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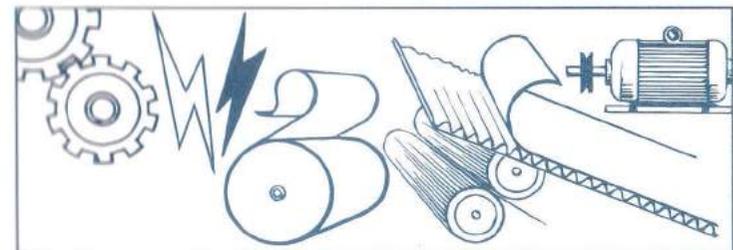
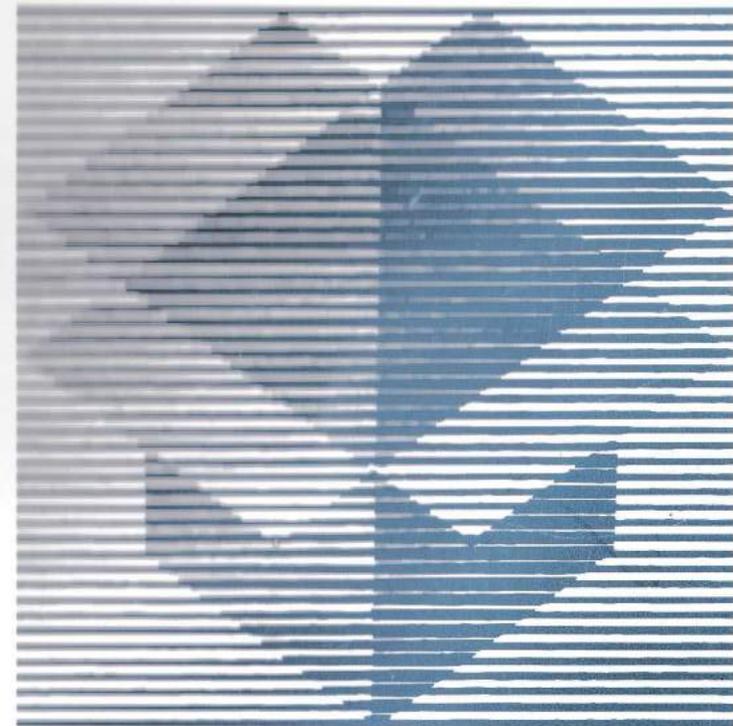
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ADHESIVES



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Published in the interest of manufacturers and users of corrugated boxes.
For additional copies, please write to:



FEDERATION OF CORRUGATED BOX MANUFACTURERS OF INDIA

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FEDERATION OF CORRUGATED BOX
MANUFACTURERS OF INDIA

FOREWORD

The R & D Committee of FCBM has been actively engaged in publishing Practical Standards and Technical Information Booklets. Over 40 such publications have been brought out, till date.

These booklets have received appreciation from our members, users of corrugated boxes and our vendors of paper, machinery, adhesives, etc.

Such standards help in understanding the technical terms, specifications and test methods. A useful step towards quality assurance of corrugated boxes.

This booklet was first published in 1994. Effort made by the then R&D Committee and the FCBM President **Shri G. B. Chamarla** is gratefully acknowledged.

The fact that some of these booklets have gone into second and third print underlines the importance and popularity of these booklets.

As many of our new members have not received these booklets, we have decided to reprint the books which are out of stock.

We are also making efforts to digitize all the booklets and prepare CD's for those who desire to have soft copies of these publications.

I am sure members will appreciate this new initiative of our R & D Committee and derive benefit from these publications.

Anil Kumar Reddy
President, FCBM

15 November, 2009

While kraft paper is the main raw material for corrugated packaging industry, adhesive – as the second most important raw material – has gained significant importance recently. This is due, in part, to the variety of kraft paper grades available.

Due to the wide range of grades of papers ... sizing, pH of paper, porosity, absorbency and some other chemical properties are different. Therefore, same type of adhesive will not be effective for all types of papers.

Additionally, the weather conditions and machines are different ... affecting the adhesive and its bonding.

We are all too familiar with wet boards, especially in monsoon. Some papers do not pick up glue well whereas some absorb too much. Some boards delaminate like 'zippers'. Some liners have bubbles or blisters. Sometimes the glue gels in trays, as a result 'lumps' are found in the gum tray.

Some of the words used in the adhesive industry, such as viscosity, pH, gel temperature, tackiness, solid content, etc., are new to many of us.

Which is the correct method for checking viscosity? What is gel temperature? What is pH value? What is the effect if it is too low or too high?

Not much is available to our members by way of published material on the subject of ADHESIVES and related problems. Hence, your R & D Committee thought it fit to publish a technical booklet on this subject. We invited written replies to a set of 16 questions from NINE well known adhesive suppliers who amongst them have a wealth of knowledge. Their replies, which are printed in a different random order for each question, is the basis of this publication.

On behalf of R & D Committee, I wish to thank all of the following nine experts, listed alphabetically, for taking time to send their replies for your benefit.

- Mr. Budhhisagar Corn Products Co. (India) Ltd., Bombay
- Dr. U. V. Doshi Dura Labs (India), Bombay
- Mr. K. B. Goyal Bharat Starch Polymer Industries, Bombay
- Mr. S. K. Joshi Corn Products Co. (India) Ltd., New Delhi
- Mr. Lodhi Synthetics Glue & Chemicals Pvt. Ltd., New Delhi
- Mr. Nandi Maxi Bond Adhesive, Bangalore
- Mr. S. B. Patel Anupam Adhesive, Vallabh Vidyanagar, Gujarat
- Mr. Mahendra Singh S. N. Adhesives, Bombay
- Mr. U. C. Vidyarthi Adhesive & Chemical Industries, Calcutta

Adhesives were discussed in full detail during one full session at the FCBM Conference at Bombay in 1993. A copy of the proceeding or a copy of the video is available from the secretariat.

This is the first of many publications we have planned on the subject of adhesives. To guide our future endeavour, please send us your thoughts and suggestions.

Pankaj Shah

Chairman, R & D Committee

30 June '94

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What is the correct definition of corrugating and pasting adhesive in layman's language?

- A. 1 Adhesive or adhesive mixture meant for online production of single wall/multiwall corrugated board, off the reels is known as corrugating adhesive.

Pasting adhesive may be defined as the adhesive used for combining paper to paper, paper to board or board to board in packaging industries. In corrugating industries, this adhesive is used for subsequent production of multiwall boards out of single faced corrugated boards and flat kraft liners or duplex or pulp boards.

- A. 2 In layman's language corrugation and pasting adhesives can be defined as adhesives which bind or cement the different components of the Corrugated Board firmly, so that it can be converted into a good looking presentable and durable box after going through all the post corrugation operations of cutting, folding, etc. The box should also be functionally adequate, which primarily depends on the quality of paper used.

Generally adhesives used for binding of fluted tips of corrugation medium to the liner are called Corrugation Adhesives.

Adhesives used for lamination, after the corrugation process are called Pasting Adhesives. Certain synthetic adhesives are used for lamination of highly sized or laminated papers.

- A. 3 Adhesive is the bind between two plies and corrugated sheet which keep them aligned. It is the substance which helps in converting a mere sheet of paper to a value added product, i.e., Corrugated box.
- A. 4 Corrugating adhesive is a thermosetting adhesive. This adhesive usually has some quantity of ungelatinised starch. The starch gets gelatinised by the heat of the corrugating medium. The adhesive gets its adhesion properties only after gelatinisation of free starch.

Pasting adhesive is cold setting laminating adhesive. No heat is required for this adhesive to set. It is a precooked adhesive.

- A. 5 Corrugating adhesive means that adhesive which is used for preparation of corrugated boards from kraft. It may be cold or hot glue and it should form bond between a liner and fluting paper by consuming heat from the machine.

Pasting adhesive is that adhesive used for preparation of boards with liners. It is a cooked variety which forms bond without applying heat on machine to prepare 3 ply or 5 ply or 7 ply boards.

- A. 6 An adhesive is a substance capable of holding materials together by surface attachment. In fact adhesion can be mechanical electrostatic or by molecular attraction.
- A. 7 The adhesive that is used on corrugating machine is called corrugation gum, whereas, the gum that is used to laminate a sheet/liner on the corrugated side is called pasting gum.
- A. 8 When two substrates could be joined together firmly by the application of another material between two surfaces and the joint is stronger than the substrate itself, such material is called adhesive.
- A. 9 CORRUGATION ADHESIVE is an adhesive which should be competent enough to paste two papers of various grammages that is liner and as well as flute, when pasted through corrugation machine.

PASTING ADHESIVE is an adhesive which should be good enough to paste pasting paper which will act as a liner to the flute of two ply corrugated sheet manufactured from corrugation machine.

What different types of Adhesives can be used in the Manufacture of Corrugated Boards?

- B. 1 For corrugating purposes, in India, generally solution of particular grade of sodium silicate or blend of cooked/ uncooked starch is used (incorporating modifying chemicals).

In developed countries, generally a blend of EVA (Ethylene Vinyl Acetate), microcrystalline wax and tackifying resin or a blend of purina protein, starch and silicate are used.

- B. 2 a) Starch and Dextrin based.
b) Sodium Silicate based.
c) Animal Glue based.

But generally starch or starch dextrin based adhesives are used for corrugation and other two for lamination. However, recently the tendency is to use only starch based and dextrin based adhesives for corrugation and pasting.

- B. 3 There are many types of adhesives available which are used with respect to their properties and need of the box manufacturer, some of which are as follows:

1. Starch Based Adhesives

- a. Pasting Gum.
- b. Corrugation Gum.

2. Sodium silicate based Adhesives

3. Animal glues & casein Adhesives
4. Synthetic rubber Adhesives

- B.4 i) Starch and Dextrin based Adhesives
ii) Silicate
iii) Water Resistant Adhesive
- B.5 1) Starch adhesives.
2) Modified Starch adhesives.
3) Sodium silicate (neutral).

- B.6 A great many types of adhesives are currently in use and there is no adequate single classification for all products. The adhesives industries have generally employed classification based on end use, such as metal adhesives, wood adhesives, paper and packing adhesives and soon. AND such corrugating and pasting adhesives can be classified or defined as corrugating adhesives used on paper corrugating machine and pasting adhesives as used on paper pasting machine. While the former gelatinizes at above hundred degree centigrade, it comes under hot setting adhesives and the latter develops bondage at room temperature. Up to the early part of this century, the only adhesives of major importance were the animal and vegetable glues which have been in use for thousands of years, and these materials are still widely employed. In the manufacture of corrugated board, though different types of adhesives have been tried, but still even in United States and Europe above 90% of the corrugated board is made with starch. For imparting properties some synthetic resins are mixed with starch based adhesives, but considering the cost and properties in general, no substitute for starch adhesives for corrugated board industries has been found so far.
- B.7 Three types of adhesives can be practically used in the manufacture of corrugated boards.
1. Sodium silicate.
 2. Starch based emulsion.
 3. Modified starch /dextrin based adhesives.
- B.8 Any type of adhesives could be used in corrugated board, such as, starch, modified starch, sodium silicate, poly vinyl alcohol, casein and thermosetting adhesive ... depending upon the economy, ease of application and characteristic behaviour of particular adhesive towards paper with its relative advantages and disadvantages.
- B.9 Vegetable based adhesive is the ideally suited adhesive for the manufacture of corrugated boards. At the same time, vegetable based adhesive mixed with synthetic adhesive, is also suitable in the corrugation industry but it is very seldom used because of various constraints involved.

WHAT ARE THEIR RELATIVE ADVANTAGES AND CONSTRAINTS?

- C.1 Up to this date in corrugated industry, only starch based adhesives have got worldwide recognition due to their excellent film forming characteristic and their flexibility towards hundreds of modifications it can be worked with to suit any requirements. Being water based and abundantly available, it is the cheapest of all other adhesives known. It, after proper modification, has greater strength than the paper itself and thus can produce very strong bond between paper. The only disadvantage is the bacterial growth, if proper preservative is not used.

SILICATE: Earlier to the invention of starch adhesive there was only Silicate adhesive available for corrugating industries. But due to its related side effects it could not stay and by now has totally been replaced by starch based adhesives. Silicate is a liquid glass which after drying forms films which is highly alkaline damaging paper fibres, printing colours and also the products packed in such containers. In rainy season it absorbs water from the atmosphere and in summer loses water up to the extent that it becomes glass film which is very brittle and can not survive under any stress like folding, compression, etc. The only advantage is that it never supports bacterial growth.

P.V.A. and CASEIN are water based adhesives having excellent bonding power but its cost does not permit to be used in corrugating industries and these adhesives cannot compete with starch adhesive in cost and functional value as well.

SYNTHETIC ADHESIVES are out of question being further costlier and do not warrant in the use unless specifically required for some special purpose.

- C.2 Starch adhesives, similar to that of Stein Hall system, is apparently the best and cheapest adhesive available to the Indian corrugators.

Silicate adhesive has limited application for its undesirable properties like:

- High alkalinity.
- Discolouration of paper and prints.
- Causing brittleness/loss of strength on storage.

C.3 Advantages:

- Easy to mix.
- Lower consumption of glue.
- Minimum rejects.
- Faster machine speed.
- Higher output of roll per shift.
- Low gelatinisation temperature.

Constraints:

Pasting gum needs to be cooked and corrugation gum needs to be mixed as per instructions, and minimum solids to be kept for effective bonding, otherwise adhesives delamination takes place, consumption will be higher and warping of boards is likely.

C.4 Following are the advantages and constraints in respective order:

Advantages:

- Starch based adhesives are cheaper than other adhesives.
- Starch is polysaccharide with glucose as monomer, there are two polymers in starch, viz., amylose and amylopectin. Upon gelatinisation above two polymers absorb water and during cooling they get entangled with paper fibre and hence bridge the two paper sheets.

Starch Adhesives have good binding property. They dry faster as compared to other adhesives which makes them superior choice of the corrugators.

Constraints:

- If proper check on quantities of ingredients and solid content is not done then lamination made with starch adhesive can easily get open.
- Shelf-life of this Adhesive is quite limited and hence it is difficult to maintain the stock.
- This gum is easy prey for bacteria.
- This gum gets easily affected by weather conditions.

C.5 Starch and dextrin based adhesives are widely used for corrugation and pasting conversion Industry.

Silicate is not commonly used as it is highly alkaline, which corrodes the paper and the container is rendered weak in strength.

Water resistant adhesive, though, not commonly used has many advantages.

The glue lines of containers, made with dextrin and starch based adhesives, when come in contact with water open up in an hour's time. But with water resistant adhesives, these glue lines do not open up even if the container is soaked in water for 24 hours.

Containers made with water resistant adhesive are suitable for packaging of sea foods and Export Containers.

C.6 The following are the advantages of using starch and modified starch based glue.

- Good bonding due to low gelatinisation.
- It provides superior machine speed.
- Viscosity and solid contents can be maintained.
- It does not affect the printed matter.

The advantage of Sodium Silicate (neutral) over starch and modified starch adhesives.

- Due to high solid content board becomes very hard.
- Increases the weight.
- Gives good bonding.
- Gives good strength.

Constraints:

- Due to high alkalinity, washboarding develops.
- Printed matter is affected.
- Due to hardness, the flaps of boxes develop cracks.

C.7 Answered along with question two.

C.8 Advantages of using vegetable based adhesive is that it could be used for a prolonged period, say, for two to three days, once it is prepared without any deterioration in the quality.

Constraints of using vegetable based adhesive amalgamated with synthetic based adhesive is that it has to be used in a very short spell of time. Overnight left over materials just cannot be used since gelling of entire mass would take place.

C.9 In the initial period of corrugated box packaging, sodium silicate happened to be a quick and easy choice as it cured quickly with very little heating and rendered firm strong lamination yet, paradoxically it carried some serious disadvantage. It degraded and discoloured paper, and was very hard on machines.

Starch based adhesive emulsions worked very well on corrugation machines and especially on automatic corrugated board making machines.

MODIFIED STARCH/DEXTRIN based adhesives are useful on a pasting machine, and in the process of air drying brings about adhesion of the plies.

WHAT IS THE RECOMMENDED MIXING FORMULA? WHAT IS THE RECOMMENDED COOKING PROCESS?

D.1 A write-up on the Stein-Hall System is available in a number of reference books on adhesives. The deviation is that the Indian Formulation has much lower solid content as compared to these recommended by Stein Hall Adhesives.

D.2 The recommended mixing or cooking is at 1 to 5 ratio, i.e., 16% solid.

Process for making corrugation adhesive:

First take water in a vessel, start stirrer and add slowly into vertex the corrugation powder, stir well till you get homogeneous mass.

Process for cooking of pasting or lamination adhesive:

First take water in the vessel and heat up to 50-60 degree centigrade, add power and constant stirring, raise the temperature of the mass to 90-95 degree centigrade and get the mass cooking at this temperature for 30-35 minutes.

D.3 Following are major constituents of starch adhesives along with their cooking process.

PASTING GUM—This adhesive is made by roasting starch with acid. During this process, starch polymers are broken down to dextrin. Dextrin upon gelatinisation with water, caustic soda, soda ash, sodium chloride, silicon flouride and borax at 85 degree gives pasting gum.

CORRUGATION GUM—Corrugating binding is a very fast process. Upon application of adhesives, wetting and drying takes place inside machine only. That's why corrugation gum is made by using raw starch and other additives. Respective amounts of ingredients are suspended in water along with starch and blended properly to get good quality gum. This blend is supplied to manufacturer as such.

D.4 No comments.

D.5 For corrugating glue, if we use powder glue, we must take required quantity of water and start stirring the water by mechanical stirrer with a speed of 1400 RPM. To this, add the required quantity of powder and the stirring should continue for about 15 minutes. After that leave the mixture for about 30 minutes at room temperature and only after that it can be used. For pasting glue, first we must heat the required quantity of water to about 70 degree centigrade and then start stirring the water. To this, add the required quantity of powder. Continue stirring the mixture till the temperature rises to about 90 degree centigrade. The vessel used in this process must be jacketed.

Here if we do not get the proper temperature required then there are chances of the mixture not getting proper viscosity and hence as a result you would not get the bond strength and drying time.

D.6 For paper corrugating adhesives the requirement of solid content range is about 20% while for pasting machine adhesives, it is usually about 30%.

For preparing adhesives for corrugating industry a calculated quantity of water is taken in a tank fitted with an electrically operated mixer. Then slowly the corrugating powder is added to the water with constant stirring. It should be allowed to mix for about one hour before use.

For pasting adhesives, calculated quantity of water is taken in a jacketed tank fitted with electric stirrer. The pasting powder is slowly added to the water with constant stirring. Water is taken in the jacket of the tank heated. As the temperature rises the colour of the inside liquid is slowly changed to brown. The temperature rises up to 85 to 90 degree centigrade and kept constant for about 30 minutes.

The glue will be ready to be used. The water and powder are taken by weight and never by volume.

D.7 Mixing formula is generally specified and recommended by the Gum Powder manufacturer, depending on the quality of the gum powder.

In respect of CORRUGATION, usually a kilo of the powder is recommended to be mixed with 4-6 liters of water, and so it is in case of PASTING gum powders. However, with the pasting gum if the gum powder is not cold soluble, the mixture has to be cooked to a temperature of 85-90 degree Celsius in an oil/steam jacketed vessel.

D.8 For single facer - 1:5 to 1:6 (16.5 to 14.5% solid).
For double facer - 1:3 to 1:4 (25 to 20% solid).
For pasting - 1:3 to 1:4 (25 to 20% solid).

Cooking process for pasting adhesive—It should be cooked up to 90 to 95 degree centigrade under constant slow stirring (150 RPM).

D.9 Corrugation Adhesive (cold process)

1 kg. of powder adhesive + 5 kg. of water

or

one bucket of powder adhesive + 3 buckets of water

Pasting Gum (hot process)

1 kg of powder adhesive + 7 kg of water

or

one bucket of powder adhesive + 4 buckets of water

RECOMMENDED COOKING PROCESS FOR PASTING GUM

Initially take 3 buckets of water and put to heat. In the balance one bucket of water, add one bucket of recommended powder adhesive and prepare a slurry in cold water. When the water put to heat attains a temperature of around 80 to 85 degree centigrade, transfer the cold slurry to hot water, put to heat and keep vigorously agitating the entire mass with a help of wooden plank till boiling is attained. At the time of boiling, the colour of glue will become dark brown which signifies the preparation of glue for usage on pasting machine.

NOTE:

- a) Use of mechanical stirrer is a must for preparing corrugation glue.
- b) Use of freshly prepared pasting glue by hot process will result in better mileage on account of low viscosity and fast drying time.
- c) The above recommended dilution for corrugation glue holds good when two papers of 100 G.S.M. each, one semi kraft and other kraft is used in corrugation machine.
- d) Same bucket has to be used for water as well as powder. While filling the bucket with powder, the powder has not to be pressed.
- e) Use of double wall container will definitely render much better quality of adhesive for preparing pasting glue.
- f) We also recommended usage of Soludex to the tune of 10% vis-a-vis pasting powder during rainy season and extreme chilly condition for reducing the drying time and at the same time for enhancing the bursting strength of the prepared corrugated board.

WHICH FUNCTIONAL PROPERTIES OF THE ADHESIVES ARE IMPORTANT TO CORRUGATED BOARD MANUFACTURERS?

- E.1 To the corrugators the following functional aspects of the adhesives are important:

CORRUGATING ADHESIVE

- a) Solid content %
- b) Viscosity / Runnability
- c) Gel point

Besides colour, odour and pH also play some part in the adhesive.

PASTING ADHESIVE

- a) Solid content %
- b) Viscosity/Runnability
- c) Drying time
- d) Tack

- E.2 The important functional properties of corrugating adhesive to make board are as follows:

- a) Proper heat to the roller of corrugating machine
- b) Total solids
- c) Viscosity by ISI cup viscosity stability and flowability of the adhesive.

(The properties of 2 and 3 above depend on the paper used).

- d) Gel temperature of the adhesive mix.
- e) pH of the adhesive.

- E.3 Following are the specifications of the gum which suits well to the corrugator:

PASTING GUM

- a) Adhesive Base : Dextrin made from Starch
- b) Solid Content : 14 to 25 %
- c) Viscosity : 19 to 29 Seconds at Ford Cup No.4
- d) pH value : 8.5 to 10
- e) Colour : Honey like

CORRUGATION GUM

- a) Adhesive Base : Raw starch and dextrin
- b) Solid Content : 8 to 10%
- c) Viscosity : 15 to 19 Seconds at Ford Cup No.4
- d) pH value : 8.5 to 9
- e) Colour : Milky white

E.4 Both solids and viscosity are equally important.

- Corrugating Adhesive Solids : 14-15%
- Pasting Adhesive Solids : 15-17%

There is no doubt that there should be different viscosity requirement for various grammage of papers.

E.5 For corrugating glue, per cent solid should be minimum to about 15 % and the viscosity should be about 40 to 50 seconds by Ford Cup no.4.

For pasting glue, the per cent solid ranges from 15% to 25% and viscosity of the glue depends upon the nature of the paper. For A grade, viscosity should be 30 to 40 seconds and for B grade, viscosity should be 50 to 60 seconds.

- E.6 Solid and viscosity are both important to corrugated board manufacturers. But solid % is more important as no adjustment of solid can be done. While by adjusting the feed roller on pasting machine, variation in viscosity can be controlled.
- E.7 The function of an adhesive is to stick well and fast enough, giving a strong, firm and yet flexible bond of the sheets. It should set and dry well in a reasonable time.
- E.8 Quick setting with workable viscosity and on drying should develop strong bond which should sustain folding, compression and peeling stresses up to the minimum requirement for particular corrugated board.
- E.9 Solid contents plays a vital role for good performance of a manufactured corrugated board and to some extent viscosity also holds the key.

WHAT VALUES OF THESE FUNCTIONAL PROPERTIES DO YOU RECOMMEND? FOR SINGLE FACER PLANT? AND SEPARATELY FOR 3 PLY/5 PLY AUTOMATIC PLANT?

F. 1	Corrugating	Pasting	
	Solid content %	15-20	20-25
	Viscosity—Ford #4	30-40	20-25
	pH	10-12	8-10
	Tack	—	should develop strings between fingers, dry fast and feel tacky

For 3 ply/5 ply automatic corrugating plants, double backer adhesive's gel point should be lowered to 60-64 degree centigrade by careful addition of caustic soda, as availability of heat is less as compared to that of single facer.

- F. 2
- The temperature of roller should be around 110-120 degree centigrade.
 - Total solids min 16% and maximum 20% depends on paper quality.
 - Viscosity minimum 20 to 30 seconds for single facer and 34 to 35 seconds for double facer by ISI cup.
 - Gel temperature of the product should be around 58-60 degree centigrade for single facer and double facer.
 - pH should be 8.5-10. A higher pH may be necessary for the double facer or even single facer if high machine speeds are used.
 - We recommend different types of total solids and viscosities depending on grammage of paper.

F.3 FOR SINGLE FACER PLANT

Corrugating gum of following specification is suitable:

- Solid content : 15 to 30%

- Viscosity : 19 to 29 seconds
- pH value : 8.5 to 10
- Colour : Honey like

FOR 3 PLY/5 PLY AUTOMATIC PLANT

Pasting gum is more suitable which should be of following specification:

- Solid content : 8 to 18 %
- Viscosity : 15 to 19 seconds
- pH value : 8.5 to 9
- Colour : Milky white

NOTE: 1. Adhesive with 14% solid content can bind suitably papers of up to 180 grammage.

2. If paper is of more grammage then solid content of adhesive goes up in direct proportion to the grammage of paper above 180.

F.4 For single facer plant viscosity should be minimum to about 40 secs. in both machines and percent solid should also be not less than 15%

In automatic 5 ply plant machine for corrugating, viscosity should be 30 secs. and percent solid should not be less than 15% while in double backer viscosity should not be less than 50 secs. and percent solid around 20 to 30%.

F.5 Answered with question 4.

F.6 No comments.

F.7 The CORRUGATION gum to work well on the machine, should not be thick and ropy, should not settle in the tray, nor coagulate. It should be properly formulated and have an adequate solid content. The two ply liner board should quickly dry and cure. The face of the

liners should look smooth showing only very faint pressure lines. The laminated sheets/ plies should have so strongly bonded that an attempt at delamination should result in rupture of the layers. Then only the 2 ply liner is good enough for further processing.

- F.8 To achieve quick setting, we have to have adequate solid contents. For single face corrugating machine 15 to 18% solids and for double faces 20 to 25% and for Pasting Machine 20 to 25% with proper pH values between 9 to 10.
- F.9 We recommend usage of prepared liquid adhesive with minimum 16% solid contents. By 16% solid contents, we mean starch contents which would be in particular be responsible for imparting adhesion to the system as such. Solid contents in the form of fillers is not going to help in terms of adhesive values. We definitely recommend different dilution or say different adhesive with solid contents for different types of papers. Because the acid test of adhesive in corrugation industry comes to the fore when two heavy GSM set of papers are to be corrugated in corrugation machine. Since, in heavy GSM paper the glue should be good enough to pierce through the glazed appearance of the heavy GSM quality paper, whereas it is the other way around in case of pasting gum. The acid test of adhesive is tested on lower GSM set of papers because in lower set of papers the absorbency of glue is much more and in this case when the two ply paper is pasted through the pasting machine after absorbance has taken place on the flute, adequate quantities of glue should be still there on the flute which should form a satisfactory bond with the pasting paper that is liner which in turn will also absorb a fair amount of adhesive while coming in contact with the flute of the two ply pasted through pasting machine.

WHAT ARE THEIR TEST METHODS? TEST APPARATUS?

- G.1 **TEST METHOD:** For ascertaining satisfactory bond, on peeling off, delamination should not take place and significantly, fibres of paper pertaining to flute should be deposited on the liner.

TEST APPARATUS: Bursting strength machine as well as puncture testing machine.

- G.2 ISI Cup No. 4 to check viscosity. This can be measured by making solution in laboratory at 1 to 5 ratio and passing through ISI Cup No.4. The time in seconds to be measured for the delivery of 100 ccs.

pH either by pH meter or by pH paper.

Total solids either by oven method or in case of lamination adhesive by Refractometer.

Gel Temperature: Take small quantity in a beaker and with the help of thermometer and a pair of tongs immerse the beaker in a boiling water bath. Stir constantly with the help of thermometer and when the solution just starts thickening the temperature is noted.

- G.3 **For Measuring Viscosity of Gum:** Ford Cup No.4 is used.

For Checking pH — pH paper is used.

For Checking Solid Content of Gum: Refractometer is used which even though records only soluble solid but it gives fairly good idea for solid content of the gum.

G.4 SOLIDS: A weighed quantity of adhesive is taken in a dish (say, 5 grams) and dried in an oven at 110 degree centigrade and weighed after cooling.

Percentage solids is calculated as follows:

Wa = Weight of sample

Wb = Weight after drying

% Solids = $Wb/Wa \times 100$

G.5 For measuring viscosity of the glue one has to use Ford Cup No. 4. For percent solids of an uncooked variety, first you have to take pre weighed glue in a dry aluminium dish and heat it in an oven for about 30 minutes at 120 degree centigrade. After that weigh the glue and re-dry it again. Now weigh the glue again after re drying it and record it. Now calculate the percent solid of adhesive using following formula.

$$\% \text{ Solids} = \frac{\text{Dry weight} - \text{weight of the empty dish}}{\text{Wet weight} - \text{weight of the empty dish}} \times 100$$

For percent solid of a cooked glue, it can be directly found by using a pocket refractometer or by above mentioned method also.

Iodine Staining of the Glue Line.

By staining the glue line with iodine solution it helps in examining the uniformity of an adhesive application between the liner and corrugated medium.

First we have to soak the sample of a board in a tub which contains clean water until the liner and medium can be easily separated by peeling. After separation, flatten the liner and medium sample and blot dry. Then dip the samples into a iodine solution. Iodine solution is made by first dissolving 75 gms of potassium iodide in 7.5 litres

of warm water followed by dissolving 25 gms of Iodine and then diluting this solution by adding more water till it becomes 20 litres. This solution has to be stored in a dark coloured glass or plastic container. When the colour has fully developed, remove the samples from iodine solution and dry them. The adhesives form a pattern of continuous lines with uniform width. In single facer width may be some what greater than the double facer width.

G.6 For testing the main properties of an adhesive, a laboratory is required. The methods and requirement of appropriate in details can be discussed separately.

G.7 The viscometer and refractometer/sacharometer.

G.8 Hand held refractometer can be used to check for dissolved solid into water phase. It can conveniently be used for cooked adhesive for pasting and cannot be used for corrugating adhesive which is mostly uncooked. For corrugation uncooked adhesive, we can use oven drying method.

G.9 Viscosity test, gelatinisation temperature, solids content, Iodine staining of glue lines, adhesive consumption are various test methods and the test procedure and apparatus are described in many reference books.

WHAT DO YOU FEEL IS REALISTIC ADHESIVE CONSUMPTION LEVEL? (In wet or dry grams per square metre of corrugated board)

FOR SINGLE FACER PLANT (corrugating and pasting)? AND SEPARATELY FOR 3 PLY/5 PLY AUTOMATIC PLANT?

- H.1 Corrugating machine : 25-35 wet grams per sq.m.
Pasting machine : 40-50 wet grams per sq.m.

Much depends on the Cobb value or water absorbency of the papers used.

- H.2 For corrugation Liquid Adhesive at 1:5 ratio, the approximate consumption is 4 to 6 dry gms per square metre for the single facer and 5 to 7 dry gms per square metre for double facer or 3 ply/5 ply automatic machine.

- H.3 In single facer plant, realistic consumption of gum varies from 6 to 8% depending upon quality of paper.

For A grade paper consumption of adhesive is 6% while for B Grade paper consumption is 8%.

Similarly for double facer plant consumption level of gum is 16 to 18%.

- H.4 We are afraid, we are unable to comment on this.

- H.5 The consumption of glue for a single facer plant may be 4% of the weight of paper.

For double facer one has to keep high viscosity and high solid percentage and so the consumption will be 4 to 6 % and the test will be done in corrugating plant method for determining overall adhesive consumption during production. The time required for each test will depend on the speed of the machine.

- H.6 The per ply, per sq. metre consumption of corrugating adhesive is generally 50 wet grams while that of pasting adhesives is 70 wet grams, if pure kraft paper is used. But the consumption to some extent depends upon the quality of the paper. In case of media paper, the consumption is more as it has more absorbing property.

- H.7 It is generally considered on the basis of double faced (double gum line, or three ply) boards of A type flutes. The consumption level is in the range of 65-70 grams (25% solid content) wet paste per square metre of a double faced corrugated faced of which 40-45% accounted by corrugation gum.

Or, if we would prefer to consider on the basis of paper conversion weight basis, it would work out approximately at 55 gms of corrugation gum and 85 gms of pasting gum per 1 kilo paper conversion keeping in mind that the gum paste is taken at 25% solid content.

- H.8 For single facer : 20 to 25 wet grams per sq.m.
For double facer : 40 to 50 wet grams per sq.m.
For pasting : 40 to 50 wet grams per sq.m.

The above are minimum application rates.

H.9 REALISTIC ADHESIVE CONSUMPTION LEVEL:

2.00 to 2.25 % by the weight of any dry form for corrugation powder.

3.50 to 3.75% by the weight of any dry form for pasting powder.

The above consumption of adhesive in powder form holds good for single facer plant and for 3 ply/5 ply automatic plant as well.

WHAT SHOULD BE THE TEMPERATURE OF THE CORRUGATING ROLLS AND THE PRESSURE ROLL? HOT PLATES?

I.1 Approximate Temperature:

Corrugating Roll	:	120 degree centigrade
Pressure Roll	:	150 degree centigrade
Hot plates	:	90 degree centigrade

Media temperature should not exceed 70 degree centigrade.

I.2 In case of single facer, corrugating roll temperature around 110 to 120 degree centigrade but in case of 3/5 ply or double facer, the rolls are either heated by steam or electricity in which case 90 degree centigrade temperature is enough. But gelatinisation temperature of starch should be low.

I.3 Corrugating rolls, pressure rolls and hot plates are normally operated at following temperature.

Corrugating roll	-	163 to 166 degree centigrade.
Pressure roll	-	180 to 182 degree centigrade.
Hot plates	-	163 to 166 degree centigrade.

I.4 The temperature of corrugated roll should be 120 degree centigrade. Temperature of the flute tip at the point of adhesive application varies from 60 to 80 degree centigrade depending on the running speed, direction of the pre-heater wrap, weight of the paper, etc.

In case of hot plates, the over head belt exerts a low pressure of less than 5 psi (35 kpa) under each weight roll. This pressure helps the adhesive film on the flute tip to wet the surface fibres of the liners. Once the two are joined they are held in continuous intimate contact as they pass through heating section. The heat required to dehydrate

the glue is obtained from the hot plates (170 degree centigrade) and the heat of friction at the sliding surface. This energy is supplied through the paper fibres of the lower liners by conduction and by mass transfer which allow through fibre and contacts the glue line directly.

I.5 Not replied.

I.6 No comments.

I.7 The temperature of the corrugating rolls is about 170 degree centigrade whereas the heating at the hot plates station is a little higher that is about 180 degree centigrade.

I.8 Upper Roll Temp	...	140 to 150 degree centigrade
Center Roll Temp	...	150 to 160 degree centigrade
Lower Pressure Roll	...	160 to 175 degree centigrade

The above depends on type of paper, moisture content, grammage and machine speed.

I.9 The temperature of the Corrugating Rolls and the Pressure Roll should be approximately 90 to 95 degree centigrade. The above temperature is required for use of conventionally prepared glue where the temperature required for adhesive to paste two papers in corrugating machine happens to be 90 to 95 degree centigrade which is also noted as the pre-gel temperature in the terminology of corrugation industry.

WHY DO WE GET DELAMINATION OF CORRUGATED BOARD? WHAT IS THE REMEDY?

J.1 The problem has two aspects, viz., the gum aspect and the machine aspect or the process aspect.

On the gum aspect, the processor has to be assured of reliability of quality. That is, besides good scientific formulation, the adhesive should have good strength, preferably between 20% to 25% solid content, good fluidity and proper viscosity. Tackiness is not so important. It should set fast enough.

Given the right type of adhesive as mentioned above, to investigate the problem of DELAMINATION, we will have to screen the processing side. There we will have to assess the quality of paper (surface uniformity, sizing, moisture content, absorbency, etc.), integrity of the corrugating rolls, their alignment, pressure gum line registration, adequacy of gum intake, heating of the rolls and hot plates and finally the speed of the machine.

Faster the machine, the setting power of the gum must be correspondingly faster.

Failure of any of the above mentioned aspects will result in delamination. So it should be remembered well that this problem of delamination should always be investigated on all three fronts, viz., Paper, Gum and Processing.

J.2 Use of adhesive with less solids than what is recommended often results in delamination. The remedy is to use powder based adhesive from which liquid adhesive could be prepared with required level of solid contents considering the type of paper to be used.

J.3 The main causes for delamination are—inadequate application of adhesive on corrugating machine, low temperature of rolls, improper

pressure and less time for drying. Drying requirements vary according to weather conditions.

J.4 One reason is the moisture content of the board. The board should have moisture content below 10. Higher moisture content may develop poor strength of the board. The moisture content in paper board should not be higher than 8% but if it exceeds, then wait for one or two days for preparing box.

The humidity also affects the board. Also the initial stickiness of the glue. If the glue is taking long time to develop stickiness then there are chances of delamination.

Cobb value also affects. Higher the cobb value, poor is the bond formation. So you should check every roll of paper. Very high viscosity and improper gluing also affects delamination.

- J.5 Causes of delamination are:
- Insufficient temperature of corrugating rolls.
 - Insufficient glue application.
 - Improper viscosity.
 - Low solids.
 - Very high machine speeds.
 - Type of papers used.

Remedy:

g. For edge delamination, ensure that the adhesive is being applied at the edges.

Also, if the adhesive solid content is too low, then there will be too much moisture for evaporation.

h. For complete delamination, use of higher solids adhesive and/or adhesive with reduced gel temperature will improve performance.

- J.6 Causes for delamination are:
- Adhesive application is not sufficient.

- b. Paper is too absorbent.
- c. Paper is highly sized.
- d. Flute height is not even.
- e. Adhesive tack is poor.
- f. Adhesive drying is either too fast or too slow.

Remedy:

One has to understand the above problems and take corrective measures that may be called for.

- J.7 There are many reasons for delamination, viz.,
- a. Poor quality paper.
 - b. Low or high viscosity of adhesive used.
 - c. Improper application of glue to board.
 - d. Insufficient temperature of corrugating rolls and hot plates.

Due to the above causes, board can delaminate. Effective checks on above parameters can avoid the problem.

- J.8 The following are responsible for delamination of corrugated board:
- a. Low level of starch in adhesive.
 - b. Over heating of corrugating medium.
 - c. Insufficient heating of corrugating medium.

- J.9 Delamination takes place due to following reasons:

- a. Defective adhesive:
Very low solid contents cannot give adequate thickness of film which can hold both papers together and, at the same time, anchoring the fibres into inner matrix of the paper. Hence proper solids of the adhesive are necessary for perfect bonding.

- b. Viscosity:

If the viscosity is too low, then the whole of adhesive will soak into the paper through its porosity and there will be no film between two papers to hold them together.

If the viscosity is too high, then it will not allow the gum to go into the inner matrix of the paper to root down the film. It means there will be no grip of the film and it will be lying unrooted, unsupported between the papers having no mechanical bonding power.

- c. Wetting ability:

Highly calendered, dense and stiff papers are resistant to water permeability. Required gum penetration is not possible unless the gum has the capability to wet the paper surface and easy penetration into paper through its porosity is achieved.

WHY DO WE GET WASHBOARDING EFFECT ON CORRUGATED BOARD? WHAT IS THE REMEDY?

K.1 As for the wash boarding effect I would feel that the laminating sheet and/or the adhesive could be implicated.

If the paper is very absorbent, fibres getting soaked easily with the adhesive; or the gum is so much penetrating by way of its own formulation, viscosity and poor solid content, that the wash boarding effect occurs on drying. So to avoid this problem, avoid its shortcomings.

K.2 Wash boarding effect on corrugated board is attributed to extra feeding of adhesive pasting of sheets during usages of prepared liquid adhesive in order to escape delamination of sheets, the user feed extra adhesive during pasting process. The remedy is to prepare liquid adhesive from powder adhesive and prepare adhesive with recommended percentage of solid contents which is normally 16%. Also at times washboarding effects are evident on account of usage of low grammage paper on the face.

K.3 Not replied.

K.4 Washboarding aspects on board is due to not proper selection of right adhesive.

- a. very high alkaline adhesive
- b. excess glue line can result in this effect
- c. lack of appropriate pressure
- d. improper setting of the machine.

K.5 When low grammage liners are used along with heavy glue application, wash board appearance results. Hence only the minimum adhesive application for the grammage of paper gives better mileage. Avoid flattening of flute by adjustments of proper pressure.

- K.6
- a. Liners too absorbent
 - b. Excess adhesive application
 - c. Excessive moisture in the paper.

K.7 Cause of wash board and its remedy is shown in the following table.

Causes	Remedy
a. Excessive adhesive application is improper	a. Adjust doctor roll and viscosity.
b. Improper relationship between glue roll speed and paper web speed.	b. Adjust glue roll speed.
c. Excessive moisture in liners.	c. Remove excess moisture by increasing wrap on preheaters.

K.8 No comments. This is a production aspect.

K.9 Wash boarding is the effect of excess water into the board whether already present into paper or freshly introduced along with the gum application. Excess application of gum will naturally be giving more water to the board which remains in the board for long time, damaging its natural fibre to fibre bonding and not allow the applied gum to set by natural atmosphere pressure. To avoid wash boarding only required quantity, i.e., 40 to 50 gm/sq.mtr should be applied which is quite enough for strong bond.

WHY DO WE GET BLISTERS ON CORRUGATED BOARD? WHAT IS THE REMEDY?

L.1 Blisters on corrugated board are caused due to:

- a. Defective gum roll.
- b. Pressure which one is applying on liner.
- c. The flutes of the corrugation should be perfectly vertical and the board should have even pasting over the entire length of the flute.
- d. Excess alkalinity of the adhesive also develops blisters.

To control blisters on corrugated boards we have to control the pH of glue up to 9.

L.2 BLISTERS

Here the problem could be attributed jointly or severally to the following causes:

- a. non-uniform rough papers
- b. variable absorbency of the paper resulting in various areas getting gum-starved
- e. uneven pressure on rolls or their bad alignment
- d. wear and tear of the rolls
- f. improper viscosity of the gum or its improper formulation
- e. improper pressing of the boards after fabrication during process of drying. Here the pressing machine is a good help.

L.3 Again blisters on corrugated board are at times is evident on account of inadequate pressing of the corrugated board after testing and again it could be because of adhesive used with lesser solid contents or on account of adhesive used being not homogeneous. We reiterate that by solid contents, we mean active solid contents that is the contents on un- adulterated starch particles which would only attribute for adhesion.

L.4 Blisters are already present in the paper used and it is not perceived by general inspection. It could be detected by purposeful inspection. In some paper reels, it is observed that it does not have uniform even surface due to manufacturing defect in the paper mills and when such paper is used in corru board the blistered portion does not meet intimately to the other counterpart for glueing. It remains unglued and on drying it is bulged out as a blister.

Next possibility for occurring blister could be traced in 2 ply corrugated sheet which can be a result of faulty brass adaptors setting which will result in faulty formation of flutes (high and low flutes or damaged flutes). In essence, the blisters are formed when the two surfaces or part of it are unable to meet intimately opposite to the gum line leaving gum applied purpose-less giving broken adhesion or blisters. These are not visible when board is still wet, and on drying when dimensional contraction of the board takes place, the unglued portion bulges out.

REMEDY

Check the paper stock for uniform formation and the corrugated 2 ply board for correct flute formation. If necessary use press machine for pressing board stock.

L.5 The main reasons are:

- a. Inherent waviness in paper.
- b. Too much machine speed.
- c. Too much heat.
- d. Insufficient adhesive application.
- e. Defective corrugating roll.

L.6 Blisters are areas where there is very little or no bonding at all. This is mainly due to mechanical defects if it is on a large scale. These defects should be removed, with the help of the machinery

manufacturers or a good operating machine.

Minor problems can be solved by proper adjustment of clean out prongs. Mainly proper cleaning of the machine parts is required.

- L.7 Causes and corresponding remedy to avoid blisters is given in the following table.

Causes	Remedy
a. Insufficient adhesive at double backer	a. Increase adhesive spread
b. Variable viscosity	b. Check adhesive formulation and adjust
c. Too much heat	c. Reduce hot plate temperature
d. Too much-speed	d. Decrease speed

- L.8 No comment. This is production aspect.

- L.9 Blisters are also caused due to less application of adhesive and uneven pressure.

WHY DO WE GET WARPED BOARD? WHAT IS THE REMEDY?

M.1 The main reasons are:

- Excessive moisture in paper
- Liner too absorbent
- Excess difference in moisture between the two surfaces of the board
- Too much web tension

- M.2 We get warped boards because of imbalance. All types of warps are caused by difference in dimensional changes that take place in the paper components and after corrugation there are further reversal changes. If one liner experiences a great dimensional change than the other, warping takes place either before or even after bonding. Warping takes place because of paper peculiarities, i.e., their dimensional instability because of the conditions near the corrugating machines.

So whatever brings in moisture and heat in the paper is a contribution factor, e.g., adhesive application, machine speed, conditioning of the medium and liner, etc., and mechanical adjustment. Hence proper tuning of the whole corrugating process is the remedy. The adhesive used should be of the proper solids content and viscosity and should be applied correctly.

- M.3 Warped boarding means board does not lay flat. It bends in either upward or downward direction.

Following are major causes for warping of board. Also corresponding remedy to respective problems is given:

Causes		Remedy	
a.	wet liner	a.	increase wrap on preheater or slow down
b.	too much tension on double face liner	b.	Loosen brake or reduce wrap on preheater
c.	combination of cylinder and fourdrinier liners or unbalanced liners	c.	reduce heat on double backer plates and reduce adhesive application at single facer for unbalanced liners
d.	high speed of web	d.	reduce speed
e.	Drag on single face web	e.	eliminate drag
f.	Too much heat on double backer	f.	speed up corrugator or reduce heat on double backer
g.	excess moisture concentrated at the single face side. This causes normal warp of board curved toward single face side or upward from the hot plates	g.	Increase preheater wrap on single face liner. Increase preheater wrap on medium. Decrease steam shower on medium. Increase wrap on single face board preheater at the end of the bridge. Decrease preheater wrap on double face liner. Increase operating speed. Decrease hot plate temperature. Use minimum amount of adhesive on single facer and increase amount on double backer.

h.	excess moisture on double face side of board. This causes reverse warp or curvature towards the hot plate.	h.	Decrease preheater wrap on liner. Decrease preheater wrap on medium. Increase steam shower on medium. Decrease or eliminate preheater wrap on single face board at the end of bridge. Increase preheater wrap on outside Increase hot plate temp. Increase application of adhesive on single facer
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M.4 Warped board is obtained due to uneven contraction of plies during drying.

M.5 Warping occurs due to excess loss of moisture in liners. It also occurs when using liners of different weights and qualities with variation of moisture content between papers.

The moisture percents should not be less than 8 to 10 and also the humidity in the plant should not be more than 60 to 65% at room temperature.

M.6 The main reason for warped board is due to fast drying of the outer layer of the board as compared to the inner liners/ layers. With a view to remedy the situation, the board should be exposed to excessive heat.

- M.7 Warping is caused by differential behaviour of the laminates and particularly by usage of low solid adhesive which set up strains on drying. So to avoid the peril of WARPING one would advice using similar liners and high quality strong adhesive and also letting boards dry under uniform pressure. Lesser the gum used the better. Apply the adhesive at room temperature. And care should be taken to use smooth and non-adsorbent papers
- M.8 Warped board is the result of uneven drying of board. The side of the board which is first dried before the other will concave and the wet side will convex. This happens when both the papers have different moisture contents on corru machines and one paper is dried first because of lower moisture content or excess heat supplied to the particular paper by the corru roller because of lower grammage of the paper. In any case, such papers will dry first and shrink down pulling other paper which is stili flexible due to excess moisture. To avoid this, check moisture content, heat on the machines to balance different moistures of two papers. Do not sun dry the board or boxes otherwise the board side facing sun, will dry faster and go concave. It requires uniform drying to achieve good shaped board.
- M.9 We get warped board on account of providing inadequate pressing time for pasted boards, i.e., freshly prepared corrugated boards. One other reason for warping is direct liner cutting and not making rolls. The right way of doing things is to prepare rolls immediately when two ply sheets are converted by corrugation machine and they should be kept aside for fair amount of time for extra heat to be relieved off so that by the time 2 ply sheets are cut for making corrugating boards they should retain moisture to the extent of 6 to 7% only.

HOW CAN THE ADHESIVE HELP IN REDUCING THE CURING TIME OF THE CORRUGATED BOARD?

- N.1 Curing of corrugated board depends on the time required to remove most of its moisture. Most of the strength properties fall with the rise in moisture content of the paper. Therefore, the object of the corrugation would be to introduce as little water as possible to the paper in the course of manufacture. Completely dry board has moisture content normally ranging from 6-20%. Another 10% of moisture is usually introduced during the processing. Of course, corrugating adhesive needs optimum quantity of water to help the starch granules to swell up to the maximum so that highest viscosity is available for green bond as well as final bond. Most of the moisture is introduced at the time of pasting of multiply boards. These boards are difficult to dry particularly in humid weather. Most of these drying problems are solved by using high solid content and low viscosity pasting adhesives whereby curing becomes faster.
- N.2 An adhesive with proper solid content and viscosity applied correctly will give a firmly bonded durable defectless board. This, stored properly, can reduce the curing time of the corrugated board. Proper storage means favourable ambient temperature and humidity.
- N.3 No comments. This is a production aspect.
- N.4 Curing time for corrugated board to an extent depends upon the solid content of the adhesive. More solid content and better viscosity of glue reduces curing time of board considerably.
- N.5 Starch adhesive should be soluble modified starch and dextrine. Extra dextrine can be added in liquid glue by increasing the solid content of the glue. Also one has to check the cobb value of the paper as higher the cobb value more will be the drying time.

N.6 The adhesive plays an important role in reducing the curing time. If the solid percentage is above 25% (which is rarely used in India) and the tack is sufficient, board can be further processed before it becomes dry.

N.7 For reducing the drying time, again percentage of solid contents are responsible. It goes without saying that more the active solid contents, better the adhesion and less the curing (drying) time. The necessity of curing times really come to fore during prolonged rainy season and extreme chilly conditions. During such situation, we recommend use of COPROCO DEXTRINE SOLUDEX which is to be used to the tune of 10% vis-a-vis pasting powder.

N.8 Only higher solid contents will reduce curing time of the board.

N.9 If by curing we mean setting and drying of the adhesive the curing time could be reduced by using concentrated high solid contented gum. Ideally, the adhesive should have around 25% solid content.

HOW MUCH DOES ADHESIVE CONTRIBUTE TO THE FUNCTIONAL PROPERTIES SUCH AS BURSTING, PUNCTURE OR COMPRESSION OF CORRUGATED BOARDS.

- O.1 The functional properties of the corrugated board are, to a large extent, dependent upon the quality of the paper. In fact, what an adhesive does is that it forms a concrete bond in the different structural components of the board. If this bond is fragile, the board ceases to be a corrugated board in the real sense. Functional properties like bursting and compression can only be very marginally attributed to the adhesive but not puncture resistance. However, one cannot improve upon strength properties of inferior quality paper merely by the use of a high quality adhesive.
- O.2 Mainly the quality of paper used is responsible for these properties. However, some improvement can be expected from the quality of adhesive used.
- O.3 To get good bursting and compression strength, adhesive must have a high solid content, optimum viscosity and also good initial stickiness. The starches which are used in making glue must have superior wet stickiness as they have better strength when fully dry. The solid percent for corrugating glue should be 15% to 17% and for pasting glue 20% to 25% for superior bond. Also one has to check the moisture content of the board. If it increases from 8% to 18%, it will reduce bursting and puncture. Compression mainly depends on size and shape of the box. The reduction due to moisture increase can be as high as 35% to 60%.
- O.4 Functional properties, i.e., bursting, puncture and compression mainly depend on quality of paper but in case of compression, adhesive also plays an important role. Of course adhesive, in every case should be good.

O.5 Use of right types of adhesive contributes discernably towards bursting, puncture & compression elements of corrugated board.

O.6 Functional properties such as bursting, puncture or compression of board largely depends upon quality of paper.

Adhesive also plays significant role in improving the above qualities. Gum made with good quality starch with more than 20% solid content, viscosity in the range of 19 to 29 seconds at Ford Cup No.-4 and pH value between 8.5 to 11 will improve the above quality parameters of the board.

O.7 Not replied.

O.8 No comments.

O.9 No comments.

SUGGESTIONS TO CORRUGATED BOARD MANUFACTURERS FOR PRODUCING GOOD QUALITY BOARD WITH MINIMUM ADHESIVE CONSUMPTION.

- P.1 To get good quality corrugated board using minimum quantity of gum, following facts are to be followed:
- a. Try to use adhesive made with starch which yields high viscosity to it.
 - b. Adhesive should be of high solid content in the range of 19% to 30%. Its viscosity should be at low level around 19 to 29 seconds at Ford Cup No.4.
 - c. pH value of adhesive should be in between 8.5 to 11.

- P.2
- a. Select good quality paper.
 - b. Select good quality adhesive (preferably not below 20% solid content).
 - c. Take proper care of the process of fabrication.

If processing is good, if paper is good, the corrugated board will be invariably better with better adhesive. Let the corrugator not be penny wise and pound foolish. Enough is at stake. Watch out.

P.3 No reply.

P.4 Use optimum level of solids and viscosity and with efficient use of machines, a good corrugated board is obtainable.

- P.5
- a. select paper of uniform grammage throughout the reel
 - b. select papers with cobb value not more than 40 gms/m²
 - c. select paper with minimum inherent defect like curl and waviness.

Adhesives:

corrugating	pasting	
adhesive base	corn/tapioca	starch/dextrin
solid content %	15-20	20-25
viscosity	30-35	20-25
pH	10-12	8-10
colour	white	grey to brown
setting time	not less than 5 hrs.	—

P.6 If you read and adhere carefully to the above stated defects and remedies, you will get insight of the mechanism of adhesion of corrugated paper boards. The adhesive is the back bone of corrugation industry to produce quality board, just like the welding in fabrication of steel. Poor welding quality can never lead you to the good and satisfactory steel fabrication jobs. In similar way, the adhesive is a welding material in paper converting industries.

I, therefore, suggest you to see that you will not try to achieve your economy on adhesive whose input cost never comes to more than 2% to 3% of your total input cost. I wonder how much could you save out of 2% to 3% only against the risk you can envisage.

In short, always use higher solid contents with good formulation and application per square metre of board should be as minimum as possible to ensure quick setting and quick drying, stronger board, avoiding washboarding and other possible defects. This all can be achieved if you avoid over-feeding of water to your board along with the adhesive. For your information, real adhesive material is only starch or modified starch which gives strong adhesion and water is only the vehicle of actual adhesives. So kindly do not trust the vehicle instead of MASTER sitting in it. If you want real economy with insured quality, kindly adhere to the above points and see for yourselves.

- P.7
- Use the right kind of paper in terms of GSM, grade, strength properties for the board as specified by your customer.
 - Use the right type of adhesive for the paper. If you are using powdered

adhesive blends, follow the manufacturer's direction regarding the preparation of the adhesive before use.

- Use the right type of adhesive for the type of machinery you have. The machinery manufacturer may also be able to recommend the most suitable type of adhesive with its specifications, consumption levels, etc.
 - In using liquid adhesives, check for bacterial infestation which results in deterioration of the adhesive and loss of its properties.
 - Do not try to mix one supplier's adhesive with the other.
 - Use optimum mechanical, thermal and humidity condition to get the best results.
 - Specify your needs to the adhesive supplier before hand. Give him complete information of machinery.
 - Generally, a high solid, low viscosity and low gel temperature adhesive is suitable for high speed single facer and double facer giving low adhesive consumption.
 - Timely cleaning and servicing of the different parts of the machinery on regular basis and replacement of worn out parts, if any.
 - Consult the adhesive manufacturer immediately when you have a problem which is attributable to the adhesive.
- P.8 Corrugated board manufacturers must use good quality of paper and adhesive. In paper, they must check in each roll the Cobb value because if it is high then naturally the consumption of glue will be high. Even though if we use more adhesive, we will not be able to produce good quality boards because if the paper is absorbing more than 25% of glue then naturally the boards will remain soft. So one has to select paper by its Cobb value, meaning its porosity toughness grammage and surface.
- P.9 For producing quality board with minimum adhesive consumption, besides other factors, one of the most important factors is use of good quality of paper. As good quality paper absorbs only just sufficient quantity of adhesive, i.e., neither more nor less.