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Improved Useage of Recycled Board in Corrugating Medium

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IMPROVED USEAGE OF RECYCLED BOARD

IN CORRUGATING MEDIUM

by

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ABSTRACT

Research was conducted to determine the optimum furnish of corrugating medium with the intentions of increasing the amount of recycled fiber in this furnish.

Furnishes were made up of various ratios of a recycled fiber source to a virgin fiber source, along with three different levels of refining. A starch additive was also used on a second set of these groups to help increase some of the properties by increasing the interfiber bonding.

The results indicated that increased recycled fiber produced the sheet with the optimum conditions. Also, with an addition of starch as a dry strength additive, the results improved even better than the non starch samples.

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OBJECTIVE

The objective of this project was to try to utilize more recycled fiber in the furnish of corrugating medium than is presently used by most medium producers. At present the trend is to use a 25% recycled and 75% virgin fiber source as the furnish for corrugating medium to obtain the best properties required by that of the medium. With the objective of using more recycled fiber must also come the ability to meet or exceed the properties of the current standards being used.

INTRODUCTION

Today there is a large interest in utilizing more recycled product in the manufacture of a large variety of products in our society. The paper industry is one of these industries where recycled fiber is of major importance. At present the amount of paper products that helps to consume our landfills is about 40% the total 160 millions of tons that we dump each year. If our industry can find ways to better utilize this recycled fiber, than it will enable us to reduce the amount of solid waste in our society.

The boxboard industry is no exception to the above considerations and one of the products used to make boxboard is that of corrugated medium. This corrugated medium is the inner fluted layer of a corrugated box. At present about 25% of the furnish or fiber for this medium is that of recycled fiber. This recycled fiber comes from a variety of sources. An important source of fiber for this medium is a new double kraft lined (K2S) boxes. These boxes are a very clean source of clippings from the corrugated manufacturer before all the contaminants such as staples, laminates, etc. are applied. This source makes it very possible for the medium mills to produce a quality product that contains some recycled fiber.

As was mentioned earlier, the current trend is to utilize about 25% recycled fiber by weight in the production of medium. The reason this recycled fiber is used is due to the amount of long fiber it needs to use to produce a product that meets all of the demands that medium requires to produce a box that can protect the product it is used for as a container.

A typical medium furnish consists of 75% virgin fiber. This virgin fiber is predominantly a hardwood fiber which is pulped using the Neutral Sulfite Semi-Chemical (NSSC) process. These hardwood fibers are predominantly short, thick-walled fibers which are stiff to give the stiffness required of the medium, although they do not maintain the ability to provide good contact between the fibers for bonding to give a strong sheet.

The other 25% is the recycled fiber source. The softwood fibers which are found in the liner portion of the K2S source give the strength needed for runnability on both the paper machine and in the corrugator at the corrugating plant. These softwood fibers are usually long, thin-walled fibers. These fibers will tend to collapse and provide more contact area (bonding area) between each other, thus producing a stronger sheet.

The purpose of this project is to determine if it is possible to increase the amount of recycled fiber used in the furnish of corrugating medium. There are plenty of reasons for increasing this source. One is to reduce the amount of landfill space wasted due to paper products. Another is to decrease the depletion rate of our forests, and try to reduce costs to the medium manufacturer since recycled fiber is less costly than virgin fiber.

BACKGROUND INFORMATION

Corrugating medium is the inner fluted layer of corrugated boxboard. Corrugated boxboard is used for packaging and protection of many products used today. Of major importance to these containers is the ability to withstand crushing and destruction during shipment. The medium is usually produced from hardwood fibers that are pulped via the Neutral Sulfite Semi-Chemical (NSSC) process.

Properties of the Medium

Medium is a very porous sheet since it is required that it be treated with steam and heat during the corrugating process to enable the sheet to be fluted. There are two properties which are very important in these regards, and they are (1) the sheet must be of at least a 26#/1000 ft^2 basis weight, and (2) it must be of at least .009 inches in thickness. The uniformity in caliper (thickness) is very important as variations will cause breaks and blisters during the fluting process.

Several other properties are also very important to optimize the properties of the medium. The other tests which are randomly done on samples in the mill include the following:

1. Float or Water Drop
2. Porosity
3. Wet Tensile Strength
4. Ring Crush
5. Concora Medium Test (CMT)

The float or water drop test is of importance because it measures the rate of adsorption of the sheet. This is important since the sheet must be able to adsorb steam during the fluting operation as well as it must be able to receive the adhesive that is used to adhere the linerboard to the fluted medium. This adhesive is usually made up of about 75% water with a starch additive.

Porosity indicates the ability of the sheet to resist the penetration of a certain amount of air. If the porosity reaches to high a number or that it is very resistant to air flow, it tends to resist flute formation in the corrugator.

Wet tensile strength is used mostly on grades that are made with high wet strength values. This will give an indication of how well it will withstand the stress applied to the medium as it is steamed and then passed through the corrugator.

The ring crush test is a test where a 6 in. by 0.5 in. strip is placed in a disk in the form of a cylinder and a force applied until failure. This force will indicate the stacking strength of a corrugated container on the edges since the fluted sheet tends to resemble that of a cylinder.

CMT or what is also known as flat crush test is performed on a strip of the same size as the ring crush test however the strip is fluted and applied to a strip of double backed tape and placed in a unit that also measures the force until failure of the flutes. This test is used to give an indication of how much resistance to failure a box can withstand when a force is applied to the side of the container.

Virgin Fiber

The virgin fiber used for corrugating medium is predominantly produced from a source of hardwoods that are pulped via the NSSC pulping process. This source of fibrous material gives the medium its properties such as stiffness and cmt because of the morphology of the hardwood fibers. These hardwood fibers tend to be short, stiff fibers that do not collapse because of their thick cell walls. The stiffness of these fibers are what lends themselves to giving the stiffness properties required. One drawback to the short, noncollapsible fibers is that they do not conform to one another to create interfiber bonding, thus they will produce a weak sheet by themselves.

Recycled Fiber

The recycled fiber in corrugating medium is used because of the long softwood fibers that are found in the liners of most corrugated or recycled products. These softwood fibers are different than those of the hardwoods in that they are long, thin-walled, and readily collapse in order to have more contact area. With this extra contact area or interfiber bonding the sheet made with these fibers will be much greater in strength than that of the hardwood fibers. The use of this recycled fiber is than used to impart strength for runnability on the paper machine and in the corrugator.

There are many different sources of recycled fiber. "Common sources of recycled fiber for long fibers are:

1. Screenings from pulping of softwoods.

2. Container plant cuttings, normally called new double kraft lined (K2S) corrugated cuttings.
3. Selected used corrugated containers.
4. Old corrugated containers." ( )

The K2S source is the preferred source of recycled fibers because it is relatively clean and free of contaminants. The two sided lining with its kraft fibers yield a very good source of strong softwood fibers.

Starch

Although medium mills do not tend to use chemical additives for strength there has been studies made that show that starch additives such as gums and galactomannans can help increase the cmt and ring crush values in bogus medium. Bogus medium is medium that is produced from a 100% recycled fiber source.

Starch is well known as a dry strength additive because it will tend to increase the fiber to fiber bonding within the sheet thus increasing the strength of the sheet.

Economic and Environmental Impact

There are several economical and environmental impacts for the use of recycled fiber as a part of the furnish in corrugating medium. The cost to produce virgin fibers exceeds that of buying recycled sources tremendously. Both in the cost of pulping because of chemicals, equipment, and effluent treatment, and the cost of recycled fiber is relatively inexpensive and easy to repulp. "Recycling wastepaper into new products uses about 60% less energy and 95% less water, and produces less air pollution and water pollution, than making the same products from virgin wood fibers."( )

The environmental issues today play a large role in the use of recycled fiber. Today about 160 million tons of solid wastes are disposed of yearly by Americans into landfills and of that 40% is from commercial and industrial wastepaper. To recycle all of our wastepaper we could reduce the amount of landfill space being utilized each year by almost 40%. Since landfill space is becoming so hard to find the costs of disposing of these wastes is increasing at such a rate that in the future it will cost more to dispose of this wastepaper than it will to recycle it.

Another environmental issue that many issues have arisen from lately is that of the decline in our forests and what many environmentalists are calling the "Greenhouse Effect". Since the source of our oxygen comes from trees through the process of photosynthesis the trees that we destroy today for virgin wood fibers could be those needed in the future for our survival.

EXPERIMENTAL

Materials

Two separate fiber sources were used in this project. They consisted of a virgin fiber source from a corrugated pulp and paper mill. These contained 50% Oak and 50% Aspen hardwoods which were pulped with NaOH and Na_2CO_3. The source of the K2S corrugated clippings were obtained from a corrugated container plant.

Also used in a group of samples was a starch additive to increase bonding to try to improve strength properties. The starch used was that of Pennford Gum 280 diluted with distilled water to a concentration of 6% solids. This was furnished and made at W.M.U.

A standard set of samples were made to compare results with. This contained 25% recycled clippings and 75% of the virgin fiber source. These samples were considered the standard to reflect the ratios currently being used by most manufacturers at present. The rest of the samples were of the ratios listed:

% RECYCLED	% VIRGIN
40	60
60	40
80	20
100	0

A second set of the above ratios were also made up with the addition of the starch at a 10 lb. solids/ton of fiber. This was used due to research that found this to be the optimum addition rate( ).

The stocks were fiberized in the Morden Slushmaker and then added to the beater at 1.57% consistency. Samples of pulp were then refined to 600, 400, and 200 Canadian Standard Freeness (CSF). Handsheets were made of each of the samples in the Noble and Wood handsheet machine.

The sheets were made based on a 26#/1000 ft.^{2} basis weight. This basis weight is the normal basis for corrugating medium, although they also produce higher weight grades. Ten sheets were made for each of the 27 various mixes of furnish and freeness levels. They were then conditioned in the constant temperature and humidity room before being tested.

Procedure and Equipment

The virgin fiber was obtained at 24% consistency from the pulp mill. A 1500 gram sample was diluted with 18.5 liters of water and added to the Morden Slushmaker and defiberized for two minutes. The slushmaker was then rinsed with 3 additional liters of water to bring the final stock slurry to consistency of 1.57%.

The corrugated clippings were considered to be at about 10% moisture in the air dry state. 400 grams of clippings were added with 19.6 liters of water and defiberized for two minutes. Again the slushmaker was rinsed with an additional 3 liters of water to bring the stock consistency to 1.57%.

Stock from each of the samples were added to the beaters in the following ratios to enable enough pulp for each of the 600, 400, and 200 freeness levels for each set of ratios of recycled to virgin stock:

% RECYCLED / % VIRGIN	g. REC. STOCK / g. VIRGIN STOCK
25 / 75	3000 / 9000
40 / 60	4800 / 7200
60 / 40	7200 / 4800
80 / 20	9600 / 2400
100 / 0	12000 / 0

At these ratios there was enough stock to make 12 handsheets for each of the three separate freeness levels at each ratio.

Once the stock was refined to the appropriate freeness level a 4000 gram sample was obtained and added to the proportionator of the Noble and Wood Handsheet machine. It was then diluted to 12 liters. Ten handsheets were made for each sample to make a sheet which was equal in weight to 5.24 grams (26 lb./100 ft.^{2}).

The starch was added to the samples in the beater at a rate of 15.8 grams of starch @ 6% solids for each group of

12000 grams of stock added. This maintained a rate of 10 lb/ton fiber. This was performed on a second set of each of the samples as above with the exception of the 25 to 75 ratio of recycled to virgin, respectively, which was the standard sample for comparisons. Again the 12000 gram samples were taken at each of the three freeness levels and handsheets made as described above.

Testing

All handsheets were then conditioned in the constant temperature and humidity room for at least 24 hours. The temperature was 73° F and 50% relative humidity.

Each of the ten handsheets from each of the 27 groups were weighed and the six best (best formation and weight) were selected for actual testing. The caliper of each sheet was measured on the caliper tester, which is an electrically operated micrometer, in three different locations on each sheet to find the average thickness of each sheet.

The internal tearing resistance of the sheets were measured using the Elmendorf tear tester. Tensile strength was measured on the Instron Tensile tester. Ring Crush test was performed on the tester in the lab. CMT was performed at a later date at a local paper mill due to problems with the fluter in the lab.

These tests were conducted by the methods prescribed by TAPPI Standard Methods as follows:

Thickness (caliper); T 411
Tensile; T 494
Tear; T 414
Ring Crush; T 472
Flat Crush (CMT), T 809

RESULTS AND DISCUSSION

The overall test results are presented in Table 1. The grade mix is presented for each freeness level as a ratio of recycled to virgin fiber source. Also listed in the grade mix is whether the sample had starch added (ST) or without starch addition (WO). These values were average values of all the data collected from each category, based on six sheets per group. Figures 1-6 and 10-11 are graphs plotting the various test results (e.g., tensile index, tear index, ring crush, and CMT) versus freeness levels. One graph from each test for both starch addition and without are included.

Caliper

From Table 1 it is indicative of how the caliper is reduced by both increased refining and again with increase in recycled fiber. The reasoning behind this can be explained first for the increase in recycled fiber. As was mentioned earlier, the long softwood fibers that collapse due to their thin-walled cells will collapse and thus reduce the bulk of the sheet. Again in the case of refining the fibers will increase fiber to fiber bonding which will lead to a decrease in the bulk of the sheet.

Tensile Index

Figures 1 & 2 indicate that the tensile index increases with an increase in refining. It was evident that the greater amount of recycled fiber used led to an increase in the tensile strength of the sheet. This would be indicative of the better bonding area with increased amounts of softwood fibers.

The addition of starch (fig. 2) indicates here that the tensile index is increased also. Here again as was mentioned earlier, that the starch should create more interfiber bonding and this would result in the increase in strength.

Tear Index

The tear index vs. freeness for each grade is shown in figures 3 & 4. It shows that the use of starch has relatively no effect on the tear index. As was expected the increase in recycled fiber had the greatest tear index and it decreased with a decrease in recycled fiber. Here tear index would increase with an increase in bonding although once the point is reached where the force required to break the fiber is reached then the tear will decrease as the refining is increased because of damage to these fibers.

This is the probable reason behind the graph being reducing as the freeness decreased.

Ring Crush

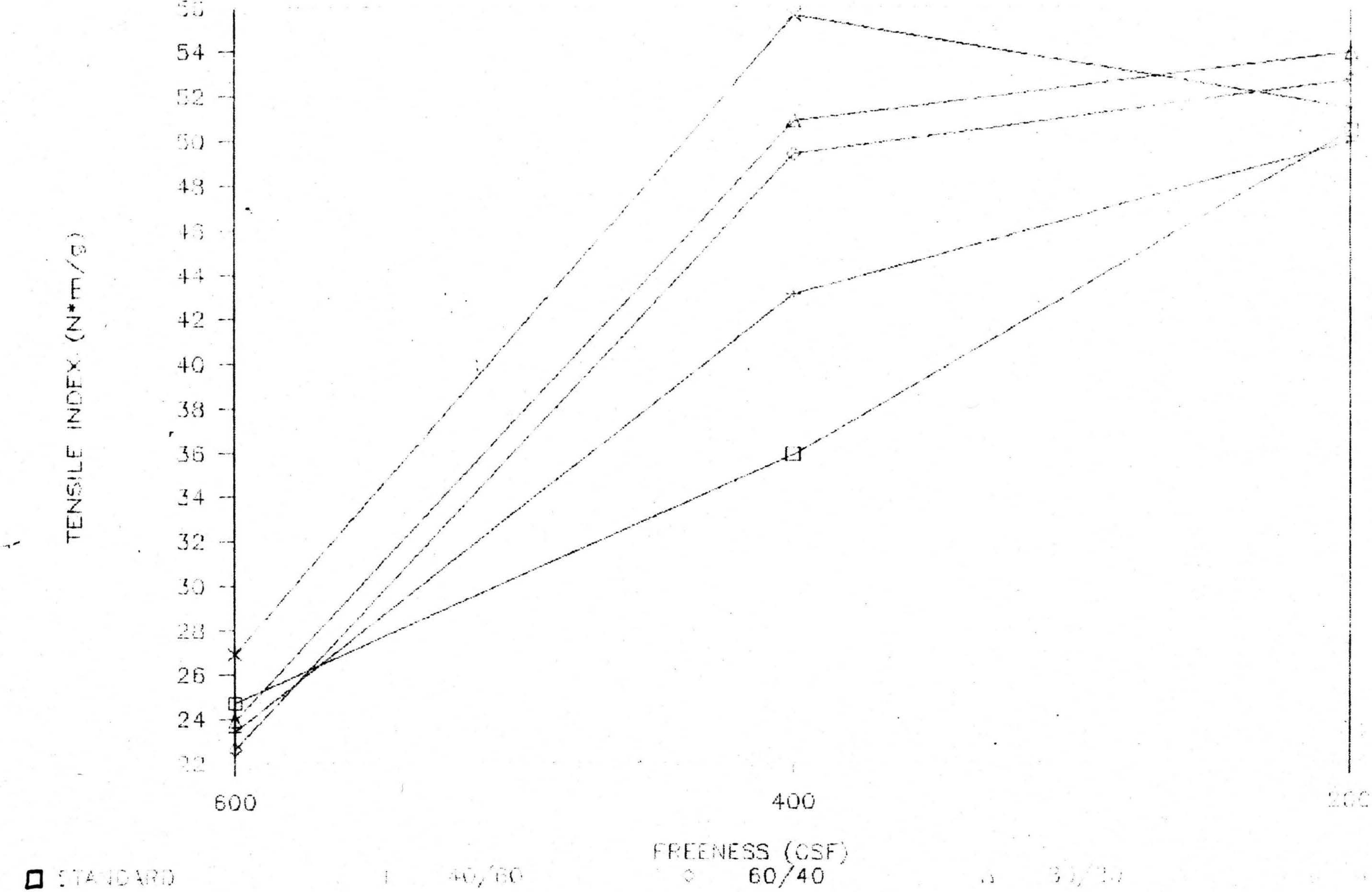
The figures for ring crush (fig. 5 & 6) indicate the increase in ring crush with increased refining. Another thing that was evident was the increase in value with increase recycled fiber, which was unexpected. Figures 7-9 indicate that a starch addition of 10 lb/ton will tremendously increase the ring crush values. This may again be due to the increase in bonding.

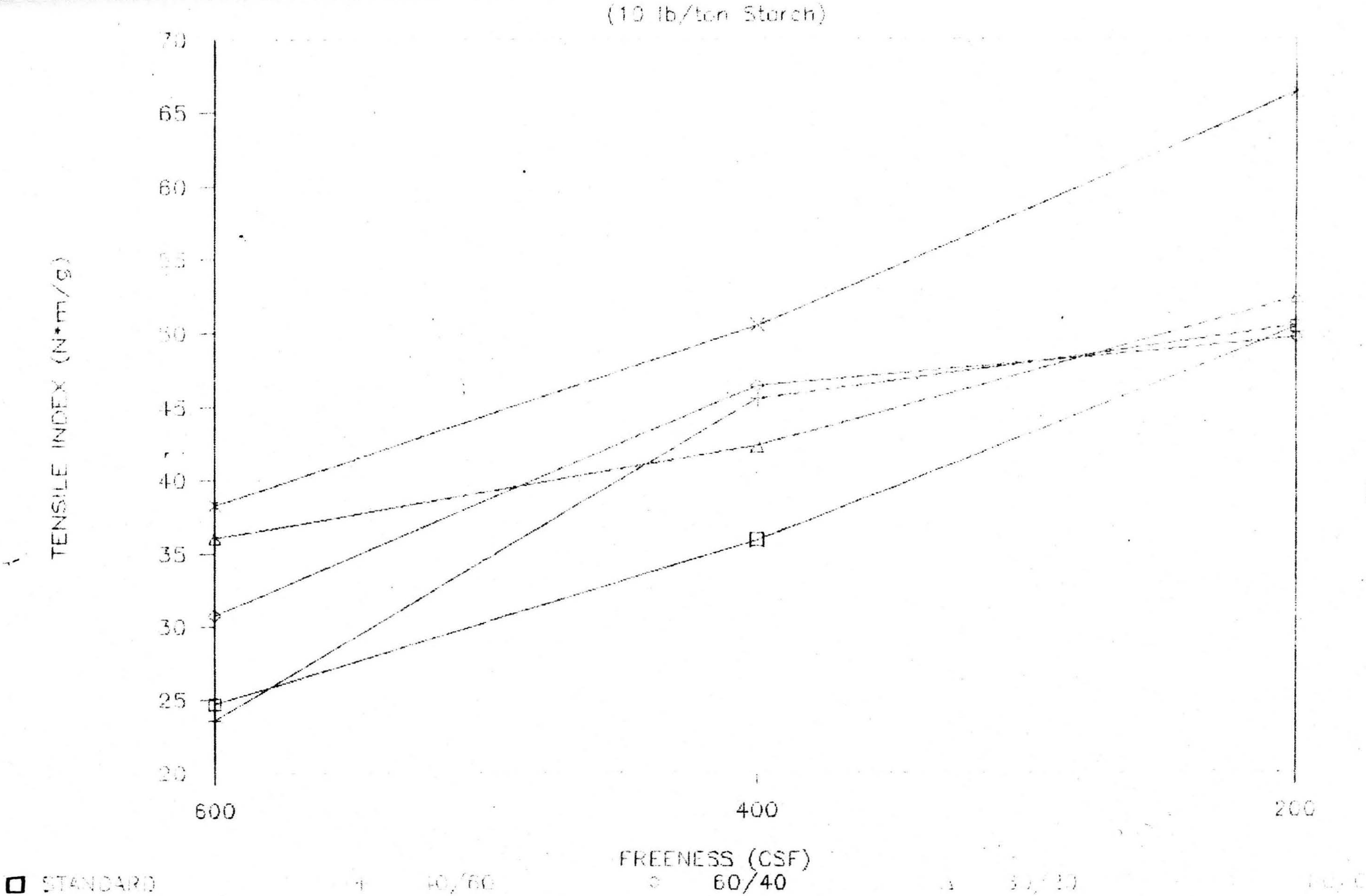
CMT

The values for CMT shown in figures 10-11 indicate that the CMT will increase with increased refining due to increased bonding. Figures 12-14 indicate that the starch additive helps bonding in higher freeness levels but as the freeness level is reduced the starch has less affect. The change in amount of recycled fibers seemed to have little affect on the CMT values.

TABLE 1 TEST DATA OF CORRUGATED MEDIUM

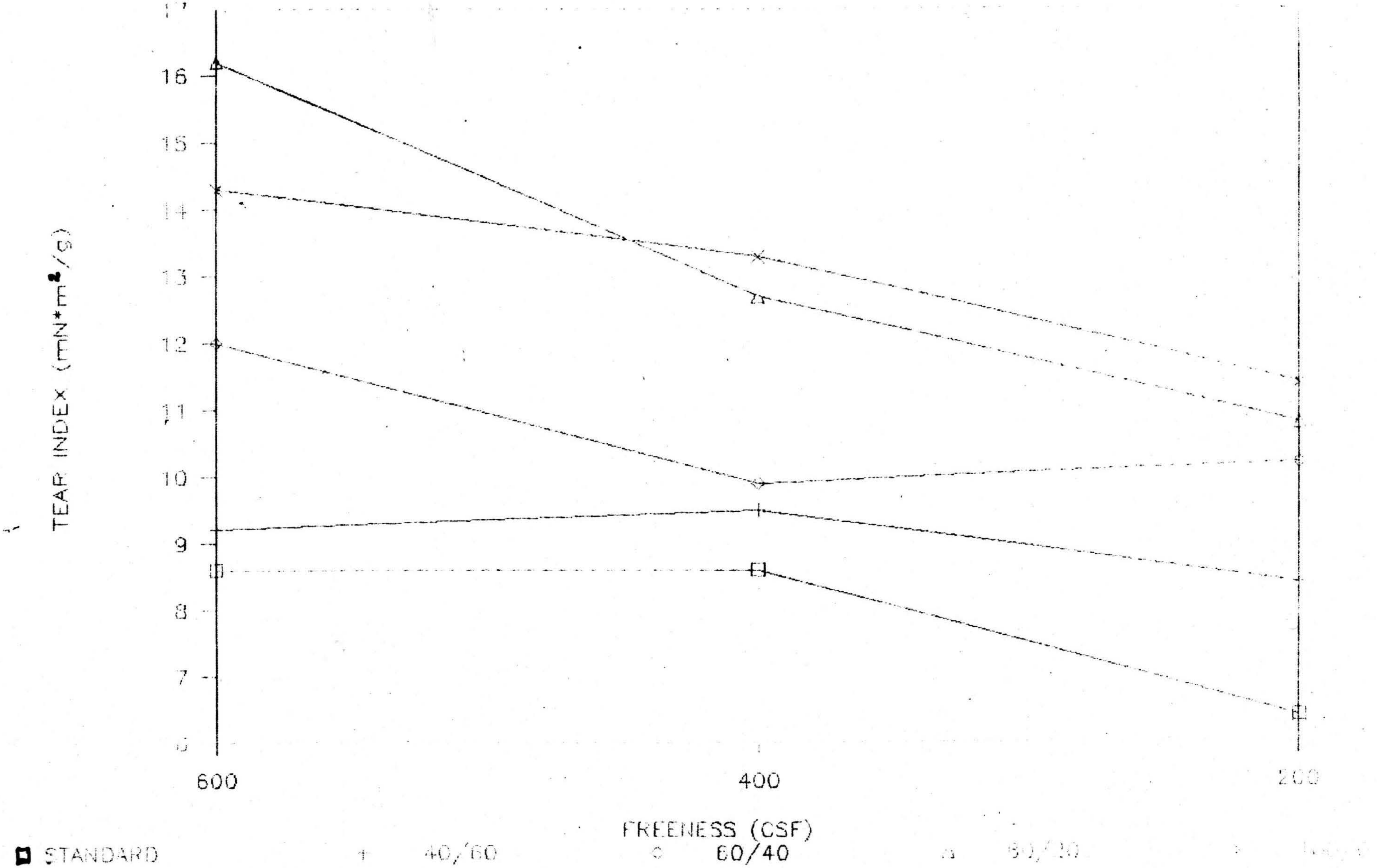
CSF	GRADE (%R/%V)	BASIS WT. (lb/1000ft)	CALIPER (pt)	TENSILE (Nm/g)	TEAR (mN*m/g)	RING CRUSH (lbs)	CMT (lbs)
	25/75 WO	26.5	15.8	24.7	08.6	29.7	29.8
	40/60 WO	27.5	16.0	23.4	07.8	21.5	22.8
	40/60 ST	27.1	15.9	23.6	09.2	32.5	24.0
	60/40 WO	26.5	15.3	22.6	10.2	18.2	20.5
600	60/40 ST	27.2	14.8	30.8	12.0	25.3	27.0
	80/20 WO	26.1	14.2	23.9	11.6	19.2	18.4
	80/20 ST	28.5	14.8	36.0	16.2	37.3	29.5
	100/0 WO	27.8	13.7	26.9	16.0	22.3	17.2
	100/0 ST	26.7	12.9	38.3	14.3	35.2	27.3
	25/75 WO	27.5	14.3	35.9	08.6	31.7	40.5
	40/60 WO	26.0	13.8	43.1	07.9	30.5	46.5
	40/60 ST	27.4	13.9	45.5	09.5	47.0	49.2
	60/40 WO	27.5	13.4	49.4	10.4	37.3	53.5
400	60/40 ST	27.3	13.5	46.4	09.9	44.7	43.0
	80/20 WO	27.5	12.9	50.9	11.1	34.5	53.8
	80/20 ST	27.6	12.7	42.3	12.7	48.0	50.7
	100/0 WO	29.5	11.4	55.6	13.0	43.0	59.2
	100/0 ST	26.5	10.7	50.9	13.3	47.7	48.3
	25/75 WO	27.1	13.3	50.4	06.4	26.8	56.8
	40/60 WO	26.8	13.3	49.9	07.7	36.3	56.2
	40/60 ST	27.1	13.1	50.5	08.4	50.0	57.7
	60/40 WO	27.1	12.4	52.7	09.3	40.2	61.7
200	60/40 ST	26.5	12.3	49.7	10.2	50.2	53.5
	80/20 WO	26.6	11.7	53.9	10.2	38.7	57.5
	80/20 ST	27.6	11.1	52.4	10.8	56.8	59.0
	100/0 WO	27.4	10.4	50.4	11.9	39.8	54.5
	100/0 ST	26.5	09.9	66.4	11.4	51.3	56.8

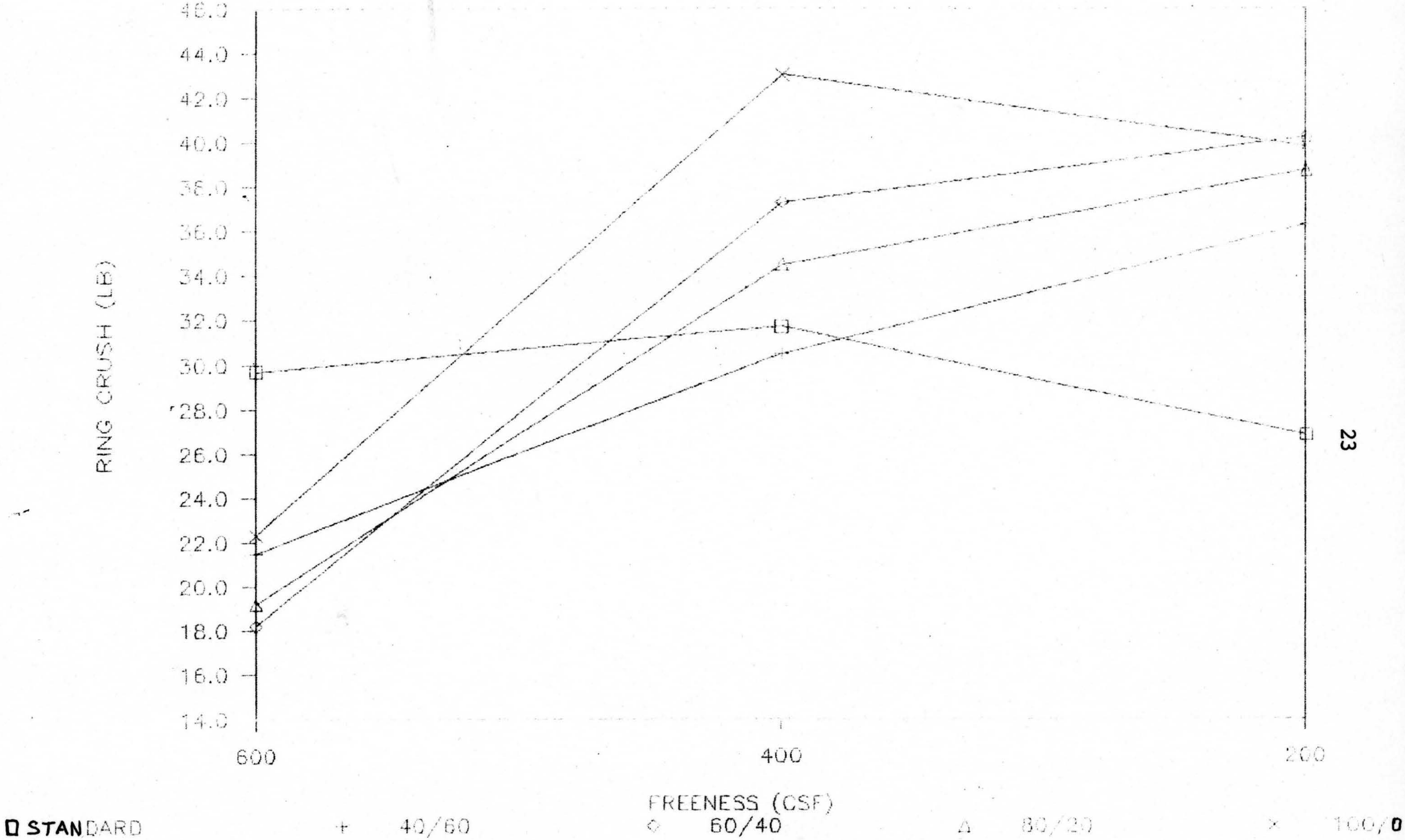

TENSILE INDEX (N*m/g)
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
600
400
200
FREENESS (CSF)
STANDARD
40/60
60/40

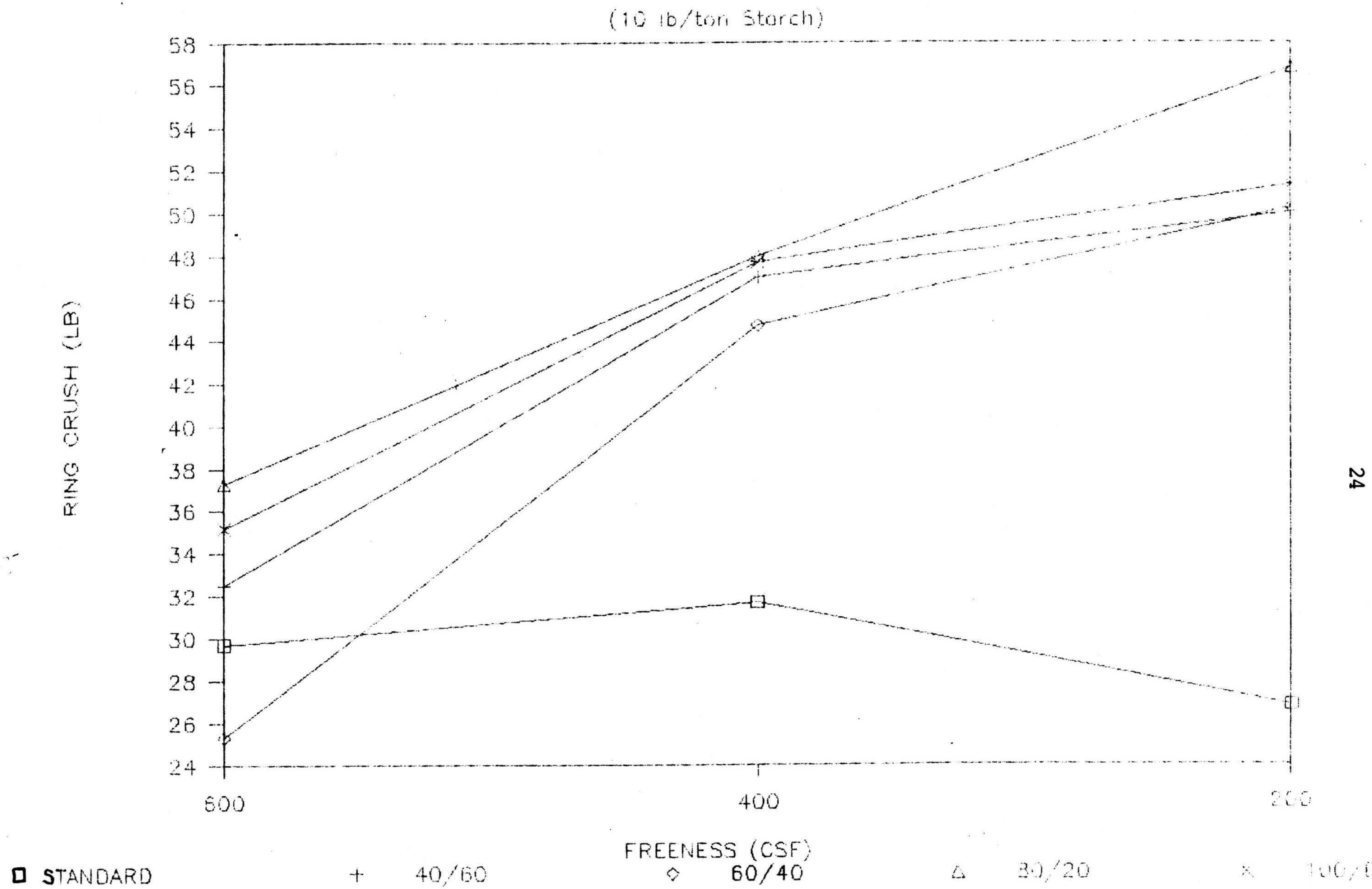

(10 lb/ton Starch)
TENSILE INDEX (N*m/g)
70
65
60
55
50
45
40
35
30
25
20
600
400
200
FREENESS (CSF)
STANDARD
40/60
60/40

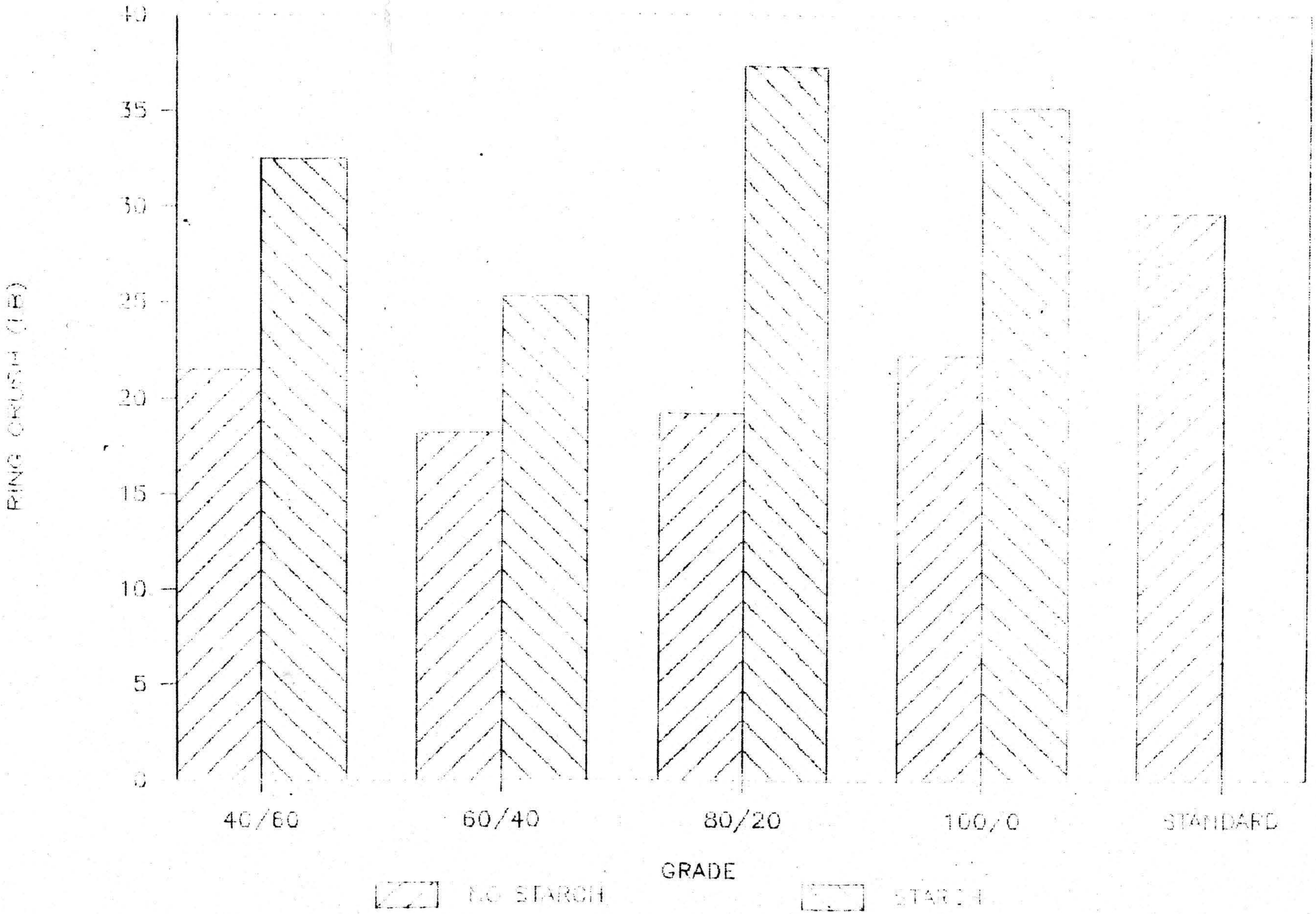
TEAR INDEX (mN*m²/G)
6
7
8
9
10
11
12
13
14
15
600
400
200
FREENESS (CSF)
STANDARD
40/60
60/40

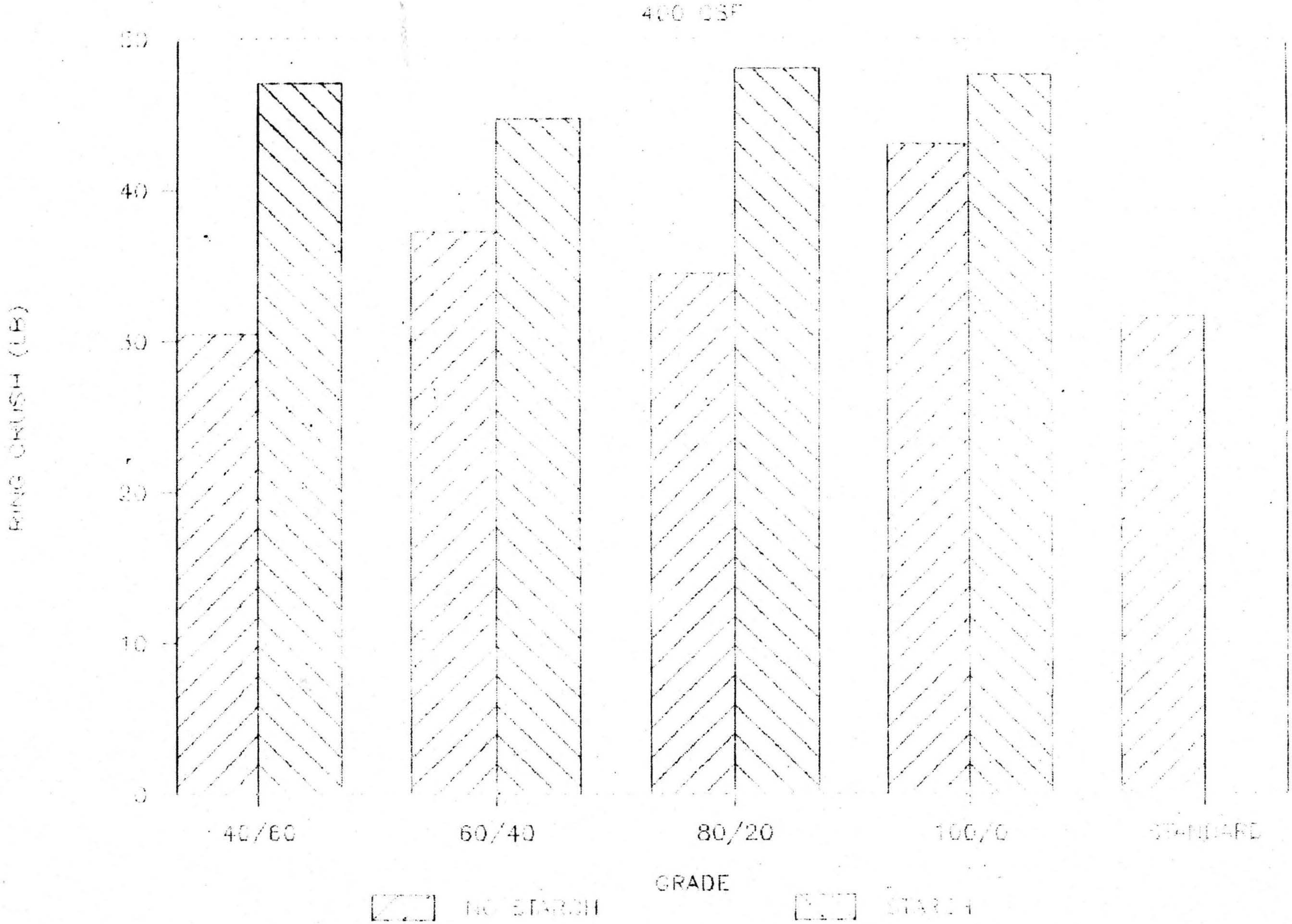
(10 lb/ton Starch)



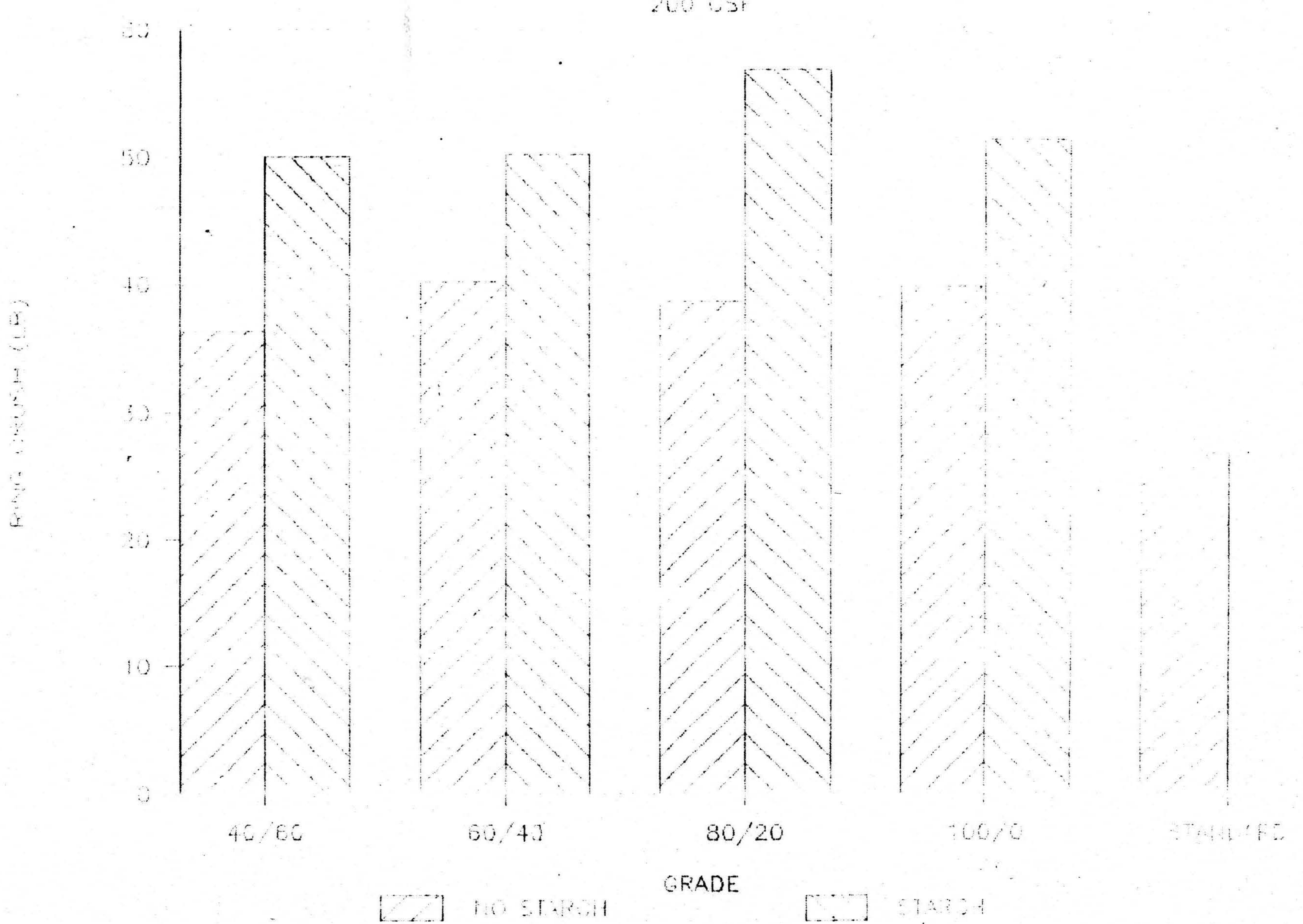

RING CRUSH (LB)
46.0
44.0
42.0
40.0
38.0
36.0
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
600
400
200
FREENESS (CSF)
□ STANDARD
+ 40/60
◇ 60/40
△ 80/20
× 100/0

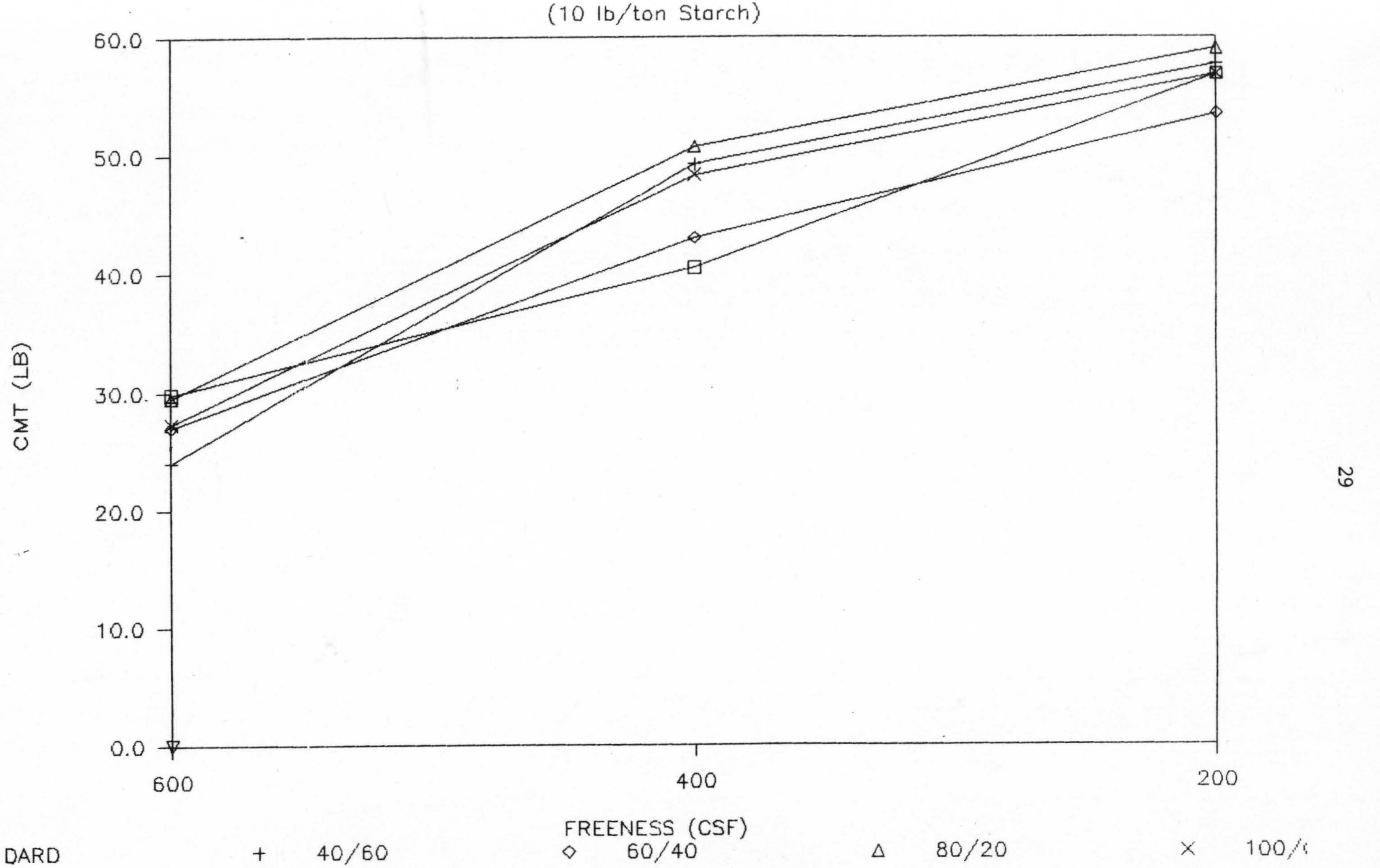

(10 lb/ton Starch)
RING CRUSH (LB)
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
600
400
200
FREENESS (CSF)
STANDARD
40/60
60/40
80/20
100/0


RING CRUSH (LB)
0
5
10
15
20
25
30
35
40
40/60
60/40
80/20
100/0
STANDARD
GRADE
NO STARCH
STARCH



400 CSF
RING CRUSH (LB)
40
30
20
10
0
40/60
60/40
80/20
100/0
STANDARD
GRADE
NO STARCH
STARCH


200 CSF
0
10
20
30
40
50
60
40/60
60/40
80/20
100/0
STANDARD
GRADE
NO STARCH
STARCH



(10 lb/ton Starch)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
CMT (LB)
600
400
200
FREENESS (CSF)
DARD
+ 40/60
◇ 60/40
Δ 80/20
× 100/

FIG. 11 CMT VS. FREENESS

(10 lb/ton Starch)

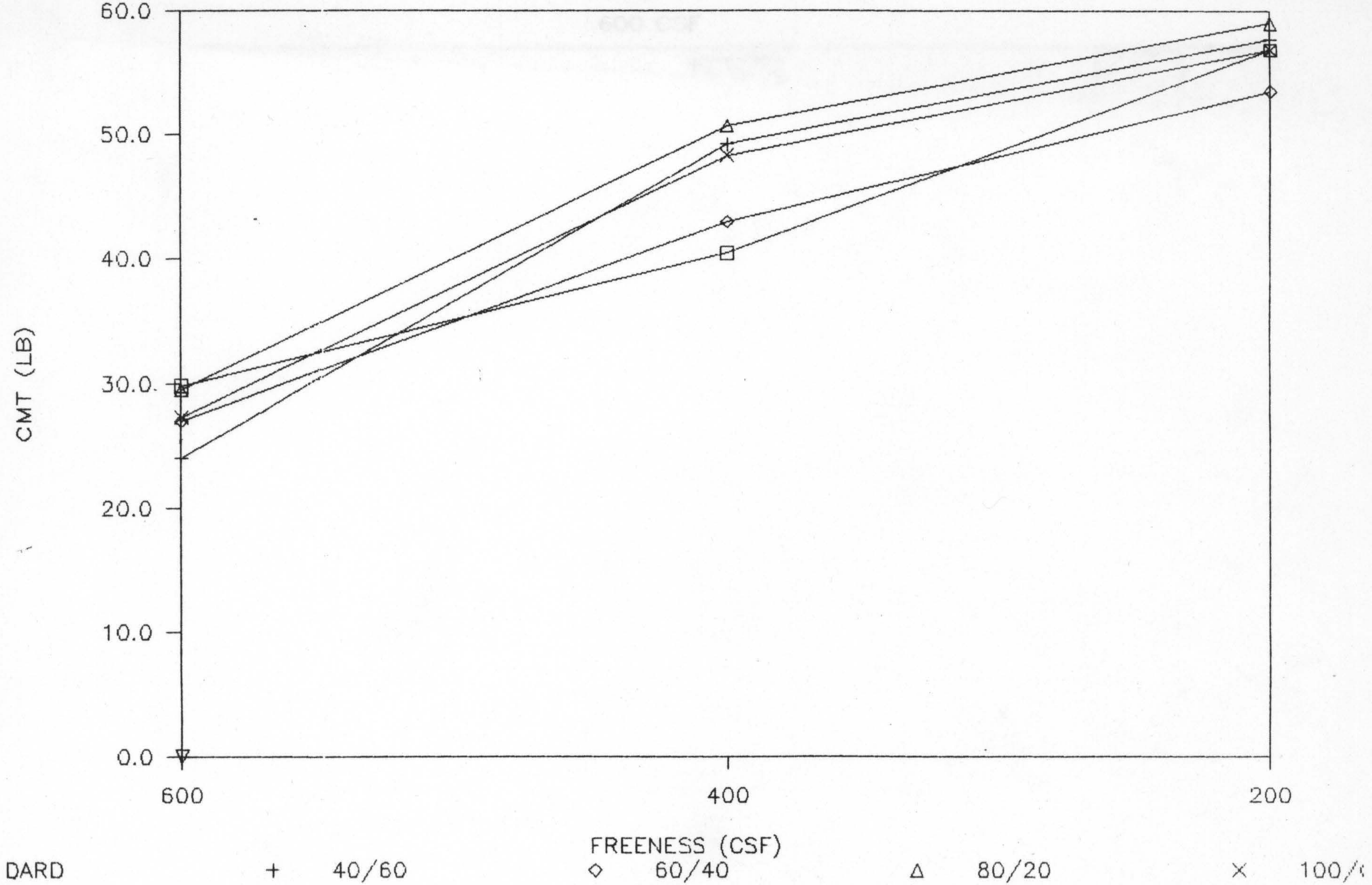


FIG. 12 CMT VALUES

600 CSF

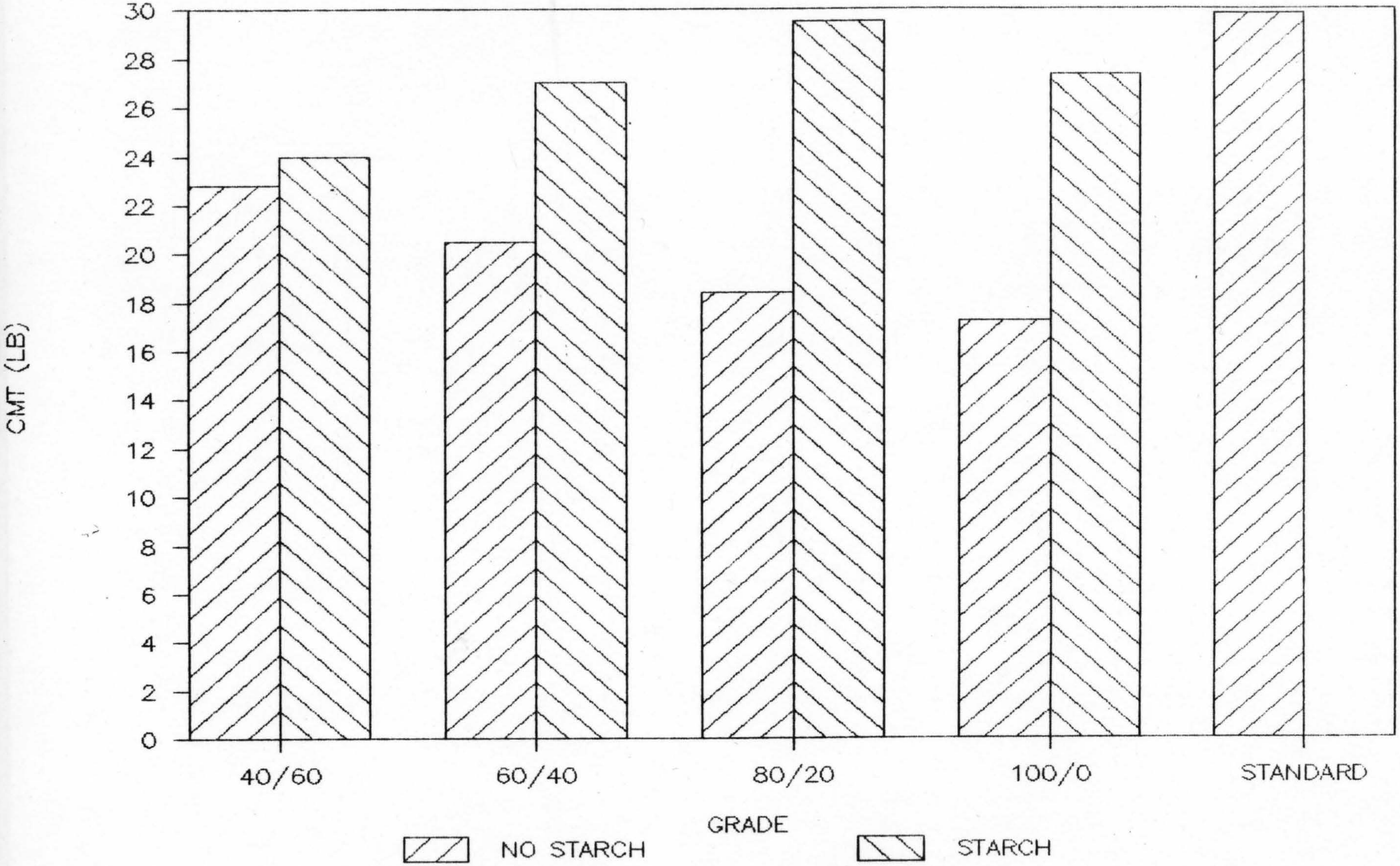


FIG. 13 CMT VALUES

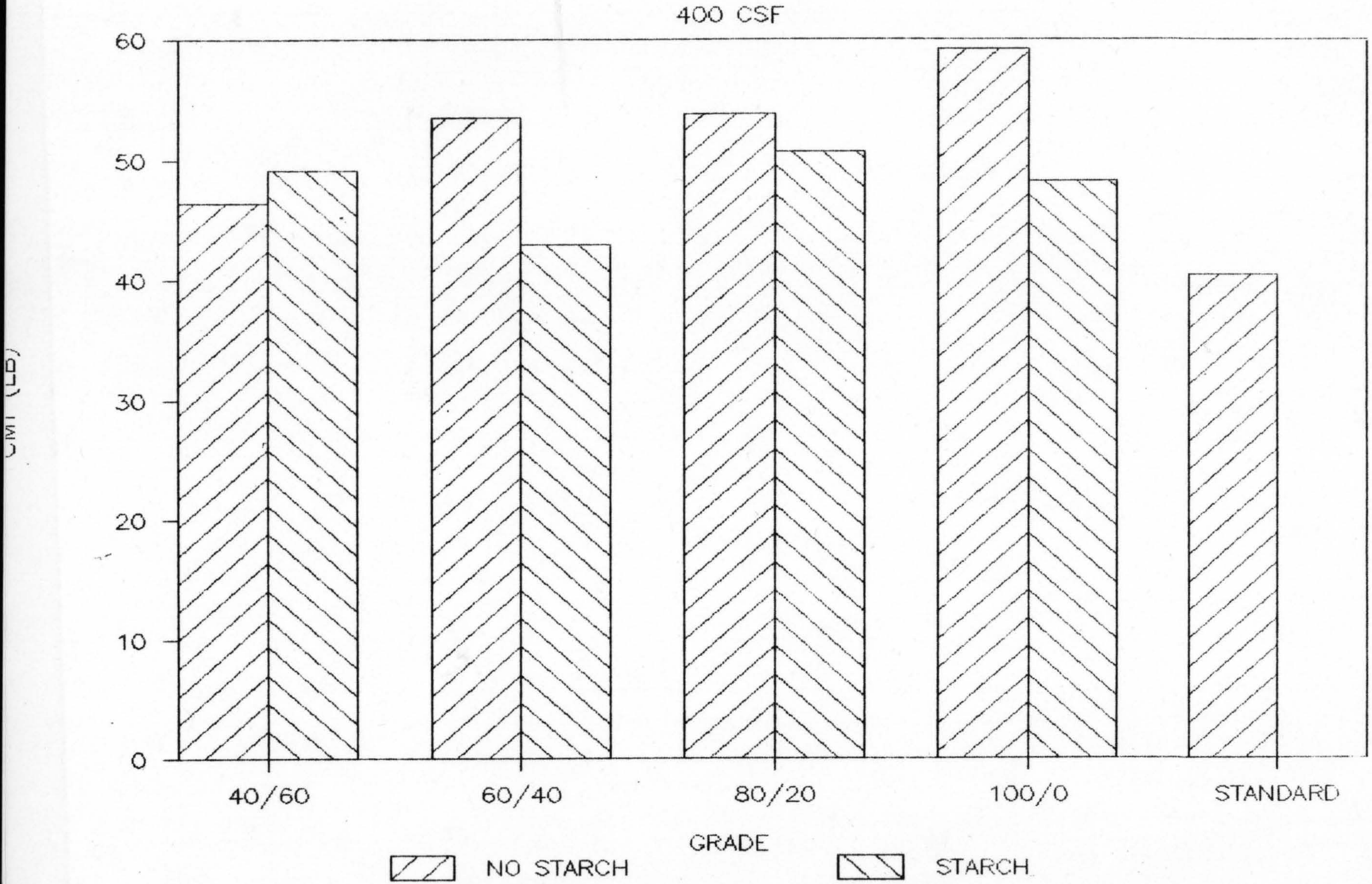
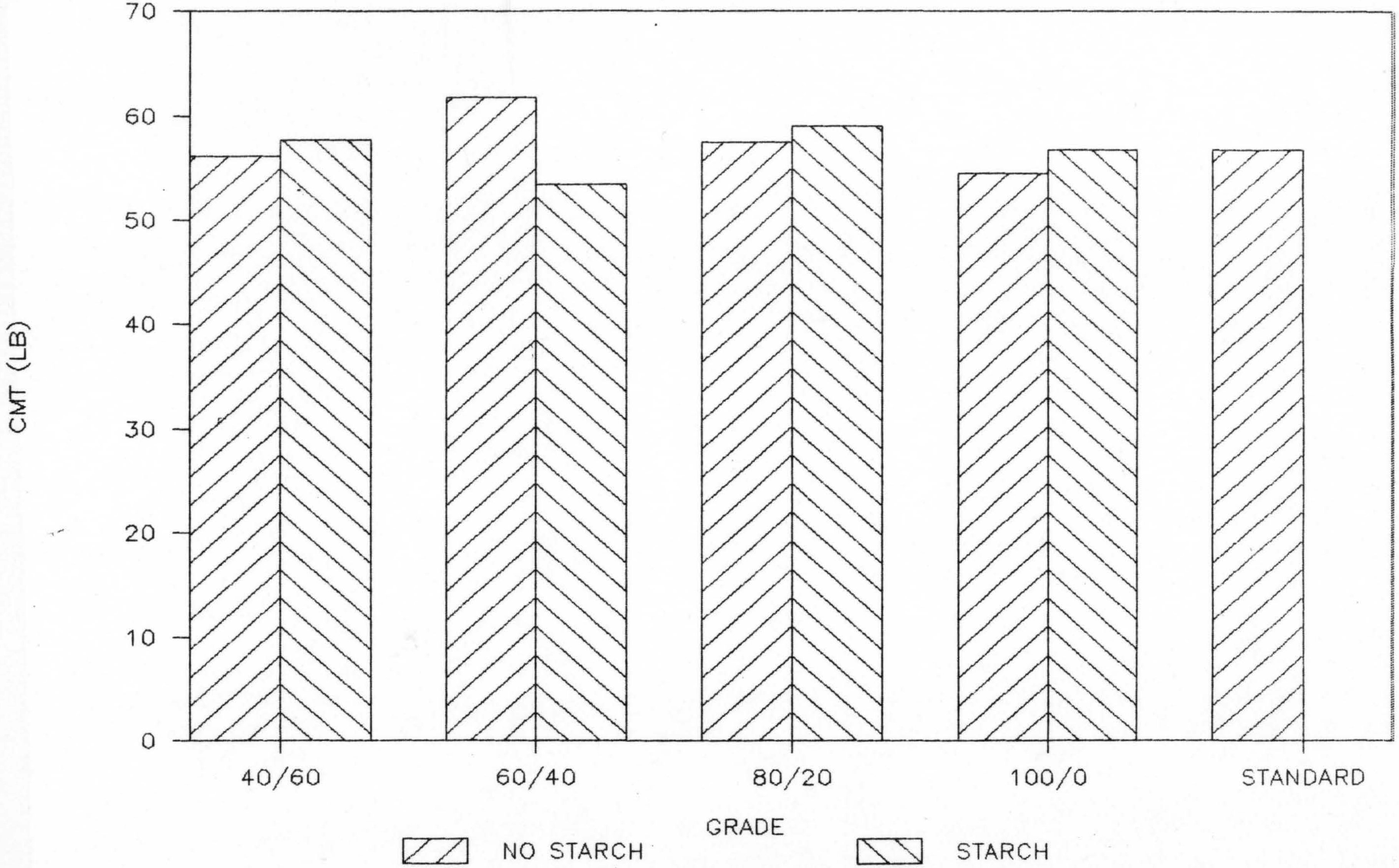


FIG. 14 CMT VALUES

200 CSF



CONCLUSIONS

From the data collected in this project it seems that increases in the amount of recycled fiber are possible. In all the data here it seemed that those samples containing 100% recycled fiber provided the best results. This is very unusual as to what was expected.

At the onset of this project it seemed likely that the increase in recycled fiber would have a positive influence on the tear and tensile strengths due to the increased fiber bonding that would occur with these longer softwood fibers in the furnish.

The values for ring crush and CMT were expected to have a negative response with an increase in recycled fiber because of the decrease in the amount of short, stiff hardwood fibers which would give those properties that are expected from these fibers. The reasons that they increased with the increase in amount of recycled fiber may be attributed to the type of recycled fiber that was used in this project. This source was a very clean source and may have contained some very good medium as well as a very good linerboard.

All results tended to deviate from what the industry is using today. The 25% to 75% recycled to virgin fiber is what mills are tending to lead towards because of the properties they obtain at this ratio. Companies are becoming so competitive that they are trying to produce the top quality furnish.

RECOMMENDATIONS

As the data in this report seems to stray so far from what was expected there may be some areas of study to find some answers to these results. Some subject areas for study could include the following:

1. Effects of recycled fiber on corrugating medium using various sources of recycled fiber.

2. Amounts of softwood versus hardwood fibers to optimize medium furnishes.

3. Additives to increase the ring crush and CMT values of corrugating medium.

BIBLIOGRAPHY

1. Carl (Fred) Mills, Technical Director; PCA; Filer City, Mi Personal Consultation.

2. <u>WITH THE GRAIN;</u> "Paper, paper, Everywhere"; April/May 1990 pp. 8-11.

3. Clark, L.E., Ianazzi, F.D.; "Fiber seperation as a means of increasing utilization of waste corrugated boxes" TAPPI J., vol 57, no. 11, pp. 59-61.

4. El-Hosseiny, F, Schirer, S.C., Patell, T.; "Effect of wet end variables on edgewise compressive strength of corrugated medium"; TAPPI J., vol. 72, no. 7, pp. 127-31.

5. Franklin, W.E.; "Trends in recovery and utilization of waste paper in recycling mills, and other users of waste paper, 1970-2000"; TAPPI J., vol. 69, no. 2, pp. 28-31.

6. Koning Jr., J.W., Mohaupt, A.A.; "Corrugating medium from household trash"; TAPPI J., vol. 57, no. 11, pp. 56-58.

7. Lowe, K; "Secondary fiber requirements for corrugating medium", Paper Trade Journal, Feb. 15, 1971, pp. 51-55.

8. Smith, W.; "Using OCC in container board grades", TAPPI J. vol. 69, no. 3, pp. 66-69.

9. Snider, B.; "Moving a mountain: paper, solid waste and recycling", PIMA Magazine, vol. 71, June 89, pp. 45-48.

10. Whitsitt, W.J.; "Runnability and corrugating medium properties", TAPPI J., vol. 70, no. 10. pp. 99-103.

11. Whitsitt, W.J.; "Papermaking factors affecting box properties", TAPPI J., vol. 71, no. 12, pp. 163-7.