4-1972

The Pulping of Hardwood Sawdust by the Neutral Sulfite Semichemical Process for Use in Corrugating Medium

James O. McClelland
Western Michigan University

"THE PULPING OF HARDWOOD SAWDUST BY THE NEUTRAL SULFITE SEMICHEMICAL PROCESS FOR USE IN CORRUGATING MEDIUM "

by

James O. Mc Clelland

A Thesis Submitted To The
Faculty of the Department of Paper Science
And Engineering in Partial Fulfillment
of the
Degree of Bachelor of Science

Western Michigan University
Kalamazoo, Michigan
April, 1972

ABSTRACT

The need for using less expensive raw materials is ever increasing. Here the use of hardwood sawdust as one of these raw materials was investigated for use in Semichemical Corrugating Medium. It was found that 20 to 30% sawdust could be used in the furnish without a significant loss in sheet strength. It was also found that sawdust could be pulped either separately or combined with hardwood chips giving the same product quality. This was accomplished by either a regular neutral sulfite semichemical cook or by a vapor phase cook. The conventional disk refiner was found to do the best job of refining, when the plate clearance is very close. The use of 20 to 30% sawdust in the furnish could lead to a substantial cost savings, and would aid in pollution control in that it would end the disposal problem of the sawdust.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
HISTORICAL BACKGROUND	2
OBJECTIVE	4
PROCEDURE	5
DATA AND DISCUSSION	7
Oak Sawdust Characteristics	7
Optimum Conditions	8
Separate Cooking and Refining	9
Combined Cooking and Refining	9
Effect of Yield on Physical Strength	10
Effect of Refining	11
Vapor Phase Cooking	12
CONCLUSIONS AND RECOMMENDATIONS	14
LITERATURE CITATIONS	16
REFERENCES	17
GRAPHS	18

INTRODUCTION

With the ever increasing cost of paper production, industry is turning to less expensive raw materials. Sawdust being one of these raw materials most often considered.

Sawdust pulping has grown greatly in the past several years. This growth has mainly been in the southern and western United States and foreign countries. The species used were usually softwoods and were pulped by the kraft process. High yield pulping of hardwood sawdust is still a rather untouched field with much work needed.

HISTORICAL BACKGROUND

Before the boom in sawdust pulping, sawdust was thought of as merely a nuisance. When quantities of more than 5% got into the digester troubles arose such as impeded liquor circulation, blow plugging, and uneven cooks. The introduction of positive displacement digesters corrected these difficulites and sawdust pulping became a reality (1).

Longview Fiber Company in Longview, Washington has the world's largest sawdust pulping installation. Installed in 1964-65 it produces 400 tons of pulp per day. This system uses two M & D digesters and pulps Douglas Fir sawdust and shavings by the kraft process. The cooking time is 30 minutes followed by washing and bleaching. The finished pulp is used in the production of linerboard (2, 3).

Olinkraft in West Monroe, Louisiana is pulping hardwood sawdust by the kraft process. The resulting pulp is reported to be equal to pulp from hardwood chips in nearly every respect. The pulp is used in bleached paperboard grades to improve printability (4, 5).

Work performed at Oregon State University for Menasha Corporation showed that 24% Douglas Fir sawdust could be used in Corrugating Medium without loosing strength. The optimum cooking conditions were 30 minutes at 150 p.s.i.g. with 9% chemical consumption using the neutral sulfite semichemical process. The wood furnish used was 68% tan oak chips, 24% sawdust, 8% alder chips, with 35% kraft clippings added before secondary refining. The percentage of kraft clippings is higher than for a non-sawdust furnish to maintain good paper machine runability (6). Menasha Corporation's North Bend mill is presently using such a process and is producing a high grade of Corrugating Medium.

A Finnish Market pulp operation shows wide spread interest in sawdust pulp. The kraft process at low yields was used for cooking softwood sawdust. There is a great demand for this pulp because of its low cost and has general utility in many different paper grades (7).

OBJECTIVE

The pulping being done by Longview Fibre Company, Olinkraft Company, the Finnish Company, and Menasha Corporation shows that sawdust is not just a nuisance, but can be successfully pulped and turned into a valuable product. By doing this, money can be saved without loss in paper quality and in some cases even improve quality. All this information leads to the thought of whether hardwood sawdust can be used in Corrugating Medium when pulped by a high yield process.

In order for sawdust to be used many questions must be answered. Some of the questions are:

1. What are the optimum pulping and refining conditions?
2. What is the strength of sawdust pulp as compared to chip pulp and what yield can be expected?
3. Should sawdust be cooked separately or can it be cooked as a mixture with chips, without ill effects?

PROCEDURE

Work done by Peckham, Nicholes, and Van Drunen (8) has shown "that certain lab-scale batch pulping equipment can be used to effectively simulate the results obtained in commercial continous pulpers utilizing high temperatures, low liquor-to-wood ratios, and short dwell times". From this work it can be assumed that the use of the bomb digesters will give the desired reproducability and accuracy for work with pulping sawdust.

In order to pulp hardwood sawdust by the neutral sulfite semichemical process, process information from such a mill is needed. This information was obtained from Menasha's Otsego Mill.

For dense hardwoods, the cooking conditions are: In the impregnation stage 50 p.s.i.g. steam is used with hydrostatic pressure to 150 p.s.i.g.. This is held for 30 minutes then the liquor is blown. The cooking phase is at 125 p.s.i.g. and is held for 15 minutes. The chips and remaining liquor are then blown. Residual liquor pH is held at 7.0. Chemical requirements are 9.2% sodium sulfite and 3.8% sodium carbonate. The pulp yield is about 78% (9,10).

These conditions give a good starting point for work in pulping hardwood sawdust by the neutral sulfite semichemical process. Some adjustments in cooking time and chemical charge were required to convert mill conditions to obtain similar yields on lab scale.

TAPPI Standard test procedures were used wherever they were applicable. A exception to this is freeness. The freeness used to evaluate sheet properties was 200 ml C.S.F which approximates the actual machine freeness used to produce nine point Corrugating Medium. The basis weight used for making handsheets was 26 lb./1000 sq. ft. which is standard for Corrugating Medium. Residual liquor analysis was done by titrating a liquor sample with 0.1 N iodine using a starch indicator.

DATA AND DISCUSSION

Oak Sawdust Characteristics

The cooking chemicals and the oak chips which were used in this work were obtained from Menasha Corporation, Otsego, Michigan. The oak sawdust used was obtained from Door Brother's Sawmill, Wayland, Michigan. The oak sawdust had a bulk density of 15.4 lbs. per cubic foot on a green basis with a moisture content of 35%. A screen classification of the oak sawdust shows that it contains much finer material than either oak chips or red pine sawdust. This data is given in Table I below.

TABLE I

Screen Classification

Screen Size	Oak Chips %	Oak Sawdust %	Red Pine Sawdust %
>14 mesh	96.1	4.1	4.8
<20>14 meash	2.2	76.1	86.0
<40>20 mesh	1.7	14.1	8.0
<150>40 mesh	-	4.2	1.2
>150 mesh	-	1.6	0.0

Optimum Conditions

A target yield of 80% was used for the evaluation of the oak sawdust and the oak chips. At the optimum cooking conditions for the sawdust, the oak chips had a higher pulp yield. This is because the smaller size of the sawdust allows better liquor penetration and faster cooking. The data for the optimum cooking conditions are given in Table II.

TABLE II

Optimum Cooking Conditions

	Oak Sawdust	Oak Chips
Sodium Sulfite %	11	11
Soda Ash %	5	5
Liquor Ratio	3.1	3.1
Temperature °C	170	170
Time Minutes	35	35
Residual Liquor pH	7.1	7.3
Residual Liquor g/l Na 1/2 0	17.0	19.5
Yield %	78	84.4
Chemical Consumption Na2O	6.0	5.25

These cooks were then defiberized in a Bauer lab refiner and beat in a Valley beater and handsheets were made on a Noble and Wood sheet machine. The test results of these sheets showed that the chip pulp was far superior to the sawdust pulp in almost every respect. The data is presented in Table III.

TABLE III

Optimum Cook Results

Wood Source	Freeness (CSF)	Caliper (pts)	Mullen (psi)	Tear (kg)	Tensile (lbs/in.)	Water Drop (sec)	CMT (lbs)
Oak Sawdust	200	14.0	15.0	40	19.5	25	39
Oak Chips	200	13.1	28.5	40	35.0	10	61

Separate Cooking and Refining

Oak sawdust and oak chips were cooked separately to 78% yield. These cooks were then refined separately to 200 m. C.S.F.. Handsheets were made by mixing the two pulps in percentages from 0 to 50% sawdust. The effect of the addition of sawdust on the physical properties of these handsheets is not linear. But rather that 20 to 30% sawdust can be added before the physical strength of the resulting sheet decreases greatly. This is shown in Graphs 1 and 2.

Combined Cooking and Refining

Oak sawdust and oak chips were blended together in varing percentages before cooking. The cooking conditions were held constant for each sample at the previously determined optimum conditions for the sawdust. These cooks showed that as the percentage of sawdust increased yield decreased and chemical consumption increased. These results are summarized in Table IV. Evaluation of the handsheets showed, as with separate cooking and refining, that 20 to 30% sawdust can be added without significant strength loss. This is shown in Graphs 3 and 4.

TABLE IV

Combined Cooking

Percent Sawdust	Chemical Consumption %	Yield (%)
0	5.25	84.4
10	5.29	83.8
20	5.48	83.5
30	6.00	83.5
40	5.64	82.0

Effect of Yield on Physical Strength

Oak sawdust was cooked to varied yields. This was done by increasing pulping time in the digester and by increasing the available chemical. This produced pulp yields of 87%, 78%, and 70%. The physical strengths of these handsheets were substantially improved as the yield was lowered. This is illustrated in Graph 5.

Effect of Refining

To evaluate the effect of different refining on sawdust pulp four different refiners were used. The refiners and conditions used were: (1) Bauer disc refiner at 6% consistency, (2) A Valley beater at 2.5% consistency, (3) Sprout-Waldron refiner at 25% consistency, and (4) A Mead disc refiner at 3.0% consistency. The sawdust pulp used here was cooked in a basket in one of Menasha rotary digesters under commercial cooking conditions. The resulting yield was 77%. The data are summarized in Table V.

TABLE V

Effect of Refiner

Refiner	Caliper (PTS)	Mullen (PSI)	Tear KG	Tensile (LBS/IN.)	Water Drop (SEC)	CMT (lbs)
Bauer	12.3	21.5	44	25.0	12.5	50
Valley	13.7	13.0	36	20.0	11.0	41
Sprout	14.5	14.5	44	17.5	35.0	40
Mead	15.5	10.0	32	13.0	8.5	29

* Freeness 200 ML C.S.F.

From this it can be seen that the Bauer refiner produced a pulp with properties far superior to those produced by the other methods. It is of interest that high consistency refining offered no strength advantages over low consistency refining. It is believed that the reason the Bauer Refiner produced superior pulp is because very close clearances can be maintained in it. Close plate clearance being necessary to refine the fine sawdust.

Vapor Phase Cooking

Except for the refiner comparison, all cooks previously reported here were made under conventional cooking conditions. A number of semichemical mills pulp by the vapor phase method. To determine if vapor phase pulping offers any advantages, a basket cook of oak sawdust was made in one of Menasha's rotary digesters. This was done by placing a sample of the sawdust in a basket inside one of their rotary digesters. This allows it to be cooked at the same conditions as the commercial chips that were being cooked at the same time. The results of the tests on the handsheets from this cook were then compared to those of the regular cook. This is shown in Table VI.

TABLE VI

Vapor Phase Cooking

	Freeness	Caliper	Mullen	Tear	Tensile	Water Drop	CMT	Yiel
Cook Type	(CSF)	(PTI)	(PSI)	(KG)	(LBS/IN)	(SEC)	(LBS)	(%)
Regular	200	13.7	13.0	36	20	11	41	76
Vapor Phase	210	14.0	15.0	40	19.5	25	39	77

From these data it can be seen that there is no significant differences between the vapor phase cook and the conventional cooks produced in the laboratory.

CONCLUSIONS AND RECOMMENDATIONS

From this work it is concluded that 20 to 30% hardwood sawdust can be used in the furnish for the production of Corrugating Medium. The addition of kraft clippings may have to be increased to avoid runnability problems on fourdrinier paper machines.

The optimum cooking conditions for hardwood sawdust to obtain an 80% yield is: 11% sodium sulfite, 5% soda ash (based on the oven dry weight of sawdust charge), 170 °C 35 minute dwell time, and a liquor to wood ratio of 3:1.

From the pulp quality standpoint combined cooking of 20 to 30% sawdust with chips will give a sheet of medium which is of high quality. But in combined cooking many problems may occur in the digester. One problem is that the resulting combined cook would be lower in yield (app. 10% less for 30% sawdust) then for a 100% chip cook. This would decrease the production rate of the digester.

With separate cooking the yield of the sawdust can be controlled independently of the chips. This would allow for the chips and the sawdust to be cooked to equal yields and save on chemical costs from the over cooking of the sawdust. This would also allow cooking the sawdust to a lower yield if it was found that too much strength was being lost by the addition of the sawdust. Cooking to a lower yield would give the sawdust pulp better strength which in turn would give a better medium.

In refining the sawdust pulp it was found that the conventional disk refiner gave the best results. High consistency refining of the sawdust pulp yielded poor sheet strength.

Vapor phase cooking showed no significant difference in sheet properties than the regular cook. Although vapor phase cooking may offer some chemical savings that could not be evaluated here. The most important reason for using sawdust would be the potential cost savings. This must be evaluated by each individual mill. If a good supply of sawdust is available within a close radius of the mill and a positive displacement digester is available to handle the sawdust a good cost savings could be expected.

A Short Summary of the Seven Main Points

1. 20 to 30% hardwood sawdust can be used without significant loss in medium strength.
2. Cooking the sawdust separately or combined with chips produces equal strength pulp. Although cooking separately can save in yield losses, and allows yield variations.
3. The strength of the sawdust pulp increases greatly when cooked to a lower yield.
4. Vapor phase or regular NSSC cooking work equally well.
5. Close plate clearance is needed in refining.
6. A significant cost savings potential may exist.
7. A higher percentage of kraft clippings would be needed to maintain good paper machine runnability.

LITERATURE CITATIONS

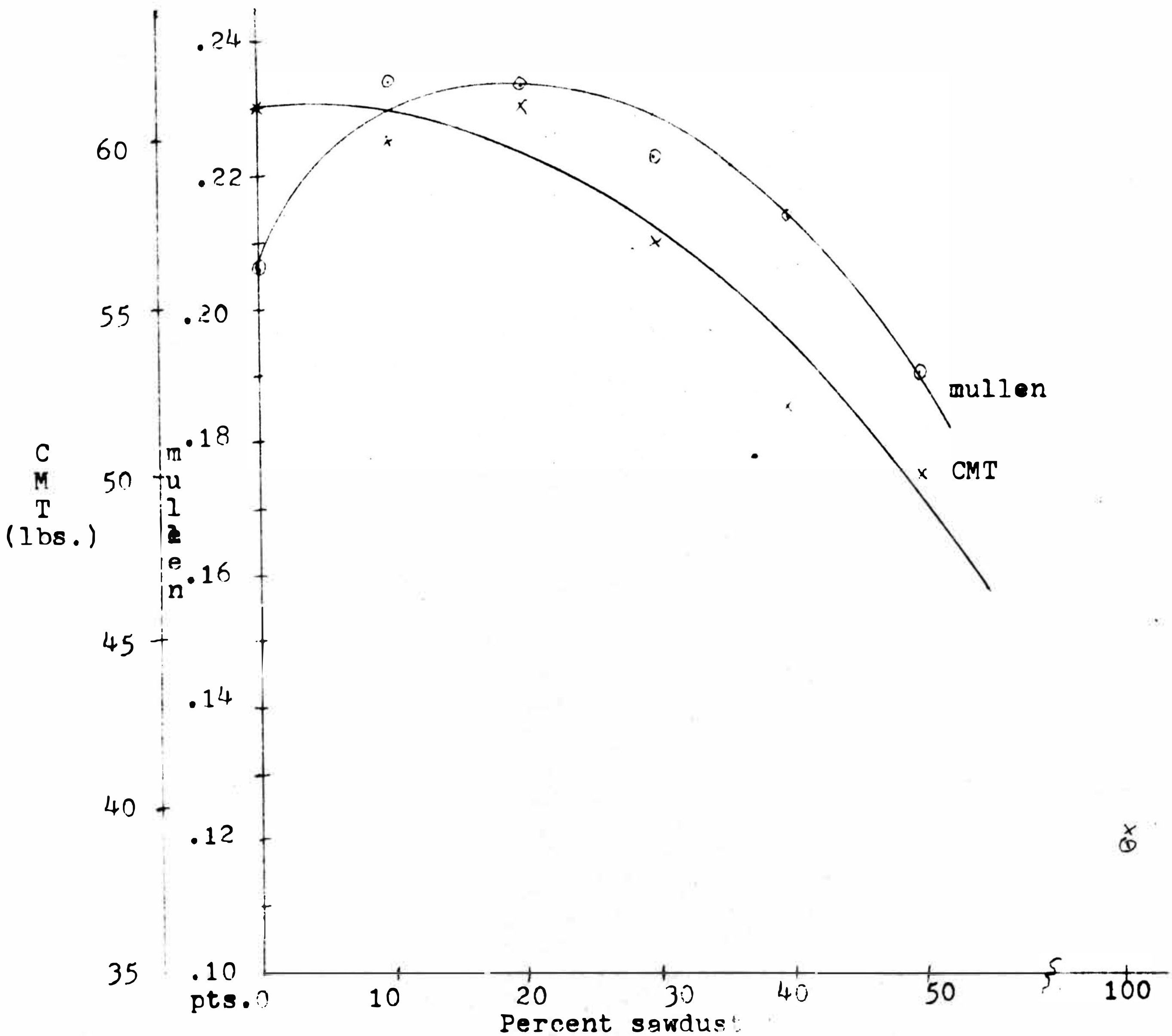
1. Peck, R.R., Tappi 54, #3, (1971).
2. Hackett, K.L., Paper Trade Journal, Vol. 151, #2, (1967).
3. Longview Fibre, Pulp and Paper, Vol. 38, No. 37, (1964).
4. Olinkraft, Pukp and Paper, Vol. 42, No. 38, (1968).
5. Olinkraft, Chem 26, Vol. 5, No. 3, (1969).
6. Menasha Corporation, Intra Mill Memo, "Optimum Douglas Fir Sawdust Pulping", December 19, 1969.
7. Jernstrom, K.E., Paper Trade Journal, Vol. 152, No. 52, (1968).
8. Peckham, J.R., I. Nicholls, G.A., and VanDrunen, V., Tappi 53, No. 12, (1970).
9. Lowe, K.E., Sage, C.C.,, and Lutey, R.W., Paper Trade Journal, Vol. 153, No. 39 (1969).
10. Menasha Corporation, Otsego, Michigan, "Process Information".

REFERENCES

1. Peck, R. R., Tappi 54, No. 3 (1971).
2. Hackett, K. L., Paper Trade Journal, Vol. 151, No. 2, (1967).
3. Peckham, J. R., Nicholls, P.A., and VanDrunen, V., Tappi 53, No. 12, (1970).
4. Gettmann, G., Pulp and Paper, Vol. 42, No. 1, (1968).
5. Olinkraft, Pulp and Paper, Vol. 42, No. 38, (1968).
6. Olinkraft, Chem 26, Vol. 5, No. 3, (1969).
7. Evans, John C.W., Paper Trade Journal, Vol. 143, No. 35, (1959).
8. Linnhart, Paper Trade Journal, Vol. 143, No. 9, (1959).
9. Martin, Paper Trade Journal, Vol. 143, No. 9, (1959).
10. Lowe, K.E., Sage, C.C., and Lutey, R.W., Paper Trade Journal, Vol. 153, No. 39, (1969).
11. Menasha Corporation, Intra Mill Memo, "Optimum Douglas Fir Sawdust Pulp", December 19, 1969).
12. Menasha Corporation , Otsego, Michigan, "Process Information".
13. Jernstrom, K.E., Paper Trade Journal, Vol. 152, No. 52, (1968).
14. Longview Fibre, Pulp and Paper, Vol. 38, No. 37, (1964).
15. Bauer Brothers Company, "M & D Sawdust Pulping Presentation".

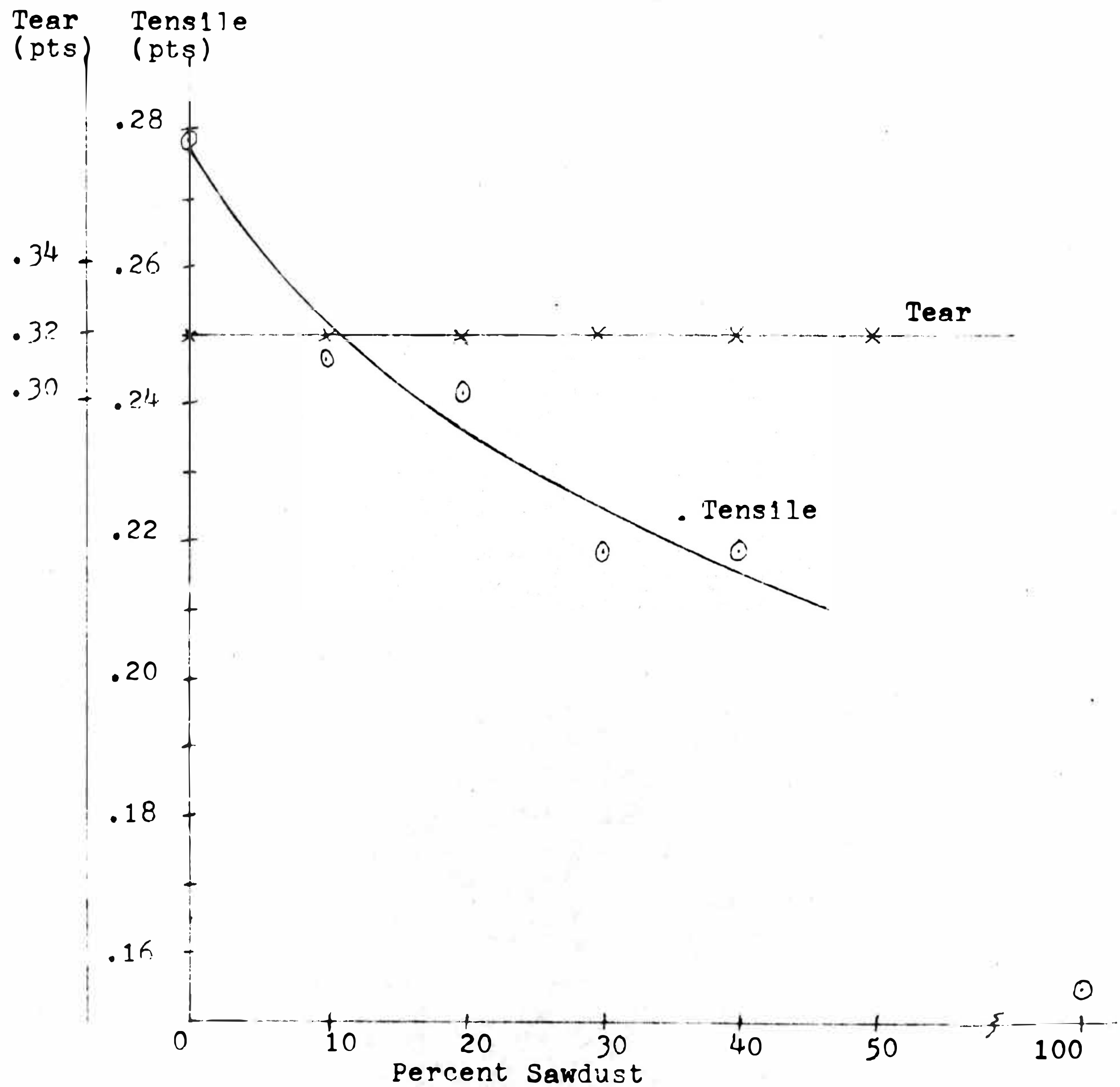
Graph 1

SEPERATE COOKING



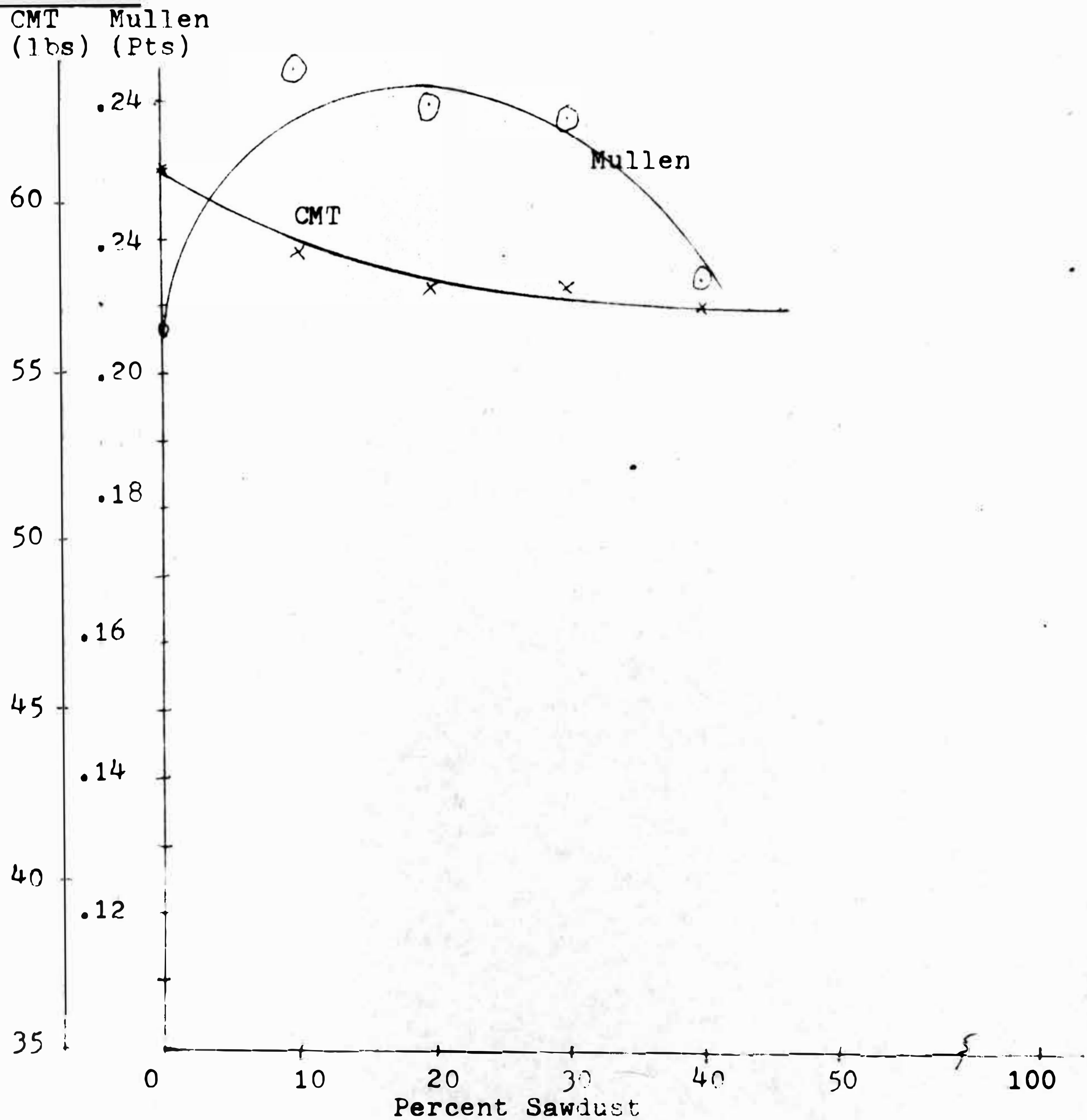
Graph 2

SEPERATE COOKING



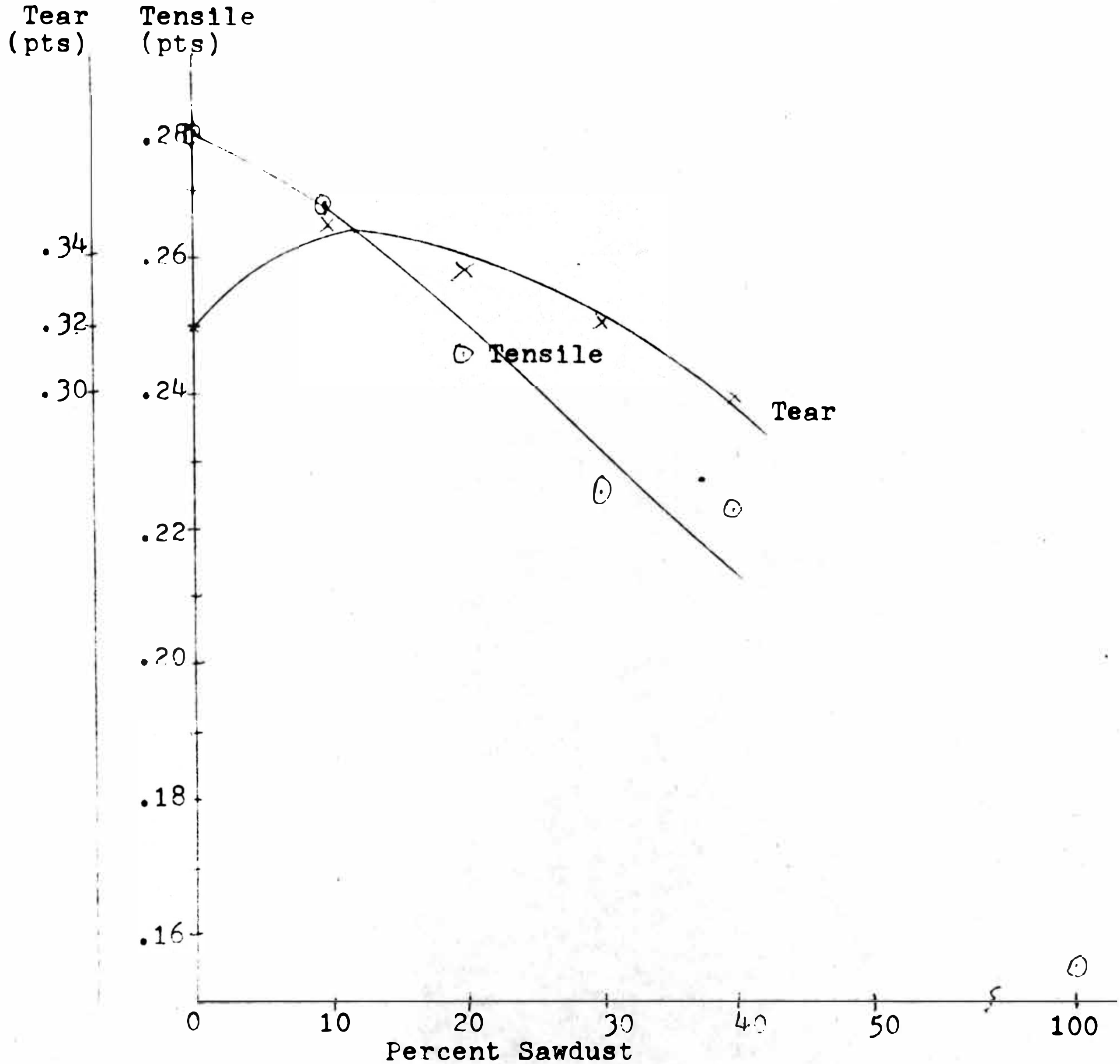
Graph 3

COMBINED COOKING



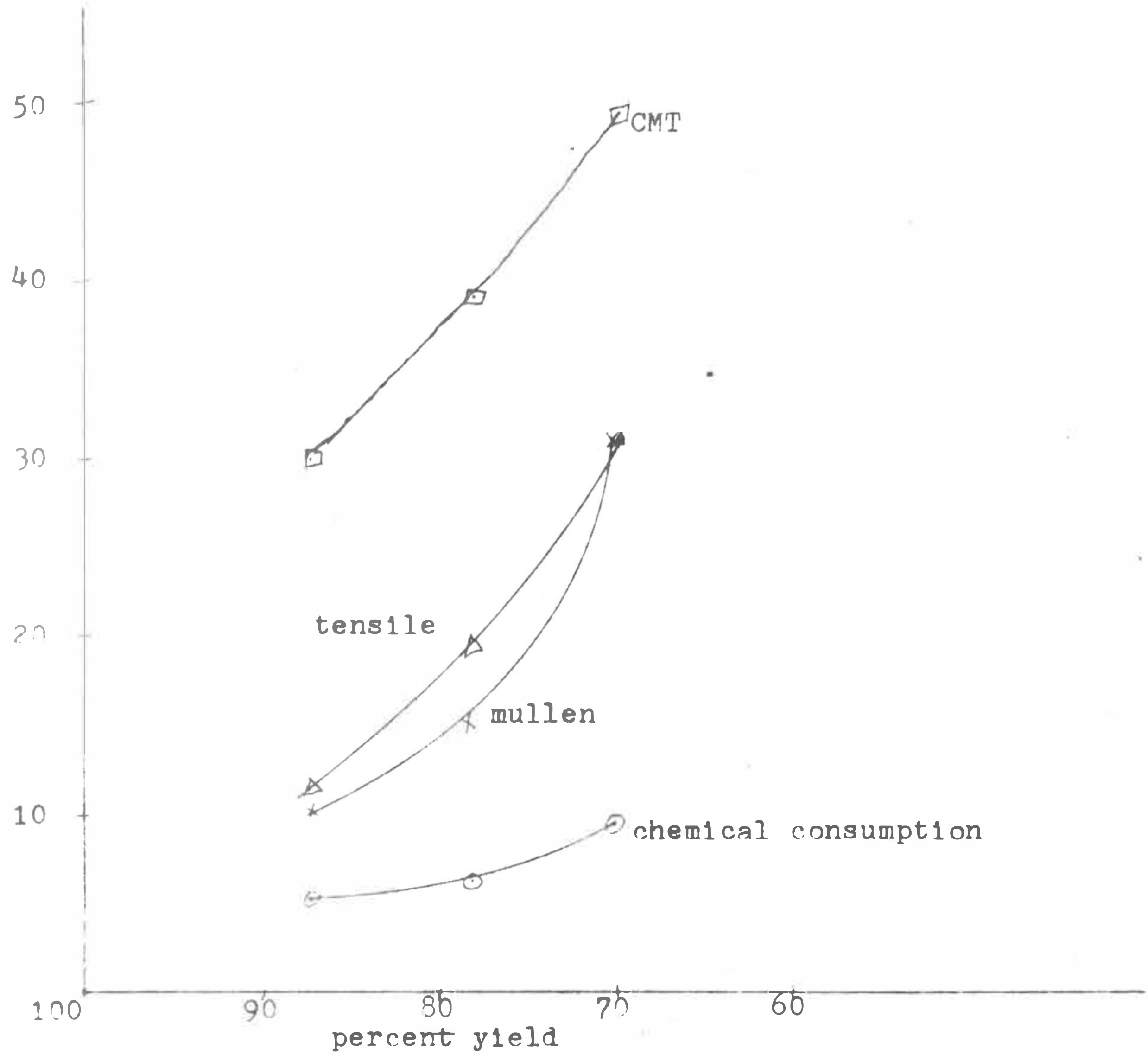
Graph 4

COMBINED COOKING



Graph 5

EFFECT OF YIELD



Oak sawdust