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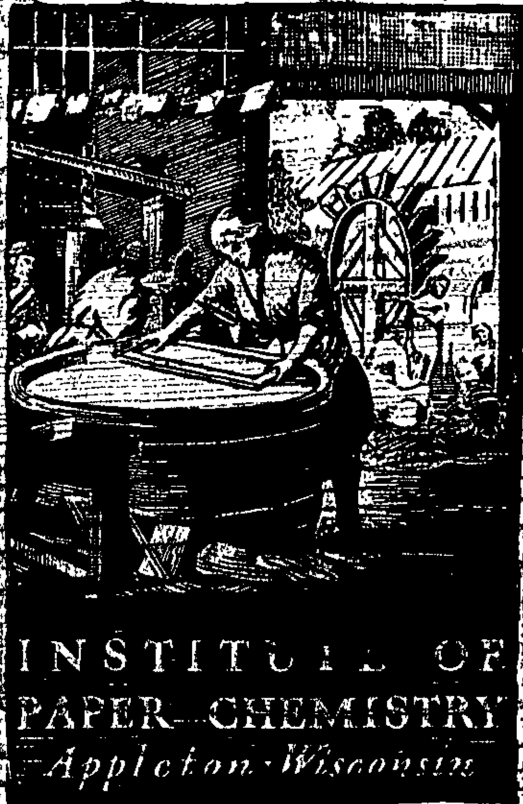

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AN INVESTIGATION OF WAYS AND MEANS OF MAKING WEATHERPROOF KRAFT BOARDS

Project 1108-5

Progress Report Two

to

FOURDRINIER KRAFT BOARD INSTITUTE, INC.

April 30, 1951

THE INSTITUTE OF PAPER CHEMISTRY

APPLETON, WISCONSIN

AN INVESTIGATION OF WAYS AND MEANS OF MAKING WEATHERPROOF KRAFT BOARDS

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Appleton, Wisconsin

During August 1950, the Fourdrinier Kraft Board Institute initiated at The Institute of Paper Chemistry a study, the object of which was to continue and expand an investigation already underway for the purpose of determining ways and means of making weatherproof kraft board without resorting to additives at the stock chest or headbox, a procedure which may necessitate a reduction in speed and, consequently, a loss of tonnage and causes inconvenience with regard to schedules and deliveries The initial concept of this study had been initiated earlier by the Inland Container Corporation as a company project, which had no relation to the Fourdrinier Kraft Board Institute research and development program. In view of the encouraging results obtained initially and the possible impact which the international situation at that time might have on the kraft board industry, the Inland Container Corporation generously made the information available to the Fourdrinier Kraft Board Institute and gave permission to pursue the study under its auspices

The study initiated by the Inland Container Corporation involved (1) treating 90-lb kraft linerboard with various impregnants as a separate operation from the paperboard making operation and (2) the subsequent comparison of the physical characteristics of the treated linerboard with those of 90-lb. melamine-treated linerboard The reason for doing this was to investigate the possibility of treating regular 90-lb. kraft linerboard at the converter's plant with suitable impregnants which would permit the substitution of the impregnated linerboard for the 90-lb. melamine-treated linerboard used in the manufacture of corrugated boxes for special purposes wherein wet strength is an important requirement

This study is being pursued by means of a series of experiments, the results of the first two series of experiments having previously been reported in Progress Report One, entitled "An Investigation of Ways and Means of Making Weatherproof Kraft Board" dated October 23, 1950.

The conclusions drawn from the above experiments were: The results obtained on samples of regular kraft linerboard impregnated with various types of resins showed that the wet and dry strength properties of many of the treated boards were comparable with those obtained on regular V-board liners.

As mentioned above, this study is being pursued by means of a series of experiments. The current report is for the purpose of presenting the information developed to date regarding the feasibility of making V-board components by impregnating regular kraft linerboard with wet strength resins.

PART III

The results obtained in Parts I and II (see Progress Report One) indicated that it is possible to treat regular 90-lb. kraft linerboard so that the wet-strength properties would be comparable with those of current 90-lb. V-board machine sized with melamine resin. The experiments carried out in Parts I and II involved base stock (90-lb.) and melamine board which were considerably lower in initial bursting strength than those currently found in the trade. Inasmuch as previous experiments had been confined almost entirely to 90-lb kraft linerboard, it was felt that the same approach should be used on the lighter weight V-board components to see if the same treatment would be as effective.

MATERIALS USED

The base stocks used in this phase of the study were current regular kraft boards of 33- and 38-lb. weight Current melamine-sized boards of 33- and 38-lb. weight also were used for comparison. The physical characteristics of the regular and melamine-sized boards used as base stock and for reference are given in Table I Because of the difficulty associated with making bursting strength evaluations on wet samples with the Jumbo bursting strength tester, tests were also made on the Model C or Paper Mullen tester. The latter results are given in Table II.

PROCEDURE

The method of impregnation used in this phase of the study was the same as that employed in Part II of Progress Report One. The general procedure followed is illustrated in Figure 1. In Part III, each roll of regular kraft board was trimmed to ten inches in width, rewound, and weighed. The rewound and weighed board was then impregnated according

TABLE I

STICS OF REGULAR AND MELAMINE-SIZED BOARDS

lmendorf Tear, g./sheet							Amthor Tensile, lb./in.							
In			Across				In				Across			
	6	24		5	6	24		5	6	24		5	6	24
*	Hr.*	Hr.*	Dry	Min.*	Hr.*	Hr.*	Dry	Min.*	Hr.*	Hr.*	Dry	Min.*	Hr.*	Hr.*
.	186	158	382	292	198	182	84.3	16.1	8.6	8.7	35.2	6.1	3.9	3.8
)	246	210	352	297	244	256	76.6	18.5	12.2	10.3	35.9	9.7	6.8	6.4
5	155	148	330	236	175	172	74.6	12.5	9.2	8.9	30.6	5.9	4.5	4.0
1	178	131	291	191	175	162	72.3	14.2	8.3	8.5	26.8	6.2	3.9	4.3

TABLE I

PHYSICAL CHARACTERISTICS OF REGULAR AND MELAMINE-SIZED BOARDS

Sample	Type	Weight, lb	Caliper, point	Density, lb per cu. ft.	Bursting Strength (Jumbo), p.s.i. (gage)				Elmendorf Tear, g./sheet In				Elmendorf Tear, g./sheet Across				Amthor Tensi In			
					Dry	5 Min.*	6 Hr.*	24 Hr.*	Dry	5 Min.*	6 Hr.*	24 Hr.*	Dry	5 Min.*	6 Hr.*	24 Hr.*	Dry	5 Min.*	6 Hr.*	24 Hr.
19	Regular	39 4	13.1	36.1	98	26	19	16	330	251	186	158	382	292	198	182	84.3	16.1	8.6	8.7
23	Melamine	38.5	13.0	35.5	92	34	25	25	318	330	246	210	352	297	244	256	76.6	18.5	12.2	10.3
20	Regular	33.2	11.7	34.1	87	26	17	15	258	206	155	148	330	236	175	172	74.6	12.5	9.2	8.9
24	Melamine	32.9	10.4	38.0	80	23	18	15	250	251	178	131	291	191	175	162	72.3	14.2	8.3	8.5

* Wet immersion time.

TABLE II

PHYSICAL CHARACTERISTICS OF REGULAR AND MELAMINE-SIZED BOARDS

Sample	Type	Weight, lb.	Caliper, points	Density, lb./cu. ft.	Bursting Strength (Model C Mullen Tester), p.s.i. (gage)			
						Wet		
					Dry	5 min.	6 hr.	24 hr.
19	Regular	39.4	13.1	36.1	94.0	16.0	11.2	9.0
23	Melamine	38.5	13.0	35.5	86.7	22.0	15.2	14.0
20	Regular	33.2	11.7	34.1	83.0	14.3	9.9	7.6
24	Melamine	32.9	10.4	38.0	80.3	13.7	10.4	8.7

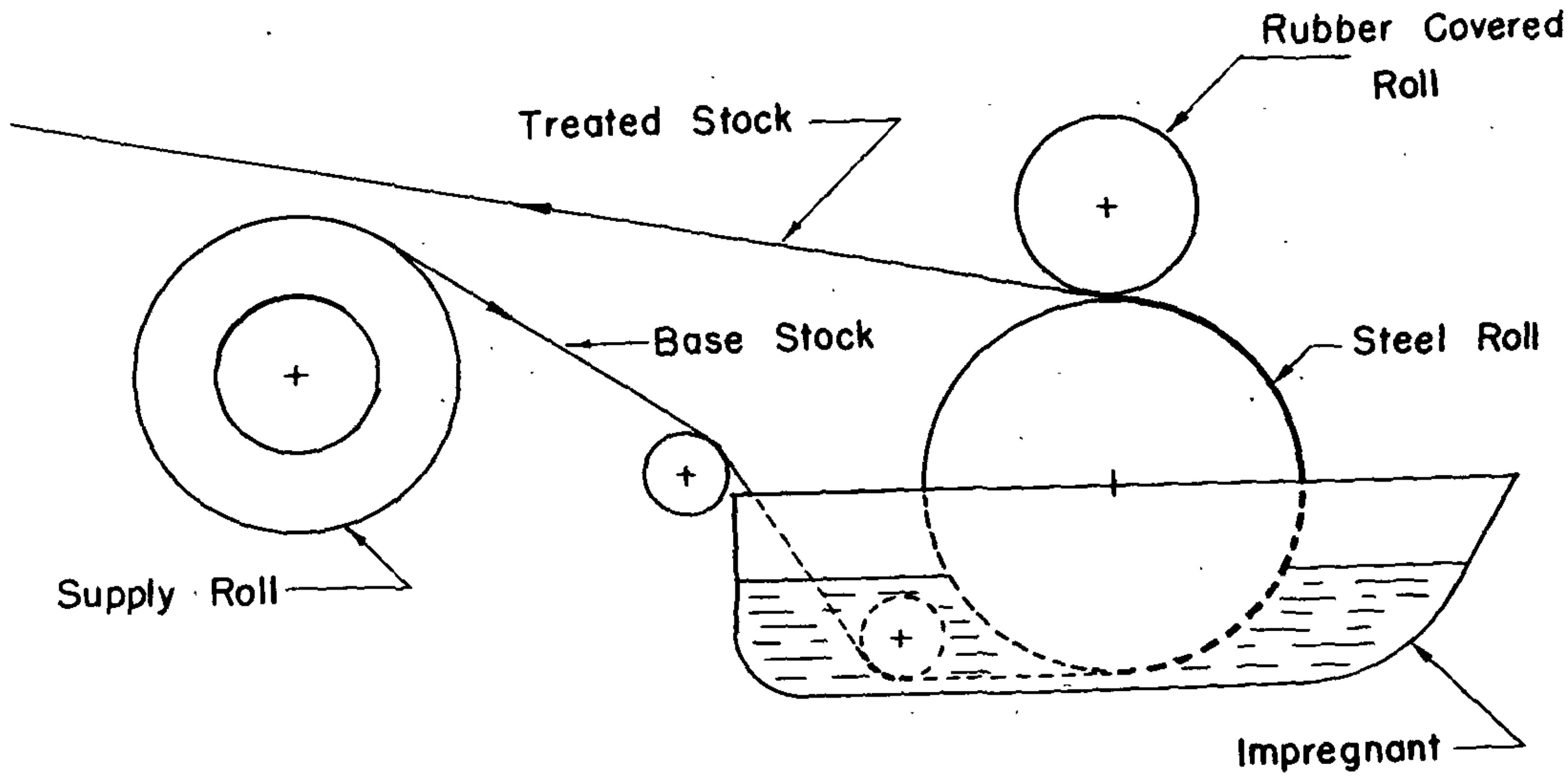

Figure I
Impregnating Equipment

to the method shown in Figure 1, and wound into a roll without drying. The impregnated and wound stock was again weighed and the amount of resin solution picked up was calculated from the difference in weight before and after impregnating. After being weighed, the wet impregnated board was dried by running it through a small drier section of a Waldron laminator consisting of five small drier drums whose surface temperature ranged from ~~300~~ 200 to 250°F.

The run numbers and the concentration of resin as well as wetting agent (Triton X-100) used in each run, are given in Table III.

TEST PROCEDURE

The test procedures used in the phases reported herein were the same as those previously reported in Progress Report One. The tests included are basis weight, caliper, wet and dry bursting strength, wet and dry Elmendorf tearing strength, and wet and dry tensile strength. As previously mentioned, the bursting strength results reported in Progress Report One were obtained with the Perkin's "Jumbo" Mullen tester; however, because the magnitude of the bursting strength of the various grades of board after 24 hours' immersion in water was in many cases lower than the maximum distension pressure of the diaphragm, extreme care was necessary in order to obtain the proper value. Because of the uncertainties associated with bursting strengths obtained under these conditions, both the Model A (Jumbo) and the Model C (paper tester) were employed. Throughout this report, the type of bursting strength tester used is reported in each table.

TABLE III

IMPREGNATION DATA

Run	1B	10B	11B	2B	5B	7B	6B	9B	12B	3B	4B	8B
Weight basestock, lb.[a]	39.4	39.4	39.4	39.4	39.4	39.4	33.2	33.2	33.2	33.2	33.2	33.2
Impregnant[b]												
Uformite, %	1.5	1.5	1.5	3.0	3.0	3.0	1.5	1.5	1.5	3.0	3.0	3.0
Triton X-100, %	0	0.1	0.25	0	0.1	0.5	0	0.1	0.25	0	0.1	0.5
Resin pickup(dry), %	0.279	0.375	0.671	0.468	0.694	2.32	0.294	0.409	0.786	0.570	0.881	2.72
Chemical cost per ton, dollars	1.01	1.50	3.13	1.69	2.65	10.76	1.06	1.64	3.67	2.06	3.36	12.62
Moisture pickup, %[c]	18.3	24.6	44.0	15.1	22.4	75.0	19.3	26.8	51.6	18.4	28.4	87.8

[a] Basestock used in above same as Run 19 and 20.

[b] 50 g. alum added per pound of Uformite 467 solids.

[c] Based on air-dry weight of base stock.

DISCUSSION OF RESULTS

The physical characteristics of the 33- and 38-lb. regular Fourdrinier kraft board impregnated from various concentrations of Uformite-467 resin with small additions of a wetting agent (Triton X-100) are given in Table IV. The physical characteristics of the untreated base stocks used in the above impregnation trials and the corresponding grade of melamine-sized V-board are included in Table IV, together with the cost of the impregnant and the percentage moisture pickup on impregnation. This latter value is included, inasmuch as it indicates the amount of water added with each treatment and, hence, the amount of subsequent drying necessary.

A comparison of the results obtained on the 38-lb. samples shows that the results obtained on Runs 5B and 7B in most cases are comparable with those obtained on the 38-lb. melamine-sized board sample. However, the chemical cost of Run 7B is $10.76 per ton and the moisture pickup is 75.0%; thus, it does not appear practical. On the other hand, the chemical cost of Run 5B is $2.65 and the moisture pickup was only 22.4%. The resin pickup in Run 5B is slightly less than 0.75%. It would appear reasonable to expect that if the resin pickup were increased to approximately 1%, the physical properties would exceed those obtained on the 38-lb. melamine-sized board with a chemical cost approaching $5.00; however, the amount of moisture to be removed would probably be in the neighborhood of 32%, which would require considerable drying surface. The results do show, however, that it is feasible to impregnate

TABLE IV

'AL CHARACTERISTICS OF IMPREGNATED
33- AND 38-LB KRAFT BOARD

'earing Strength, g./sheet							Amthor Tensile, lb./in.										
		Across				In				Across						Moisture
't			Wet				Wet				Wet			Impregnant	Pick-
6	24		5	6	24		5	6	24		5	6	24	Cost/Ton,	up,
Hr.	Hr.	Dry	Min.	Hr.	Hr.	Dry	Min.	Hr.	Hr.	Dry	Min.	Hr.	Hr.	dollars	%
186	158	382	292	198	182	84.3	16.1	8.6	8.7	35.2	6.1	3.9	3.8		
175	130	353	310	206	148	86.1	18.6	11.4	11.1	36.7	8.4	5.0	4.7	1.01	18.3
181	152	368	280	207	174	91.0	15.7	10.4	10.8	36.0	7.2	4.8	5.0	1.50	24.6
183	139	382	285	209	167	88.3	14.6	11.7	11.3	35.5	6.7	5.1	5.3	3.13	44.0
190	123	354	358	218	196	89.0	20.4	12.8	12.0	37.4	8.4	4.8	4.4	1.69	15.1
191	151	362	302	214	170	87.5	16.8	11.3	10.4	37.9	8.1	5.0	4.8	2.65	22.4
234	211	360	298	286	280	95.3	21.3	20.4	20.3	37.1	9.8	9.0	9.8	10.76	75.0
246	210	352	297	244	256	76.6	18.5	12.2	10.3	35.9	9.7	6.8	6.4		
155	148	330	232	175	172	74.6	12.5	9.2	8.9	30.6	5.9	4.5	4.0		
160	118	295	249	177	121	79.7	14.6	9.5	9.6	30.6	6.3	4.2	4.1	1.06	19.3
178	120	300	230	183	131	77.2	13.8	10.0	10.3	30.8	6.0	4.2	4.5	1.64	26.8
167	135	342	214	182	162	82.2	13.2	11.3	11.6	32.5	5.4	4.8	4.8	3.67	51.6
166	122	310	250	164	123	80.7	14.7	9.7	8.8	31.5	6.8	4.3	3.9	2.06	18.4
168	143	311	244	186	138	78.7	14.4	9.9	9.8	31.6	6.7	4.4	4.3	3.36	28.4
224	218	286	267	232	229	87.0	19.6	18.3	17.7	33.2	8.7	8.3	8.0	12.62	87.8
178	131	292	190	175	162	72.3	14.2	8.3	8.5	26.8	6.2	3.9	4.3		

TABLE IV

PHYSICAL CHARACTERISTICS OF IMPREGNATED
33- AND 38-LB KRAFT BOARD

Run	Resin Content, %	Weight, lb.	Caliper, pt.	Density, lb. per cu. ft.	Bursting Strength*, p.s.i. (gage) Dry	Bursting Wet 5 Min.	Bursting Wet 6 Hr.	Bursting Wet 24 Hr.	Elmendorf Tearing Strength, g./sheet In Dry	In Wet 5 Min.	In Wet 6 Hr.	In Wet 24 Hr.	Across Dry	Across Wet 5 Min.	Across Wet 6 Hr.	Across Wet 24 Hr.	Amthor Tensile, lb./i In Dry	In Wet 5 Min.	In Wet 6 Hr.	In Wet 24 Hr.	Dry
19	0	39.4	13.1	36.1	94	16	11.2	9.0	330	251	186	158	382	292	198	182	84.3	16.1	8.6	8.7	35.2
1B	0.279	41.0	13.6	36.2	95.9	21.8	13.6	10.5	284	292	175	130	353	310	206	148	86.1	18.6	11.4	11.1	36.7
10B	0.375	40.5	13.6	35.7	96.5	21.0	13.2	10.8	302	234	181	152	368	280	207	174	91.0	15.7	10.4	10.8	36.0
11B	0.671	40.9	13.9	35.3	99.0	18.3	13.0	11.2	315	246	183	139	382	285	209	167	88.3	14.6	11.7	11.3	35.5
2B	0.468	41.1	13.9	35.3	97.4	20.9	13.8	10.4	312	262	190	123	354	358	218	196	89.0	20.4	12.8	12.0	37.4
5B	0.694	40.8	14.1	34.7	99.8	20.4	14.1	11.8	302	262	191	151	362	302	214	170	87.5	16.8	11.3	10.4	37.9
7B	2.32	41.1	14.1	35.0	94.6	19.4	17.9	16.6	273	270	234	211	360	298	286	280	95.3	21.3	20.4	20.3	37.1
23	Melamine	38.5	13.0	35.5	86.7	22.0	15.2	14.0	318	330	246	210	352	297	244	256	76.6	18.5	12.2	10.3	35.9
20	0	33.2	11.7	34.1	83.0	14.3	9.9	7.6	258	206	155	148	330	232	175	172	74.6	12.5	9.2	8.9	30.6
6B	0.294	33.0	11.8	33.6	83.6	16.9	12.5	9.5	242	221	160	118	295	249	177	121	79.7	14.6	9.5	9.6	30.6
9B	0.409	33.3	11.7	34.2	84.4	18.4	13.5	11.0	250	206	178	120	300	230	183	131	77.2	13.8	10.0	10.3	30.8
12B	0.786	33.8	11.9	34.1	83.7	16.4	13.0	10.9	262	197	167	135	342	214	182	162	82.2	13.2	11.3	11.6	32.5
3B	0.570	33.0	11.8	33.6	83.6	16.0	12.1	9.2	256	246	166	122	310	250	164	123	80.7	14.7	9.7	8.8	31.5
4B	0.881	33.4	12.0	33.4	85.7	17.6	12.6	10.1	252	241	168	143	311	244	186	138	78.7	14.4	9.9	9.8	31.6
8B	2.72	34.1	12.0	33.8	83.6	19.5	17.6	17.0	246	238	224	218	286	267	232	229	87.0	19.6	18.3	17.7	33.2
24	Melamine	32.9	10.4	38.0	80.3	13.7	10.4	8.7	250	251	178	131	292	190	175	162	72.3	14.2	8.3	8.5	26.8

* Model "C" tester.

regular 38-lb. kraft board and obtain sufficient wet strength to equal or exceed the wet-strength properties of the corresponding grade of melamine-sized board.

When the results obtained on the 33-lb. samples are compared, it may be observed that all the impregnated samples exhibited higher bursting strength values after 24-hour immersion than the 33-lb. melamine-sized board. From the standpoint of over-all strength characteristics, it would appear that Runs 4B and 8B give the best results. The resin pickup in Run 8B was 2.72%, with an approximate chemical or resin cost of $12.62 per ton and a 87.8% moisture pickup; thus, it would appear impractical. The chemical cost in Run 4B is approximately $3.36 per ton and the moisture pickup 28.4%. As was observed in the case of the 38-lb. samples, it appears that wet and dry strength characteristics comparable with those on melamine-sized board can be obtained by impregnating regular 33-lb. board with approximately 0.75% resin.

The resin pickups obtained in this phase indicate the effectiveness of Triton X-100 as a wetting agent. For example, the inclusion of approximately 0.25% of Triton X-100 in the resin solution more than doubled the percentage resin pickup. The results further indicate that a resin content of approximately 1% is needed to give wet and dry strength results comparable with the melamine-sized boards. In addition, the higher concentrations of resins are indicated because of the lower water pickup per given resin pickup. For example, for the same resin pickup, doubling the concentration of the resin solution decreases the moisture pickup by 50%. Thus, these results indicate the advisability of using greater concentrations than those used in this phase, provided sufficient penetration can be obtained, in order to keep the moisture pickup at a minimum and consequently reduce the drying surface required.

PART IV

Previous experimental trials with impregnants containing a wetting agent indicated that the use of a wetting agent (such as Triton X-100) materially increased the resin pickup from a solution of Uformite 467. The impregnations carried out previously with and without the use of a wetting agent had been made on a laboratory scale in which the stock was impregnated from a continuous web but required auxiliary equipment for drying. In order to approach a commercial method more closely, it was decided to investigate the use of a 24-inch Waldron laminator equipped with five small rotating steam-heated driers. In order to obtain a direct comparison between the method of impregnation used in Part III and that with the Waldron laminator, one of the same impregnating solutions as that used in Part III on the 38-lb. regular kraft stock was repeated in Part IV, so that a comparison could be made of the effect of impregnating technique on final wet-strength results. In addition, two impregnating materials and one wetting agent not tried previously were evaluated by this impregnating method.

MATERIALS

The base stock used in this phase consisted of the same roll of 38-lb. regular kraft board as that used in Part III.

The impregnating materials consisted of Uformite 467, Ketac 1156 (an alkaline setting resin), and Arboneeld "B." The wetting agent used was Alryl T. Ketac 1156 is an acetone-formaldehyde resin marketed by the American Cyanamide Company. Arboneeld "B" is a urea-formaldehyde resin containing 28 grams of urea per 100 grams of Arboneeld "B" solids.

PROCEDURE

As previously mentioned, a small commercial-size Waldron laminator equipped with a set of steel pressure rolls and a steam-heated drier section was used for the impregnating operation. A schematic layout of the laminator and the method of impregnating may be seen in Figure 2. The run numbers and the concentrations of resins used in each run are given in Table V, together with the approximate chemical cost per ton and the approximate percentage moisture picked up as a result of the impregnation. It may be seen from Table V that the type and concentration of the resin used in Run 6-C is the same as that used in Run 2B in Part III.

DISCUSSION OF RESULTS

The physical characteristics of the 38-lb. regular kraft board impregnated from various resin solutions and using Alryl T as a wetting agent in place of Triton X-100 (which was used in the previous section) may be seen in Table VI. When the results obtained on the sample impregnated with Ketac 1156 resin (Runs 1C and 2C) are compared

TABLE V

IMPREGNATION DATA

Run	1C	2C	3C	4C	5C	6C	7C
Wet-Strength Resin	Ketac 1156	Ketac 1156	Uformite 467	Arboneeld"B"	Arboneeld"B"	Uformite 467	Uformite 467
Concentration, %	5.5	5.5	6.0	3.0	3.0	3.0	3.0
pH	Alkaline	Alkaline	3.8	3.7	3.7	4.0	4.0
Acidifying agent	None	None	Alum	Hydrochloric Acid	Hydrochloric Acid	Alum	Alum
Wetting agent	None	Alryl T	None	None	Alryl T	None	Alryl T
Concentration	--	0.25	--	--	0.25	--	0.25
Resin pickup, %	1.48	2.14	1.41	1.13	1.05	1.11	0.78
Chemical cost per ton, dollars	11.80	18.05	5.08	2.26	2.97	4.01	3.47
Moisture pickup, %	25.4	36.0	22.1	36.5	34.0	35.9	25.2

TABLE VI

PHYSICAL CHARACTERISTICS OF IMPREGNATED
38-LB. KRAFT BOARD

Tearing Strength, g./sheet						Amthor Tensile, lb./in.								Impreg- nant Cost/Ton, dollars	Mois- ture Pick- up, %
et		Across				In				Across					
			Wet				Wet				Wet				
6 Hr.	24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.		
186	158	382	292	198	182	84.3	16.1	8.6	8.7	35.2	6.1	3.9	3.8		
166	137	353	277	180	164	89.8	15.8	9.2	8.9	35.7	7.0	4.3	4.0	11.80	25.4
172	168	366	257	192	212	82.2	11.3	8.6	8.3	34.5	5.7	4.6	4.3	18.05	36.0
214	192	354	300	258	202	91.5	20.7	12.7	12.5	36.9	10.2	5.9	5.9	5.08	22.1
180	182	369	314	214	186	86.1	18.2	10.3	10.8	35.7	8.1	5.0	4.3	2.26	36.5
227	209	347	338	244	229	87.8	16.8	12.9	11.8	36.2	9.0	6.8	6.3	2.97	34.0
197	180	358	282	190	198	87.5	19.0	11.0	10.8	36.2	9.3	5.6	5.4	4.01	35.9
198	199	369	286	218	206	93.4	22.2	13.8	12.8	36.5	9.3	5.4	5.3	3.47	25.2
246	210	352	297	244	256	76.6	18.5	12.2	10.3	35.9	9.7	6.8	6.4		

TABLE VI

PHYSICAL CHARACTERISTICS OF IMPREGNATED
38-LB. KRAFT BOARD

Run	Resin Content, %	Weight, lb.	Caliper, pt.	Density, lb. per cu. ft.	Bursting Strength,* p.s.i. (gage)				Elmendorf Tearing Strength, g./sheet In				Elmendorf Tearing Strength, g./sheet Across				Amthor Tensile, lb./in In				Amthor Tensile, lb./in Ac[ross]
						Wet				Wet				Wet				Wet			
					Dry	5 Min.	6 Hr.	24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.	Dry
19	0	39.4	13.1	36.1	94.0	16	11.2	9.0	330	251	186	158	382	292	198	182	84.3	16.1	8.6	8.7	35.2
1C	1.48	40.8	13.5	36.3	87.5	15.8	10.6	8.7	294	218	166	137	353	277	180	164	89.8	15.8	9.2	8.9	35.7
2C	2.14	41.5	13.6	36.6	93.4	15.4	9.6	8.2	290	237	172	168	366	257	192	212	82.2	11.3	8.6	8.3	34.5
3C	1.41	40.4	13.5	35.9	93.8	21.6	14.3	11.6	308	315	214	192	354	300	258	202	91.5	20.7	12.7	12.5	36.9
4C	1.13	40.2	13.5	35.7	87.1	19.4	12.6	12.0	321	254	180	182	369	314	214	186	86.1	18.2	10.3	10.8	35.7
5C	1.05	40.4	13.6	35.6	82.7	20.5	13.6	10.8	299	266	227	209	347	338	244	229	87.8	16.8	12.9	11.8	36.2
6C	1.11	40.1	13.5	35.6	88.8	20.4	13.5	10.7	313	290	197	180	358	282	190	198	87.5	19.0	11.0	10.8	36.2
7C	0.78	40.2	13.3	36.3	93.2	21.8	14.0	11.8	319	280	198	199	369	286	218	206	93.4	22.2	13.8	12.8	36.5
23	Melamine	38.5	13.0	35.5	86.7	22.0	15.2	14.0	318	330	246	210	352	297	244	256	76.6	18.5	12.2	10.3	35.9

* Model "C" tester.

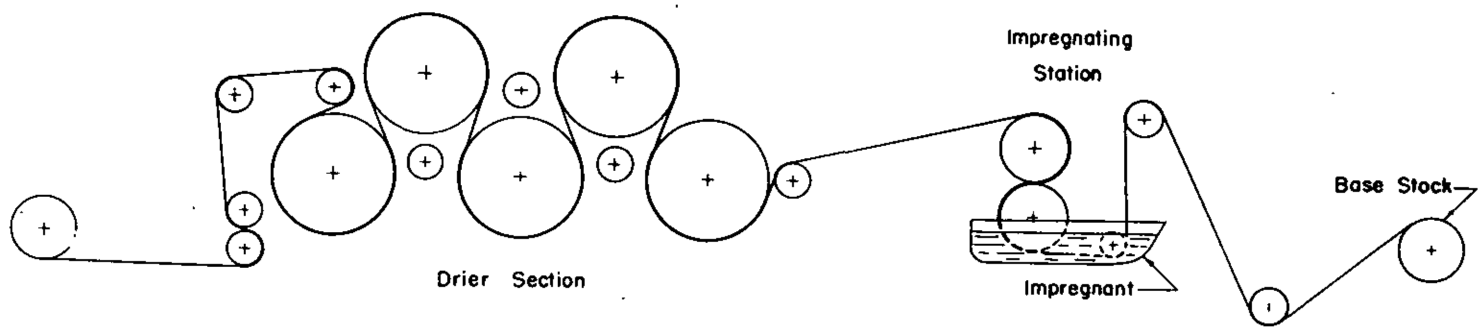

Figure 2
Waldron Laminating Machine

with the corresponding results on the base stock (Run 19) and the melamine-sized sample (Run 23), it may be seen that the Ketac resin does not increase the wet-strength results much if any above those of the regular kraft board, even though the resin content was slightly more than 2% in the case of Run 2C.

A similar comparison of the results obtained with Arboneeld "B" resin, which is a lower priced resin than Uformite 467, shows that the wet bursting strength values of the samples impregnated with this resin were higher than that of the base stock but lower than that of the melamine-sized sample; thus, it does not appear as efficient for this purpose as Uformite 467 resin.

The resin pickups obtained with solutions containing Alryl T wetting agent were greater in the case of Ketac 1156 resin but lower when used in conjunction with Arboneeld "B" and Uformite 467. The resin pickup, wet-strength properties, and the moisture pickups obtained in Parts III and IV indicate that the resin employed in Part III (Uformite 467), as well as the application procedure, have certain advantages over those employed in Part IV. For example, the results obtained with Ketac 1156 and Arboneeld "B" were inferior to those obtained with Uformite 467. The method of impregnation used in this phase showed a higher resin pickup from the same concentrations of resin and same base stock than that employed previously. This, no doubt, is the result of the greater submergence in this phase; however, because of the presence of a steel top roll instead of a rubber roll, the impregnant tended to be squeezed out of the middle of the sheet and to build up at the edges as a result of resin "runback." All the impregnation runs made in this phase exhibited a relatively high moisture pickup, thus requiring an impractical amount of subsequent drying.

PART V

Previous work reported in Progress Report One, as well as the results obtained in Parts III and IV of this report, pointed out the need for developing some method of impregnating board with a wet-strength resin so that the ratio of water to resin in the impregnant would be as low as possible and still permit a high degree of penetration and a low resin pickup. With a low water-resin ratio, a low resin pickup would result in a correspondingly low moisture pickup and, consequently, fewer drying facilities would be required, a condition which is to be desired from the standpoint of capital investment, space, and operating cost.

In studying the above requirements, two methods of attack were proposed for investigation. The first method proposed consisted of using a resin-carrying medium which would be capable of rapid change from a high to a low viscosity under the influence of heat or catalytic action and would also hold a high concentration of the resin during such a change. The purpose of this viscosity characteristic is that the amount of impregnant pickup could be controlled more easily if the impregnant was applied as a coating at a high viscosity. After such a coating is applied, it would be necessary to reduce its viscosity suddenly so that it would penetrate into the sheet.

The second method proposed was that of modifying the impregnating method in such a way that the stock was exposed for a relatively brief interval to a high solids, highly penetrating impregnant and then passed through a set of squeeze rolls which would cause a small amount of the impregnant to be left near the surface of the stock, but which, by virtue of its penetrating power, would migrate towards the center of the sheet prior to drying. An extreme example of this method would be the use of offset or gravure rolls to supply a metered amount of relatively high concentration of resin so modified as to have good surface wetting and penetrating characteristics.

PROCEDURE

In order to determine the feasibility of the first method proposed, two water-soluble materials which form reversible gels were selected. These were polyvinyl alcohol (fully hydrolyzed type) and a monogalactan (locust-bean gum). It was hoped that, if diluted solutions of these materials were subjected to the conditions which ordinarily cause changes to and from gels, a change from a low to a high viscosity would be obtained. Upon investigation, it was found that a locust bean gum solution at a concentration of 0.8% in water was incompatible with two urea-formaldehyde resin solutions, Uformite 435 and 467, and a floc separated out which, on standing, progressively coagulated. In the case of a 5% solution of Elvanol 71-24 (a nearly 100% hydrolyzed polyvinyl alcohol manufactured by the Du Pont Company), a compatible combination was obtained with both Uformite resins (435 and 467) and the addition of borax caused a thickening of the Elvanol. However, this thickening was not homogenous and ultimately resulted in the separation of gel lumps from the solution. These lumps were unsatisfactory from the standpoint of uniform application. The possibility of coating a thick Elvanol-Uformite solution on the surface of the board and subsequent spraying with a borax solution to separate the coating into liquid and gel phases was tried in the hopes that the liquid phase containing a major portion of the Uformite would be free to penetrate into the board while the gel phase containing the Elvanol could be scraped off and reused. The results obtained by the above procedure were not promising, since the gel formed apparently isolated the liquid, from which it had separated and prevented it from being absorbed by the stock.

In the investigation of the second method proposed, a setup was employed whereby the stock to be impregnated was passed directly into the nip between two squeeze rolls after a brief exposure to the impregnant. The technique used is schematically illustrated in Figure 3. This method is essentially the same as used in Progress Report One and Part III of this report except that the board is not submerged. The bottom roll runs only slightly submerged in the resin solution being squeezed back as shown in Figure 3.

Three wet-strength resins were investigated by this latter method. These were Uformite 435 and 610 (both urea-formaldehyde resins) and Plaskon 345-11L [an aminoplast resin (Libby-Owens-Ford)]. Trial

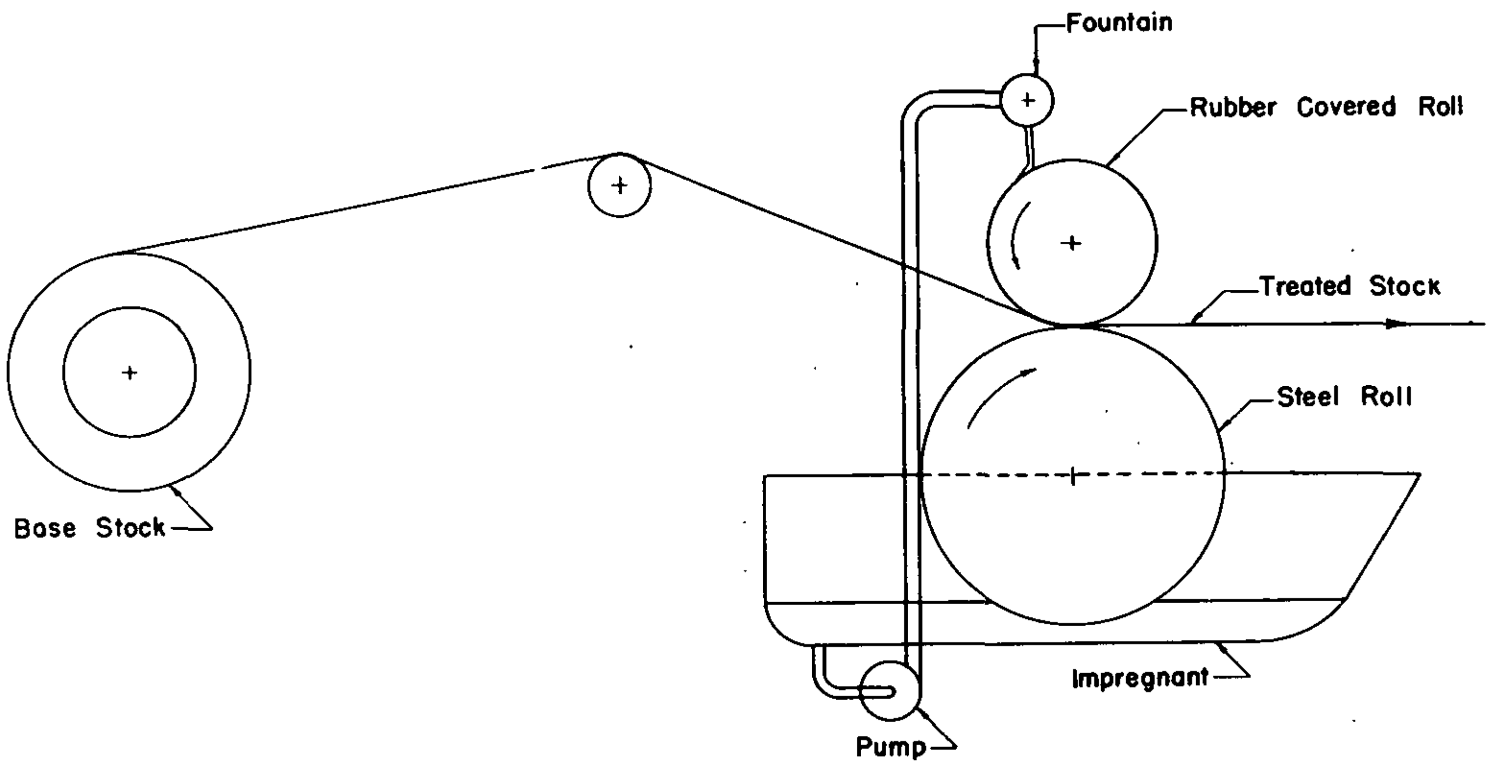

Figure 3
Impregnating Equipment

runs were made on 90-lb. regular kraft linerboard, using the concentrations and types of resins shown in Table VII. The 90-lb. linerboard used in this phase was of the same vintage as that used in Progress Report One; thus, it was considerably lower in strength than the corresponding grade as it is currently manufactured. The percentage resin and moisture pickups are also given in Table VI, with the approximate resin cost per ton of board thus treated.

Because of insufficient sample, only the bursting strength tests were made on the samples impregnated in this phase. All bursting strength results reported in this part were obtained on the Jumbo tester.

DISCUSSION OF RESULTS

The results of the bursting strength determinations on the samples impregnated with Plaskon 345-11L and Uformite 435 and 610 are shown in Table VII. As previously mentioned, there was insufficient sample of each to permit more than bursting strength determinations. It may be seen from the results in Table VII that the dry bursting strengths of the impregnated samples are only slightly lower than those of the base stock and the corresponding grade of melamine-sized board currently made when the base stock was manufactured. When the bursting strength values after 24-hours immersion are considered, it may be seen that the impregnated samples retained a greater percentage of their dry bursting strength. It should also be mentioned that the maximum moisture pickup was only 12.4%, thus indicating that, by this method of applying

TABLE VII

IMPREGNATION DATA

Run	1D	2D	3D
Weight of base stock	90	90	90
Impregnant			
Resin			
Type	Uformite 435	Uformite 610	Plaskon 345-11L
Concentration, %	23.2	18.6	20
Triton X-100, %	0.5	0.5	0.5
Resin pickup, %	3.8	2.9	2.6
Cost per ton, dollars	13.90	9.50	[a]
Moisture pickup, %	12.4	12.4	10.0

[a] Cost of resin not available

TABLE VIII

PHYSICAL CHARACTERISTICS OF IMPREGNATED 90-LB. KRAFT BOARD

	Bursting Strength*, p.s.i. (gage)					
		Wet				
Run	Dry	5 Min.	6 Hr.	24 Hr.	Impregnant Cost/Ton, dollars	Moisture Pickup, %
1D	149	88	51	46	13.90	12.4
2D	131	--	54	48	9.50	12.4
3D	144	79	49	46	--	10.0

* Jumbo

the resin, the amount of drying can be substantially reduced without a sacrifice in resin pickup or wet-strength characteristics.

Because of the encouraging results from the viewpoint of moisture pickup, two additional trial runs were made on regular 38-lb. board and one on 90-lb. regular kraft board of a more recent vintage than that employed in Runs 1D, 2D, and 3D. The resin used in these latter runs was a 20% solution of Plaskon Aminoplast resin type 345-11L. In the above three runs, essentially the same setup as shown in Figure 3 was used except that the impregnated stock was run directly through the drier section of the Waldron laminator from the squeeze nip, instead of rewinding and then drying in a separate operation as in the D series.

It was found that the resin pickup with this type of application was too high in the case of the 38-lb. stock. Consequently, in an effort to reduce the percentage of resin pickup on the lighter weight stock, two additional runs were made on regular 38-lb. board using a slightly modified impregnation technique from that used previously. This procedure involved the use of a Mayer rod (see Figure 4) which acts as a doctor or metering rod to control the amount of impregnant on the transfer roll at the point of contact with the paper. For the purpose of this experiment, the impregnation took place from only one side at a time; thus, it was necessary to run a given sample through the impregnator twice to obtain a two-sided application. This method

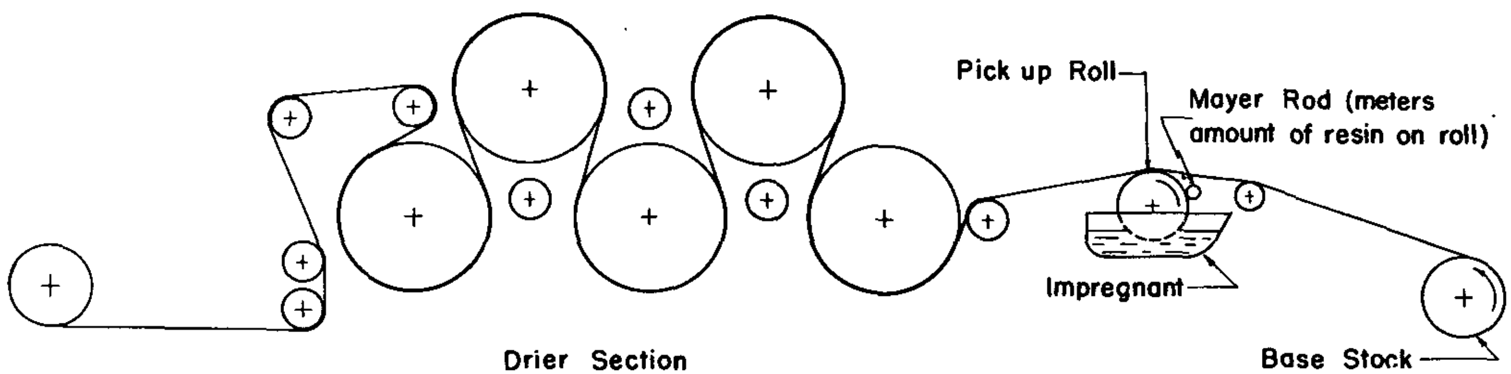

Figure 4

Waldron Laminating Machine

of impregnation could be designed, however, to impregnate from both sides in one pass. The run number, resin concentration, and resin pickup associated with these latter five trials are shown in Table IX.

The results of the physical tests on the samples impregnated according to the method listed in Table IX are given in Table X, together with the results obtained on the corresponding samples of base stock and melamine-sized boards. It may be seen that the wet bursting strength values after 24 hours' immersion in water were higher for the 38-lb. impregnated samples than for either the base stock or the melamine-sized samples. However, because of the high resin pickup, the cost is so high as to appear prohibitive, although the results appear very promising from the standpoint of moisture pickup--this amounted to approximately 10% or less when the Mayer rod was used to control the amount of pickup. The same general trend may be noted from a comparison of the results obtained on the 90-lb. sample.

The "flood and squeeze" method employed in Runs 1E, 2E, and 3E apparently does not lend itself to reducing the resin pickup to practical percentages compatible with cost. On the other hand, when the Mayer rod is used to control the amount of resin on the lower roll, it appears possible to control the amount of resin within the desired limits.

TABLE IX

IMPREGNATION DATA

Run	1E	2E	3E	1F	2F
Weight of base stock, lb.	38	38	90[a]	38	38
Impregnant					
Resin type	Plaskon 345-11L	Plaskon 345-11L	Plaskon 345-11L	Plaskon 345-11L	Uformite 467
Concentration, %	20	20	20	20	20
Wetting agent	Triton X-100	--	Triton X-100	Triton X-100	Triton X-100
Concentration, %	0.5	0.0	0.5	0.5	0.5
Method impregnation	Flood and squeeze	Flood and squeeze	Flood and squeeze	Mayer rod	Mayer rod
Resin pickup, %	6.4	6.4	2.2	2.6	2.4
Moisture pickup, %	26.0	26.0	8.8	10.4	9.6
Approximate cost per ton, dollars	36.90	36.10	13.70	15.00	9.00

[a] Roll 382

TABLE X

ıRACTERISTICS OF IMPREGNATED
ƗD 90-LB] KRAFT BOARD

ːaring Strength, g./sheet					Amthor Tensile, lb./in.								Impregnant	Moisture
	Across				In				Across					
		Wet				Wet				Wet				
24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.	Dry	5 Min.	6 Hr.	24 Hr.	Cost/Ton, dollars	Pick-up, %
158	382	292	198	182	84.3	16.1	8.6	8.7	35.2	6.1	3.9	3.8	--	--
180	333	263	214	222	100.2	15.4	14.4	13.1	37.2	5.8	5.6	5.5	36.90	26.0
217	312	329	273	255	108.5	19.8	16.2	15.6	39.4	7.5	7.1	7.0	36.10	26.0
210	299	314	273	250	99.7	22.0	18.6	18.7	42.5	8.3	6.1	5.7	15.00	10.4
182	341	290	236	235	90.0	17.1	13.0	13.7	35.1	6.9	4.8	4.7	9.00	9.6
210	352	297	252	256	76.6	18.5	12.1	10.3	35.9	9.7	6.8	6.3	--	--
420	907	910	410	391	132.8	45.7	13.1	11.1	90.9	35.8	9.4	8.3	--	--
362	883	842	407	380	140.8	28.6	15.3	14.7	89.5	18.4	10.2	10.2	13.70	8.8
565	893	1048	550	538	161.1	59.9	19.2	17.7	83.2	37.1	12.6	11.9	--	--

TABLE X

PHYSICAL CHARACTERISTICS OF IMPREGNATED
38- AND 90-LB] KRAFT BOARD

Run	Resin Content, %	Weight, lb.	Cali-per, pt.	Density, lb./cu. ft.	Bursting Strength*, p.s.i. (gage) Dry	Bursting Wet 5 Min.	Bursting Wet 6 Hr.	Bursting Wet 24 Hr.	Elmendorf Tearing Strength, g./sheet In Dry	Elmendorf In Wet 5 Min.	Elmendorf In Wet 6 Hr.	Elmendorf In Wet 24 Hr.	Elmendorf Across Dry	Elmendorf Across Wet 5 Min.	Elmendorf Across Wet 6 Hr.	Elmendorf Across Wet 24 Hr.	Amthor Tensile, lb./in. In Dry	Amthor In Wet 5 Min.	Amthor In Wet 6 Hr.	Amthor In Wet 24 Hr.	Amthor Acrc Dry	Amthor Acrc We 5 Min.
19	0	39.4	13 1	36.1	98	26	19	16	330	251	186	158	382	292	198	182	84.3	16.1	8.6	8.7	35.2	6.
1E	6.4	--	--	--	112	31	28	27	266	230	199	180	333	263	214	222	100.2	15.4	14.4	13.1	37:2	5.
2E	6.4	41.3	13.8	35.9	109	39	32	30	252	289	233	217	312	329	273	255	108.5	19.8	16.2	15.6	39.4	7.
1F	2.6	39.7	13.3	35.8	106	45	35	33	261	286	241	210	299	314	273	250	99.7	22.0	18.6	18.7	42.5	8.
2F	2.4	38.7	13.3	35.2	101	48	36	30	297	227	192	182	341	290	236	235	90.0	17.1	13.0	13.7	35.1	6.
23	Melamine	38.5	13.0	35.5	92	34	25	25	318	330	246	210	352	297	252	256	76.6	18.5	12.1	10.3	35.9	9.
17	0	92.3	24.4	45.4	181	97	35	32	861	898	445	420	907	910	410	391	132.8	45.7	13.1	11.1	90.9	35
3E	2.2	90.1	24.9	43.4	172	93	45	46	832	784	384	362	883	842	407	380	140.8	28.6	15.3	14.7	89.5	18
21	Melamine	89.3	24.5	43.7	188	119	54	49	792	950	558	565	893	1048	550	538	161.1	59.9	19.2	17.7	83.2	37

* Jumbo

PART VI

Inasmuch as Runs 3E, 1F, and 2F of Part V showed promising results in so far as moisture pickup and wet strength were concerned it seemed advisable to obtain more complete data on the application of Uformite 467 and Plaskon 345-11L when applied to 33, 38, 69, and 90-lb. board, the objective being to determine the most practical amount of resin for impregnation compatible with cost and performance.

PROCEDURE

In this phase, samples of 33, 38, 69, and 90-lb. regular kraft board samples were impregnated from a 20% solution of Plaskon 345-11L and Uformite 467, using the same procedure as shown in Figure 4, wherein a Mayer rod is used to meter the amount of the resin solution on the impregnating roll. In order to obtain greater penetration into the board, 0.5% of a wetting agent (Triton X-100) was added to each of the resin solutions. The data obtained as regards pickups, etc. may be seen in Table XI. Because of an error in calculating the resin pickup on the first run in this series, all the runs were made with a resin pickup approximately double that desired. This naturally resulted in abnormally high costs per ton.

Inasmuch as the trials mentioned (G series) above were made with double the resin content intended, five additional trials (see H series) were made using a lesser resin pickup. The resin used in the five trials was a 20% solution of Uformite 467 because, in the previous

TABLE XI

IMPREGNATION DATA

Run	Grade of Base Stock	Mayer Rod No.	Type Resin	Resin Pickup, %	Moisture Pickup, %	Approximate Cost per ton, dollars
2G	33	8	Plaskon 345-11L	2.2	8.6	12.84
1G	38	8	Plaskon 345-11L	1.8	7.4	10.88
5G	69	20	Plaskon 345-11L	3.6	14.1	21.08
7G	90	34	Plaskon 345-11L	3.2	12.6	18.88
11G	33	16	Uformite 467	5.8	22.4	21.40
10G	38	20	Uformite 467	5.2	20.2	19.18
9G	69	34	Uformite 467	4.2	16.2	15.46
8G	90	34	Uformite 467	3.4	13.2	12.68
10H	33	4	Uformite 467	1.4	5.6	5.26
9H	38	4	Uformite 467	1.1	4.4	4.06
8H	69	12	Uformite 467	1.1	5.7	4.25
12H	69	12	Uformite 467	2.2	8.7	8.13
7H	90	16	Uformite 467	1.4	5.8	5.45

trials (G series), the Uformite 467 resin appeared to be about as efficient as Plaskon 345-11L and considerably lower in cost. The resin pickup, moisture pickup, and approximate cost of the resin for these latter five trials are also given in Table XI. It may be observed that only one trial was made on each grade of board--i.e., 33, 38, 69, and 90--except for the 69-lb. grade, in which case two trials were made, one with 1.1% resin pickup and one with approximately 2.2% resin pickup. The procedure used is shown in Figure 4.

DISCUSSION OF RESULTS

The results of the wet and dry bursting strength tests on the samples impregnated in Part VI may be seen in Table XII. It may be observed that, in all cases, the wet bursting strength of the treated samples was higher than the bursting strength on the untreated or the melamine-sized samples. The percentage of resin picked up in the impregnation process is double what was intended; thus, the costs are excessively high. A comparison of the wet-strength results and the percentage resin indicates that it should be possible to reduce the resin content by one or two fold and still be comparable with the melamine sample strengthwise. Such a reduction in resin pickup would naturally reflect a corresponding reduction in the cost of the resin.

The results of the wet and dry bursting strength results on the impregnated samples of the H series are shown in Table XIII. It may be noted from a comparison of the results shown in Table XIII that the sample impregnated with 1 to 1.5% resin exhibited dry bursting

TABLE XII

PHYSICAL CHARACTERISTICS OF IMPREGNATED BOARDS

Run	Resin, %	Weight, lb.	Caliper, points	Density, lb./cu. ft.	Bursting Strength (Jumbo), p.s.i. (gage) Dry	Bursting Strength (Jumbo), p.s.i. (gage) Wet 5 Min.	Bursting Strength (Jumbo), p.s.i. (gage) Wet 24 Hr.	Bursting Strength (Model C), p.s.i. (gage) Wet 6 hr.	Bursting Strength (Model C), p.s.i. (gage) Wet 24 hr.	Approximate Cost per ton, dollars
20	0	33.2	11.7	34.1	87	26	15	--	7.6	
2G	2.2	33.9	11.8	34.5	93	34	29	14.6	14.8	12.84
11G	5.8	33.5	11.8	34.1	91	41	42	25.6	24.3	21.40
24	Melamine	32.9	10.4	38.0	80	23	15	--	8.7	
19	0	39.4	13.1	36.1	98	26	16	--	9.9	
1G	1.8	40.1	13.1	36.7	108	39	28	16.8	14.8	10.88
10G	5.2	41.5	13.9	35.8	101	54	44	36.4	37.1	19.18
23	Melamine	38.5	13.0	35.5	92	34	25	--	14.0	
18	0	70.0	19.6	42.9	138	55	19	--	15.6	
5G	3.6	70.1	19.0	44.3	149	84	47	36.9	36.7	21.08
9D	4.2	71.2	20.0	42.7	132	90	61	51.8	52.6	15.46
22	Melamine	71.1	19.8	43.1	146	81	34	--	24.5	
17	0	92.3	24.4	45.4	181	97	32	--	24.0	
7G	3.2	91.9	25.1	43.9	156	132	69	58.3	59.2	18.88
8G	3.4	89.4	25.0	42.9	170	146	80	68.6	53.9	12.68
21	Melamine	89.3	24.5	43.7	188	119	49	--	41.7	

TABLE XIII

PHYSICAL CHARACTERISTICS OF IMPREGNATED BOARDS

Run	Resin, %	Weight, lb.	Bursting Strength (Jumbo), p.s.i. (gage)		Bursting Strength (Model C), p.s.i. (gage)		Moisture Pickup, %	Approximate Chemical Cost per ton, dollars
			Dry	Wet, 24 hr.	Dry	Wet, 24 hr.		
20	0	33.2	87	15		7.6		
10H	1.4		91	23		11.1	5.6	5.26
24	Melamine	32.9	80	15		8.7		
19	0	39.4	98	16		9.9		
9H	1.1		98	26		10.0	4.4	4.06
23	Melamine	38.5	92	25		14.0	4.4	4.06
18	0	70.0	138	19		15.6		
8H	1.1		142	32		20.9	5.7	4.25
12H	2.2		146	36		26.0	8.7	8.13
22	Melamine	71.1	146	34		24.5		
17	0	92.3	181	32		24.0		
7H	1.4		183	45		33.2	5.8	5.45
21	Melamine	89.3	188	49		41.7		

strength results comparable with that of the base stock or the melamine-sized board; however, the wet bursting strength results are in most cases slightly lower when compared on the basis of the Model C tester but are about equal or higher when determined on the Jumbo tester. In view of the uncertainties associated with the Jumbo tester at this test level because of the diaphragm distention pressure, it is believed that the Model C results are more reliable. Although slightly lower at 1 to 1.5% resin, the difference in magnitude is not great in most cases. For example, in the case of the 33-lb. stock, the wet bursting strength value (MOdel C) after 24 hours' immersion in water is slightly higher than the corresponding value for the melamine-sized sample. However, the magnitude of the difference is probably not significant.

The wet bursting strength value (Model C) obtained for the 38-lb. stock impregnated with 1.1% resin was significantly lower than that of the 38-lb. melamine-sized sample. However, on the basis of the results obtained at 1.1% and those obtained in the G series (see 1G and 10G) that, if the resin content were increased slightly--i.e., 1.5 to 2%--the wet strength results would be comparable with only a moderate increase in moisture pickup and resin cost. A good indication of this possibility may be seen in the results obtained for the 69-lb. stock. In this grade, two trials were made: the resin pickup for 8H was 1.1% and for 12H it was 2.2%. The wet bursting strength results with the 1.1% resin were slightly less than the corresponding results for the 69-lb. melamine-sized sample; however, the results for the 2.2% resin sample were higher. The moisture pickup for this latter sample was 8.7% and the resin cost was approximately $8.13 per ton.

The wet bursting strength (Model C) results obtained for the 90-lb. sample using 1.4% resin were lower than the corresponding value for the 90-lb. melamine-sized sample. As mentioned above, it is believed that a slightly higher resin content would give sufficient wet strength to be compatible with the melamine-sized sample. Also, it is felt that a better distribution of resin can be obtained with the heavier weight grades by a slight modification of the method of impregnating. If the board were passed through a set of squeeze rolls immediately after impregnation, the resin would be distributed more evenly throughout the sheet.

Additional trials are in progress with approximately 2% resin pickups. If results comparable with melamine are obtained, as is expected, it would be well to make a few runs with a slightly lower concentration of resin. The purpose of this is to determine if a slight dilution of the resin will enhance its efficiency as far as wet strength is concerned with only a slight increase in the moisture pickup.

The results to date indicate that it appears possible to obtain wet strength, based on the bursting strength test, by impregnating with a solution of Uformite 467 which will be comparable with melamine-sized board and still maintain the moisture pickup as a result of the impregnation up to 10% or less. The cost of the resin appears to be in the neighborhood of $5 to $8 per ton.