Kaunas University of Technology

Faculty of Mechanical Engineering and Design

An Assessment of Grease Penetration Properties of Special Barrier Carton Board for Food Products

Master's Final Degree Project

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Kaunas, 2018

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Industrial Engineering and Management (621H77003)

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Declaration of Academic Integrity

I confirm that the final project of mine, Mohammed Imran Pasha, on the topic "An Assessment of Grease Penetration Properties of Special Barrier Carton Board for Food Products" is written completely by myself; all the provided data and research results are correct and have been obtained honestly. None of the parts of this thesis have been plagiarised from any printed, Internet-based or otherwise recorded sources. All direct and indirect quotations from external resources are indicated in the list of references. No monetary funds (unless required by law) have been paid to anyone for any contribution to this project.

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KAUNAS UN IVERSITY OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING AND DESIGN

Study programme INDUSTRIAL ENGINEERING AND MANAGEMENT 621H77003

TASK ASSIGNMENT FOR FINAL DEGREE PROJECT OF MASTER STUDIES

Given to the student: Mohammed Imran Pasha

1. Title of the Project: An Assessment of Grease Penetration Properties of Special Barrier Carton Board for Food Products.

specialaus maisto pakavimui skirto barjerinio kartono riebalų pralaidumo savybių tyrimas

Approved by the Dean Order No. V25-11-6, 12 April 2018

2. Aim and Tasks of the Project: To determine rate of grease penetration on carton board food packaging materials and discussion of properties and review of carton board types with coating process and technology.

3. Initial Data: ASTM Standards

4. Main Requirements and Conditions: Samples of six different carton board packaging materials are required. The grease penetration experiment should be conducted in laboratory oven.

5. Structure of the Text Part: Introduction, Literature Review, Coating Used In Carton Board, Properties Of Carton Board, Results, Conclusion, References

7. Consultants of the Project: Lect. dr. Vaidas Bivainis

Student ..... Mohammed Imran Pasha .....

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Supervisor ..... Lect. dr. Vaidas Bivainis .....

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Mohammed Imran Pasha. An Assessment of Grease Penetration Properties of Special Barrier Carton Board for Food Products. Master's Final Degree Project / Supervisor: Lect. dr. Vaidas Bivainis. The Faculty of Mechanical Engineering and Design, Kaunas University of Technology.
Study field and area (study field group): Production and Manufacturing Engineering, Technological Sciences.

Key words: cardboard, packaging materials, grease penetration, coatings, coatings Technology.

Kaunas, 2018 56 p.

SUMMARY

Carton board packaging is a rapidly improving type of packaging. It uses composite structures in which combination of different materials like pulp, coatings, wax, adhesive and other materials with the use of coating, impregnation, and lamination. For food packaging many automated and advanced techniques are carried out for testing transmission rate of grease, oxygen, and moisture. They are few basic methods which determine the resistance of package to grease penetration and many methods give the best quality measure of grease penetration. Cardboard which can be recycled are integrated with packaging and simple process is used for determining grease barrier properties of high substance content product coating and these test results of several different type of coating are presented to describe the effectiveness of these cardboard and which helps in developing the grease barrier properties of these material. Materials for packaging is commonly classified as single materials and multilayer materials with coatings Food packaging of flexible material subjected to pasteurization and sterilization regularly shows delamination phenomena and for many packaging applications, barrier properties play a key role. This contribution is aimed to know the possibility to improve cost-effective and analysis of different cardboard material with great barrier properties.

Mohammed Imran Pasha. specialaus maisto pakavimui skirto barjerinio kartono riebalų pralaidumo savybių tyrimas. Magistro baigiamasis projektas / vadovas Lekt. Dr. Vaidas Bivainis; Kauno technologijos universitetas, Mechanikos inžinerijos ir dizaino fakultetas.
Studijų kryptis ir sritis (studijų krypčių grupė): Gamybos inžinerija, technologijos mokslai.
Reikšminiai žodžiai: pakuotė, kartonas, pakavimo medžiagos, riebalų skvarba, dangos, dangos technologija
Kaunas, 2018. 56 p.

SANTRAUKA

Grafinis kartonas pastaruoju metu yra vis dažniau naudojamas įvairios paskirties pakuotėms. Pakuotėms, kurios turi pasižymėti įvairiausiomis savybėmis reikalingas kartonas, turintis specialias dangas, užpildus masėje, polimerinių plėvelių sluoksnius siekiant suteikti visas reikiamas savybes. Vienos iš vienasluoksnių ir daugiasluoksnių pakuočių pagrindinių savybių yra jų nepralaidumas (barjerinės savybės) riebalams, atmosferos deguoniui ir aplinkos garams. Laboratorijose ir pramonėje naudojami keletas metodų pakuočių medžiagų riebalų pralaidumui. Riebalų nepralaidumas yra labai svarbi savybė, pakuojant maisto produktus, kurie tiesiogiai kontaktuoja su maistu. Vienas iš būdų suteikti hidroskopiškam kartonui šias savybes tai jį laminuoti polimerine plėvele arba tos plėvelės sluoksnį įterpti į medžiagą jos gamybos metu. Šiuo metu gaminamos pažangios pakuočių medžiagos, kuriose į kartono plaušienos masę įterpus tam tikrą kiekį polimerinių užpildų, pagamintas kartonas išoriškai yra panašus į tradicinį grafinį kartoną, bet papildomai yra atsparus riebalų prasiskverbimui. Darbe atliktas kelių grafinio kartono su skirtingais užpildais riebalų pralaidumo eksperimentiniai tyrimai.

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INTRODUCTION

The carton board packaging has great feedback and it is versatile, robust, light weight, able to recycling, in the form of dynamic and particle of packaging. It is highest volume of using packaging material in the world.it is usage and some sort of application providing solutions globally every day in our daily life. Carton board is a rigid packaging and shipping medium that can be easily cut and folded into an infinity number of size and shape that can be cut and fold easily because of a packaging medium and rigid shipping features .It is developed to a number of scientific specifications, even allowing direct coat and print with high resolution graphic. This is very effective from of transport packaging that provides safety and protection of product from one place to another place.

The product will transport or store safely in the carton board box. It has boundless possibilities in board type of combination and also have some sort of treatment and coatings, some kind of adhesive, carton weight flute size. To meet the customer demands custom based designs are routinely its available for all purpose of recovery and recycling process with it has some unavoidable and cannot beatable records in packaging [1]. Carton board is made up from cellulose fibre which can be produces from virgin wood pulp or recycle carton board depend on customer requirement. Completely new have good barriers and mixed recycle have less barriers. It makes carton board technology as natural renewable resource. There is a combination of sheets are used to make a carton board box which called as fluting medium and liner.

Carton board carton board can be packed automatically or manually. The packing can either filled and closed or formed around the product and closed. To ensure the packaging efficiency, carton board boxes also referred as Cartons and Cases, have to present flatness, suitability for closer and structure stability for better packaging. It can be used in many applications like Food, Vegetables, Meat, Electronic devices, Rapping, Mechanical products, Shipping and after used reused for transporting during shifting home or office

Nowadays, packaging in used not for shipping or transporting but also for advertising and brand promotional support from the seller. It is a medium communication, carrying information and artwork, and printing quality which meet these advertising needs. The attractive of the print can attract the customer eyes [1].To make printable smoothness on the carton board it coated with several types of coating material such as Polyethylene (PE), Wax etc.

Carton board is used as a medium of extremely flexible and its various range of coating and printing benefit to fully support the end user requirement which gives card board better printing option and increased the barriers such as improve the board resistance to moisture. Water is the biggest

enemy of carton board to safe from water or grease resistance coating can be protect for some period for product like frozen product, Vegetable, Meat and other items [2].

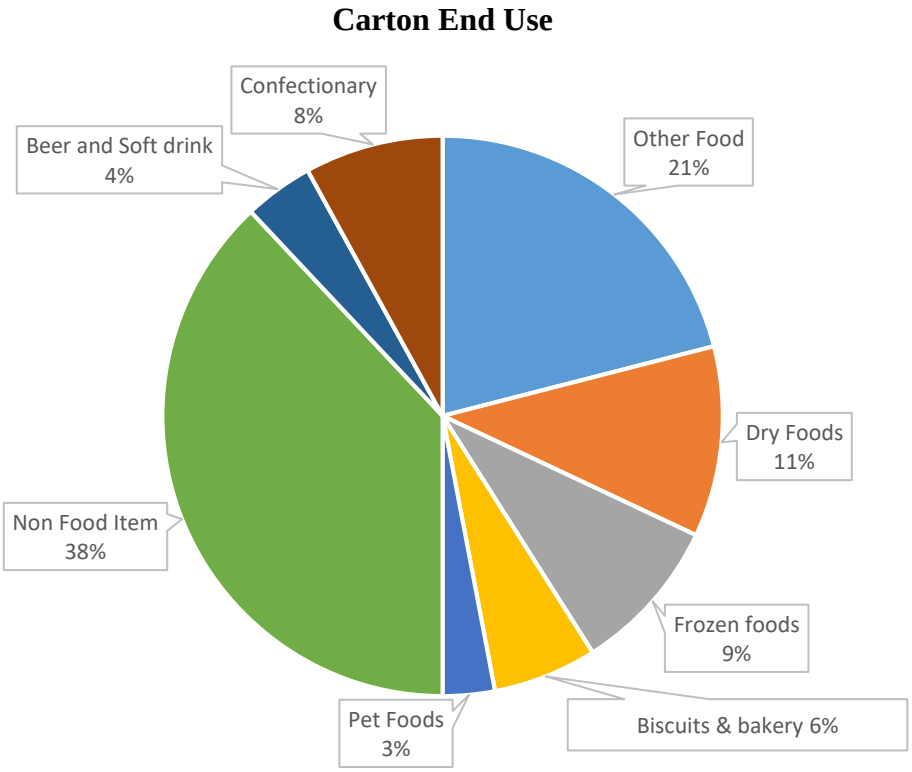


Figure 1. Carton uses [3]

Special carton board made with high quality of virgin fibre and mechanical pulp for specific applications precisely customised for their respective purpose.

Carton board is made from a renewable raw material which, in Europe, is sourced from sustainably managed forests. Responsible sourcing of raw materials can be demonstrated for both wood and recovered paper. A “chain of custody” certificate shows the legal and traceable origin of the fibre materials [3].

Consumers buying habits may be influenced by the digital world, but once they have the packed product in front of them they want a good experience from handling it. The pack must be:

- Easy to open and close
- Informative
- Attractive and representative
- Protect and preserve the contents
- Easy to dispose of

Cartons can deliver all these attributes as well as other solutions which are driven by modern technologies, benefiting the brand owner and retailer as well as the consumer. For example:

- Food safety using food contact approved chemical additives and other raw materials, low migration inks, barriers and coatings, when required
- Anti-counterfeiting systems e.g. on pharmaceutical cartons

Modern technologies enabled by the digital world can be applied onto carton board packaging, making these new developments more eco-efficient, since cartons are recoverable, recyclable and continuously being light weighted so that lighter packs perform to ever higher specifications [3].

AIM

The aim of this work to carry out experimental investigation the barrier properties of the carton board packaging material which is used food products. This property analyses by rapid grease penetration testing method.

TASKS FOR WORK AIM

1. Carryout review of manufacturing process and properties of carton board used for special carton board
2. Do the review of coating technology and process used for carton board.
3. Carry out experiment and investigate of flat cardboard with grease penetration method.
4. Carry out experiment and investigate of creased or uncreased cardboard with grease penetration method in different type of bending on cardboard.

1. LITERATURE REVIEW

A carton board is a thick carton-based material. Carton board is generally thicker than carton and it can be single- or multi-ply. Carton board can be easily cut and formed, is lightweight and because it is strong, is used in packaging. Another end-use would be graphic printing and coating, such as book, food packs, magazine covers and postcards. Carton board is made up wood or recycle waste carton. Almost more than 70% are made with new wood pulp.

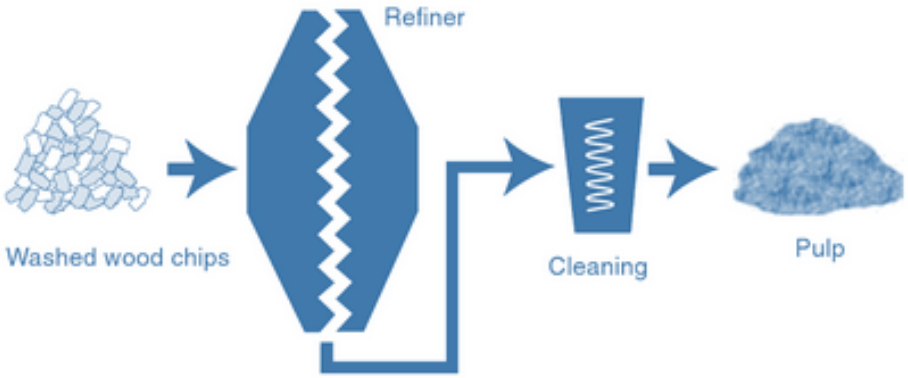


Figure 2. Pulp Produce [29]

1.1 Type of pulp

There are different type of pulp:

- Mechanical pulp
- Chemical pulp
- Recycle pulp
- Chemical beach

Mechanical pulp

In mechanical pulp first process is removing bark from wood, which is either used as product or source of energy in the mill. It is simply means that fibre separated by subjecting wood form grinding pressuring and crushing. The wood will be in form of logs, which is known as “ground wood pulp”, or then it crushed into small pieces which known as “refiner mechanical pulp”. Later heat generated for softens and results in fibre separation. The pulp is then separated and cleaned, and any remaining fibre bunches are reused. Then wood chips will re-heated with same steam temperature to assist the refine process in which case the pulp is known as “TMP” or thermomechanical pulp or TMP, and when limited chemical pre-treatment is also applied it is called CTMP“ or chemi-thermomechanical pulp”

As the colour of mechanical wood pulp same as like wood which is derived. Using the option of chemical action reduces the quantity of lignin and this results in lighter dyed pulp. In principle this treatment is a type of bleaching and the chemical action can be mixed depending on the level of whiteness and degree of lignin reduction required [3].

Chemical pulp

For chemical pulping, the wood log are chipped and treated with chemical re stream.in this process dissolves the resins which blind the fibre mixed together in wood logs. There are many different verities of chemical process. The sulphate or Kraft, Process is by far the more widely used nowadays because of its ability to process all the commonly used species of wood and its high rate of chemical recovery. The Sulphite method can also dissolves the non-fibrous components of the wood logs. In this both method the non-fibrous compound are used deliver energy for pulping and for both pulp and carton board manufacture in integrated mills [3].

Recycle pulp

Recycled pulp is pulp made generally made from paper and board, which including carton waste and carton waste, which has been already used and then recovered for recycle process schemes. In this Fibre extract to achieved by mechanical agitation in water. Pulp made in this way is known as recycled fibre, simply, secondary or waste paper fibre and fibre recovered fibre, recycled pulp

Chemical beach

Chemically extract fibres are normally bleached in the wood pulp mill to remove the last traces of lignin and any other remaining material. Bleached pulp is white in form and it is pure cellulose in content even though individual fibres are white and glowing. Bleaching is no longer carried out with chlorine gas. Nowadays the most commonly used method is elemental chlorine free “ECF”. This replaces chlorine with following treatments of hydrogen peroxide, chlorine dioxide and oxygen. This product are harmless and simple and same with compound which occurs in sea water naturally. Another process is known as totally chlorine free “TCF” where the chemicals used are hydrogen peroxide oxygen and oxygen [3].

Today carton board packaging in generally in many uses and especially products from certified sustainable sources, are receiving new attention, as manufacturers dealing with environmental, health, and regulatory issues look to renewable resources to meet increasing demand. It is now mandatory in many countries for carton-based packaging to be manufactured wholly or partially from recycled material.

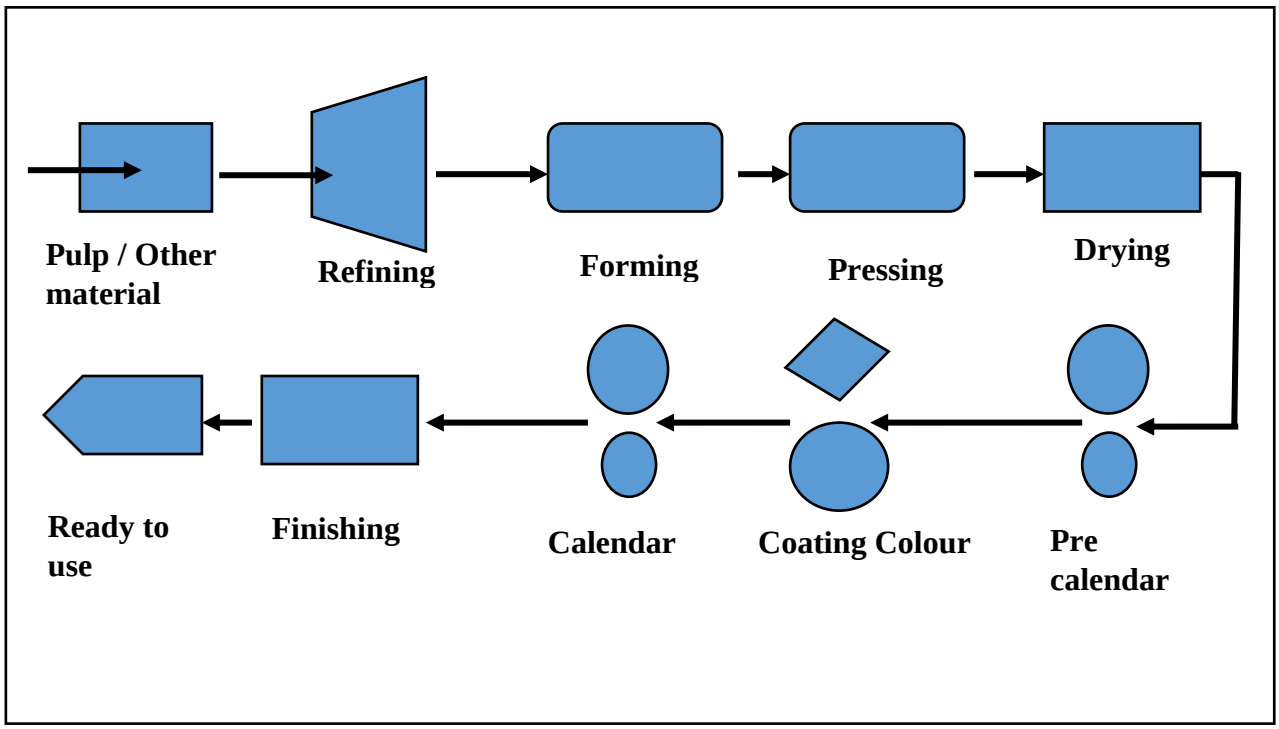


Figure 3. Carton Board Making Process [4]

Depending on carton board quality, weight and thickness they are made with different raw materials.

1. Hardwood
2. Softwood
3. Other (Recycling, Sugar Cane waste and other source of plants)

1.2 Carton board classification

Carton board are different types according material some of them are:

1. Solid Bleached Sulphate (SBS)
2. Coated Unbleached Kraft Carton board (CUK)
3. Uncoated Recycled Carton board
4. Coated Recycled Carton board

Solid Bleached Sulphate (SBS)

Solid bleached sulphate (SBS) or Bleached carton board is a high coated carton board grade that is made from a furnish containing at least 85% bleached wood pulp. This material is purely made from bleached chemical pulp and which has a mineral or synthetic pigment coated top surface in one

or more layers and often also a coating on the reverse side. Most bleached carton board is coated with a very thin layer of kaolin clay for better improve its printing surface smooth and may also be coated with polyethylene (PE) resin for wet strength food packaging. Solid Bleached Sulphate is most popular in the Europe and US [4].

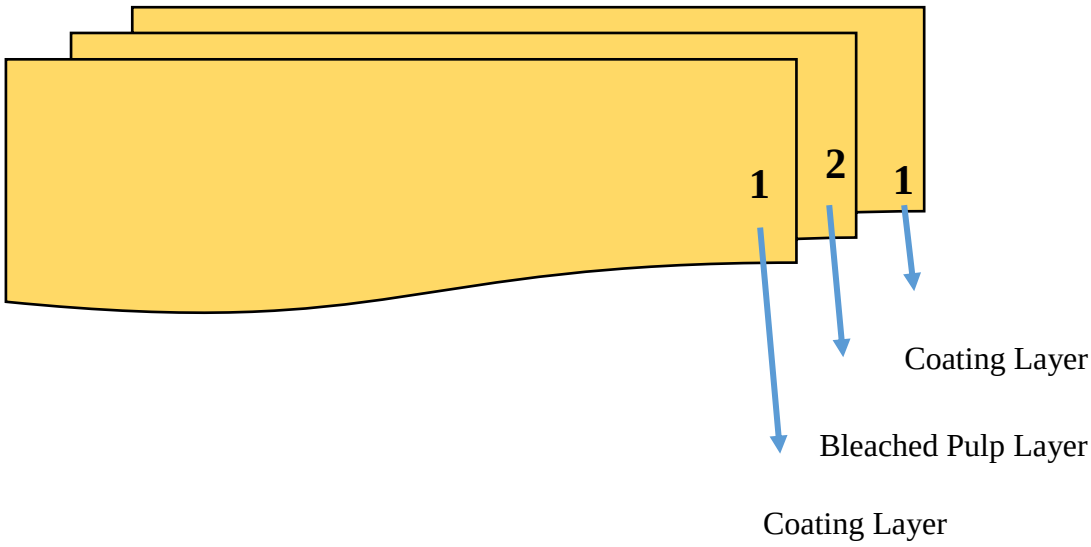


Figure 4. Carton board layer

Solid bleached sulphate mostly uses in following packaging products

- Medical packaging
- Milk and juice gable top cartons
- Aseptic drink boxes
- Cosmetic and perfume packaging
- Frozen food packaging
- Candy boxes

Solid unbleached sulphate (SUS)

Solid unbleached sulphate (SUS) or Clay natural Kraft (CNK) is a superior strength carton board grade that is produced from a furnish containing at least 80% virgin unbleached, natural wood pulp. Most often it comes with two to three layers of mineral or synthetic pigment coating on the top and one layer on the reverse side. Solid unbleached have very thin layers to improve its printing

surface smoother and may also be coated with polyethylene (PE) resin for wet strength food packaging [4].

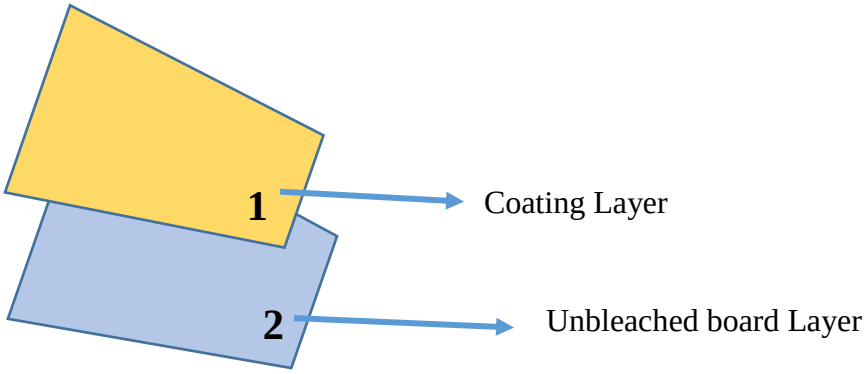


Figure 5. Carton board layer

Solid unbleached sulphate mostly uses in following packaging products

- ❖ Frozen food packaging
- ❖ Beverage Cartons and Carriers
- ❖ Pharmaceutical packaging

Uncoated Recycled Carton board

Uncoated recycled carton board is made from 100% recovered recycle material collected from carton manufacturing which contain newspaper, box board, cartons. It is converting into new carton board. This type of carton not used for food and other packaging due to low per quality and bad smile in carton board. It mostly used in good packaging [5].

Figure 6. Uncoated recycle carton & layer [30]

Uncoated recycled carton board mostly uses in following packaging products:

- Shoe boxes
- Automotive
- Composite cans and fibre drums

Coated Recycled carton board

This also made from 100 % recovered recycle material collected from manufacturers just like uncoated recycle carton board. But this coated cycle carton board is better quality than uncoated recycle carton board. It has thin layer of kaolin clay on the top of all layers to improve its printing surface smother to add some extra coating like polyethylene, wax etc. Newspaper is carton all over which made from recycle carton and again it for same carton making process [4].

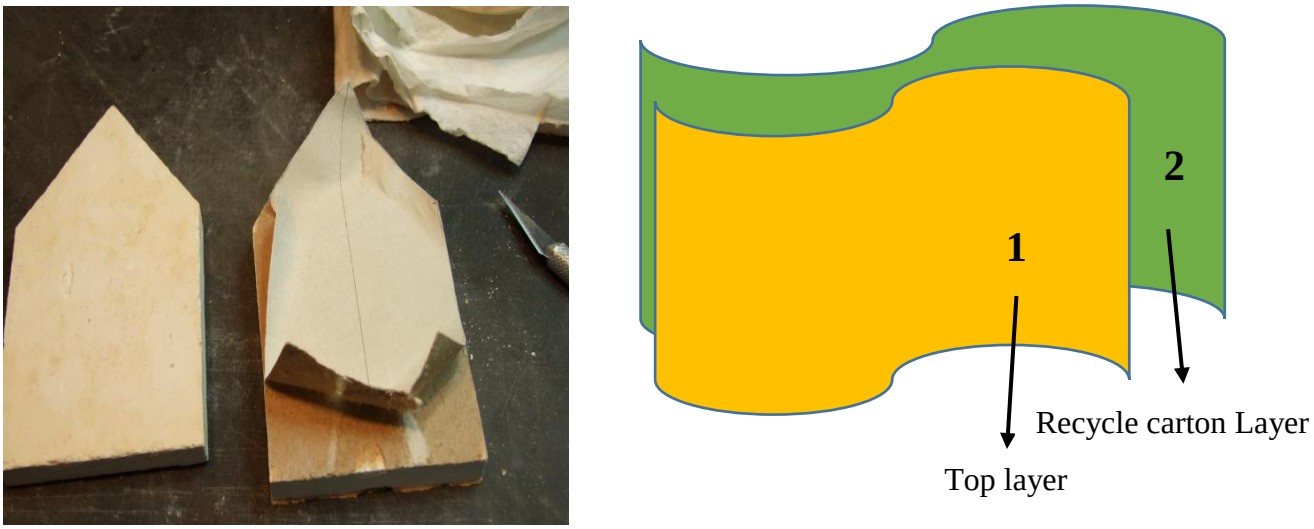


Figure 7. Coated recycle carton board & Layers [31]

Coated recycled carton board mostly uses in following packaging products:

- Soap and laundry detergent packaging
- cracker packaging
- Biscuit and cookies
- Carton goods packaging (facial tissue and napkin)
- Cake packaging
- Other dry food packaging

2. COATING USED IN CARTON BOARD

Coating on carton board is used to cover the surface of material usually it referred as the Support. The main idea to apply the coating may be Functional, decorative or it for both. Carton can also have coated by polymer coating to impact certain qualities changes to the carton. Changes which may include weight, Smoothness or Softness, Surface Glossy and reduced ink absorbency. In the production coating process take places in the end as shown in Figure below.

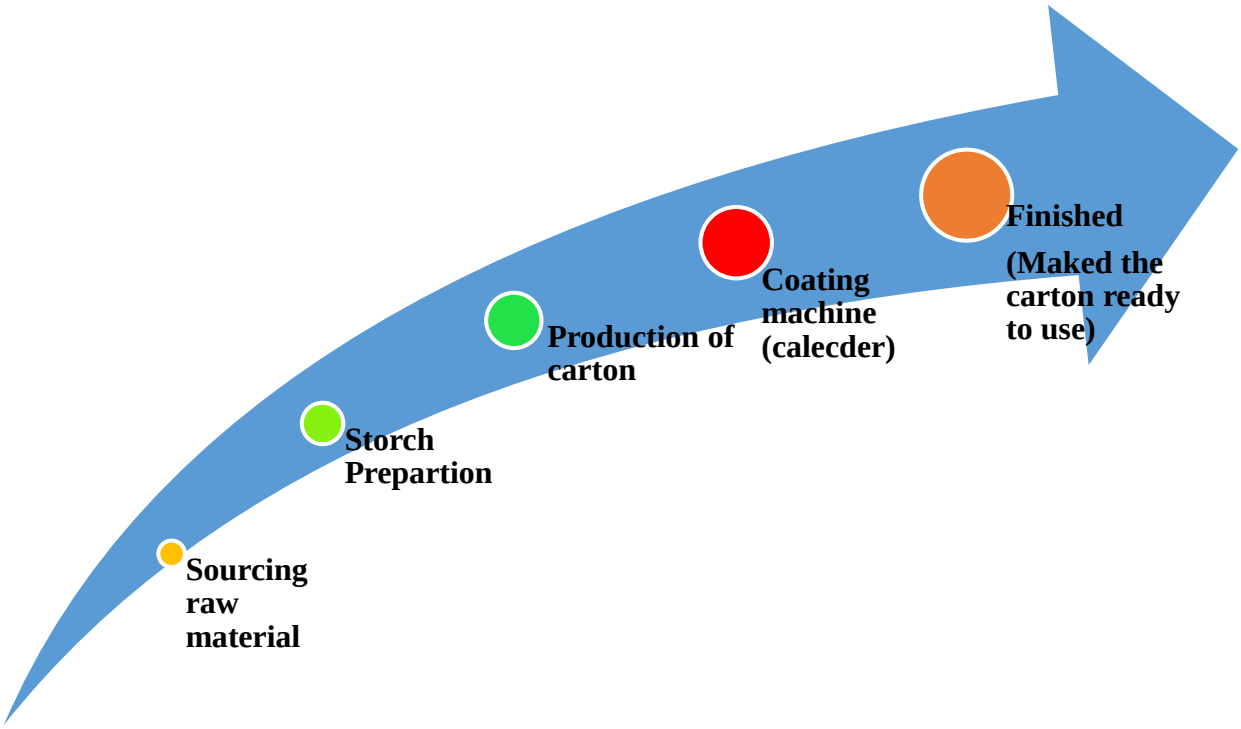


Figure 8. Production Coating Process

Various type of material used for coating the carton like China clay is bounded to the carton board with synthetic Smoother such as styrene butadiene and organic blinder such as starch. For Premium quality coating materials Calcium Carbonate, Talc, Kaolinite and Bentonite. It may also contain extra chemical as dispersant polyethylene, resins coating to make water proof and wet strength to the Carton board. Also used to protect against sun rays and ultraviolet radiations. This allows for cleaner crisper printing, especially in photos, blends and fine details. Coated cartons come in numerous options: Varnish, matte, dull and satin finish.

2.1 Coating Options

- **Varnish** - Varnish or gloss coated paper has a high sheen. Varnish papers have less bulk and opacity and are typically it's cheaper than dull & matte paper of equal thickness. Varnish coatings reduce ink absorption, which give the sheet an excellent colour definition.

Figure 9. Gloss Surface Finishing [33]

- **Satin** - a satin or silk coating is a less shiny coated finish. It has a less glossy level than varnish finish yet has better glossy level than matte finish. Colours are sharp and bright.

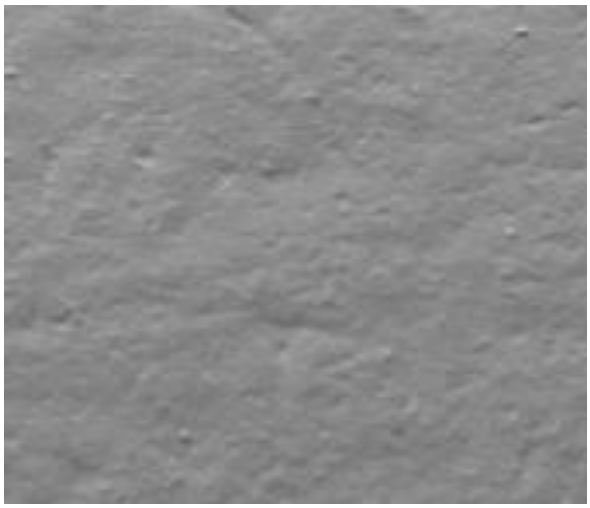


Figure 10. Silk Surface finishing [34]

- **Matte** - a matte coated paper is a non-glossy, flat looking paper with very little sheen. Matte papers are extra thicker, contain greater volume, and are higher in cost. This matte coating still keeps much of the printing colour from being consumed by the paper, which gives great, vibrant colour.

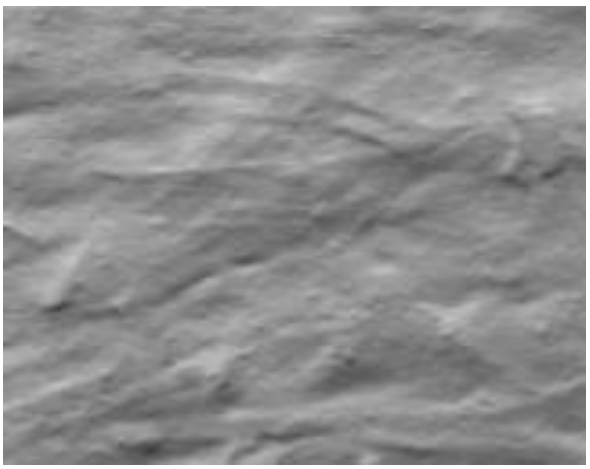


Figure 11. Matte Surface finishing [35]

- **Dull -** a dull finish coated paper is a smooth surface paper that is low in gloss. Dull coated paper can fall between matte and glossy paper depending on the manufacturer.

Figure 12. Dull Surface finishing [36]

2.2 Uncoated option

This type of paper that has not been coated with any surface sealant. Printing colour or Ink can be dry by absorbing into the paper. This paper can dull the colour immediately that are printed. This paper comprises a great number of paper types and are available in many variety of surfaces, both smooth and pattern. Some of the common types are wove or smooth, laid and linen.

Wove or Smooth this has a very smoother surface.

- **Laid: -** laid paper is created with pattern lines on its surface. This finish is used mostly for good quality stationery elements, like Visiting cards, letterhead and envelopes.

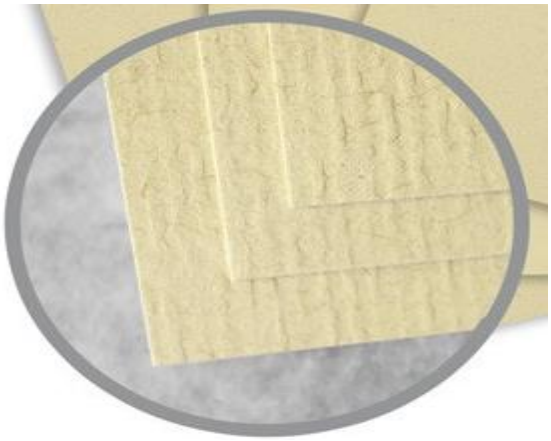


Figure 13. Laid Surface finishing [37]

- **Linen: -** same as laid finish, this paper has pattern lines on the surface of the sheet, but they are finer and better than those that appear on a laid finish coat. This paper is also used regularly for business and education type stationery.

Figure 14. Linen Surface finishing [38]

- **Coated one side and coated two sides**

This paper is commonly referred to as coated one side (C1S) and coated two sides (C2S). In a C1S paper the coating has been apply to only one side of the paper. C2S the coating is applying on both sides.

Typically, the coated side is glossy. You will find this type of paper used primarily on postcards. It Seen a glossy feel to the front of the card while using the back uncoated side for addressing.

- **Different coating methods**

Polymer or any chemical can be applied as a coating over paper and paperboard by several methods such as extrusion, dispersion coating and solvent coating. As shown in the fig blow coating method of thermoplastic polymer.

2.3 Adhesion and Additives

An adhesive is a substance, which holds two separate bodies such as adherent, or substrate and this process is called adhesion. An adhesive is generally referred as glue, which joins materials like glass plastic, metal and this substance mechanism works by means of hydrogen bonding, intermolecular bonding forces, chemical bonds etc. Places across the cross-section of a composite structure, adhesive bond separation may occur [2]. The adhesion process can be done by adherent heating and press them together. Cohesive bonds act with the adhesive holding it together and adhesive bonds act with adhesive and adherent interface [2].

The factors like viscosity, surface tension, solubility parameter effects adhesive bond strength. To meet certain adhesive to set of adherents these all factors are taken into consideration. Applying primer and other like plasma, corona discharge treatments to adherent's surface tension can be improved. For good adhesive bonds, the viscosity of adhesive plays a major role and for even spreading of adhesive is gained by low viscosity adhesive. According to the temperature and molecular weight, there will be decreased and increased in viscosity. There must be a similar solubility parameter for adherents and adhesives for prudent adhesive bond strength.

The strength of regarded physical and chemical nature of adherent and adhesive relates to cohesive bond strength. Cohesive bond strength should be preferably less or equal to its adhesive bond strength to achieve good performance of adhesive. Cohesive bond strength decreaseds with wettability and increaseds with high molecular weight. For achieving a prudent level of overall bond strength there should be a balance of these factors [1].

Organic based solvents, hot melt, water-based solvents are natural and synthetic adhesives. The base polymer is mixed in an organic solvent with other ingredients to form solvent-based adhesives. After the solvent evaporates, the strength of the adhesive is gained. Water is used as a solvent in water-based adhesives. Hot melt adhesives gain strength as it cools down and it is an essential molten polymer (like PE, EVA, and PP) which does not react chemically or discharge harmful solvents. Adhesives like cyanoacrylate, polyurethanes are reactive which composes low molecular weight, which on the application will begin to polymerize, eventually achieving the desired bond strength values, and they are flexible to a large variety of adherents [2].

2.4 Coating Technology

- **Curtain Coating Technology**

Curtain coating Technology is a process that creates an uninterrupted curtain of fluid that falls onto an object. The substrate is passes at a constant speed, mean to say regulated range of speed on a conveyor to ensuring the coat in an even coating of the die through the curtain. A slit or die is used at the holding tank base to create the curtain which allows the liquid on the substrate by fallen on it. Different kind of polymers are melted together and extruded at even level for the purpose of coating and it includes some catch pan for the purpose of reuse and retrieving the additional fluids [5].

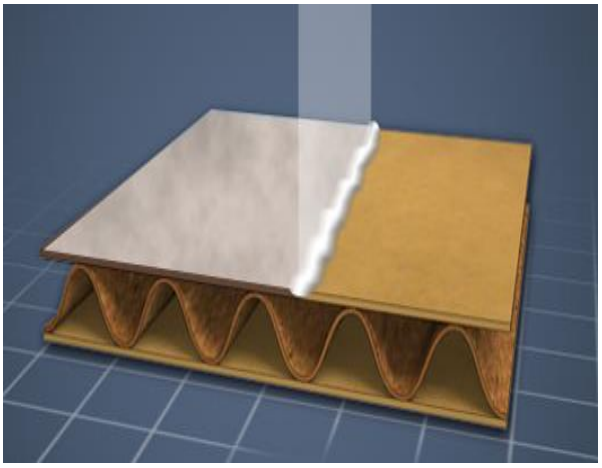


Figure 15. Curtain coating on corrugated paperboard [39]

Process

Cardboard process of Curtain coating: The object or substrate that must be coated by guiding through a fluid that is located between the two conveyors gap is called curtain coating. A mechanism of fluid coating is formed by a fluid in the tank which will be fallen to form a thin screen between the conveyors. The coating thickness of the layer is measured by the conveyor speed and the leaving material amount from the tank that is pump speed. The amount of liquid which is required from the tank is pre-metered to the screen must deposit on the screen or substrate. For both laboratory and Industry [6].

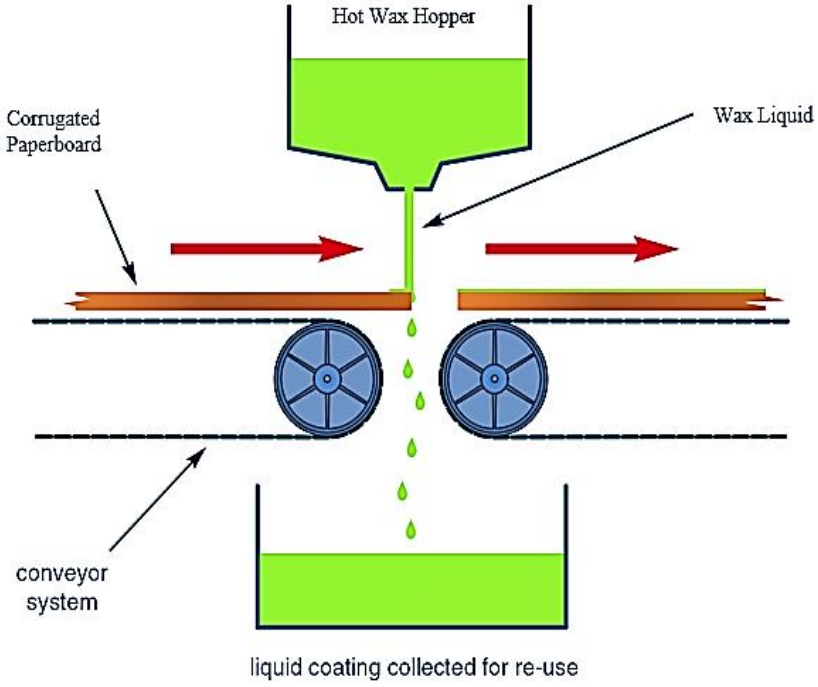


Figure 16. Curtain Coating Process [40]

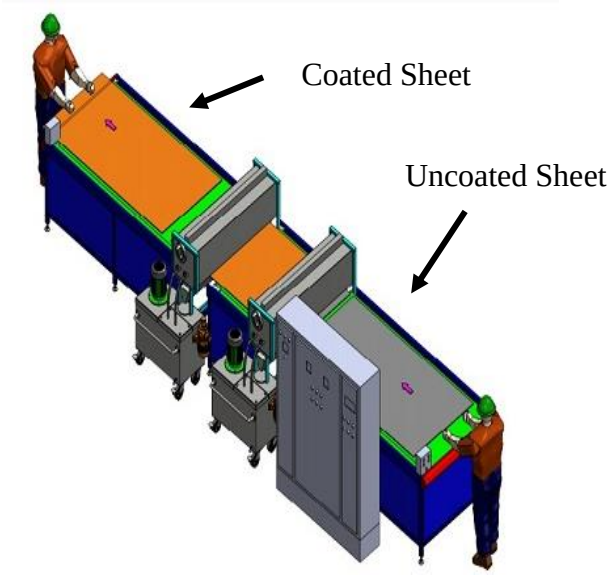


Figure 17. Industrial Coating Machine

[41]

For laboratory coating process is same but the machine is compact for small length sheet coat.

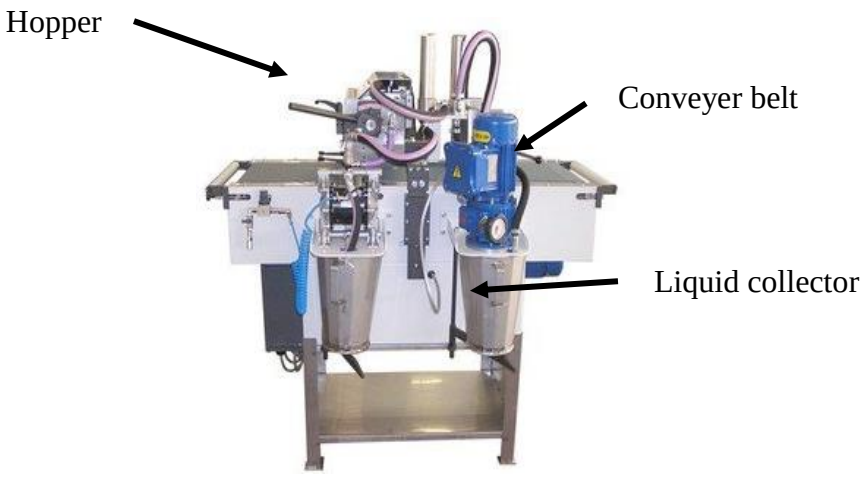


Figure 18. Laboratory Coating Machine [42]

- **Mayer rod Coating**

Mayer rod coating is oldest and most using coating method. On many subtracts with different material in this coating process a Mayer rod is a steel rod that is tightly fixed with stainless steel wire of varying diameter. The rod is used to balance the excess amount of coating solution and also control the thickness of coating as shown in Figure 19.The hot liquid thickness after doctoring is composed by the diameter of the wire used to wind the roll and its thickness in approx. 0.01 mm. Depend on the coating thickness wire would be adjust [7].

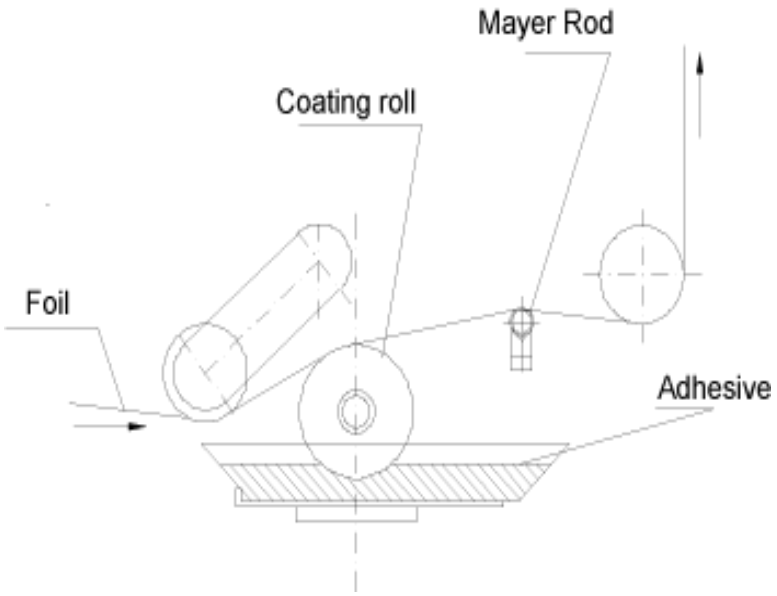


Figure 19. Industrial Coating Machine [43]

Wire and wire wound rod made with stainless steel or carbon steel can be used corrosion free.

Figure 20. Mayer rod [44]

The shape of the wire can be customized for different type of applications. Also the gap between the winding rod can be adjust for heavier and high solid coatings. Substrates used in this process CPB, Films and Foils, Rubber, Aluminium Sheet and other.

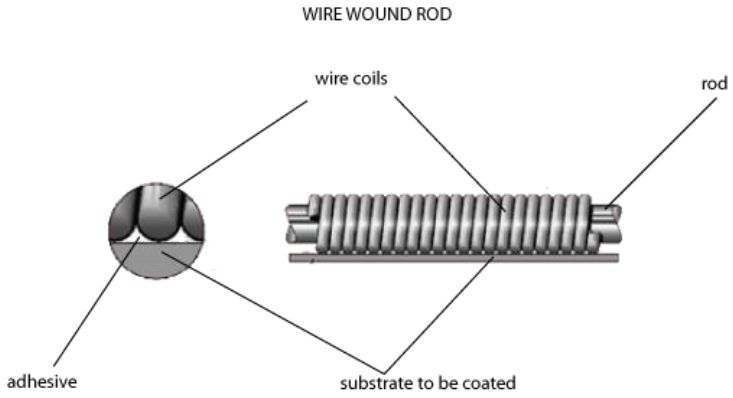


Figure 21. Mayer rod wire [45]

The table shows the different wire size that are available and the wet thickness of the coating. The dry thickness is determining by the sloid combination of the coating solution. Mayer bar coating machine for laboratory for coating sample or small subtracts [8].

Figure 22. Mayer rod machine for laboratory [46]

3. PROPERTIES OF CARTON BOARD

Carton board is a paper-based product made from virgin wood pulp or recycle pulp which have Superior durability or good mechanical properties such as rigidity, foldability and resistance. The can be made single to multi-layer product. This can use in many products such packaging. The resistance of penetration of grease and oil by cardboard is particular important for certain packaging purpose, for example the packaging food products.

As strength properties vary with moisture content, it is necessary for specifications and test procedures to be based on samples conditioned at, and therefore in equilibrium with, a fixed temperature and relative humidity. This is set in laboratories at 50% RH and 23°C. It is therefore necessary to correlate specification values with the main conditions prevailing during manufacture on the machine such that when subsequently tested after conditioning that the cardboard conforms to the specification [9].

The specific type and value of the various performance properties required will depend on the needs of the packaging concerned. Both the thinnest tissue and the thickest paperboard will have specific requirements and the actual properties may be the same properties as tensile strength, elongation (% stretch), tear, creasing and folding, wet strength, etc. This testing method shows standard condition for defining the rate of grease penetration of flexible barrier material. Pinpoint dot, which can be measure on ground glass which will increased the rate penetration as determine by standard test method [10].

Flexible barrier material creased or uncreased tested by oil according to the standard process, then exposed on one side to grease contained in weighted cotton patch. Depending on testing time seen visual changes caused on other side of material and that measured on ground- glass plate which can see under UV light.

This method is important in the development of material barrier. This test method is rapid in comparison of other methods. Because of the easy and it require very small amount oil to get the result. The failure is obtained on different time and values [9].

3.1 Different testing methods

1. **ASTM F119-82: Standard** method for rate of grease penetration of flexible barrier materials (Rapid Method)

Abstract: The cardboard is placed between coated glass and grease absorbed cotton patch and weights are placed on cotton patch. The signs of grease are observed on the coated glass plate by removing all other material from the cardboard [9].

Duration: Depend on Time taken by the grease to penetrate.

During experiment:

- Requires continues monitoring.
- Careful handling of equipment during the experiment.
- Required elevated temperature up to 40°C is used and large error is possible fast results.

Advantages: Low cost and simple experiment with minimal equipment.

2. **CHENEY AND BREESE:** Improved technique for monitoring the grease penetration through substrates.

Abstract: In this method monitoring is done with time elapsed photography and without a weight and the rest of the experiment is same as ASTM standard.

Duration: Time taken by the grease to penetrate.

- During experiment:
- Difficult to see failure.
- Larger error is possible.

Advantages:

- This Experiment same as ASTM but error is minimum

3. **WYSER ET AL:** Novel method for testing the grease resistance of plastic based dry pet food packaging.

Abstract: The substrate with fat source and weight on the source are placed on TLC plate. After a certain period, the TLC plate is observed under Ultraviolet rays for an amount of grease penetration.

Duration: Area of grease strain by U-V rays.

During Experiment:

- Based on ranking given by the operator.
- The significant error in quantifying.

Advantages:

- Clear and simple detection system

TAPPI T507 cm-09: Grease resistance of flexible packaging materials.

Abstract: For materials like glassine, vegetable parchment, greaseproof and other plastic coatings. The substrate is placed between oil statured blotter and clean blotter and stains are observed on clean blotter after 4 hours, at 50°C.

Duration: Visual observation.

4. **TAPPI T 454:** Turpentine test for voids in glassine and greaseproof papers.

Abstract: this testing method same as glassine, vegetable parchment, greaseproof and other plastic coatings. It provides an accelerated comparison of the relative rates at which oils or greases, such as those commonly found in foodstuffs, can be expected to penetrate voids in papers such as greaseproof or glassine [11]. It may not be applicable to grades of paper or paperboard that are given grease or oil resistance by means of a coating or internal treatment [12].

Duration: Visual observation.

During Experiment:

- Detection of stains potentially difficult.
- For PE films time is shorter.
- The significant error in quantifying.

Advantages:

- Potential for quantification.

3.2 Experiment

The rate of grease penetration of carton board materials in standard conditions can be obtained by this method. This method is useful in innovation and development of a selection of flexible barrier materials used for grease barriers. It takes less equipment compare to other experiments and amount of oil (grease) for detection is less. Depending upon the variation in and thickness of structure the of carton board failure time varies for each material. During the experiment continuous monitoring is needed for better results.

3.3 Materials

Carton board which made from virgin fibre to protects your food and other product with an ultimate functional barrier. Packaged food is protected from defined, unintended substances such as mineral oils, phthalates and Bisphenol which give the material excellent barrier properties [13].

Multilayering, that is forming the carton board in several layers, provides important technical features and gives flexibility in the choice of fibres (pulp) for each layer. It gives the carton board good stiffness, creasing, folding, and gluing properties. It also assists grammage and thickness control. It is particularly portent to use good quality fibre in the two outer or surface layers. This is because the fibres in these layers, or plies, experience the greatest effect of externally applied stresses which can extend or compress them in printing, conversion (creasing/folding) and use [3].

Sample test cardboard, it is not for one sampling test, however it designed to give different results in each situation on different cardboards. The guidance and selecting the appropriate sampling procedure for test. There are two types of cardboards:

- Flat Cardboard Test
- Creased Cardboard Test

Flat Cardboard Test

Prepare and cut a minimum of three similar test cardboards 10cm X 10cm there are four different type of sampling material. Which cut in same size in different thickness material, conditioning before test at least 40 h at 23% to 50% relative humidity.

Figure 23. Flat Cardboard [47]

Creased Cardboard Test

Prepare and cut a minimum four test cardboard with same measurement as like same above. This cardboard already punched in the shape of box on punching die to easily fold during packaging [14].

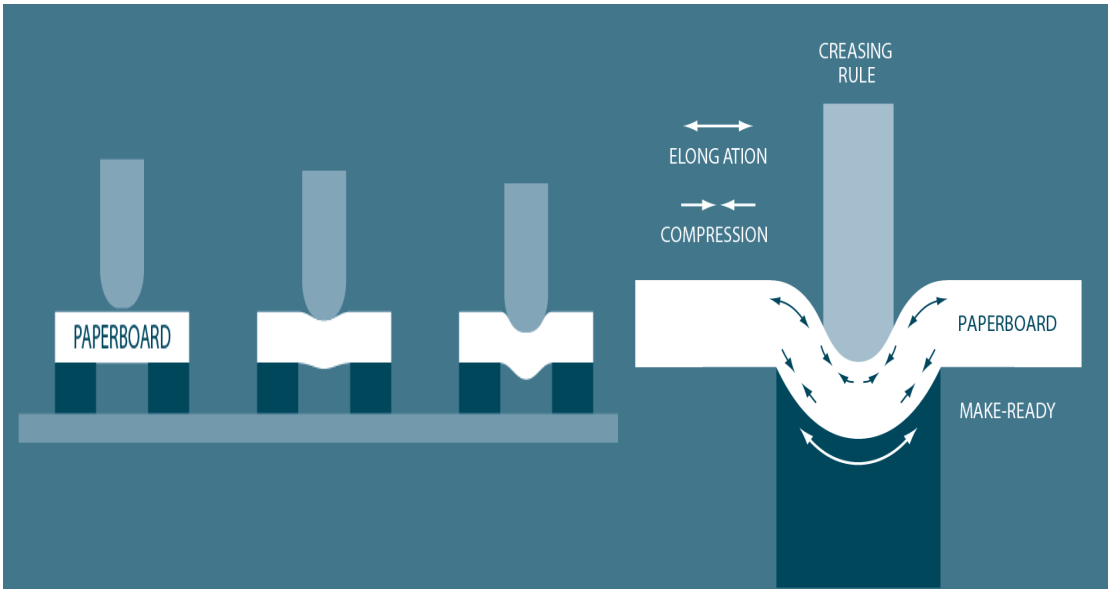


Figure 24. Creasing operation [48]

But this test, there are several types of fold cardboard like 0 bending, 1 bending, 2 bending and 3 bending which will be pressed with 1 kg weight bar on flat wood strip. The direction of the creaseds was alternated to achieve a bellows fold appearance. A second series of creaseds was then made in the same manner, but at right angles to the first series of creaseds one bending on upper side and press for 15 s leave it at rest position. And fold through the centre parallel to one side. For two bending first, upper side and then lower side as shown symbols below [15].

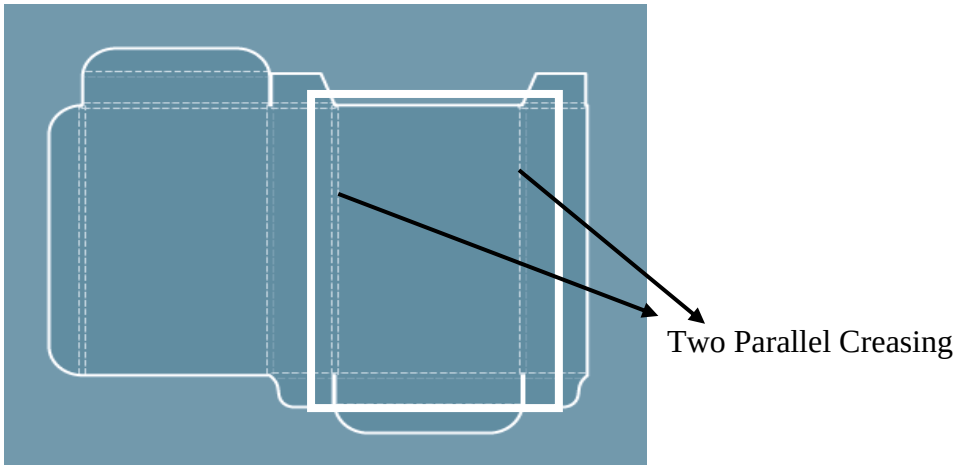


Figure 25. Creased cardboard [49]

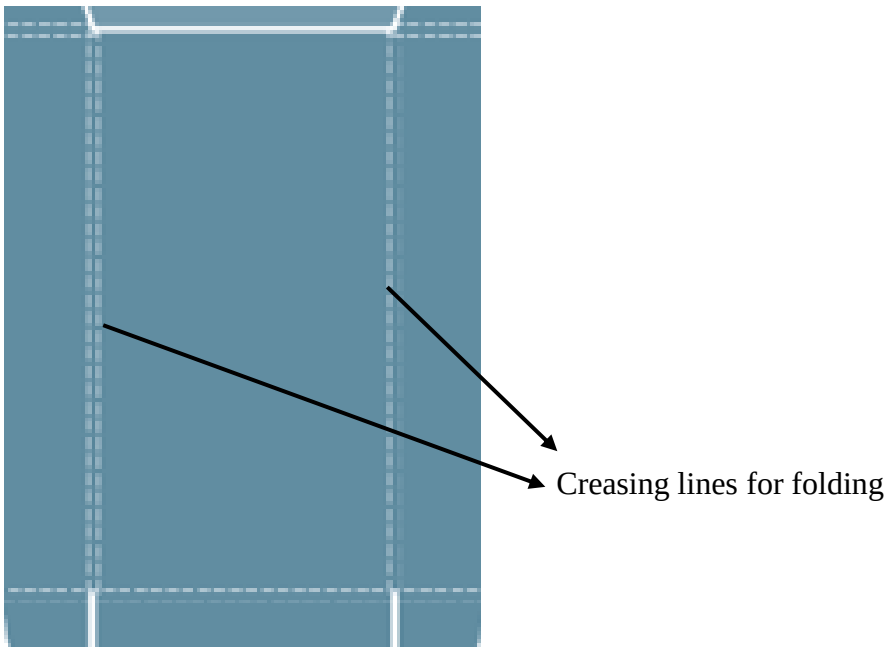


Figure 26. Creased cardboard for testing [49]

Bending process and movement as shown Figure 27. For three different sample of cardboard

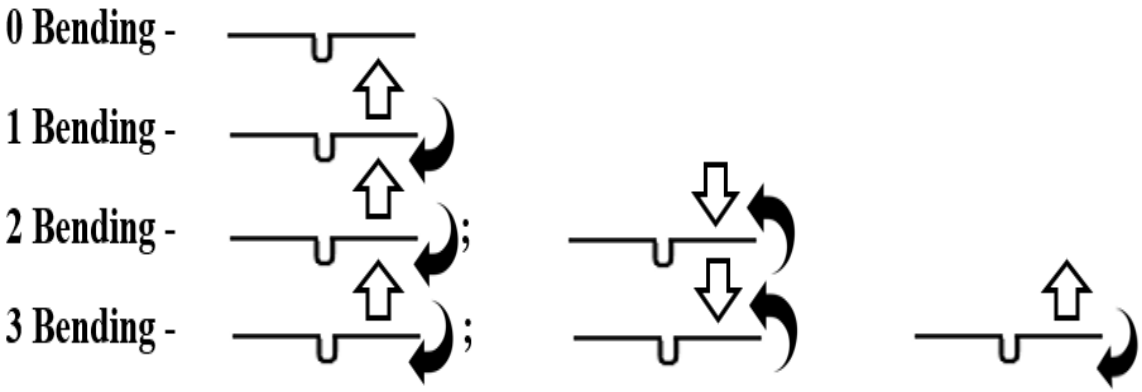


Figure 27. This process done on above showing Figure 26 Cardboard

Specification of the material is take from company which all details about material and their standards

Table 1. Specification of material

Table 1. Carton board properties [13]

Cardboard		**ACCURATE (1)**	**LINO – FREEZE (2)**	**LINO - FREEZE GR KIT 7-9 (3)**	**LINO - FREEZE GR KIT 9-11 (4)**
Code		AC/GC2 12176	LIF FR/GC2 12120	LIF FR GR 7-9 /GC2 12168	LIF FR GR 9-11 / GC2 12160
Fibre Material		Virgin fibre 90%	Virgin fibre 65%	Virgin fibre 65%	Virgin fibre 65%
		Pigmentation 10%	Pulp Substitute 25%	Pulp Substitute 25%	Pulp Substitute 25%
			Coating 10%	Coating 10%	Coating 10%
Grammage g/m^2		305	300	300	300
Brightness Top %		90 Elrepho	84 Elrepho	84 Elrepho	84 Elrepho
Thickness µm		520	520	520	520
Testing Temp.		23ºC	23ºC	23ºC	23ºC
Chromaticity	**Top**	92	<60	<60	<60
	Bottom	0	<50	<50	<50
Grease Barrier		Cheese food, food products, soap	Chilled food Frozen goods	Greasy food, pet food, cosmetic	Greasy food, pet food, cosmetic

➢ **Board Structures**

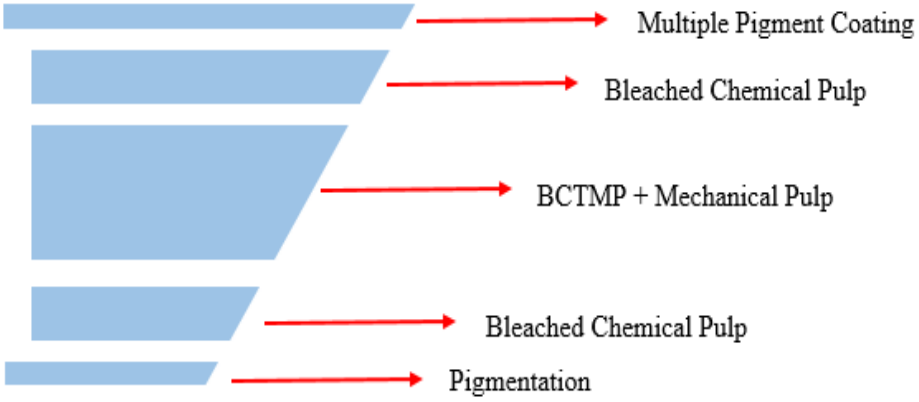


Figure 28. Board Structures

3.4 Equipment's

1. **Backing plate or Ground glass** coated with florescent indicator 10cm X 10cm, very fine grid on one side which is silicon carbides abrasive. On this plate it easy to visible penetration patches.

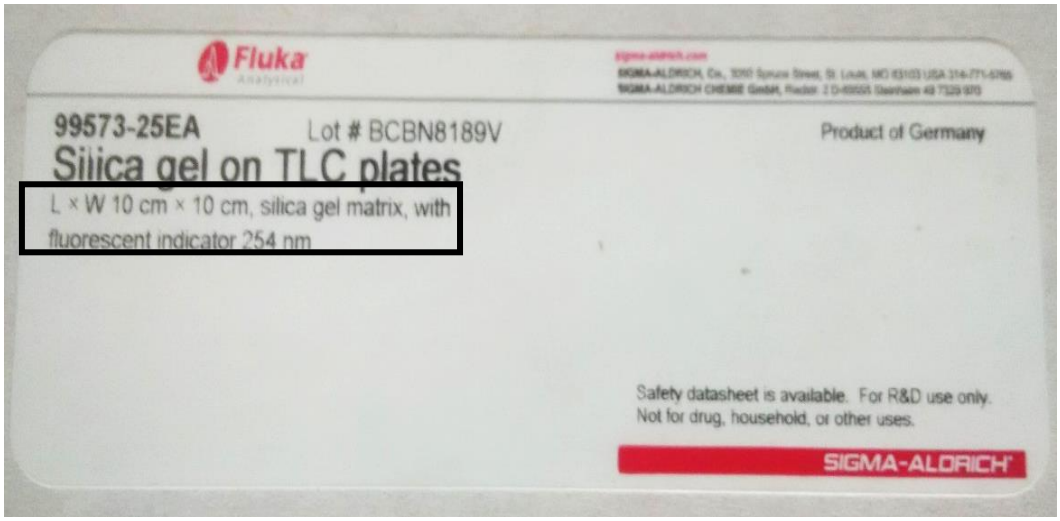


Figure 29. TLC plates with silica gel produced by FLUKA

2. **Weight round bar** 50 g, 20mm diameter at the base.to keep pressure on the cardboard. Due to weight on it patches are formed in that area.

Figure 30. Weight round bar

3. **Cotton flannel** to place between cardboard and weight to avoid any flow of oil and damage.

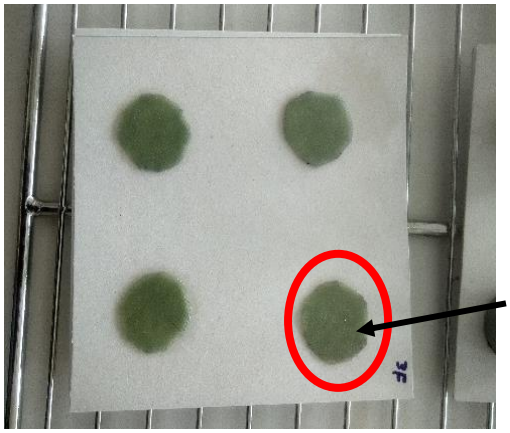


Figure 31. Cotton flannel

4. **Medicine dropper** to add oil drop wise.

Figure 32. Medicine dropper

5. **SNOL oven** which maintain test temperature of 40ºC or 50ºC within ± 1ºC.

Figure 33. SNOL Oven

6. **Weight bar** of 1-kg Square metal bar with 65 mm with one side flat to keep equal pressure on creased folding.
7. **Flat wood strip** to give cardboard preliminary light creased during folding with weight bar.
8. **Thickness measuring device** to measure the cardboard thickness.
9. **UV lamp** to trace the wet patches on backing plate which is not easy visible it naked eyes.

Figure 34. UV lamp

10. **Digital pocket microscope** to see the structure cardboard which formed after the test.
11. **Olive oil** which is suitable for standard reagent. [16]

Figure 35. Olive oil

3.5 Procedure

Take an oven tray and keep measure cardboard of set three similar on clean ground-glass backing plate, note backing plate completely cover the cardboard should be cut as same size because smaller size may occur failure on the edges. Before placing the cardboard check that the printing side of cardboard is down side and rough side is on top.

Cut the cotton flannel rifle cleaning patches into 20mm (0.75”) diameter round which can be fit under the 50g weight bar and place the cotton flannel patches on the top of the test cardboard, each cardboard contains four patches.

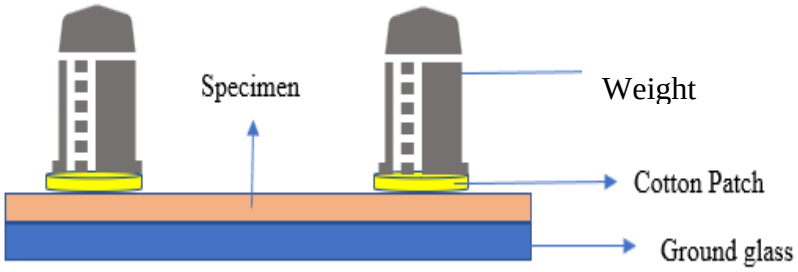


Figure 36. Assembly set

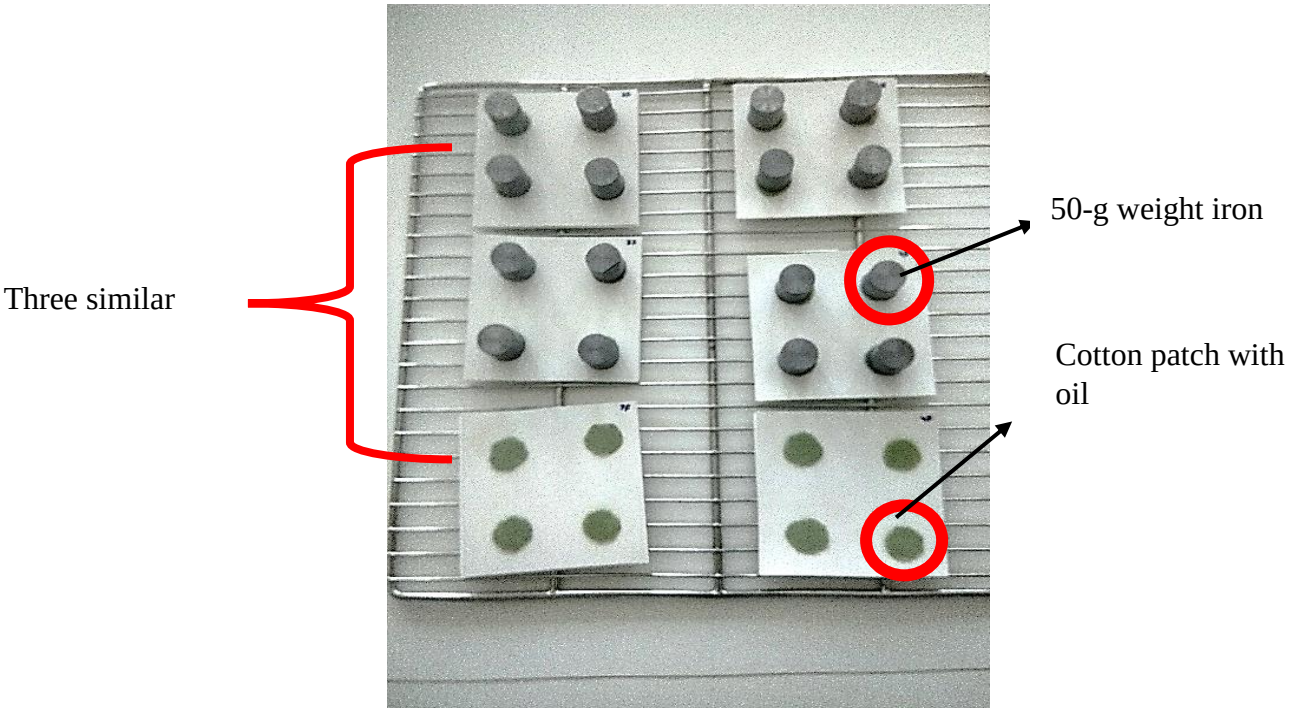


Figure 37. Assembly set

Then placed the 50-g weight on the patches and pre heat complete set (test cardboard, glass, cotton patch sand weight) to desired test temperature at 40^{o}C for 30 min. It is necessary when short failure result is expected, where $\pm$ 30 min. would be critical.

After the finish take assembly out of oven, remove the weight and add six drops of oil, to the cotton patches check the oil not added extra.

Replace the 50-g weight on the oiled patches. Close the oven door and note the time.

At the periodic interval, depending on time for penetration. (Which is, every 15 min for first hour; every 30 min for next one hour; then convenient interval for next three hours). After time end remove the cardboard, cotton patches, weight from the ground-glass plate and observe the surface of the glass in UV lamp to trace wetting. If there is no failure record the time and continue the test [17].

If there is a failure, then record the time and no. wetting patches occurs on glass in less than one hour

4. RESULTS

As shown in the Figure below the oil absorbed

Figure 38. Before penetration

Figure 39. After penetration

Figure 40. After penetration

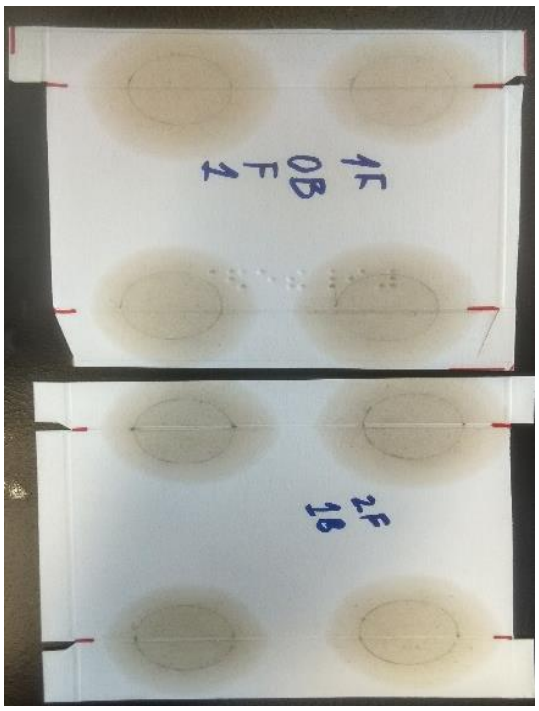


Figure 41. Oil Patches

Calculation

Table 2 calculated the average and standard deviation of the thickness measured from each cardboard and recorded them.

Table 2. Average and Standard deviations of carton board thickness

Cardboard	1	2	3	4
Mean	0.495	0.498333	0.51	0.506667
Standard Error	0.002887	0.001667	0	0.003333
Median	0.495	0.5	0.51	0.51
Standard Deviation	0.005	0.002887	0	0.005774
Range	0.01	0.005	0	0.01
Minimum	0.49	0.495	0.51	0.5
Maximum	0.5	0.5	0.51	0.51
Confidence Level (95, 0%)	0.012421	0.007171	0	0.014342

Flat cardboard oil absorbed image at 45x magnification

Figure 42. Flat Cardboard 1

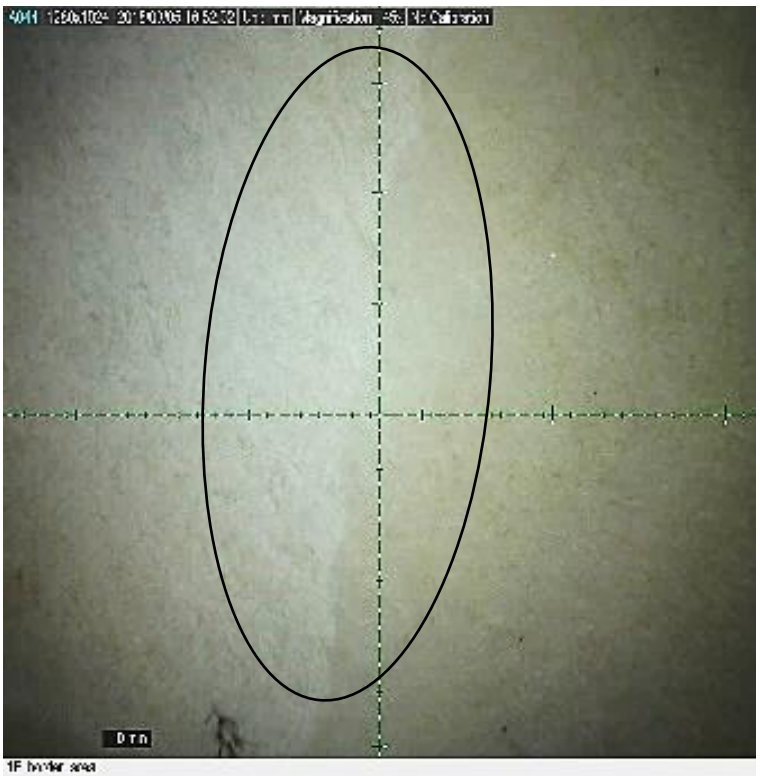


Figure 43. Flat Cardboard 2

In cardboard 1 and 2 oil absorbed completely as shown in figures above

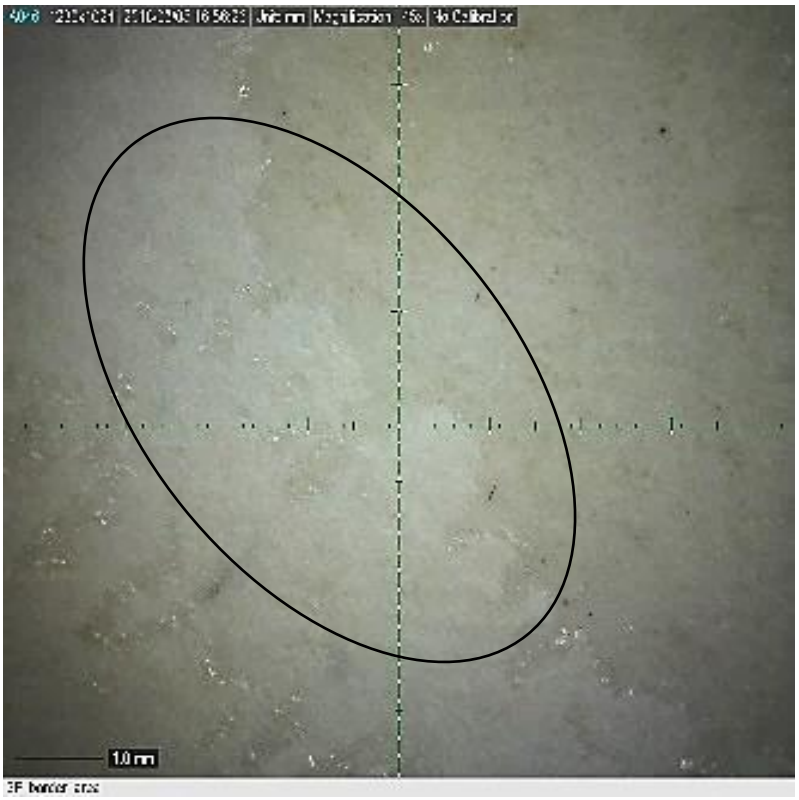


Figure 44. Flat Cardboard 3

Figure 45. Flat Cardboard 4

All images capture in electronic mini microscope to see the oil patches of both sides of the material and it more oil absorbed on bending are when compare flat this happen due to folding of the material and damage in its properties.

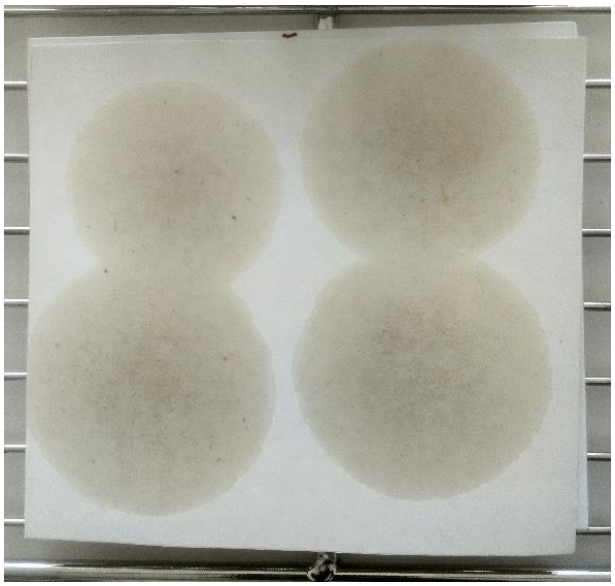


Figure 46. Flat Cardboard oil absorbed

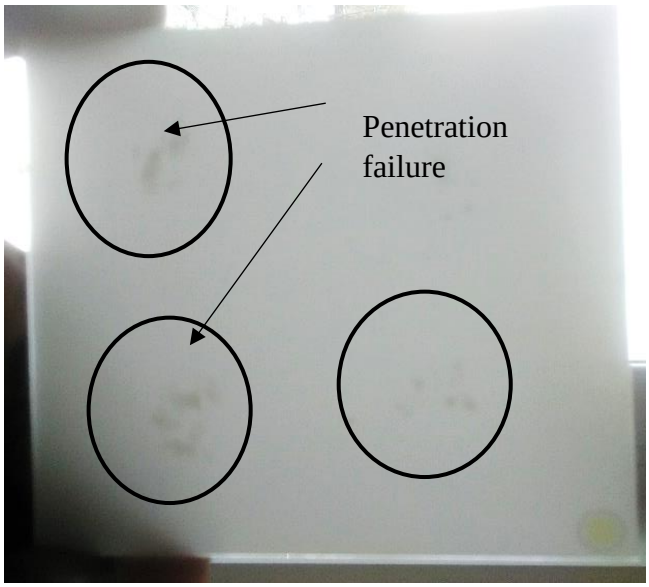
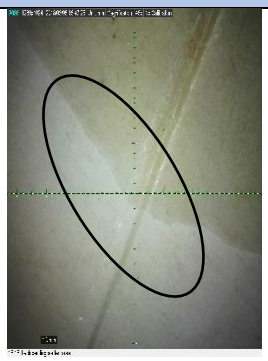
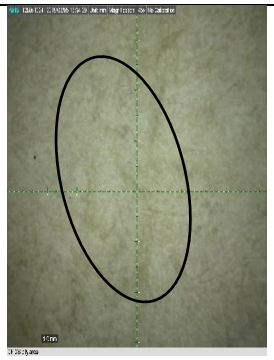
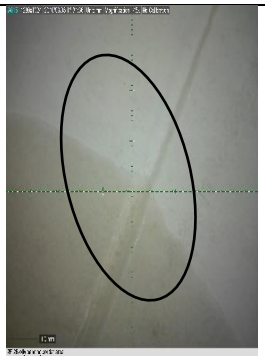
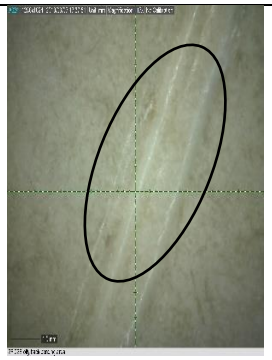


Figure 47. Flat Cardboard ground glass

Below table creased cardboard oil absorption image at 45x magnification.

Table 3. Creased cardboard oil absorption

Cardboard	0 Bending	1 Bending	2 Bending	3 Bending
1				Not Tested
2				Not Tested
3				
4				

- Creased cardboard oil absorption and penetration patches as we can see 3 and 4 0bending has less oil absorption.

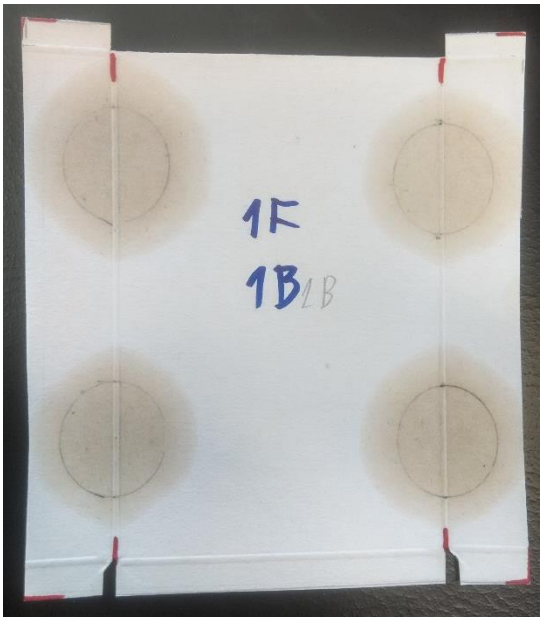


Figure 48. Creased cardboard oil absorbed

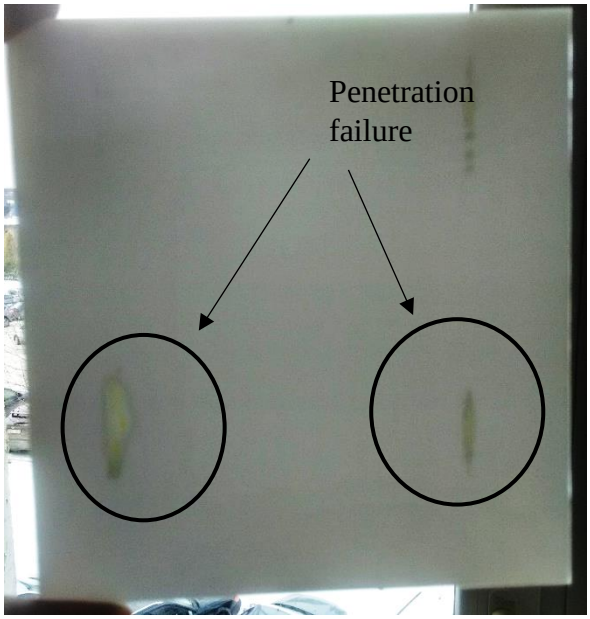


Figure 49. Creased cardboard ground glass

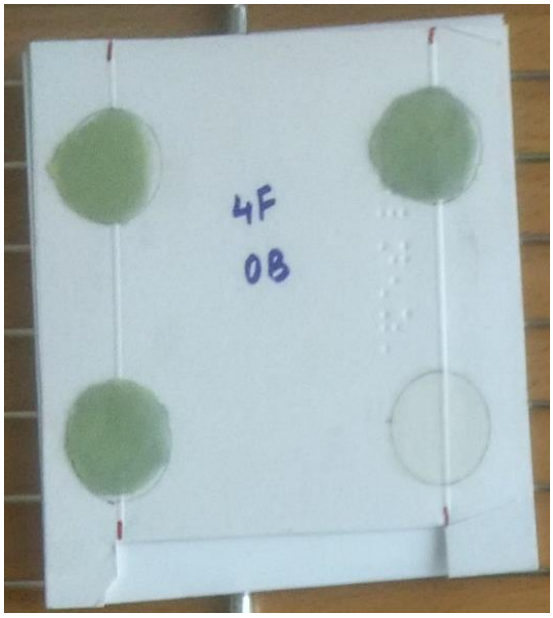


Figure 50. creased cardboard no oil absorbed

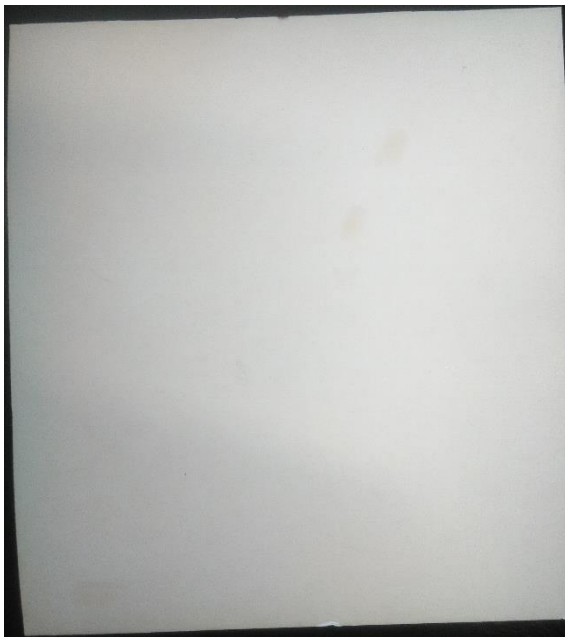


Figure 51. Creased cardboard no penetration

As shown in Figure 48 above increased cardboard 1 and 2 there is an oil absorption and penetration failure in all samples but in the creaseds cardboard 3 and 4, 0 bending there is an no oil absorption and penetration failure as shown Figure 50.

Below table shows testing result of flat cardboard

Table 4. Testing result of flat cardboard

Bond	Time	Flat Cardboard 10cm X 10cm																							
		1						2						3						4					
1	15 Min	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
2	15 Min	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
3	15 Min	P	N	P	N	P	N	P	N	N	N	P	N	N	N	N	N	N	N	N	N	N	N	N	N
		N	P	N	P	N	N	N	N	N	N	N	P	N	N	N	N	N	N	N	N	N	N	N	N
4	30 Min	P	P	P	P	P	P	P	P	P	P	P	P	N	N	N	N	N	N	N	N	N	N	N	N
		P	N	P	P	P	P	P	P	P	P	P	P	N	N	N	N	N	N	N	N	N	N	N	N
5	30 Min	P	P	P	P	P	P	P	P	P	P	P	P	N	N	N	N	N	N	N	N	N	N	N	N
		P	P	P	P	P	P	P	P	P	P	P	P	N	N	N	N	N	N	N	N	N	N	N	N
6	1 H	-	-	-	-	-	-	-	-	-	-	-	-	N	N	N	N	N	N	N	N	N	N	N	N
		-	-	-	-	-	-	-	-	-	-	-	-	N	N	N	N	N	N	N	N	N	N	N	N
7	1 H	-	-	-	-	-	-	-	-	-	-	-	-	N	N	N	N	N	N	N	N	N	N	N	N
		-	-	-	-	-	-	-	-	-	-	-	-	N	N	N	N	N	N	N	N	N	N	N	N
8	1 H	-	-	-	-	-	-	-	-	-	-	-	-	N	N	N	N	N	N	N	N	N	N	N	N
		-	-	-	-	-	-	-	-	-	-	-	-	N	N	N	N	N	N	N	N	N	N	N	N

Note: P - Penetration Failure, (-) Out from test

N - No Penetration

Tables shows Testing Result of Creased Cardboard

Table 5 Testing result of creased cardboard 1

Cardboard 1	**Time**	**15 Min**		**15 Min**	
	Bond	**1**		**2**	
	0 Bending	P	N	P	P
		N	N	P	P
	1 Bending	P	P	-	-
		P	P	-	-
	2 Bending	P	P	-	-
		P	P	-	-

- In creased cardboard 1 penetration failure in first half interval for all samples

Table 6. Testing result of creased cardboard 2

Cardboard 2	Time	15 Min		15 Min	
	Bond	1		2	
	0 Bending	P	P	P	P
		N	N	P	P
	1 Bending	P	P	-	-
		P	P	-	-
	2 Bending	P	P	-	-
		P	P	-	-

- In creased cardboard 2 penetration failure in first half interval for all samples

Table 7. Testing result of creased cardboard 3

	Time	15 Min		15 Min		15 Min		15 Min		30 Min		30 Min		1H		1 H		1 H	
	Bond	1		2		3		4		5		6		7		8		9	
Cardboard 3	0 Bending	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	P	N	P
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	1 Bending	N	N	N	N	N	N	P	P	P	P	-	-	-	-	-	-	-	-
		N	N	N	N	N	N	P	P	P	P	-	-	-	-	-	-	-	-
	2 Bending	N	N	N	N	N	P	P	P	P	P	-	-	-	-	-	-	-	-
		N	N	N	N	P	N	P	P	P	P	-	-	-	-	-	-	-	-
	3 Bending	N	N	P	N	N	P	P	P	P	P	-	-	-	-	-	-	-	-
		P	N	P	N	P	P	P	P	P	P	-	-	-	-	-	-	-	-

- In creased cardboard 3 penetration failure in second half interval for all bending samples and in 0 bending fourth interval

Table 8. Testing result of creased cardboard 4

	Time	15 Min		15 Min		15 Min		15 Min		30 Min		30 Min		1 H		1 H		1 H	
	Bond	1		2		3		4		5		6		7		8		9	
Cardboard 4	0 Bending	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	1 Bending	N	N	N	N	N	N	N	N	P	P	P	P	P	P	-	-	-	-
		N	N	N	N	N	N	N	N	P	N	P	P	P	P	-	-	-	-
	2 Bending	N	N	N	N	N	P	P	P	P	P	P	P	P	P	-	-	-	-
		N	N	N	N	N	N	N	N	N	N	N	P	P	P	-	-	-	-
	3 Bending	N	N	N	N	P	P	P	P	-	-	-	-	-	-	-	-	-	-
		N	N	N	P	P	P	P	P	-	-	-	-	-	-	-	-	-	-

- In creased cardboard 3 penetration failure in third interval for all bending samples and in 0 bending no failure

➢ Figures shows below the penetration level with flat cardboard and creased cardboard

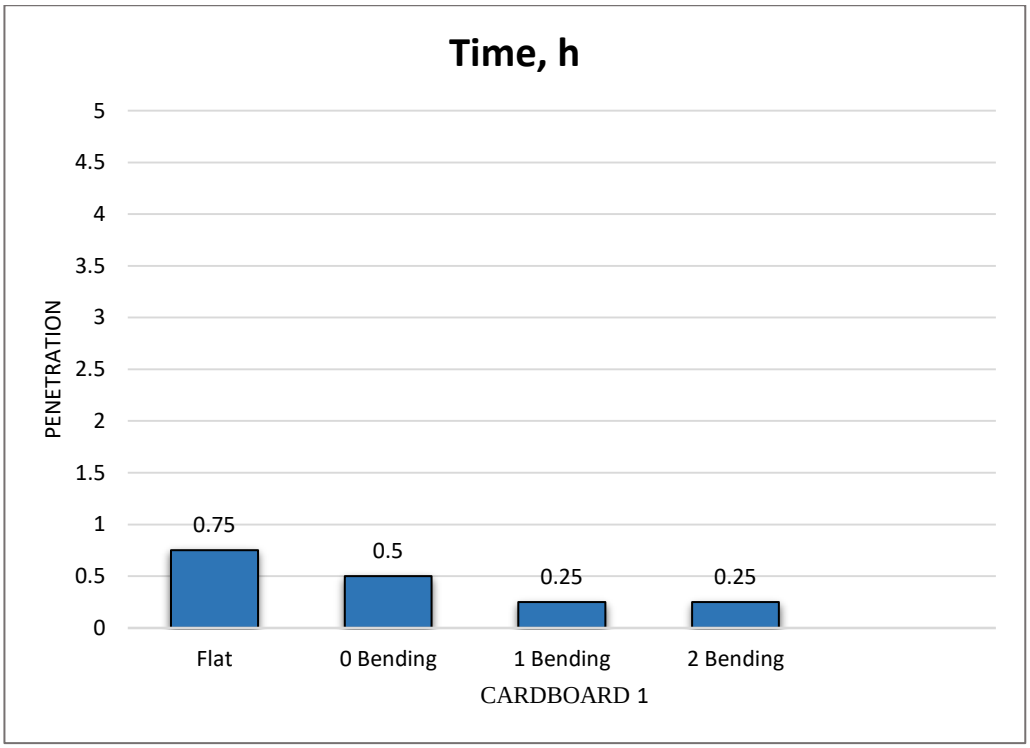


Figure 52. Cardboard 1 average penetration time average

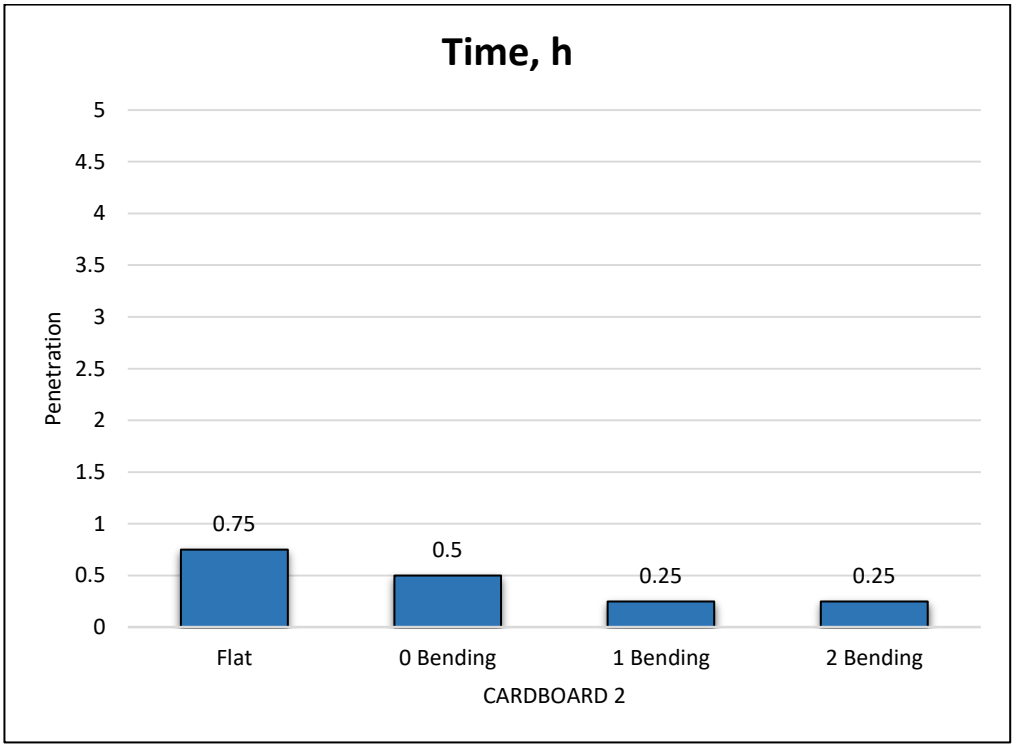


Figure 53. Cardboard 2 average penetration time

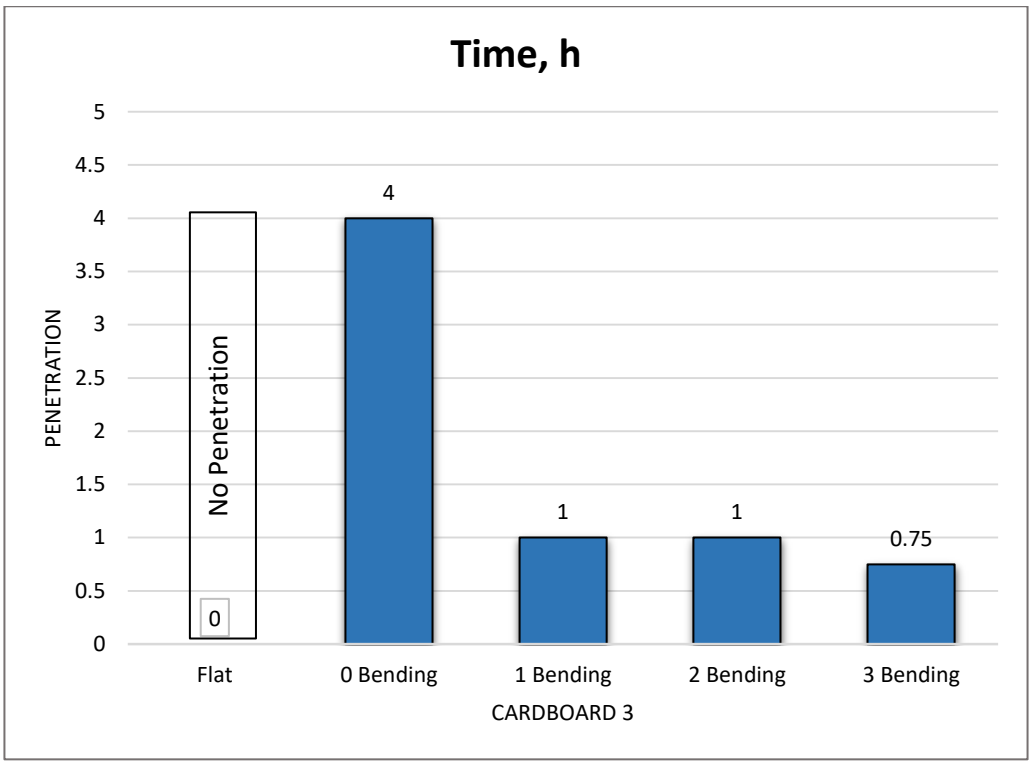


Figure 54. Cardboard 3 average penetration time

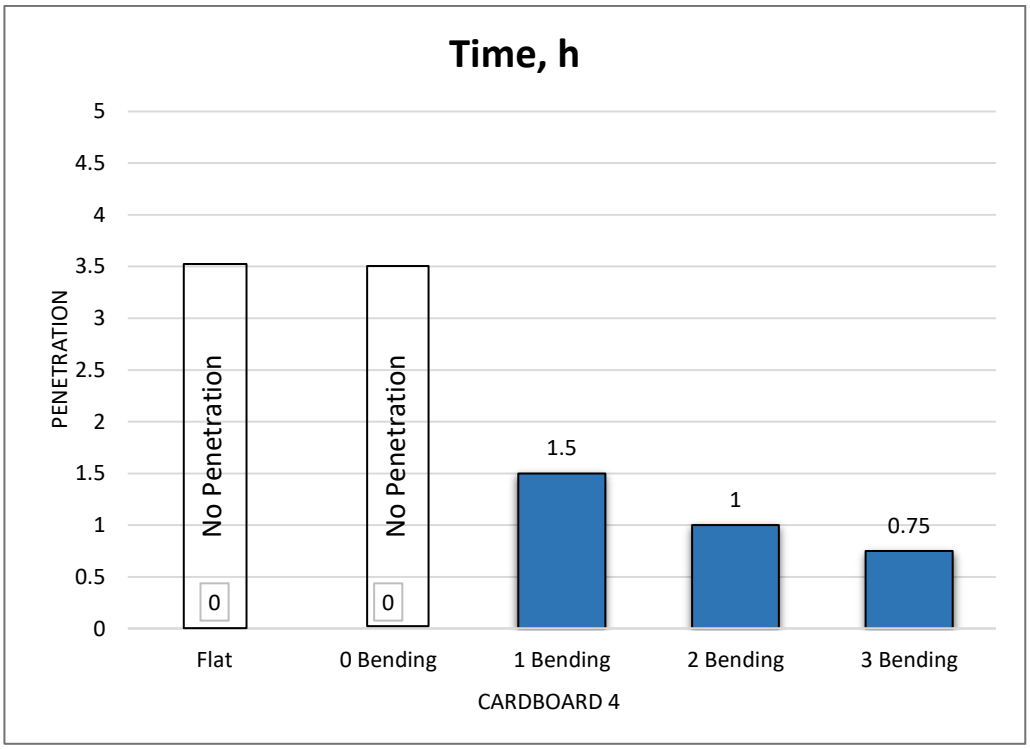


Figure 55. Cardboard 4 average penetration time

CONCLUSIONS

1. Different types of carton board pulp are identified with different processing method for making pulp.
2. Identified coating options and coating technology which easier to coat carton board packaging material.
3. Flat cardboard 1 is late penetration compare to when compare to all creased cardboard due folding and punching on cardboard it penetrates faster. But 0 bending take more time compare to other.
4. Flat cardboard 2 is same result as like cardboard all bending penetrates faster.
5. Flat cardboard 3 is not penetrate is any sample in total time 5 hours. But in creased cardboard bending cardboard are slowly penetrate complete and 0 bending cardboard penetrate only one part after 5 hours which under penetrate or not penetrate.
6. Flat cardboard 4 is not penetrate is any sample in total time 5 hours same as cardboard 3. But in creased cardboard bending cardboard are slowly penetrate complete and 0 bending cardboard is not penetrate even after 5 hours and no traces of oil on front and back side of cardboard.
7. The method used for grease penetration requires constant observation and cautious handling of equipment. This experiment requires minimal equipment and there is a possibility of less errors.

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APPENDICES

Appendix 1

Jaunųjų mokslininkų konferencija

pažymėjimas

PRA
MO inžinerija
NĖS
2018

Nr. V24-11-60

pažymime, kad 2018 m. gegužės 10 d.

Mohammed Imran Pasha,
Vaidas Bivainis

dalyvavo KTU Jaunųjų mokslininkų konferencijoje
„Pramonės inžinerija-2018“ ir pristatė pranešimą

GREASE PENETRATION TEST OF SPECIAL CARTON BOARD FOR FOOD PRODUCT

MIDF Dekanas dr. Andrius Vilkauskas

„Santakos“ slėnis, Kaunas

organizatorius

ktu mechanikos inžinerijos ir dizaino fakultetas 1922

partneris

PTO PAKUOČIŲ TVARKYMO ORGANIZACIJA