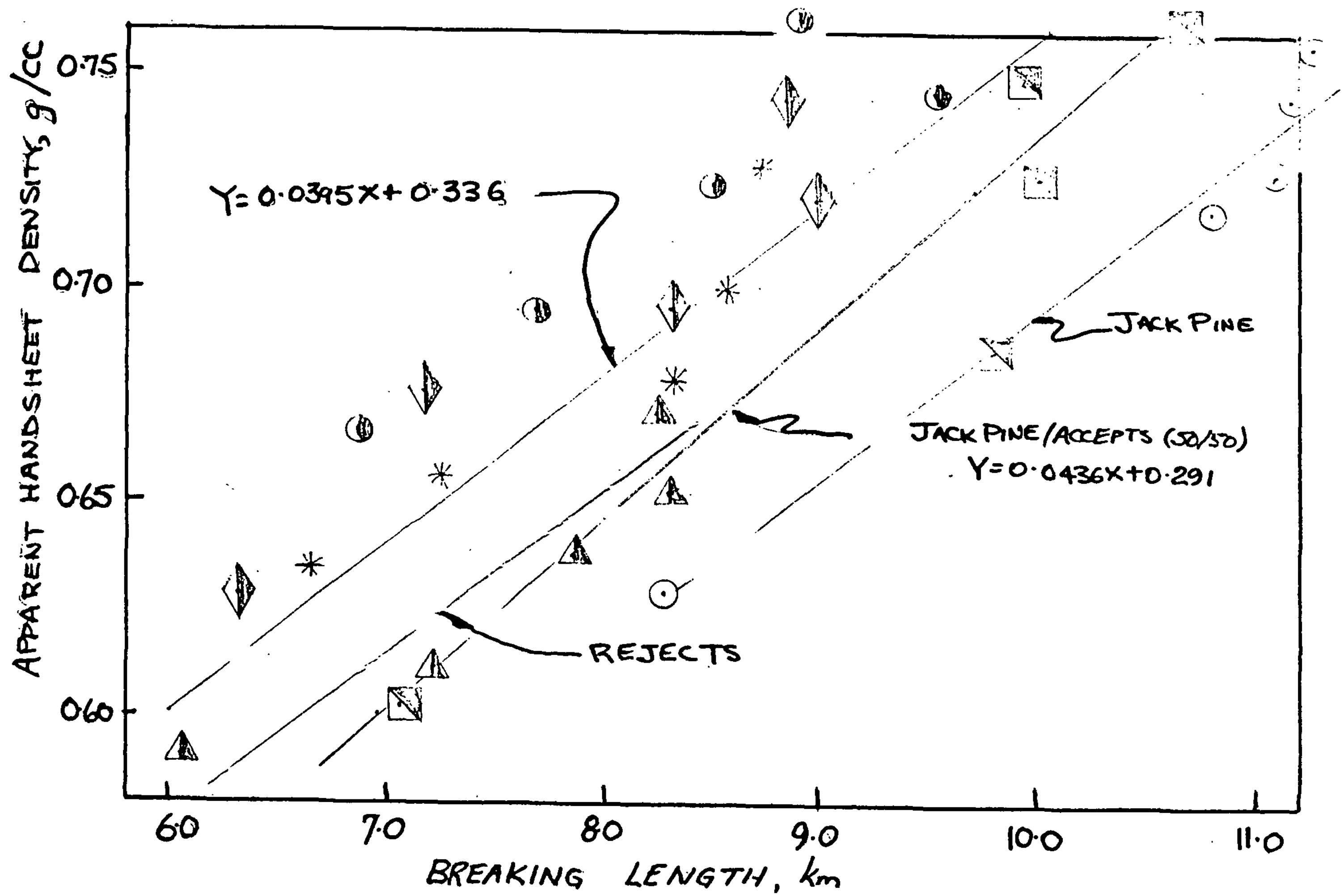


Fig. 6 APPARENT HANDSHEET DENSITY VS. BREAKING LENGTH

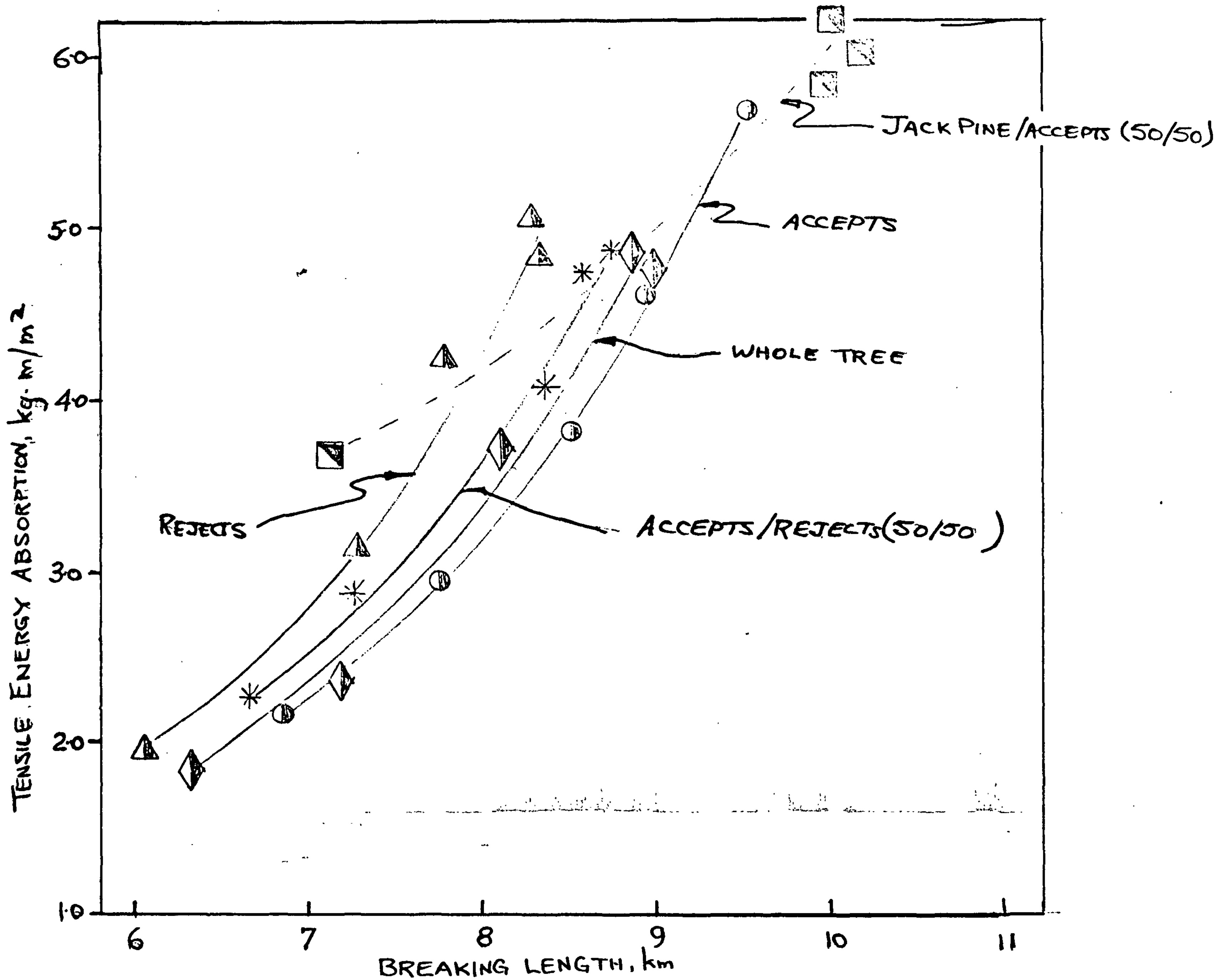


Fig. 7 TENSILE ENERGY ABSORPTION VS. BREAKING LENGTH

those of whole tree. The high tear at a given breaking length for the jack pine accepts mixture is due to the strength of the jack pine, which shows the highest tear-breaking length correlation.

Figure 4 shows the amount of beating required to reach a given breaking length as a function of breaking length and illustrates differences which exist between the pulps. The whole tree, accepts and accepts/rejects mixture all beat at similar rates. But the rejects are considerably more difficult to beat and attain a lower maximum tensile strength. The jack pine accepts mixture beats and achieves ultimate tensile strength which is lower than that of the pure jack pine. Similar observations may be made for freeness, as shown in Fig. 5.

The apparent handsheet density versus breaking length (Fig. 6) shows a fair degree of scatter, although the rejects do show an apparent lower handsheet density for a given breaking length, somewhat similar to the jack pine accepts mixture.

Figure 7 illustrates the TEA as a function of breaking length. Again, the whole-tree, accepts and accepts/rejects mixture are comparable to, but weaker than, the pure jack pine.

BLEACHING

A CEHD sequence was used to determine the bleachability of whole tree, accepts, rejects and a mixture of accepts and rejects. Because the bleach sequence employs both hypochlorite and chlorine dioxide, it should be amenable to dirt removal, a problem compounded by the very nature of the whole-tree chip mixture and its fractions.

The chemical consumptions, brightness and dirt count are shown in Table IV. Overall, the bleach consumptions were similar and resulted in equivalent brightness. However, the CEHD sequence at the higher chlorine dioxide level was more effective, producing a cleaner pulp (lower dirt count) for both the whole tree and accepts. Nonetheless, all bleach responses represented dirt levels that are normally acceptable. This means the above sequence did result in bright and clean pulp for all the pulps examined.

## CONCLUSIONS

1. There is no practical advantage to be gained by segregating the whole-tree chip mixture into component fractions as described in the introduction.

2. The fractionated whole-tree chips, except the fines, pulped at the same rate and gave similar yields and rejects levels. The fines cooked at a much slower rate and gave significantly lower yields and, therefore, were not considered in the rest of the study.

3. In general, both the physical strength properties and bleach response of pulp prepared from the segregated materials was similar to pulp from whole-tree chips.

TABLE OF SYMBOLS

FOR FIGURES 2-7

VAS Accepts

VAS Rejects

50% Jack Pine + 50% VAS Accepts

Whole Tree

50% VAS Accepts + 50% VAS Rejects

100% Jack Pine

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