Cold Corrugation Process-Clues

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Traditional corrugation, as well known, is performed at high temperatures (say about 150^0 C). This temperature is required to make fluting on paper as also to keep adhesive in gelatinized form. Nevertheless operational difficulties are numerous with elevated temperatures. Cost of production is also high due to cost of steam and heat required for pre-heating, pre-conditioning & corrugating. In order to avoid high temperature operational difficulties and to reduce costs & investment in equipment. "The cold corrugation process" has been developed. In this process, forming and bonding operations are accomplished at room temperature; with little or no heating of paper components & adhesive.

The basic difference cold & hot (regular) processes are quite a few but extremely important differences are in.

1. Type of adhesive, its application & setting temperature
2. Tension control
3. Frictional coefficient of paper
4. Picking and its control
5. Wrap on top corrugating roll
6. Medium moisture
7. Forming pressure
8. Pre-treatment of paper
9. Finger guides and/or vacuum handling of web
10. Double-backer and bond formation there.

Quite a lot of research work is in progress at institute of paper chemistry & union camp Inc. US and elsewhere (in India as well), regarding cold corrugation. Current knowledge on the subject is derived from machine trials & experiments with corrugators and published papers, personal experience and discussions with technologists on corrugation and paper making. Now we shall review the subject in little more detail.

(a) Adhesive & Bond: In conventional hot-corrugation process uncooked starch is dispersed in semi cooked solvent with additives. At elevated temperatures, the starch granules swell by water absorption and gelatinization occurs. This slurry gets to the pores & voids of paper & solidifies there by making a bond. In cold corrugation process something like the reverse happens; i.e. the adhesive develops high viscosity during cooling process (instead of gel formation in heating during hot-corrugation). The adhesive is made up of fully cooked starch which is applied at high temperature to the cold paper, with very low viscosity; then it undergoes cooling. The adhesive is chemically made by thermo chemical modification of corn-starch. Cooking is carried out at a temperature of about 130/150 ^{0}C in the presence of Ammonium persulfate. Sodium Hydroxide is then added at a high pH (9-10) which helps to increase alkalinity, stabilise the solution & bonding. Boric acid can also be added to improve viscosity.

On application of the adhesive which is at a high temperature, say 90^{0}C, the molecules of starch get into the pores & voids, This happens by absorption process due to the paper (at room temperature) trying to establish equillibrium with hot glue and in the process heat transfer, water absorption & molecule migration into paper occurs. Further, the process is aided by high pressure (about 25% more than what is applied in hot process);

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applied on corrugating rolls. The absorption of glue under high pressure takes place in a split second time as the Production process operates at 300-350 m/min. The small portion of glue that goes into paper develops "green bond" which is just adequate to take the paper lines and fluting off the laybrinth. Subsequently a few seconds later, as the glue cools down, its viscosity increases more & more and the bond solidifies.

(b) Paper Speed & Tension : If paper enters laybrinth at a very high speed the subsequent speed of its travel through the nip line needs to be much more. Higher speeds than desirable levels at laybrinth would lead to poor corrugation due to inadequate time available for paper to form flutes and such flutes to pick up gum. This would also result in poor bonding and resultant delamination.

Web tension is much more critical. Under high tension, the corrugations would develop cracking at the tips because in cold process the paper is not heated & moistened to make cellulose and lignin more pliable. In cold condition the paper is rather brittle or less plastic in nature and when such paper is fluted under high tension it is bound to crack on flute tips. Hence in the cold process it would be necessary to provide pre feeder to control tension and keep speed. Adjustments of regular break tension may also be given as required, to keep medium entering the fluting nip line at constant tension. The pre-feeder and break-tension adjustments would also help to even out any piping in paper which if continues upto lay brinth, will surely develop creasing and high-low flutes. Tension adjustment of medium is also required to even out wobbling of paper due to bad winding of reel, besides providing initial tension required to feed paper properly just at the entrance of laybrinth along upper corrugating roll.

(C) Co-efficient of friction : In the regular hot-process, the friction is mitigated due to higher heat, flexible paper surface (as preheated & moistened) and more particularly due to use of chemical agents. However in the cold process, due to low temperature the friction between paper & metal surface of rolls is very high. Hence paper movement becomes difficult and this leads to de-shaped corrugations. Cold-Process, hence requires that paper is manufactured at Mill-stage itself with low co-efficient of friction such as 0.35-0.45 by surface treatment of paper (may be by running of water or Rosin water in size press and subsequent calendering. Please note that slight reduction in caliper due to calendering may not pose any problems with respect to cold-process CFC, because paper under goes less reduction in bulk in cold process as compared to that in hot-process).

Co-efficient of friction can be reduced by use of chemical agents (like parafin wax), by keeping higher moisture in medium. by less wrap of medium on corrugating roll and by adjustments on pre-feeders.

The latest in metallurgical sciences can help to manufacture rolls with less co-efficient of friction & very high smoothness so that paper under tension & speed, can move smoothly on such rolls. Nevertheless it is important to see that friction is not very low as to avoid slippage of paper which is much more dangerous.

(d) Control of Picking : Picking relates to accumulation of loose fibres detached from paper surface. In hot process such dust or fluff is reduced by release properties of paper roll-surface due to high heat. In the cold process the loose fibres can be blown off by air-jet web cleaner suitably designed. Certain chemical agents can be also used to treat medium against picking.

(e) Wrap on top roll : As the flutes are continuously formed, the medium develops wrap and it wraps itself around top corrugating roll. This needs to be reduced so that fluff-out, i.e. detachment from the roll and movement to take liner is easy. This may be done by finger guide adjustment or by vaccum pull.

(f) Other factors : Forming pressure is one important factor which helps in glue absorption mentioned above as well as flute forming. In hot process the paper is flexible and therefore greater nip pressures are not required to bend the paper to corrugate. In cold process, the paper is less flexible and hence a 25% more pressure than usual would greatly help to form perfect flutes.

Moistening the paper prior to entering laybrinth would go a long way in making the paper slighty flexible but care should be taken to ensure no loss of strength or surface properties occurs.

So, paper is usually given a pre-treatment (not pre- heating or conditioning), with chemicals for reducing friction/picking and moistening for making the paper less brittle or plastic slightly.

(g) Single Face Bonding in Cold-process: Green Bonding on the Single facer, as described earlier, takes place under more pressure, cold & moistened medium and relatively slower speed (200 m/min) in cold process. This initial bond should be strong enough to withstand subsequent mechanical operations on the elevator & the bridge. Hence the machine is run at relatively slower speed to allow the glue molecules to get into paper and solidify. Here the slight difference in bonding in cold process is that the glue runs at a very high viscosity (30% solids) and hence the starch particles get into force by absorption under high pressure. The single facer bonds made in cold process would be as strong as that of hot process because partially cooked starch is used which solidifies in paper pores and voids on either side with small glue-bridge at the middle between flute tip and liner contact point.

(h) Double Face Bonding in cold-process: Adhesive application at the double facer is rather demanding. It has to be put on the fluted paper flute-tips when it is not supported by any back-up roll. There is a much open time between glue application and double-facer joining. Hence the double facer-glue needs to be slightly different so as to take into account the transport time. If the adhesive solidifies before joining of liner then there is no bonding. It may help, to pre-heat the liner at about 40-50^{0}C (or slightly above room temp.) so as to allow glue to penetrate liner easily. This pre heating is required only for double-backer.

The cold corrugation process is still in the experimental stages in India. More studies will be undertaken by leading corrugators in the years to come because it has promising future.