THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

INVESTIGATION OF MEDIUM FEEDER AS MEANS OF IMPROVING RUNNABILITY OF CORRUGATING MEDIUM

Project 1108-22

Report Five

A Progress Report

to

FOURDRINIER KRAFT BOARD INSTITUTE, INC.

March 20, 1962

TABLE OF CONTENTS

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

INVESTIGATION OF MEDIUM FEEDER AS MEANS OF IMPROVING RUNNABILITY OF CORRUGATING MEDIUM

SUMMARY

A study has been carried out comparing the runnability and mechanical characteristics of corrugated board fabricated with and without a feeding device. The feeding device consists essentially of a set of pull rolls which are positioned just prior to the entrance to the corrugating labyrinth. The feeder rolls are driven over-speed relative to the corrugating rolls. The purpose of the feeder is to feed the medium to the labyrinth with minimum web tension as a means of improving runnability. It has been well established that the frictional drag of the medium against the bottom corrugating roll prior to and in the labyrinth greatly increases the web or transport tension. The greater the transport tension or strain, the less subsequent strain it can undergo without rupture during the fluting operation. The lower the web tension entering the labyrinth, the more strain the medium can endure in the labyrinth.

The results obtained on six different mediums fabricated with and without the feeder indicate the following:

1. The use of the web or medium feeder improves the runnability--as much as 4-5 fold in the case of the mediums exhibiting poor runnability.

2. The combined board produced using the medium feeder exhibited higher caliper and more uniform flutes.

3. The flat-crush results obtained on the combined board made with the medium feeder were slightly lower than the corresponding board made without the medium feeder. This behavior would be anticipated from the higher caliper of the board made with the medium feeder. It was anticipated that the draw factor

for the feeder-made board would be higher. Therefore, box compression would tend to be higher for boxes made with board fabricated using the feeder because, other things equal, the higher the caliper of the combined board, the higher the flexural stiffness. The greater the draw, the more medium there will be per flute and, consequently, the greater the ultimate edgewise compression strength of the board. Ultimate edgewise compression and flexural stiffness are the two fundamental properties of the combined board which govern box compression.

It is believed that the medium feeder principle has practical application as a means of producing higher caliper and more uniformly fluted board at appreciably higher speeds. Further, it is believed that the basic principle of the medium feeder is novel and amendable to patent protection for which application has been made.

INTRODUCTION

From a quality standpoint, manufacturers of corrugating medium and corrugated board are both concerned with two major aspects of corrugating medium--namely, how well it functions on the corrugator and in subsequent conversion operations, and how well it performs as an integral part of a corrugated board or box. In the early days, corrugator speeds were slow and the mechanical strength requirements of the box were far less severe than today. Developments in equipment, adhesives, and components have made it possible to operate at higher corrugator speeds which are necessary if the industry is to remain in a competitive position. From a conversion standpoint, one of the major limiting factors in corrugating is the stresses and strains imposed on the medium during corrugating and the ability of the medium to withstand such stresses and strains. The faster the speed of corrugating, the more critical the stresses and strains apparently become (1, 2). Excessive stresses and strains may manifest themselves in the form of high-low corrugations or fractured flutes. On occasions, "bedding down" occurs, wherein the medium adheres to the bottom roll and does not fluff out to receive the adhesive. In these areas the board is not bonded and the resulting combined board is unsatisfactory structurally. The bedding down is due to adhesion between the corrugating roll and the medium.

Over the years a number of techniques have been employed to eliminate or minimize "bedding down" and fracturing of the flutes. Probably the most successful of the early remedies was the use of graphite, oil-in-water emulsion, and oil mist spray. In recent years there have been developed a great many materials which exhibit "antifriction" characteristics. Notable among these are the silicones and fluorocarbons which perform admirably but are too expensive. Other agents such as wax, wax emulsions, polyethylene, etc., if applied in the proper amount, materially reduce the coefficient of friction and thereby improve runnability.

Some years ago, while studying the action of the mediums in the single-facer, the idea was conceived that, if the medium were to be fed into the labyrinth under minimum web tension, the use of antifriction agents, etc., could be dispensed with, since the subsequent increase in web tension due to the frictional drag in the labyrinth would now be below the critical level. In order to test out this idea, a set of variable-speed feed rolls were installed on the Institute's experimental corrugator after the shower and immediately prior to entry into the corrugating nip. These rolls provide the tension necessary to unwind the paper from the rolls, etc., and feed the medium to the corrugating rolls with little tension (or strain) into the corrugating rolls. The present study is concerned with a limited investigation of this method of operation and its effect on (a) runnability and, (b) quality of the combined board.

GENERAL PROCEDURE

As previously mentioned, the purpose of the web-feeding device is to relieve the medium web of tension forces which normally result as the web is pulled over the corrugating teeth and into the labyrinth by the corrugating roll. The web-feeding device used in this study is shown in Fig. 1. The device consisted of a driven knurled roll (diameter, approximately 9 inches) directly connected to the take-off side of a Link Belt PIV adjustable-speed transformer. The power side of the speed changer is mechanically coupled to the corrugator drive to give average speed ratios of approximately 1.5 with further adjustment of ± 10%. The knurled roll was positioned about 12 inches from the entrance nip of the corrugating rolls in such a manner that the medium passed around a portion of the roll before entering the corrugating nip. To insure more positive feeding action, a smooth idler roll was mounted so that it could be spring loaded against the knurled roll. The L-B speed changer was used so that the operator could adjust the feed rolls so as

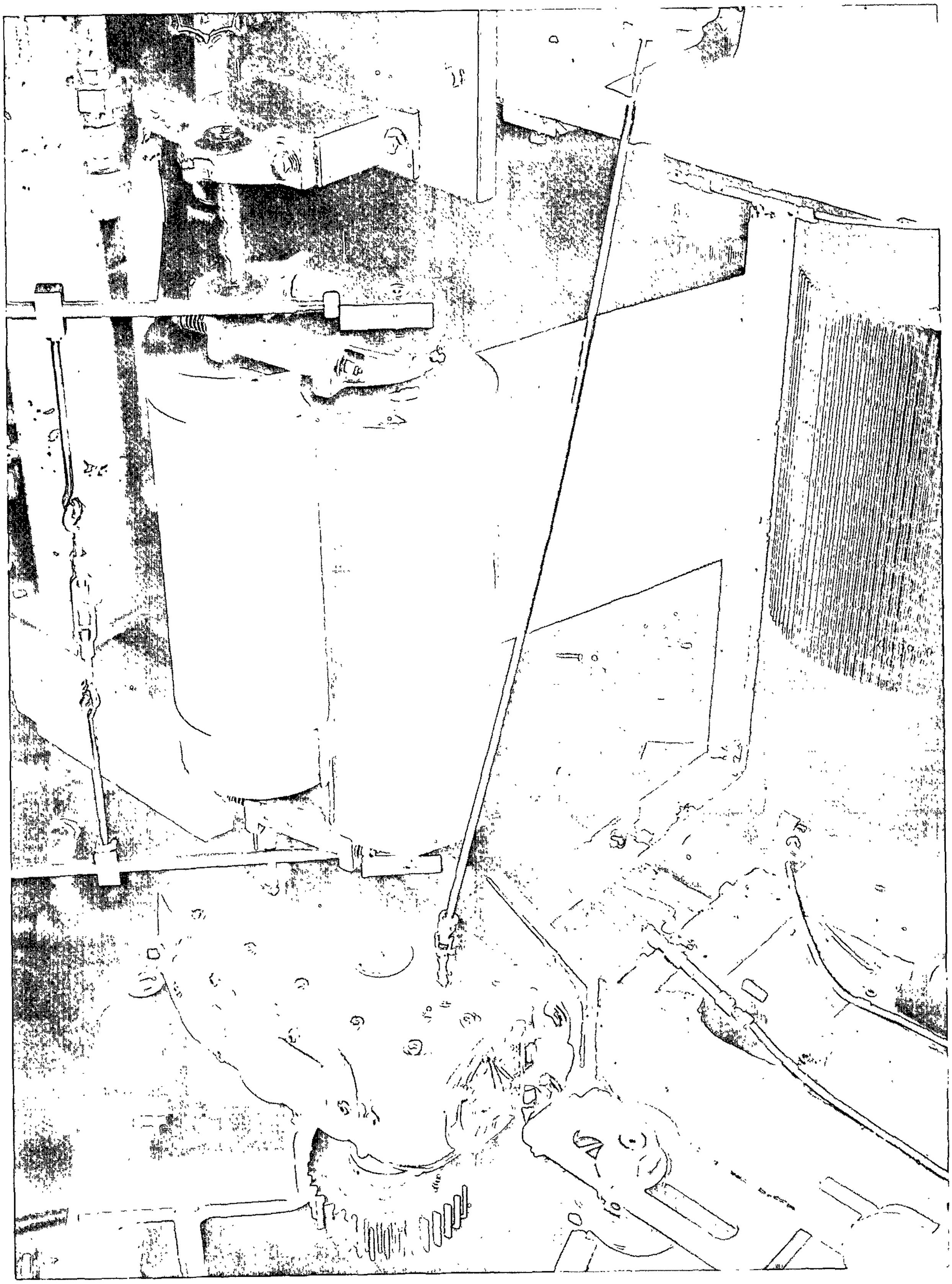

Figure 1. Medium Web Feeder

to obtain the desired tension in the web as it entered the corrugating labyrinth. It was found that caution had to be exercised in controlling the tension in the web. If the tension were reduced too much, the web would "walk" to one side or the other; if too tight, the opposite effect resulted in a build-up of tension which ultimately resulted in fracture of the sheet.

MATERIALS AND PROCEDURE

In order to explore the possible merits of the medium feeder, several commercial mediums were corrugated (using A-flute rolls), with and without the web feeder. The materials used are tabulated in Table I. In the case of Samples A and B, the mediums were corrugated at the same speeds up to and including 450 f.p.m. Sample C was run to the point of flute fractures without the feeder (maximum satisfactory runnability, 575 f.p.m.); however, with the feeder, the maximum speed tried was 300 f.p.m. because of the instability of the device as initially designed. The feeder was subsequently modified to permit speeds up to 900 f.p.m. Samples D, E, and F were run with the modified device. Speeds greater than 900 f.p.m. were not tried because the supports were not heavy enough. All other operating conditions were kept constant, the web tension up to the feeder being maintained at minimum tension.

EVALUATION

The single-faced board produced in each trial under each condition was evaluated for the following characteristics using regular Institute methods:

1. Average flute height
2. Average difference in consecutive flute height
3. Flat crush

TABLE I

MATERIALS USED

Sample	Roll No.	Type of Medium	Nominal Weight, lb./1000 sq. ft.
A	4077	Semichemical	26
B	4031	Semichemical	26
C	4039	Semichemical	33
E	4077	Semichemical	26
F	4331	Semichemical	26
D	6685	Kraft	26

DISCUSSION OF RESULTS

The runnability and physical characteristics of the single-faced board produced with and without the use of the medium feeder are tabulated in Table II. As previously mentioned, Samples A, B, and C were fabricated with the original design of the feeder and Samples D, E, and F with the modified feeder. The modification was necessary because of an error in calculation--i.e., the speed ratio was such that it was necessary to operate at the extreme end of the speed range of the speed transformer. Also "throw" of the knurled roll was encountered at speeds above 450 f.p.m. with the original model because the journals were too small in diameter.

It may be observed from the data tabulated in Table II that, at equivalent corrugator speeds, the single-faced board made with the feeder exhibited a higher caliper than the corresponding board fabricated in the conventional manner (without feeder). In addition, all the samples fabricated, using the modified feeder, exhibited both lower average differences in consecutive flute height as well as lower maximum difference in consecutive flute height. Further and probably of greatest importance, it may be noted that in all cases where the mediums were run to

TABLE II

COMPARISON OF SINGLE FACED BOARD FABRICATED WITH AND WITHOUT MEDIUM FEEDER

		Normal (Without Feeder)				With Medium Feed Device			
Sample No.	Roll No.	Corrugating Speed at Min. Tension, f.p.m.	Average Caliper, pt.	Diff. in Height of Consecutive Flutes, pt.	Flat Crush, p.s.i.	Corrugating Speed at Min. Tension, f.p.m.	Average Caliper, pt.	Diff. in Height of Consecutive Flutes, pt.	Crush, p.s.i.
A	4077-A	--				50	194.5	2.0 (3.8)	35.2
		100	192.3	2.3 (4.8)	34.5	100	194.9	3.4 (5.6)	35.9
						300	194.7	2.3 (5.8)	35.5
						450	193.2	3.6 (8.4)	34.9
B	4031	50	194.6	0.6 (1.6)	36.6	50	195.5	1.5 (3.1)	32.9
		100	194.7	1.4 (4.5)	34.3	100	195.9	1.1 (2.6)	34.4
		300	195.1	1.8 (3.2)	36.6	300	196.2	1.9 (3.9)	34.8
		450	195.3	1.3 (4.1)	35.8	450	196.4	1.5 (3.4)	35.8
C	4039	50	196.0	0.7 (1.2)	37.8	50	196.5	1.0 (2.5)	36.4
		100	195.9	1.1 (2.9)	38.4	100	196.0	1.2 (2.6)	38.3
		300	196.2	0.6 (2.2)	42.6	300	196.8	1.9 (4.3)	38.7
		575	195.9	3.1 (7.2)	41.8	--[a]			
D	6685	125	193.8	3.6 (7.4)	36.3	125	196.9	1.6 (3.3)	33.9
E	4077-B	400	197.0	2.6 (6.4)	29.0	400	198.0	1.8 (4.1)	26.3
F	4331	400	196.0	1.8 (3.8)	32.0	400	196.6	1.5 (2.9)	28.8
		900	195.4	2.5 (9.1)	31.3	900	197.0	2.2 (7.1)	28.9

[a]Mechanical difficulty with equipment prevented running at this speed.

"fracture speed", the use of the feeder permitted much higher runnabilities as shown in Table III. The runnability data shown in Table III demonstrate the importance which the transport tension (tension in web) has on runnability. The results indicate that if the medium is fed to the corrugating rolls properly, commercial speeds are possible even with mediums which normally exhibit very poor runnability. One of the major variables which influences transport tension is the frictional drag of the medium against the fluted rolls. The runnability results indicate that the feeder achieves the same result as antifriction agents.

TABLE III

RUNNABILITY RESULTS

Sample No.	Runnability, f.p.m.[a]		
	Without Feeder	With Feeder	Difference, %
A	100	450	350
D	125	600	380
E	575	900+[b]	56+
F	900	900+[b]	--[c]

[a]Maximum speed in f.p.m. at which board would corrugate satisfactorily.
[b]Maximum speed could safely operate medium feed device because of instability of supports.
[c]Indeterminant.

When the flat-crush results are considered, it may be noted that, in general, the flat crush was equal or lower than board fabricated without using the feeder. The lower flat crush on board made with the feeder would be anticipated from the caliper data--the higher the caliper the lower the flat crush. The lower flat crush might be interpreted as indicating poor structural quality as measured by box compression. However, it should be borne in mind that the two combined board material properties which govern top-load box compression are (1) ultimate edgewise compression of the combined board and (2) flexural stiffness (EI) of the combined board. The modulus of elasticity, E, is a material property whereas I, the moment of inertia, is a geometric quantity depending on configuration in which the caliper enters as a power factor the exact magnitude varying with cross-sectional shape. Thus, the higher caliper board should give higher flexural stiffness and, consequently, higher box compression.

Although no measurements were made in this study, it is anticipated that the higher caliper board will also exhibit a higher draw factor. Since the ultimate edgewise compression strength of the board is proportional to the sum of the ultimate edgewise compression strength of the single-face liner, double-face liner, and corrugating medium multiplied by its draw factor, it is anticipated that the ultimate edgewise compression of the board will increase with increase in draw. Thus, even though the flat crush is lower, the top-load box compression should be equal or higher.

LITERATURE CITED

1. McKee, R. C. Corrugating variables and the effect on combined board characteristics. Tappi 43, no. 3:218-28A (March, 1960).

2. The Institute of Paper Chemistry. Behavior of fibrous and nonfibrous components in the corrugating operation. Part I. Analysis of stress and strain in medium during formation of flutes. Progress Report One to Fourdrinier Kraft Board Institute, Inc., Project 1108-22, Feb. 29, 1960.

THE INSTITUTE OF PAPER CHEMISTRY

R. C. McKee, Chief, Container
Section