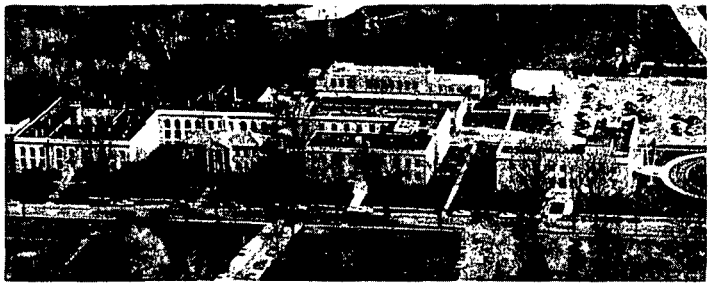

THE INSTITUTE OF PAPER CHEMISTRY, APPLETON, WISCONSIN

PRELIMINARY TRIAL OF COLD CORRUGATING PROCESS

✓ Project 2698

Report Two

A Progress Report

to

TECHNICAL DIVISION
FOURDRINIER KRAFT BOARD INSTITUTE, INC.

February 27, 1974

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

PRELIMINARY TRIAL OF COLD CORRUGATING PROCESS

Project 2698

Report Two

A Progress Report

to

TECHNICAL DIVISION
FOURDRINIER KRAFT BOARD INSTITUTE, INC.

February 27, 1974

TABLE OF CONTENTS

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

PRELIMINARY TRIAL OF COLD CORRUGATING PROCESS

SUMMARY

A development which could reduce the energy and capital requirements of corrugating is "cold" corrugating. Cold corrugating involves the proper pretreatment of the medium — e.g., with lubricants — so that it can be fluted satisfactorily using corrugating rolls at room temperature or reduced temperature. This process would require an economical adhesive which does not require heat to set up in order to achieve reasonable speeds. The cold-set starch adhesive under development at the Institute for Fourdrinier Kraft Board Institute, Inc. (FKI) should have merit for this purpose. Accordingly, a limited series of corrugating trials were carried out on the Institute's single face corrugator to explore the possible merits of cold corrugating.

Two semichemical mediums were corrugated using various lubricating agents on hand. The temperature of the corrugating rolls was about 80-85°F — i.e., room temperature.

In order to provide adhesion during the initial trial of the cold corrugating process, a polyvinyl acetate adhesive was substituted for the conventional starch adhesive which requires heat for forming and "curing" of the adhesive. In the absence of heated corrugating rolls, the polyvinyl acetate provided satisfactory adhesion up to approximately 300 fpm. Above 300 fpm the adhesion decreased with increase in speed. The maximum speed employed in these trials was 400 fpm.

The following results were obtained:

1. The appearance of the single-faced board was satisfactory (absence of fractures, etc.) at speeds up to 300 fpm — the limiting speed for satisfactory adhesion with adhesive conditions used. No fracturing was encountered at speeds up to 400 fpm in most cases and presumably higher speeds could have been attained without fracture.

2. The flute height of the cold corrugated board was about the same as that of board produced using heated corrugating rolls at 350°F temperature. High-lows were somewhat more pronounced for the cold corrugated board but are believed to be within commercially acceptable limits.

3. The edgewise compression characteristics of the cold corrugated board were, in most cases, from about 3 to 7% lower than for board produced with heated corrugating rolls. The flat crush results for the cold corrugated boards were 17 to 20% lower. It should be noted that it was not possible in these limited trials to optimize the operating conditions on the corrugator or the type and amount of the lubricating agent. Some past data obtained under cold conditions suggests that improvements in flat crush can be effected by varying the operating conditions — e.g., use of steam showers.

4. Based on the above results, it appears that the cold corrugating process may be commercially practical assuming that a suitable adhesive such as cold-set starch is available to permit operation at high speed. Taken together, these developments could (a) reduce operating costs, (b) reduce corrugator

capital requirements, and (c) reduce personnel heat exposure as well as have other potential benefits.

Accordingly, it is suggested that further work be carried out in the cold corrugating process as follows:

a. To determine the most effective lubricating agents for the medium.

b. To determine the best operating conditions in terms of runnability and board quality.

c. To compare the performance of various grades and types of medium under "cold" conditions.

d. To determine if adhesives such as cold-set starch would permit operation at practical speeds under cold corrugating conditions.

INTRODUCTION

A development which could reduce the energy and capital requirements of corrugating is "cold" corrugating. Cold corrugating involves the proper pretreatment — e.g., with lubricants — of the medium so that it can be fluted satisfactorily using corrugating rolls at room temperature or reduced temperatures. In order to corrugate at reasonable speeds and cost, it is necessary to use an adhesive which does not require heat to set up such as the cold-set starch adhesive under development at the Institute for FKI (1).

It is well known that various "lubricants" can be used to prevent fracturing in the normal (hot) corrugating process. A recent study for FKI compared the effectiveness of various solid lubricants under normal conditions (2). The most effective agents under hot conditions were the lower density polyethylenes. It is believed that "lubricants" can also prevent fracturing under cold corrugating conditions; however, the relative effectiveness of various agents may not be the same under cold conditions as under hot conditions.

A patent on cold corrugating using stearin-wax as a lubricant has been issued to A. W. Morris and R. J. Norman (U.S. pat. 3,676,247 issued 7-11-72) (3). There is some question as to the validity of this patent due to prior art.

It should also be mentioned that past work at the Institute has shown that a number of different types of medium can be corrugated fairly well under cold conditions by the judicious use of steam showers.

In order to explore the possible merits of cold corrugating, a limited series of corrugating trials were carried out with the corrugating rolls at room temperature. The results are summarized herein.

MATERIALS

The trials were carried out using two different samples of 26-lb semichemical mediums.

FABRICATION CONDITIONS

The following corrugating conditions were employed:

1. Corrugating roll temperature: Room temperature (80-85°F).

2. Main steam showers: None (Note: It is believed some shower steam would be beneficial; however, due to the design and location of the showers on the Institute's corrugator, excessive drippage on the medium tends to occur under cold operating conditions. Consequently, it was decided to avoid their use during these runs rather than relocate and modify the showers).

3. Medium web tension: Minimum.

4. Lubricants for corrugating medium: Based on previous work, the following "lubricants" were selected for these trials:

   a. PE — Eastman N-11 polyethylene

   b. PE-D — N-11 PE plus 16% polyethylene glycol dioleate

   c. PE-S — N-11 PE plus 10% stearic acid

   The lubricants were applied to both sides of the medium. In all runs, the PE-D lubricant was applied to the bottom side of the medium while either PE or PE-S lubricant was applied to the other side.

5. Adhesive: For the purpose of these trials, a special heat-set adhesive (polyvinyl acetate) was employed. Using steam in the liner preheater and pressure rolls, it was possible to obtain satisfactory adhesion up to 300 fpm.

DISCUSSION OF RESULTS

The corrugating results are summarized in Table I. In general, very satisfactory board with no fractures were produced at speeds up to and above 300 fpm. Above 300 fpm, the adhesion was unsatisfactory but no fractures were evident in Runs 2-5. Presumably, with a cold-set adhesive, board with satisfactory adhesion could be produced at considerably higher speeds with these mediums. These results indicate the "cold" corrugating process has commercial possibilities in so far as corrugating without flute fracturing.

It should be mentioned that the corrugating rolls used in this study had been in storage at the Institute for over a year. Because of the adverse effect of storage time on corrugating medium runnability, most if not all plants try to rotate their medium roll stock so as to limit storage time to no longer than 3-6 months. Accordingly, these trials represent a more severe condition for cold corrugating than would be encountered normally in a box plant.

The best fabrication results seemed to be obtained when either polyethylene or polyethylene plus stearic acid was applied to the top side in conjunction with polyethylene plus dioleate on the bottom side. However, considerable work would be required to determine the best lubricants and methods of application.

The runs with the Roll 16085 medium indicate that it may be possible to run without medium preheat or preheat showers if desirable. However, it should also be noted that it seemed desirable to increase the roll pressures with this medium to improve the molding and obtain better adhesion with the polyvinyl acetate adhesive employed. This, perhaps,

TABLE I

"COLD" CORRUGATING FABRICATION RESULTS

Run No.	Medium Roll No.	Speed, fpm	Medium Preheater Conditions: Temp.,[b] °F	Wrap	Shower Pressure, psi	Lubricant[a]: Top Side	Bottom Side	Draw Factor	Comments on S. F. Board Appearance
1	5479	100	260	1/2	2	PE-D	PE-D	1.560	Satisfactory, no fractures
		200	260	1/2	2	PE-D	PE-D	1.556	Satisfactory, no fractures
		300	260	1/2	2	PE-D	PE-D	1.536	Fractured medium
2	5479	100	260-	1/2	2	PE-S	PE-D	1.564	Satisfactory, no fractures
		200	260-	1/2	2	PE-S	PE-D	1.565	Satisfactory, no fractures
		300	260-	1/2	2	PE-S	PE-D	1.560	Satisfactory, no fractures
		300+	260-	1/2	2	PE-S	PE-D	--	No fractures, but poor adhesion
3	16085[c]	100	260-	1/2	2	PE-S	PE-D	1.560	Satisfactory, no fractures
		200	260-	1/2	2	PE-S	PE-D	1.558	Satisfactory, no fractures
		300	260-	1/2	2	PE-S	PE-D	1.555	Satisfactory, no fractures
		400	260-	1/2	2	PE-S	PE-D	1.550	No fractures, but poor adhesion
4	16085[c]	100	--	None	None	PE-S	PE-D	1.559	Satisfactory, no fractures
		200	--	None	None	PE-S	PE-D	1.559	Satisfactory, no fractures
		300	--	None	None	PE-S	PE-D	1.556	Satisfactory, no fractures
		300+	--	None	None	PE-S	PE-D	--	No fractures, but poor adhesion
5	16085[c]	100	--	None	None	PE	PE-D	1.562	Satisfactory, no fractures
		200	--	None	None	PE	PE-D	1.558	Satisfactory, no fractures
		300	--	None	None	PE	PE-D	1.560	Satisfactory, no fractures
		300+	--	None	None	PE	PE-D	--	No fractures, but poor adhesion

[a] PE = Eastman N-11 polyethylene; PE-D = N-11 + 16% polyethylene glycol dioleate; PE-S = N-11 + 10% stearic acid.

[b] Initial temperature was 260°F, allowed to cool down during remaining trials.

[c] Increased pressure, roll pressure, and top corrugating roll pressure to obtain better molding and, hence, adhesion.

could be avoided by other lubricant choices or by proper use of showers or preheaters.

Table II compares flute height results for the cold corrugated single faced board with board produced using normally heated corrugated rolls. Slightly higher flute heights were obtained under cold conditions, perhaps because less permanent transverse compression of the medium occurs at the flute tip under cold conditions. The high-lows were greater under cold conditions than under hot conditions, but should be commercially acceptable.

TABLE II

FLUTE HEIGHT RESULTS[a]

	Run No.	Flute Height, pt.	High-Lows, pt.
Roll 5479			
Normal corrugated[b]	--	194.6	1.0
Cold corrugated[c]	2	197.8	1.8
Roll 16085			
Normal corrugated[b]	--	192.6	1.3
Cold corrugated[c]	3	195.4	2.2
Cold corrugated[c]	4	196.6	2.8
Cold corrugated[c]	5	196.8	2.1

[a]Average of results at 200 and 300 fpm.

[b]Corrugated under normal (350°F roll temperature) conditions using starch adhesive.

[c]Corrugated under cold (room temperature) conditions using special heat-set adhesive (see Table I for run conditions).

Flat crush and single-faced ring compression results are shown in Table III. The single-faced ring compression test is a measure of the cross direction edgewise compression strength of the board and, hence, provides an indication of the stacking characteristics of the board. The single-faced

ring results for the cold corrugated board were 7% low for one roll sample and ranged from 2.9 to 16% low for the other roll sample, apparently depending on the corrugator operating conditions employed. These results also reflect the difference in the contribution to starch and polyvinyl adhesive to flat crush and edgewise compression. The results suggest that board corrugated under cold conditions may have stacking properties nearly equivalent to conventional board, if the corrugating conditions are optimized.

TABLE III

FLAT CRUSH AND SINGLE-FACED RING COMPRESSION RESULTS[a]

	Run No.	Flat Crush, psi		Single-Faced Ring Compression, lb	
		Av.	Percent Difference	Av.	Percent Difference
Roll 5475					
Normal corrugated[b]	--	28.8	--	604	--
Cold corrugated[c]	2	24.0	-17	562	-7.0
Roll 16085					
Normal corrugated[b]	--	33.9	--	620	--
Cold corrugated[c]	2	28.3	-17	590	-4.8
Cold corrugated[c]	3	27.2	-20	602	-2.9
Cold corrugated[c]	4	28.2	-17	521	-16.0

[a] Average of results at 200 and 300 fpm.

[b] Corrugated under normal (350°F roll temperature) conditions using starch adhesive.

[c] Corrugated under cold (room temperature) conditions using special heat-set adhesive (see Table I for run conditions).

The cold corrugated board exhibited flat crush strengths which were from 17 to 20% lower than for normally corrugated board. For commercial use of cold corrugating, it would be desirable to determine if changes in the corrugator operating conditions could be made which would give higher flat

crush strength under cold conditions. In this connection a past study at the Institute for FKI was concerned with the effect of corrugating roll temperature and medium moisture on runnability of medium and other properties (4). Table IV shows flat crush values obtained on board made with cold (105°F) and hot (350°F) corrugating rolls using various steam shower conditions. The flat crush values under cold conditions range from 24.8% lower to 4.1% higher than the results obtained with heated rolls depending on the medium and shower pressure employed. Where decreases occurred, the reductions on flat crush generally were not as great as obtained in the present study. Thus, it seems that it may be possible to attain commercially satisfactory flat crush levels under cold conditions by proper use of steam showers and other operating conditions.

TABLE IV

EFFECT OF CORRUGATING ROLL TEMPERATURE ON FLAT CRUSH

Roll No.	Main Shower Pressure, psi	Flat Crush, psi: 105° Corrugating Roll Temperature	Flat Crush, psi: 350° Corrugating Roll Temperature	Difference, %[a]
4801	6-7	32.0	33.6	-4.8
4802	6-7	30.6	34.2	-10.5
4802	12-14	28.4	34.2	-17.0
4803	0	24.6	25.4	-3.1
4803	6-7	21.8	29.0	-24.8
4805	6-7	30.0	30.2	-0.7
4805	12-14	30.6	29.4	+4.1
4806	6-7	36.8	36.0	+2.2
4806	12-14	31.8	36.0	-11.7
4807	6-7	28.6	32.8	-12.8
4807	12-14	29.2	31.2	-6.4

[a]Based on normal 350°F corrugating roll results.
Note: Data taken from results reported to FKI under Project 1108-22 (July 20, 1965).

Thus, it appears that the cold corrugating process may be commercially practical assuming that a suitable inexpensive adhesive is available to permit operation at reasonable speeds. At present, it is believed that the cold-set starch formulations developed at the Institute for FKI offer promise in this regard. Taken together, those developments would have such advantages as the following:

1. Reduced operating costs, reduction in energy.
2. Reduction of corrugator capital requirements due to reduction or elimination of hot-plate section and preheaters.
3. Reduced personnel exposure to heat.

With regard to (1) above, there appears to be little published information on the amounts of steam used by the various parts of the corrugator — preheaters, corrugating rolls, hot plates, etc. One source suggests that an average figure for overall corrugator steam consumption is about 100-lb steam per 1000 sq ft of board though the figure apparently varies widely from corrugator-to-corrugator. Present corrugated production is in excess of 200 billion sq ft, hence, corrugated steam usage may be in excess of 10 billion lb. It is difficult to assign any average fuel cost; however, at present, it is estimated that fuel costs for Institute steam plant are in the neighborhood of $0.90 per 1000 lb while if operational costs are included the steam cost increases to $2.00+ per 1000 lb steam. If these values are representative, just the fuel costs for corrugators would be in excess of eighteen million dollars per year. Operation and investment costs for the steam plant would further increase the cost assigned to steam consumption. In addition, it has been observed that the electrical power requirements about double when the machine is heated rather then cold. It is believed that cold corrugating

with a cold-set starch adhesive could potentially effect a savings of several millions to the industry based on fuel costs alone.

Accordingly, it is suggested that further work be carried out on the cold corrugating process with the following objectives:

1. To determine the best lubricating agents for cold operation.
2. To determine the best operating conditions for cold corrugating in terms of runnability and board quality.
3. To compare the performance of various grades and types of medium under cold corrugating conditions.

LITERATURE CITED

1. Project 2696-11. Development of cold-set adhesive. Report One to FKI, Nov. 7, 1973.

2. Project 2696-10. Investigation of solid lubricants as an aid in corrugating. Report Two to FKI, Jan. 12, 1973.

3. Morris, A. W., and Norman, R. J. U.S. pat. 3,676,247(July 11, 1972). Assigned to Australian Paper Manufacturers Limited.

4. Project 1108-22. Data presented to FKI, July 20, 1965.

THE INSTITUTE OF PAPER CHEMISTRY

Robert C. McKee
Chairman

William J. Whitsitt
Research Associate
Container Section