KAUNAS UNIVERSITY OF TECHNOLOGY
MECHANICAL ENGINEERING AND DESIGN FACULTY

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AN INVESTIGATION OF HOT SEAL PROPERTIES OF PACKAGING MATERIALS WITH THERMOPLASTICS POLYMERS

Master's Degree Final Project

Supervisor
Dr. Vaidas Bivainis

KAUNAS, 2018

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Industrial Engineering and Management (621H77003)

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Industrial Engineering and Management 621H77003

(Title and code of study programme)

"An investigation of Hot Seal Properties of Packaging Materials with Thermoplastics Polymers"

DECLARATION OF ACADEMIC INTEGRITY

05 JANAUARY 20 18

Kaunas

I confirm that the final project of mine, **Makireddy Vamsi Krishna**, on the subject "An Investigation of Hot Seal Properties of Packaging Materials with Thermoplastics Polymers" 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 plagiarized 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 thesis.

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FACULTY OF MECHANICAL ENGINEERING AND DESIGN

Approved:
Head of
Production engineering
Department

(Signature, date)

Kazimieras Juzėnas
(Name, Surname)

MASTER STUDIES FINAL PROJECT TASK ASSIGNMENT
Study programme INDUSTRIAL ENGINEERING AND MANAGEMENT

The final project of Master studies to gain the master qualification degree, is research or applied type project, for completion and defence of which 30 credits are assigned. The final project of the student must demonstrate the deepened and enlarged knowledge acquired in the main studies, also gained skills to formulate and solve an actual problem having limited and (or) contradictory information, independently conduct scientific or applied analysis and properly interpret data. By completing and defending the final project Master studies student must demonstrate the creativity, ability to apply fundamental knowledge, understanding of social and commercial environment, Legal Acts and financial possibilities, show the information search skills, ability to carry out the qualified analysis, use numerical methods, applied software, common information technologies and correct language, ability to formulate proper conclusions.

1. Title of the Project

AN INVESTIGATION Of HOT SEAL PROPERTIES OF PACKAGING MATERIALS WITH THERMOPLASTIC POLYMERS.

Approved by the Dean Order No. V25-11-12, 11 December 2017

2. Aim of the project

The main Aim of my project is to investigate the hot seal properties of packaging materials with thermoplastics polymers.

3. Structure of the project

1. To perform the polyethylene coated paper test, and investigate the obtained results.
2. To perform the Thermal gluing test.
3. To perform the Laminated gluing test.
4. To perform the peeling test for Thermal gluing test results, and Laminated gluing test results.
5. To inspect the obtained results from Thermal gluing and Laminated gluing results.

4.Requirements and conditions

1. The dimensions of the specimen or polyethylene paper used for the experiment should be 10cm and 0.8cm.
2. The failure mode can be explained only by visual determination of the manner.
3. Peeling test must be done for both Thermal gluing and Laminated gluing experiments.
4. Calculations should be precise to investigate the final results.

5. This task assignment is an integral part of the final project

6. Project submission deadline: 21 December 2017

Student — Vamsi Krishna Makireddy (*Name, Surname of the Student*) — (*Signature, date*)

Supervisor — Dr. Vaidas Bivainis (*Position, Name, Surname*) — (*Signature, date*)

Vamsi Krishna, Makireddy. An Investigation of Hot Seal Properties of Packaging Materials with Thermoplastics Polymers. Master's Final Project / supervisor Dr. Vaidas Bivainis. Faculty of Mechanical engineering and design, Kaunas University of Technology.
Research field and area: Technological Science, Production Engineering.
Keywords: *Polyethylene coated paper, Laminated seal, Thermal seal, Frictional peel tester.*
Kaunas, 2018. 45 p.

SUMMARY

In this experiment we are going to investigate the seal properties. The tests from laminated and thermal gluing machine are investigated. The results from the laminated and thermal gluing machine are tested under frictional peeling tester. Applying same load with same time the results of peeling experiment have shown that the laminated results are more better and the seal strength is more accurate and strong when compared to thermal seal results. Different types of failure modes have occurred for the same temperatures for the both experiments. The Break failure mode occurs from 120° in laminated gluing method where as there is no break point failure for thermal gluing tests at 120°. Various temperatures are taken while testing the polyethylene as 120°, 130°, 140°, so, we are using polyethylene coated paper of 10cm length and 0.8cm of width these specimens were put to test to get the final results and the investigation shown the results as expected. I have found that each specimen at all the temperatures shown the best results only from laminated gluing process.

Makireddy Vamsi Krishna. Pakuočių Medžiagų su Termoplastiniais Polimerais Terminio Suklijavimo siūlių Savybių Tyrimas.Magistro Baigiamasis Darbas.

Darbo vadovas Dr. Vaidas Bivainis. Kauno Technologijos Universiteto Mechanikos inžinerijos ir dizaino fakultetas.
Tyrimo sritis: Technologijų mokslas. Produkcijos inžinerija.
Raktiniai žodžiai: *Politilenu padengtas popierius, Sandarinimas laminavimo metodu, Sandarinimas terminiu metodu, Nulupimo trintimi metodas.*
Kaunas, 2018 45 p.

SANTRAUKA

Darbe pateikti atliktų pakuočių medžiagų, padengtų polietileno sluoksniu terminio suklijavimo siūlės savybių tyrimų rezultatai. Terminio suklijavimo tyrimai atlikti panaudojant kaitinamąją plokštę bei bandinių suklijavimo vietų prispaudimą. Taip pat atlikti suklijavimo tyrimai panaudojant laminavimo įrenginį. Tyrimų rezultatai parodė, kad esant tai pačiai sulitavimo temperatūrai bei analogiškam spaudimui, vertinant bandinių atplėšimą, laminavimo įrenginio suformuota siūlė buvo atsparesnė plėšimui. Be atplėšimo jėgos nustatymo buvo vizualiai vertinamas sulitavimo siūlės atplėšimo-atsisluoksniavimo pobūdis: adhezyvinis, medžiagos kohezyvinis, medžiagos atsisluoksniavimas ir kt. Tyrimuose naudoto popieriaus padengto PE sluoksniu suklijavimui buvo naudoto 120^0, 130^0 ir 140^0 C temperatūra. Gauta, kad atsisluoksniavimas prasideda nuo 120^0 prikeitinėjimo temperatūros, o tvirčiausias terminis suklijavimas gautas esant 130^0 temperatūrai. Atplėšimo tyrimams naudoti 0,8cm pločio ir 10 cm ilgio bandiniai. Nustatyta, kad geriausi sulitavimo rezultatai gauti naudojant šių bandinių laminavimą.

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1. To perform the polyethylene coated paper test, and investigate the obtained results.

2. To perform the Thermal gluing test.

3. To perform the Laminated gluing test.

4. To perform the peeling test for Thermal gluing test results, and Laminated gluing test results.

5. To inspect the obtained results from Thermal gluing and Laminated gluing

1.3. HOT SEAL STRENGTH

Hot seal fixing is the way toward fixing one thermoplastic to another comparable thermoplastic utilizing warmth and weight. The immediate contact technique for warm fixing uses a continually amazing fixing bar to apply warmth to a contact territory or way to seal or weld the thermoplastics together.

These are used to connect the following:

1. Connectors

2. Thermal films

3. polyethylene coated papers, etc.

Seal quality is identified with the pack opening power and a measure of the consistency of the bundling procedure. greatest seal compels, normal peel power and aggregate vitality assimilated in peeling the seal can be recorded.

A hot sealer is a machine used to seal items, bundling, and other thermoplastic materials utilizing heat. Hot fixing can combine two comparable materials or can join disparate materials, one of which has a thermoplastic layer.

There are two main types of gluing or sealing machines. They are

1. Thermal gluing machine 2. Laminated gluing machine. (2)

1.4. POLYETHYLENE COATED PAPER

The combination of polyethene and paper is known as polyethylene coated paper.

Figure.1.1.Polyethylene coated paper (10)

Previously, thin thermoplastic specimens have been broadly utilized for the bundling of a wide assortment of wares and have discovered far reaching acknowledgment in the bundling of foodstuffs.

Incorporated into such thermoplastic bundling films will be movies, for example, biaxially arranged polyethylene, which is especially suited for use in such applications because of its amazing optical and mechanical properties.

Furthermore, it offers phenomenal dampness boundary qualities. Before, extended use of this kind of film for bundling has been hampered to some degree by its powerlessness to offer great warmth seal qualities over a wide temperature run.

One earlier craftsmanship strategy which has been utilized to cure this has been the use of warmth sealable coatings onto the film surface after the film has been framed and arranged. Be that as it may, such covering applications following film introduction are to a great degree exorbitant and require costly hardware including drying stoves, dissolvable recuperation frameworks, and the like

A substitute means for utilization of warmth sealable coatings onto the surface of movies, for example, polyethylene, includes the expulsion of a surface layer, Mo plastic covering gum is chosen which has a liquefying point underneath that of the polyethylene film. [2]

Hot tack measures the quality of warmth seals framed between thermoplastic surfaces of adaptable networks, promptly after the seal has been made and before it cools to room temperature. This property is critical since this circumstance regularly happens on vertical shape fill-seal bundling.

In this procedure, the substance is dropped into the sack quickly after the even seal bars have opened. Since the substance can be substantial, the hot seal must have the capacity to withstand high loads, therefore requiring a high hot tack drive

This expulsion step may happen at a phase where the base polyethylene material has just been situated one way, for example, the machine bearing. All things considered, after expulsion covering, the composite get together is consequently situated the transverse way.

it has been discovered that amid crack of the warmth seals to access the bundle substance, the film layers themselves are normally tore and torn ensuring the open bundle with the first wrapping material troublesome or unthinkable. [3]

PORTRAYAL OF SPECIFIC EMBODIMENTS

As hereinbefore talked about, the essential target of the present innovation is to offer a technique which might be utilized in the produce of situated polyethylene films which are warm sealable over an extensive variety of temperatures; which give an abnormal state of warmth seal quality; which offer great optical lucidity; and which offer solid yet peel able warmth seal attributes. As per the present development, movies might be created which give solid and peel able warmth seals, and they might be routinely fabricated without the requirement for any exceptional hardware. This protest might be accomplished with either a solitary layer polyethylene film, when a straightforward low fog film is wanted, or in conjunction with a polyethylene item, for example, a coextrusion of a polyethylene center with pigmented surface layers. As per a epitome of the present development, a polyethylene base web is expelled and therefore arranged in the machine bearing by passing the base web through a progression of draw rollers using ordinary earlier workmanship film introduction tech - niques. The machine heading focused base sheet might be along these lines expulsion covered with a thin layer of ethylene-vinyl acetic acid derivation copolymer. After expulsion covering, the covered machine course arranged polyethylene base movie is in this manner preheated and extended the transverse way using customary film introduction hardware such as, a material sort tenter edge. As per the technique for the present creation, it has been discovered very attractive to control the preheating before transverse heading introduction of the base web, with the goal that the preheating step is at a continuous rate of no more prominent than 40 F. every

second. This warming rate is characterized as the normal increment in web temperature preceding transverse bearing introduction over the time in seconds this expansion is refined. Too much quick warming rate brings about decreased peel ability and poor measure consistency. Likewise, as per the present procedure, it is wanted to work in a scope of preheat rates between 5 F. every second and 40" F. every second with a favored preheat scope of 15 F. to 25 F. every second. Moreover, it is noticed that the measure consistency of the subsequent transverse course situated web is significantly enhanced by keeping up this low warming rate as it permits time for non-uniform warm conditions presented by need in the expulsion covering and extinguishing venture to equilibrate and be evened out preceding the genuine transverse heading introduction or extending. It has likewise been found as per the present innovation, that an exceedingly attractive vinyl acetic acid derivation content in the copolymer covering layer is from around 6% up to around 10% by weight. (5)

HOT SEAL QUALITY

Seal quality is identified with the pack opening power and a measure of the consistency of the bundling procedure. The most extreme seal constrains, normal peel power and aggregate vitality assimilated in peeling the seal can be recorded. The quality of seals in adaptable hindrance materials is likewise routinely estimated as a major aspect of the approval practice on medicinal gadget bundling. seal quality tests are regularly performed on pockets and lidded plate as a measure of warmth seal quality.

A warmth sealer is a machine used to seal items, bundling, and other thermoplastic materials utilizing heat. his can be with uniform thermoplastic monolayers or with materials having a few layers, no shy of what one being thermoplastic. Warmth fixing can consolidate two comparable materials or can join different materials, one of which has a thermoplastic layer.

WARMTH FIXING PROCESS

Warmth fixing is the way toward fixing one thermoplastic to another comparable thermoplastic utilizing warmth and weight. The immediate contact strategy for warm fixing uses an always amazing fixing bar to apply warmth to a particular contact territory or way to seal or weld the thermoplastics together. Warmth fixing is utilized for some, applications, including heat seal connectors, thermally enacted cements, film media, plastic ports or thwart fixing.

BASIC APPLICATIONS FOR THE WARMTH FIXING PROCESS

Warmth seal connectors are utilized to join LCDs to PCBs in numerous shopper gadgets, and additionally in therapeutic and media transmission gadgets. Warmth settling of things with warm concretes is used to

hold clear show screens onto purchaser electronic things and for other settled thermo-plastic social events or contraptions where warm staking or ultrasonic welding are impossible because of part outline prerequisites or other get together contemplations.

Warmth fixing additionally is utilized as a part of the assembling of blood test film and channel media for the blood, infection and numerous other test strip gadgets ed as a piece of the therapeutic field today. Overlay thwarts and movies regularly are warm fixed over the highest point of thermoplastic restorative plate, Microtiter (miniaturized scale well) plates, jugs and compartments to seal and additionally forestall sullying for therapeutic test gadgets, test accumulation plate and holders utilized for nourishment items. Remedial and fluid packs used as a piece of the therapeutic, bioengineering and sustenance wanders. Liquid packs are produced using a huge number of fluctuating materials, for example, foils, channel media, thermoplastics and overlays.

SEAL QUALITY

Great seals are a consequence of time, temperature and weight for the right clean material. A few standard test techniques are accessible to quantify the quality of warmth seals. Also, bundle testing is utilized to decide the capacity of finished bundles to withstand determined weight or vacuum. A few techniques are accessible to decide the capacity of a fixed bundle to hold its uprightness, boundary attributes, and sterility.

Warmth fixing procedures can be controlled by an assortment of value administration frameworks, for example, HACCP, measurable process control, ISO 9000, and so on. Confirmation and approval conventions are utilized to guarantee that determinations are met and last materials/bundles are suited for end-utilize.

SEAL STRENGTH TESTING

The viability of warmth seals is frequently definite in overseeing determinations, contracts, and directions. Quality administration frameworks once in a while request occasional subjective assessments: For instance, a few seals can be assessed by a basic draw to choose the nearness of a bond and the part of disillusionment. With some plastic movies, perception can be upgraded by utilizing enraptured light which features the birefringence of the warmth seal. A few seals for touchy items require intensive confirmation and approval conventions that utilization quantitative testing. Test techniques may include

SEAL STRENGTH PER ASTM F88 AND F2824

Seal Strength testing, otherwise called Peel Testing, measures the quality of seals inside adaptable obstruction materials. This estimation would then be able to be utilized to decide consistency inside the seal, and also assessment of the opening power of the bundle framework. Seal quality is a quantitative measure for use in process approval, process control and capacity. Seal quality isn't just pertinent to opening power and bundle respectability, however to estimating the bundling procedures' capacity to deliver reliable seals. (2)

THERMAL GLUING MACHINE

In this machine the thermal polymer will be stamped on placing the specimen on the aluminum hot surface and we will get the seal by pressing on it. (ASTM F1921-98)

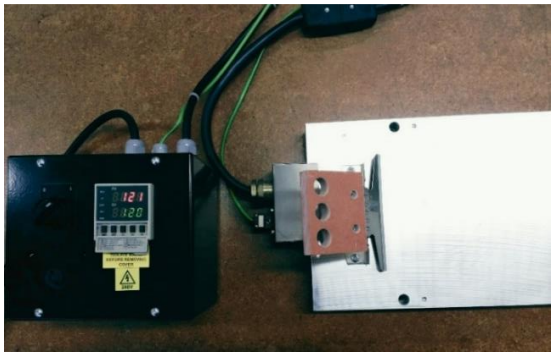


Figure.1.2. Thermal gluing machine

LAMINATED GLUING MACHINE

The purpose of this machine is to seal the thermal polymers. Here the seal will be done by placing the specimen on the pouch from forward and it will roll inside under some hot temperatures and will be sent with seal or glued from the opposite pouches. (ASTM F1921)

Figure.1.3. Laminated gluing machine.

2. LITERATURE REVIEW

As per the present innovation, films might be delivered which give solid and peel able hot seals, and they might be routinely fabricated without the requirement of gear.

As per ASTM standards:

ASTM-D882 Test Method for tensile properties of thin plastic sheeting

ASTM-E 171 Specification for atmosphere for conditioning and tensile flexible barrier materials. Heat seals made between polyethylene polymers and other materials which are flexible, immediately when it they get glued they will cool to ambient temperature. (ASTM F1921-98)

Also, the haze and sparkle estimations of such motion pictures are impressively poorer than those shown by the uncoated arranged polyethylene base film. As hereinbefore talked about, the essential goal of the present creation is to offer a technique which might be utilized in the fabricate of situated polyethylene films which are warm sealable over an extensive variety of temperatures; which give an abnormal state of warmth seal quality; which offer great optical clearness; and which offer solid yet peel able warmth seal attributes

Seal Strength testing, otherwise called Peel Testing, measures the quality of seals inside adaptable obstruction materials. Seal quality is a quantitative measure for use in process approval, process control and capacity. Seal quality isn't just applicable to opening power and bundle respectability, however to measuring the bundling procedures' capacity to deliver reliable seals. (ASTM F88 AND F2824)

This protest might be accomplished with either a solitary layer polyethylene film, when a straightforward low murkiness film is wanted, or in conjunction with a polyethylene item, for example, a coextrusion of a polyethylene center with pigmented surface layers.

As per an epitome of the present innovation, a polyethylene base web is expelled and in this way arranged in the machine course by passing the base web through a progression of draw rollers using regular earlier craftsmanship film introduction techniques.

This warming rate is characterized as the normal increment in web temperature before transverse heading introduction over the time in seconds this expansion is proficient. Too much fast warming rate brings about lessened peel ability and poor gage consistency. In like manner, as per the present procedure. (ASTM F88 AND F2824)

It has likewise been found as per the present development, that an exceptionally alluring vinyl acetic acid derivation content in the copolymer covering layer is from around 6% up to around 10% by weight. (ASTM F88 AND F2824)

Hot tack measures the quality of warmth seals framed between thermoplastic surfaces of adaptable networks, quickly after the seal has been made and before it cools to room temperature. This property is vital since this circumstance much of the time happens on vertical frame fill-seal bundling. In this procedure, the substance is dropped into the sack quickly after the even seal bars have opened. Since the can be overwhelming, the hot seal must have the capacity to withstand high loads, hence requiring a high hot tack constrain. (ASTM F1921)

The three-point check design exposed only a little segment of the example to the greatest stress. alongside those lines, 3-point flexural characteristics are likely going to be notably greater noteworthy than 4-point flexural qualities. 3-factor flexure has some possibilities. it makes use of less complex look at installations. It is much less demanding to alter to high temperature, and it is many the time supportive in Weibull authentic examinations. be that as it can, four-factor flexure is Preferred and cautioned for most portrayal purposes. (ASTM C1211-13)

Because of contrasts between a research facility sealer and assembling gear (for instance, scale, size of fixing territory, and preparing speed), there might be a noteworthy distinction between the capacity and yield of a lab warm sealer and that of assembling hardware. Consequently, mind must be taken while applying a warmth seal bend ponder as illustrated in these practices to assembling gear. The warmth seal bend and the comparing seal quality information are expected to give a beginning stage to assurance of fixing conditions for full scale producing gear. (ASTM F2029 – 16)

This training is expected to help with building up beginning connections for fixing adaptable boundary materials. Extra direction might be required on the most proficient method to set up fixing conditions for adaptable obstruction materials on business/creation fixing hardware. Seals might be made between networks of the same or unique materials. The individual networks might be homogeneous in structure or multilayered (coextruded, covered, overlaid, et cetera). (ASTM F2029 – 16).

There are numerous other temperature and mugginess conditions that might be fittingly used to test end utilize conditions, (for example, cooler, refrigerated, or oppressive capacity). These should be exclusively settled and are not in the extent of this training. Just those materials that fall under the general territory

of adaptable obstruction bundling materials are incorporated into this training. (ASTM E171 / E171M - 11(2015).

Malleable properties can be used to give information to innovative work and building configuration and quality control and. In any case, information from such tests can't be viewed as huge for applications varying broadly from the heap time size of the test utilized. The tractable modulus of flexibility is a file of the firmness of thin plastic sheeting. The reproducibility of test outcomes is great when exact control is kept up finished all test conditions.

At the point when distinctive materials are being looked at for solidness, examples of indistinguishable measurements must be utilized. (ASTM D882 – 12).

Elastic properties can shift with example thickness, technique for planning, speed of testing, kind of holds utilized, and way of measuring augmentation. Therefore, where exact relative outcomes are wanted, these elements must be deliberately controlled. (ASTM D882 – 12).

Ductile properties are known to shift with example arrangement and with speed and condition of testing. Thusly, where exact relative outcomes are wanted, these variables must be precisely controlled. It is understood that a material can't be tried without additionally testing the strategy for arrangement of that material. Henceforth, when near trial of materials as such are wanted.

practice incredible care to guarantee that all examples are set up in the very same way, unless the test is to incorporate the impacts of test planning. (ASTM D638 – 14).

Pressing and bundling arrangements are laid out as required for sufficient transport of gums and completed items with at least setbacks in shipment. Business levels are incorporated for all business and most government and military shipments. Level A necessities are included for unique military buys as it were. (ASTM D3892 – 15).

Reused polyethylene film or pitch might be utilized as feedstock, and the film or sheeting may contain added substances for surface property change, shades, or stabilizers, or a blend of these, however they should adjust to the prerequisites determined. Material canvassed in this should be assigned by a five-digit write number, with every numeral (from 0 to 5) demonstrating as far as possible inside which the estimations of the thickness, affect quality, active coefficient of erosion, murkiness, and ostensible thickness of the material falls under. (ASTM D2103 – 15).

The characterization of polyethylene film and sheeting up to 0.3 mm (0.012 in.) in thickness, comprehensive. The film or sheeting may contain added substances for the change of the surface properties, shades, or stabilizers, or blends thereof. (ASTM D2103 – 15).

2.1. FRICTIONAL PEEL TESTER

The peel tester is used to test the seal specimens under laminated or thermal gluing processes. The detailed structure will be explained below. Here the sealed specimens will be applied with some force and will be pulled on one end and other end is fixed. We need to apply some force at some speed and time. (ASTM F1921-98)

2.2. SPECIMENS

Here we are using the PE coated paper as specimens. We need to cut them at certain diameter and need to experiment on either laminated or thermal gluing machines. (ASTM F1921-98). Each time we test we need 2 specimens to be joined.

2.3. HAND MICROSCOPE

Here in this experiment we are using a hand microscope where we must clearly take the peeling stage of the specimens. We need to set the focus by certain reading and take the pictures by placing it on the black surface.

Only on black surface because it can increase the picture detain and the accuracy of the view.

3. METHODS AND METHODOLOGIES

3.1. POLYETHYLENE COATED PAPER TEST

MATERIALS REQUIRED

3 specimens of polyethylene coated paper required to be cut with measurements of 10cm in length and 10cm in breadth and 60 grammage of paper and polyethylene 30 grammage. As equipment we need a weighing machine for the weighing test for polyethylene coated paper.

PROCEDURE

1.For the polyethylene coated paper test, we need to cut the paper into respected shape and size. Here we are planning to cut the polyethylene coated paper into 3 rectangular sheets.

2.While we are experimenting we need the material for experiment so, I have taken 60 grams of paper and polyethylene 30 grams combined as a coated paper. 15cm and 0.8cm.

3. Now after cutting we need to take the weight of paper that is going to be tested.

4.After weighing keep it a side and do the same weighing process for another 2 times so totally we are planning to perform test on 3 specimens. After weighing all the three specimens, heat some water and take in any container.

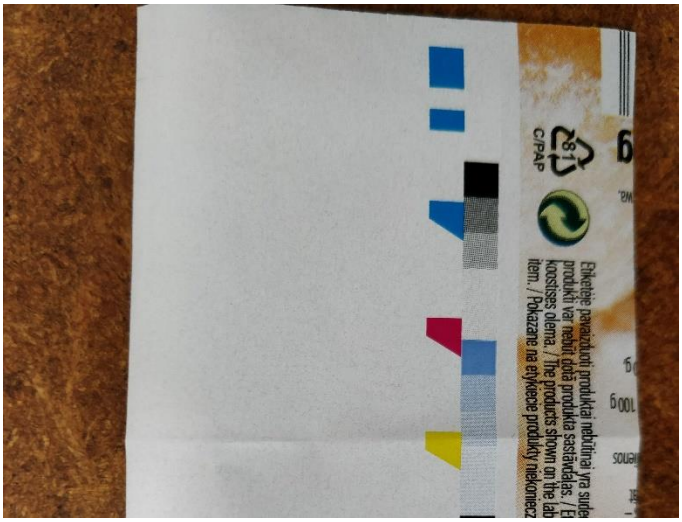


Fig.3.1. PE coated paper cut into square pieces with 10cm length and 10cm width.

5. The temperature of the water is negligible but not too hot, now place these three sheets of paper or specimens in the heated water container and leave it overnight. Need not to close the lid of the container can be allowed to atmosphere.

6. On the next day we can easily see the paper coming out from the polyethylene. This is because the paper got totally melted or torn leaving the polyethylene.

7. So now we need to remove the upper layer of the polyethylene sheet by placing the specimen on any soft surface and rub gently and slowly until you can see no paper on the polyethylene. We need to rub and wipe it with water and cloth to totally remove all the excess material and this is important because we need to weigh down the polyethylene layer.

Fig.3.2. Polyethylene cover after removal of paper10cm ×10cm

8. After we remove all the excess material, the polyethylene layer will look like the above figure.

10. So, the test of polyethylene ends by taking down the values of the remaining layer of the polyethylene.

9. Take down the values and compare them for results.

10. Likewise, we need to take the values for all the three specimens. The results can be noted down according to the table as shown in results.

11. While weighing, care should be taken to place the material in the center of the weighing machine pad and gently close the door of the apparatus by not disturbing the specimen. (5)

3.2. THERMAL GLUING TEST

MATERIALS REQUIRED

We need 2 specimens that are needing to be cut at 10cm in length and 0.8cm in width. Here we need a small weighing solid bar to press the seal. The below is the picture for specimens to test.

Fig.3.3. Polyethylene coated paper measured at 10cm in length and 0.8cm in breadth

In this experiment the main concept is to glue the specimens with the help of any hard stamper may be iron or any other hard and plain surface material. Here we have two main parts.

1. CONTROLLER

2. ALUMINIUM PAD (WITH HETAED COIL INSIDE)

1. CONTROLLER

The controller is used to control and display the values related to the experiment. Here we can see from the below figure the display is showing the temperature that we have set for the experiment.

We have some set of parts that are to be explained they are:

These are all the main parts that are stated below in the figure and will be explained in the below process.

Fig.3.4. Controller box

1. Controller 2. Display 3. Temperature display 4. Temperature increasing button 5. Temperature decreasing button 6. Mode button 7. Main switch.

The explanation of the above stated terms:

1. CONTROLLER

As I have explained earlier this will act as the main controller of the experiment. There are many other parts on this controller which are explained below.

2. DISPLAY

The display is used to display the preset temperature. There are certain temperatures we require, to complete out experiment.

3. TEMPERATURE DISPLAY

Here we can see that when we set certain temperature it will slowly increase as the heating coil or material will get heated and the temperature is shown on this display.

4. TEMPERATURE INCREASING BUTTON

This button is used to increase the temperature, as I have explained earlier when we want to increase the temperature we need to access this button and we can increase the temperature.

5. TEMPERATURE DECREASING BUTTON

The name itself says that we can decrease or reduce the temperature of the heated aluminum surface.

6. MODE BUTTON

This button is used to access all the display settings. If we want to increase or decrease temperatures we must set by using this button, then we can increase or decrease the temperature.

7. MAIN SWITCH

This is used to on or off the whole system. This is for the total equipment the main control button.(5)

2. ALUMINIUM PAD (WITH HEATED COIL INSIDE)

This also the main component in this experiment. Here we work with help of controller by increasing or decreasing the temperature as we do that the heating material or coil inside this aluminum surface will get heated and we are able to do the experiment.

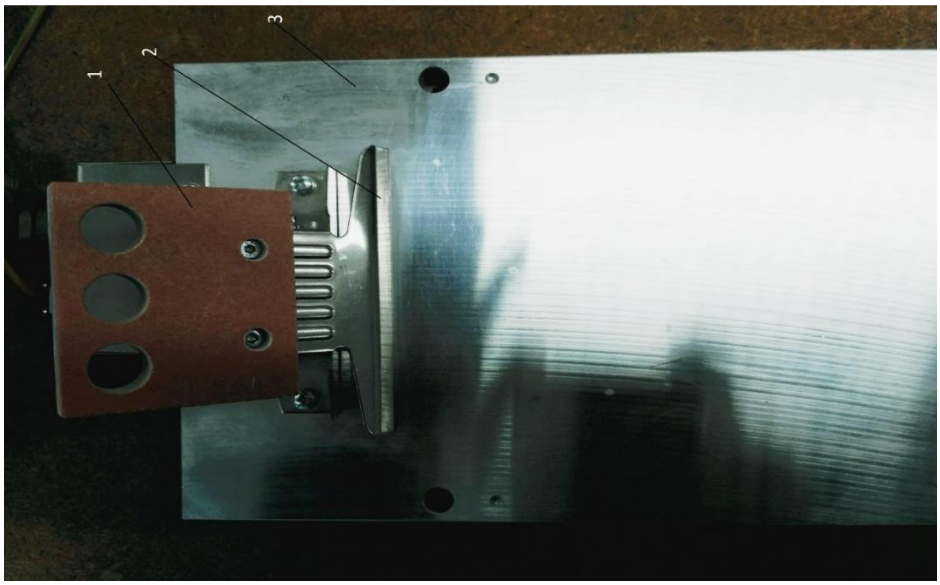


Fig.3.5. Aluminum plain surface with heated coil or material inside.

1. Non-heated material 2. Holder 3. Aluminum surface

There are 3 main parts for this aluminum surface, they are.

1. NON-HEATED MATERIAL

This a hard marble like material where it won't transfer any kind of heat through it. This is very useful because for the safety of our hands while experimenting.

2. HOLDER

The holder is used to hold the specimen while experiment of gluing.

3. ALUMINUM SURFACE

Under this surface there is a heating coil where it gets heated by the increase in temperature. The specimen will be placed on this surface and will be pressed by any hard metal or material to glue the specimen.(5)

PROCESS OF THE EXPERIMENT

1. In this experiment the main concept is to glue the specimens with the help of any hard stamper may be iron or any other hard and plain surface material. The polyethylene film will be placed on the hot plain surface of the machine.
2. In this experiment we are taking three different temperatures before starting the experiment we need to set the temperature to 3 different Temperature's. The Temperatures are 120 -130-140°.
3. Initially we are testing on 120°c temperature followed by 130 and 140. So, we must increase the temperature by using the increasing button and set the temperature to 120°c. After we set the temperature we need to wait till the aluminum surface gets heated.
4. After the surface got heated we must place the specimen and test. So first we need to take the 120 °temperature and start the test by pressing the start button and we must wait until the machine gets heated and we can see the temperature reading of the heat on the upper reading area.
5. when it shows 120°c we can start the test by placing the specimen on the plain hot surface of the gluing machine and press with any hard and plain surfaced equipment.
6. After pressing wait for 2secs and then we must remove the specimen and check whether it got glued correctly or not because with the same specimens we must conduct the peeling test to check the gluing capacity of the experiment.
7. So, in the same way we must conduct the test with more 6 specimens and check in the same way we done for the first specimen. Here we are conducting the experiment on 6 or 7specimens. And note down with the marker after every seal is done.
8. Next, we must perform the same experiment on 130°c and 140 ° temperature's too and note down the time as 2secs. Care must to taken while experimenting by not touching the hot surface with plain hands. While gluing we can stick the ends of two specimens just to avoid incorrect gluing or to reduce specimen misplacement.
9. After completion of all the specimens we need to write the specimens temperature on them and the numbers for specimen just to not get confused while experimenting.

10. Care should be taken while experimenting, wear gloves to hands to get rid of burns while experimenting. Initial set up should need some qualified personnel or manual. (5)

3.3. LAMINATED GLUING TEST

As we have conducted the gluing test on thermal gluing machine we have another gluing test also and this is called laminated gluing machine. Here as in the before process we are performing the test on 3 different Temperature's with 6 or 7 pair of specimens.

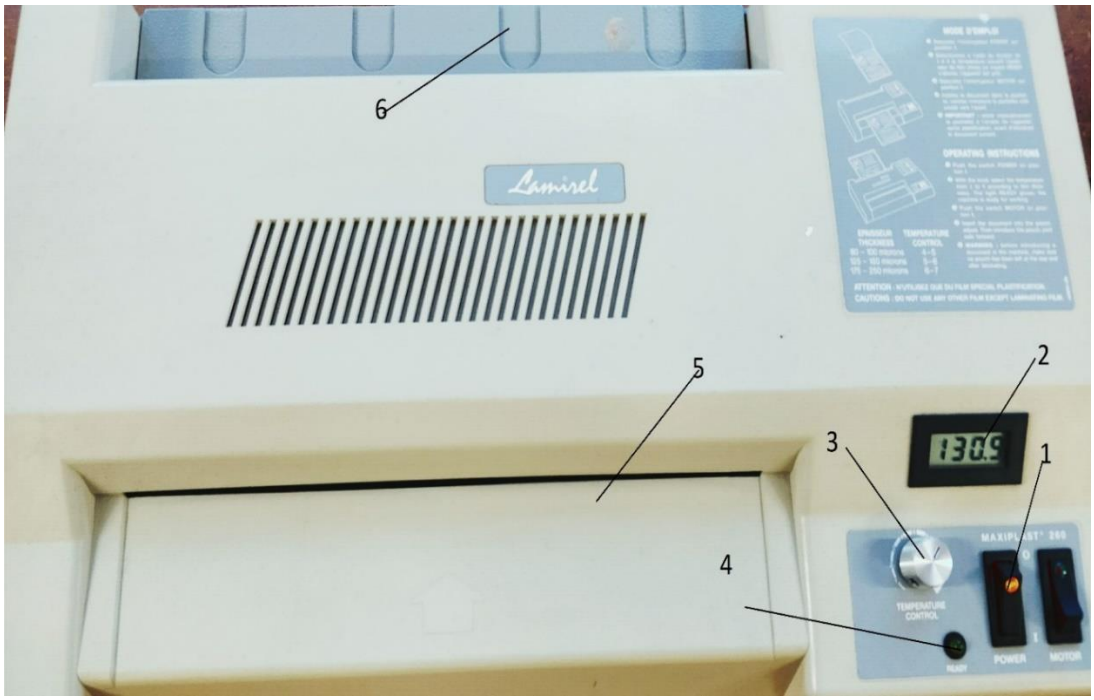


Fig.3.6. Laminated gluing machine

1. Power 2. Display 3. Temperature control 4. LED indicator 5. Laminated seal input
6. Laminated seal output 7. Motor

As we wrote for the above experiment here also we have some main features for the laminated gluing machine. They are:

1. POWER

We know this power button is to ON or OFF the whole experimenting process.

2. DISPLAY

The display will show the temperature that we set while doing the experiment. Either decrease or increase.

3. TEMPERATURE CONTROL

This is to control the temperature that we need. We can use this for either increase or decrease.

4. LED INDICATOR

This helps in showing weather the machine is in ON position or OFF position. If its green, we can say it's ready for doing the experiment or if it is red it is in off position.

5. LAMINATED SEAL INPUT

Here this is the place where we need to place the specimen. When we insert the specimen, it will slowly roll inside the rollers and get sealed at certain temperature we had set before the experiment.

6. LAMINATED SEAL OUTPUT

Here the specimen that is placed near the laminated seal input can be collected at any of the slots provided. That's why it's called output or we can say the result.

7. MOTOR

Here we have motor where we need to switch it on or to position I and can start the process of working.(5)

PROCESS OF THE EXPERIMENT

1. Push the power button on position I

2. With the temperature control select the temperature from 1 to 9 according to the film thickness. The light READY glows. The machine is ready for working. While its ready we can make our specimen's cut and ready for experiment.

3. Before pushing the switch MOTOR in on position, we must stick the both ends with any tape or small sticker.

4. After we stick them together we need to place a non-sticking material in-between the two polyethylene coated paper sheets.

5. Insert the specimen into the pouch where we call it as laminated seal input and adjust it to correctly placed into the machine having rollers inside. Then introduce the pouch, joint forward side.

6. After inserting we need to carefully collect the output from the other side of the laminated pouch. We have 4 columns, so we can collect exactly at the opposite direction of the input.

7. After inserting we must wait until the glued specimen comes out. We should not push or pull the specimen while gluing.

8. After the specimen is perfectly done the seal we need to do the same process for 2 more specimens.

9. In this experiment I am experimenting with 120, 130, 140°c temperatures. And with 3 specimens each. If one temperature is done, we need to increase the temperature to 130°c and again perform the same experiment in the same process.

10. Before introducing the document in the machine make sure no pouch has been left at the rear end after laminating.

11. When we experiment we must insert only laminating film. We cannot insert any other film.

Temperature control	Thickness
4-5	80 - 100 microns
5-6	125 -150 microns
6-7	175 - 250 microns

3.4. FRICTIONAL PEEL TESTER FOR THERMAL AND LAMINATED TEST RESULTS

MATERIALS REQUIRED

Polyethylene coated paper sealed from the thermal and laminated gluing machines. And load is used here to to apply loads to find the strength.

The peel tester is used to test the seal specimens under laminated or thermal gluing processes. Here we describe certain main components of the peeling machine.

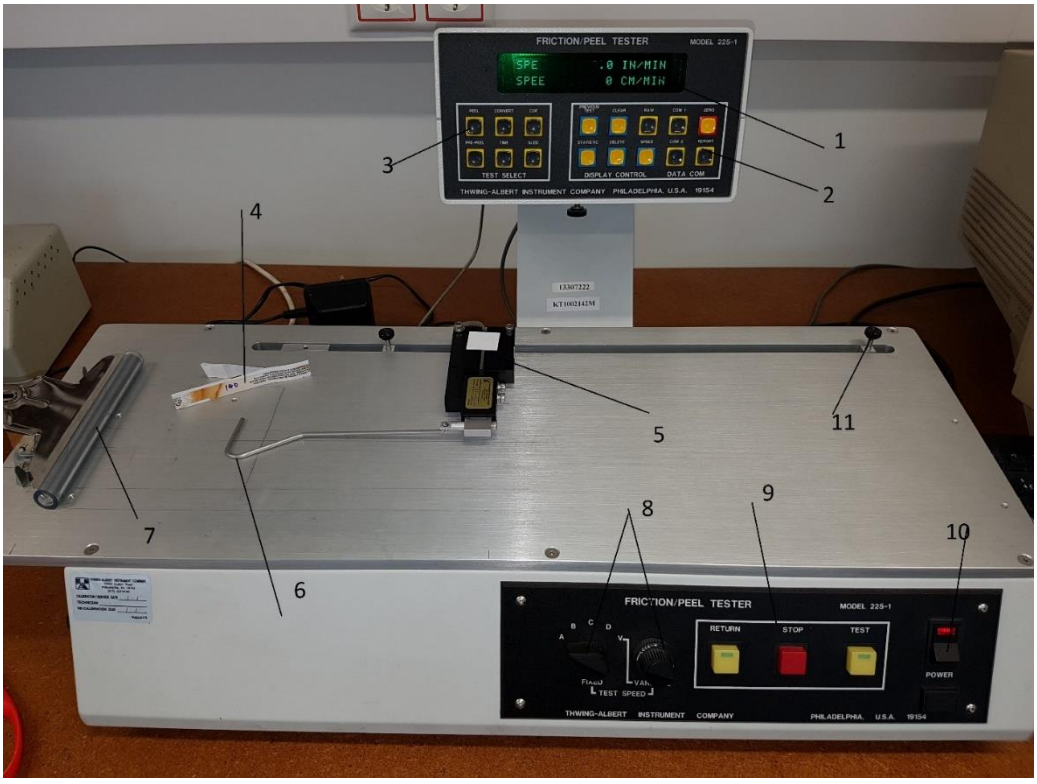


Fig.3.7. Frictional peel tester

1. Output screen 2. Display control button's 3. Test select 4. Specimen 5. pully

6. Aluminium metal probe or clamp 7. holder 8. Speed tester 9. Main controllers 10. power

11. Fixers

Below all the stated controls will be explained.

1. OUTPUT SCREEN

The output screen shows the values that we preset for the following peeling test about the speed, time, weight, etc.

2. DISPLAY CONTROL BUTTON'S

The control buttons are used to control the ongoing peeling test. These are used to control the peeling test that to be carried. There are buttons for:

1. Previous test
2. Clear
3. Raw
4. Statistic
5. Delete
6. Speed
7. Zero
8. Report

3. TEST SELECT

The test select is used to select which test we are using so we need to press peel test on the area button. And we have pre-peel where we must select the time for pre -peel.

4. SPECIMEN

Here we can see the specimen where the polyethylene coated paper is glued and ready for the peel test.

5. PULLY

Here the pully is used to help the probe or aluminum metal to peel the specimen.

6. ALUMINIUM METAL PROBE OR CLAMP

This is used to pull the specimen where one end is rolled for the specimen and attached to the probe to pull for the peel test.

The specimen will be folded for the clamp to get grip while experimenting.

The load cell then will start the test for the readings that are utilized in the investigation. The maximum capacity it can withstand is 500gm.

With these readings the same experiment will be done for both laminated and thermal gluing tests.

7. HOLDER

The holder is used to hold the other end of the specimen because not to slide when the peeling test is going on. We can also hold with a finger while the test just to reduce any sliding friction.

8. SPEED TESTER

Here the speed tester is used to control or adjust the speed of the peeling test. We have two main testers here.

1. FIXED where the speed is adjusted and will be fixed throughout the test.

2. VARIED where the speed can be increased or decreased for the test.

9. MAIN CONTROLLERS

There are the main control buttons where we will use to control the peeling test, we have 3 control buttons for three different tasks.

1. RETURN- this button is used to return the pully to its original position.
2. STOP- this button helps in stopping the test.
3. TEST- where we all know this is used to test.

10. POWER

The power button is used to on or off the peeling machine.

11. FIXERS

The main purpose of these fixers is to tighten or fix the position of the pully before test(5)

PROCESS

1. This is the test for knowing the gluing capacity of the thermal gluing machine, and laminated gluing machine. Here we need to start the peeling test by hooking one end of the glued specimen to the clip side just to provide some grip while peeling.

2. For hooking we must stick the material with some glue just to provide some grip to connect with the pulley cable.

3. Initially we must set the position of the pully to zero. Then we must set the time to 30 secs and weight in Newtons.

4. Everything what we are feeding, or inputting will be displayed on the screen which is also called the display screen. And these inputs are given by display control buttons.

5. Before we input the values for the test we need to select the test and press the button to peel test near the test buttons. We have per- peel also in this area. The pre- peel is the time taken in between the peeing tests carried on different specimens.

6. After we select everything we need to make test the specimen, for this we must make a fold for the grip of the probe or clam.

Fig.3.8. The specimen attached to the clamp for the test.

7.So, this the load cell with capacity 500-gms. So, will be connected to the clamp, where everything for the test is initially loaded. The other end of the clamp is connected to the pully motor where it will pull the specimen and peel the specimen.

8. While the peeling starts we need to keep one hand on the holder just to reduce any sliding friction. For starting the test, we must press the TEST button the main area. To stop we must press the STOP button.

9. After the completion of peeling we need to press the RETURN button so set the pully to its original position and ready for the next test.

10. The adjustments for the pully can be made and can be tightened by the fixers near the pully on either side.

11. This machine will be connected to the computer software where it will automatically draw the readings and graphs which are obviously the results.

12. Here we can select all the data that we need like time, load, speed units, per-peel, test type etc. the results will be in the form of test files where we use these test files for drawing graphs and compare with the other test results.

4. EXPERIMENTAL RESULTS

4.1. RESULTS FOR THE POLYETHYLENE COATED PAPER TEST

Below are the results for the polyethylene test before and after the water soaking test. The results shown below are taken for 3 different specimens for about 2 times just to check the difference in deflection of the weights.

TABLE BEFORE POLYETHYLENE TEST:

No.	WEIGHT OF FIRST READING		
1.	FOR SPECIMEN 1 0.909g	FOR SPECIMEN 2 0.912g	FOR SPECIMEN 3 0.931g
	WEIGHT OF SECOND READING		
2.	FOR SPECIMEN 1 0.910g	FOR SPECIMEN 2 0.912g	FOR SPECIMEN 3 0.933g

Table.4.1. Before polyethylene test

TABLE AFTER POLYETHYLENE TEST:

No.	WEIGHT OF FIRST READING		
1.	FOR SPECIMEN 1 0.302	FOR SPECIMEN 2 0.300g	FOR SPECIMEN 3 0.299g
	WEIGHT OF SECOND READING		
2.	FOR SPECIMEN 1 0.302g	FOR SPECIMEN 2 0.300g	FOR SPECIMEN 3 0.299g

Table.4.2. After polyethylene test

From the results we can easily say that in the first readings when we test for whole paper we can see there is small deflection in the readings. And the readings after the experiment are way less than the 1st readings because we are left only with polyethylene so, the value or weight decreased showing the loss in weight.

4.2 RESULTS FOR THE LAMINATED AND THERMAL SEAL EXPERIMENTS.

The result of the experiment is shown in specimens as below:

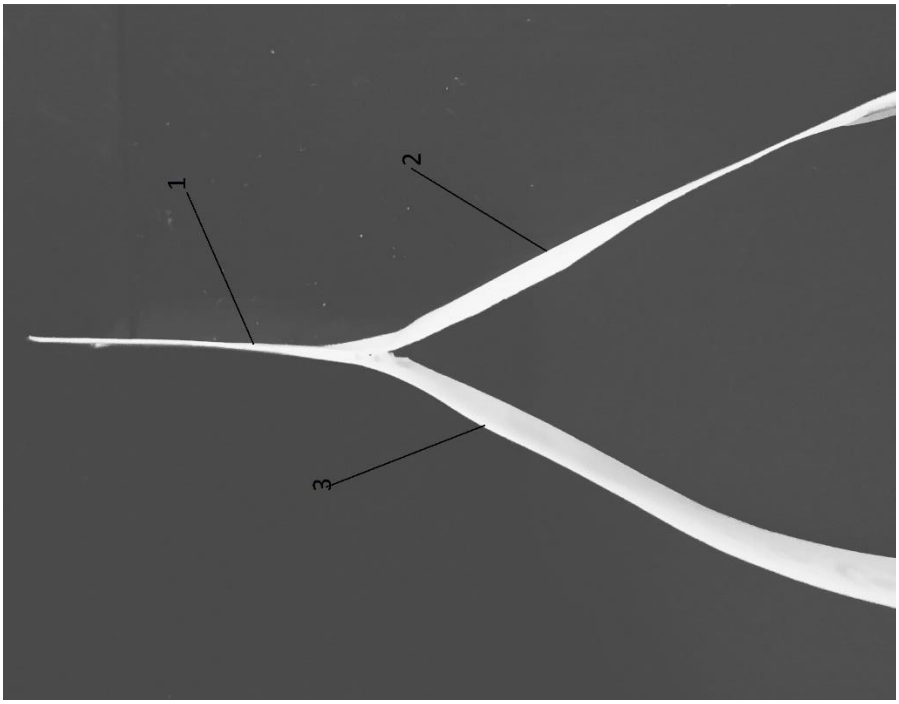


Figure.4.1. Result of the gluing test.

1. Seal of the 2 specimens that are tested in thermal and laminated seal experiments. 2 and 3 are the polyethylene coated paper sheets specimens that are cut to test the seal strength of the coated paper.

1. The result of the gluing the two specimens were glued, and the ends are left free because we need only one side of the specimens to be glued and the other side is used to check the peeling test.

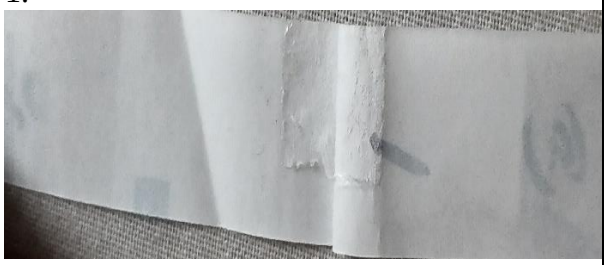
2. Single polyethylene coated paper

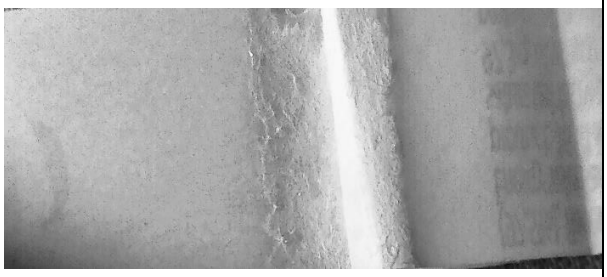
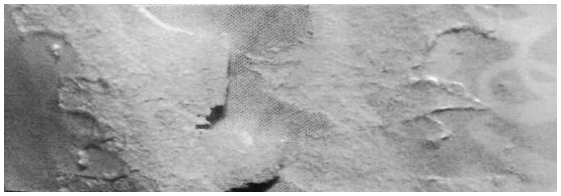
3. Second sheet of specimen.

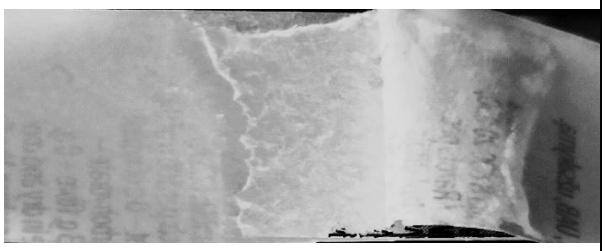
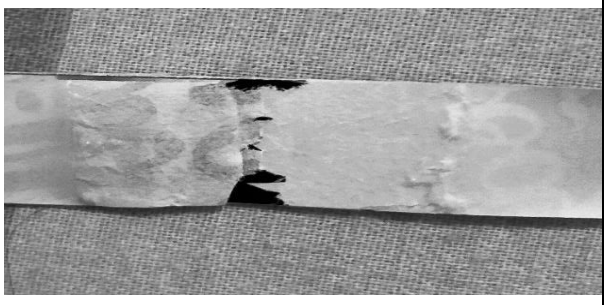
So that's the end of the experiment of thermal gluing machine on polyethylene coated paper.

For both the tests are result of the seal is same but the strength is different and varied in these two experiments for all the temperatures and specimens.
While doing the experiment the specimens may vary in seal strength so be careful while sealing them at different temperatures.

4.3. TABLE FOR PEELING RESULTS OF THERMAL GLUING TESTAND LAMINATED GLUING TEST

Temperature in °c	THERMAL GLUING TEST SPECIMEN'S	Pealing type	Max. force n/s	Avg. force mm/s
120°c	1. 	ADHESIVE PEEL	1.786	0.198
	2. 	ADHESIVE PEEL	0.557	0.097
	3. 	ADHESIVE PEEL	1.575	0.374
	1. 	COHESIVE	5.002	1.404

130°c	2.  3. 	COHESIVE MATERIAL DELAMINATION	6.639 5.477	1.403 1.861
140°c	1.  2.  3. 	COHESIVE BREAK DELAMINATION	5.087 6.098 5.351	2.320 2.257 2.556

TEMPERAT -URE in °c	LAMINATING MACHINE SPECIMEN'S	Peeling type	Max. force	Avg. force
120°c	1. 	BREAK	5.929	1.837
	2. 	COHESIVE	7.781	3.658
	3. 	COHESIVE	6.974	4.597
130°c	1. 	COHESIVE-BREAK	6.921	4.136

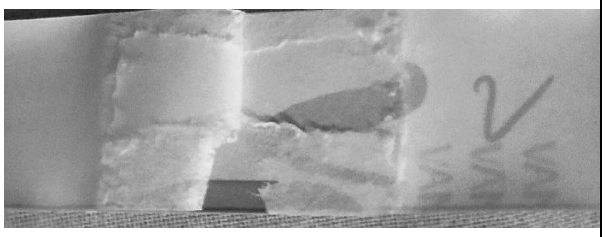
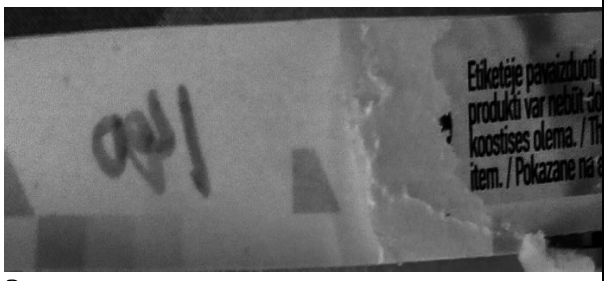
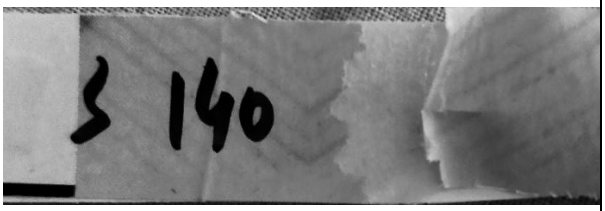
	2. 	COHESIVE	7.786	2.766
	3. 	BREAK	7.620	1.844
140°c	1. 	COHESIVE - BREAK	4.368	1.194
	2. 	COHESIVE	6.310	3.128
	3. 	BREAK	4.299	0.936

Table.4.3. Tables for Thermal and Laminated specimens after peeling test

4.4. PEELING TYPES BASED ON THE RESULTS OF PEELING TESTER

1. ADHESIVE

From the above figures we can easily say that in this type of peel only the seal will be failure and the type is adhesive. From the figure we can see that the seal was only peeled a little and the material is good enough because of the strength in pulling. To get the material it should be a hard seal of greater temperature.

2. COHESIVE

In this type of peel, the material will get damaged from the figure we can see the seal material of one specimen is attached by failure and attached to the other specimen resulting is failure of material and this type of failure is called cohesive peeling.

3. DELAMINATION

We have also some delamination type of peels, from the figures we can see clearly the seal layer is torn and attached to the substrate layer of the other specimen. Here the material will get failed and the failure type is delamination.

4. BREAK

As we all know that break means the failure of the material. Here from the picture we can see clearly that the material of the specimen got broken at the seal place of peeling. It's the last point of the peeling from there maybe it will elongate or break at the very end of the peel. So, this kind of failure of material is known as break.

5. BREAK OR TEAR

In this type of peel, the specimen will be sealed at high temperatures, so here while we apply some weight or force when we peel the material wont peel and that results in breaking of the material at the point of grip of the clamp where it was stick to the clamp to start peel. So, this type of material failure is known as break or tear failure peel.

6. ELONGATION

At temperatures like 130°c or 140 or 150 or more the peel will not start even though we apply some weight on it. So, then this kind of failure occurs when the seal is too hard and the material will be enlarged and will not be broken peeled.

7. SEAL-ELONGATION

Here in this type of peels its same as the upper peel section. The only difference is that here the seal will be enlarged and along with the material. So here also there will be no broken peel. This type of failure mode is known as the seal-elongation peeling.

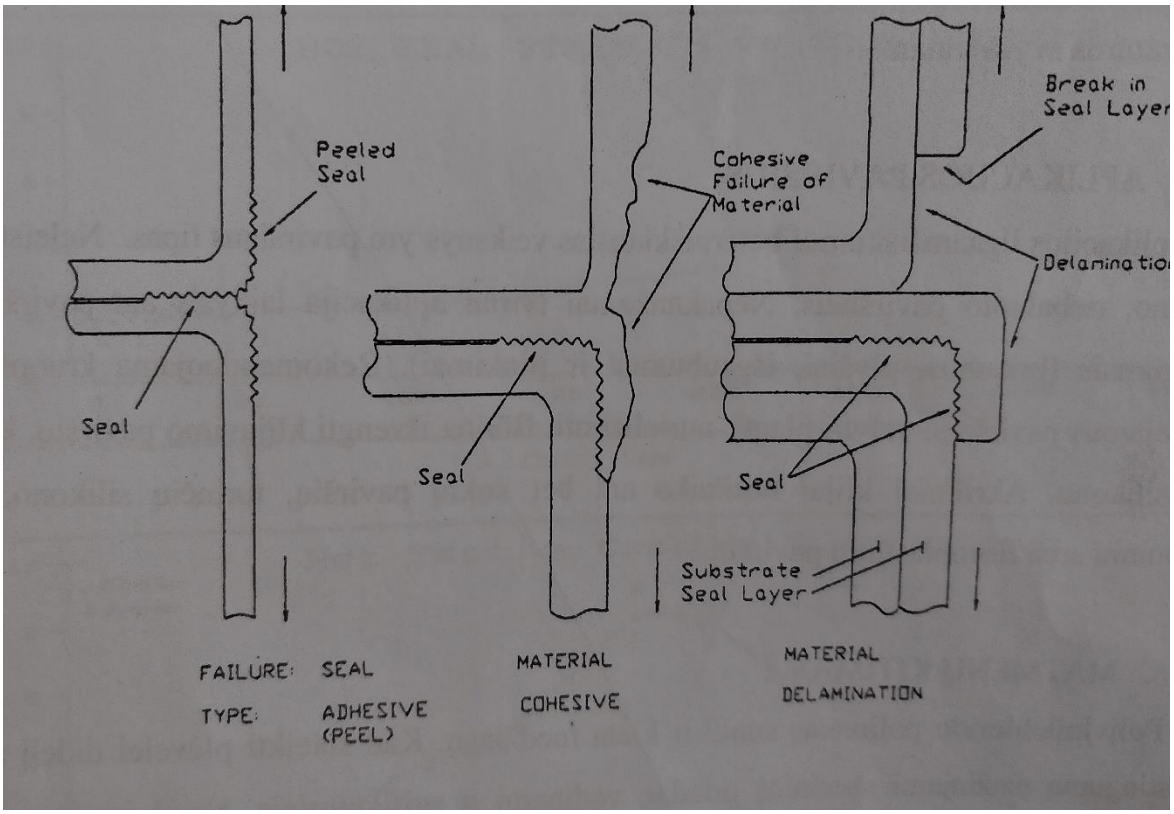


Figure.4.2. Peel test failure modes A, B, C

From the above fig.19. we A, B, C describes the adhesive peel, cohesive peel, and delamination.

As we see that I have earlier explained each stage of section how it peels. And, we have 4more types of peelings that are below.(5)

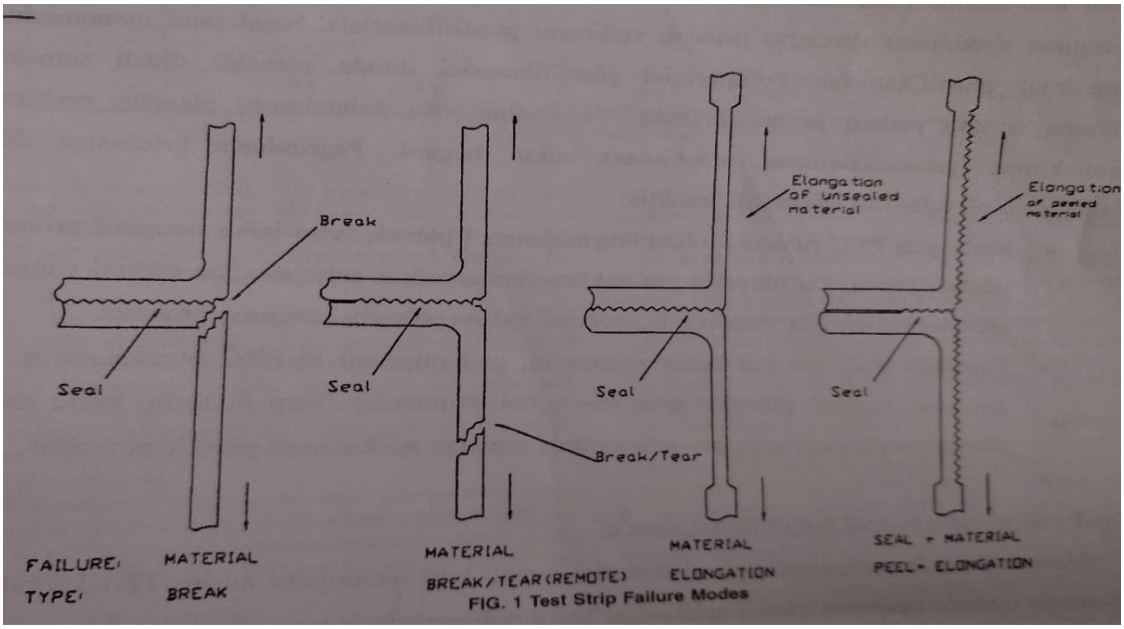


Figure.4.3. Peel test failure modes D, E, F, G

So, as we see here these are the peelings of D, E, F, G.

Describes the Break, Break/Tear, Elongation, Seal-Elongation.

HAND MICROSCOPE

There is also some other visual inspection done on the peelings with the hand microscope.

Here in this experiment we are using a hand microscope where we must clearly take the peeling stage of the specimens. We need to set the focus by certain reading and take the pictures by placing it on the black surface.

Figure.4.4. Hand microscope

Here with this microscope after the peel test we will capture some pictures and we will investigate with the hand microscope with the help of software called DINO CAPTURE- 2.0. This is the software where we will use to inspect the peels that we experimented.

DINO CAPRTURE is a versatile hand microscope specially built for the convince of the experts to take the pictures easily with high precision and every detail can be seen exactly and can be investigated. So, below are the pictures that are taken with the hand microscope after the Thermal and Laminated peel tests.

After doing the peel test from the seal obtained from thermal and laminated seals we will the take pictures which are further needing to be investigated to find the exact breakage of the specimens. So, we can easily find out which type of damage or elimination have the specimen taken place.(5)

4.5. LAMINATED SEALING MICROSCOPIC IMAGES FROM PEELING TEST

We have captured pictures for Thermal Gluing test the pictures are below.

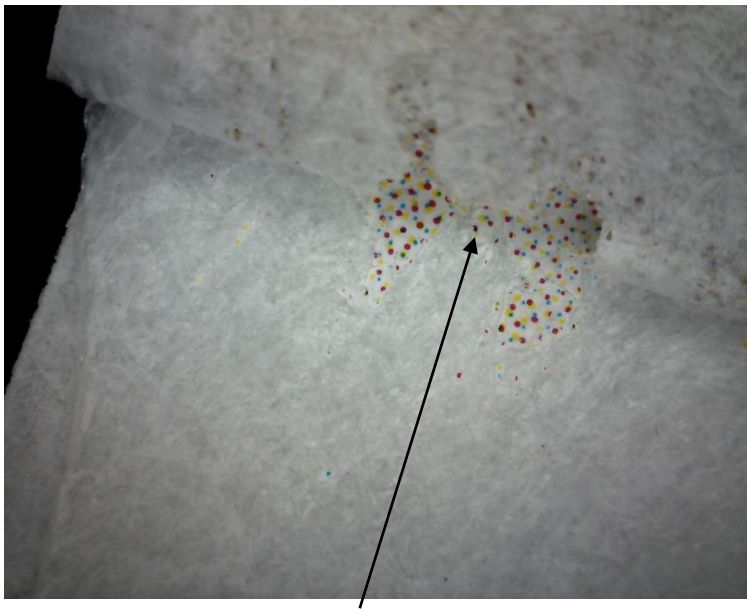


Figure.4.5. Break or cohesive failure mode.

In this picture we can see the material got peeled and about to break so can be written as break or cohesive failure mode because as we described earlier break means completely broken out from the fellow specimen.

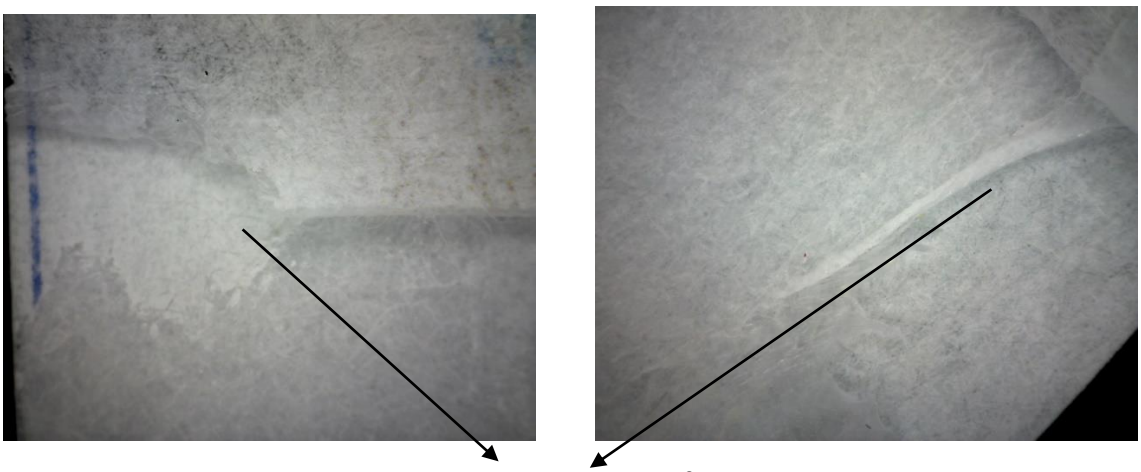


Figure.4.6. Failure mode of Delamination

In the same way we have another failure mode like the above figure here this mode is known as delamination as the seal got torn and broken attached to the other specimen.

The below failure mode is known as Break. Here the whole material got broken and from the seal this happens and high temperatures usually as I have tested under 140°c.

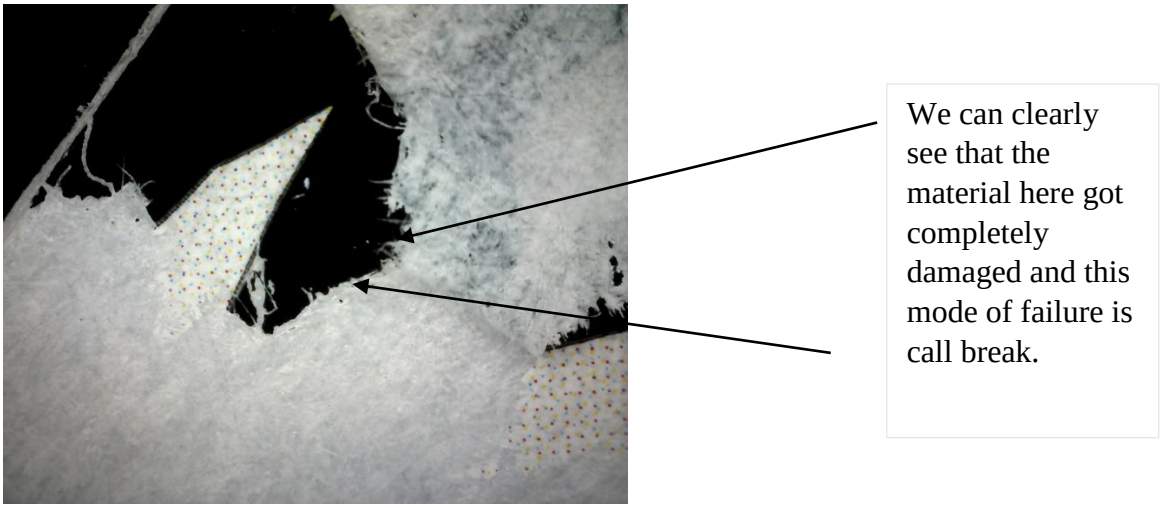


Figure.4.7. Failure mode of Break

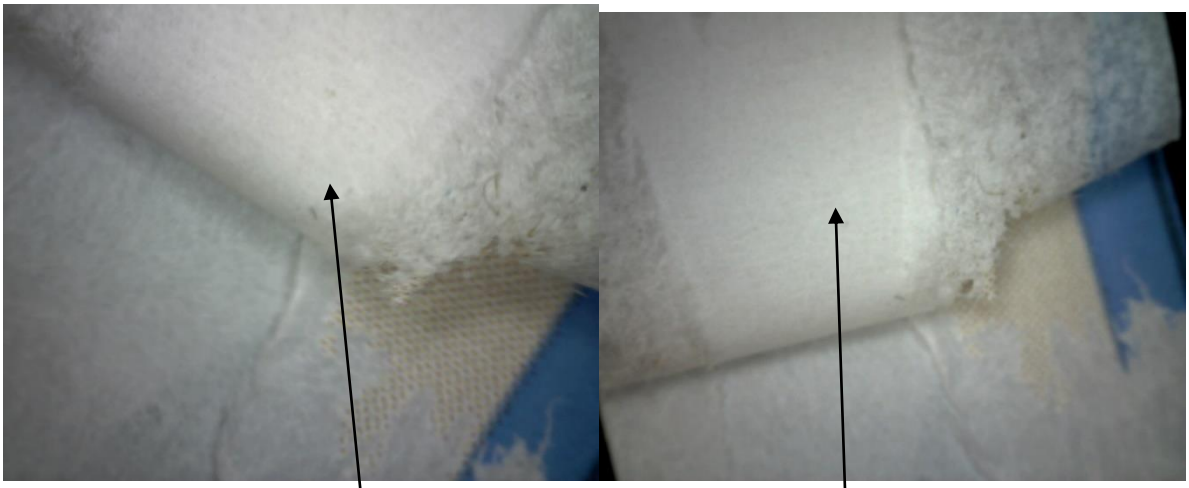


Figure.4.8. Failure mode of Cohesive.

Here the material got peeled and attached to the other specimen usually at 130°c and 140°c

So, when at temperatures of specimen test undergo 130°c the specimens will definitely lose their material and will get attached to the other specimen where we call the failure mode as cohesive tape of failure.

The below figure explains the failure mode of Break or Tear type of failure mode.

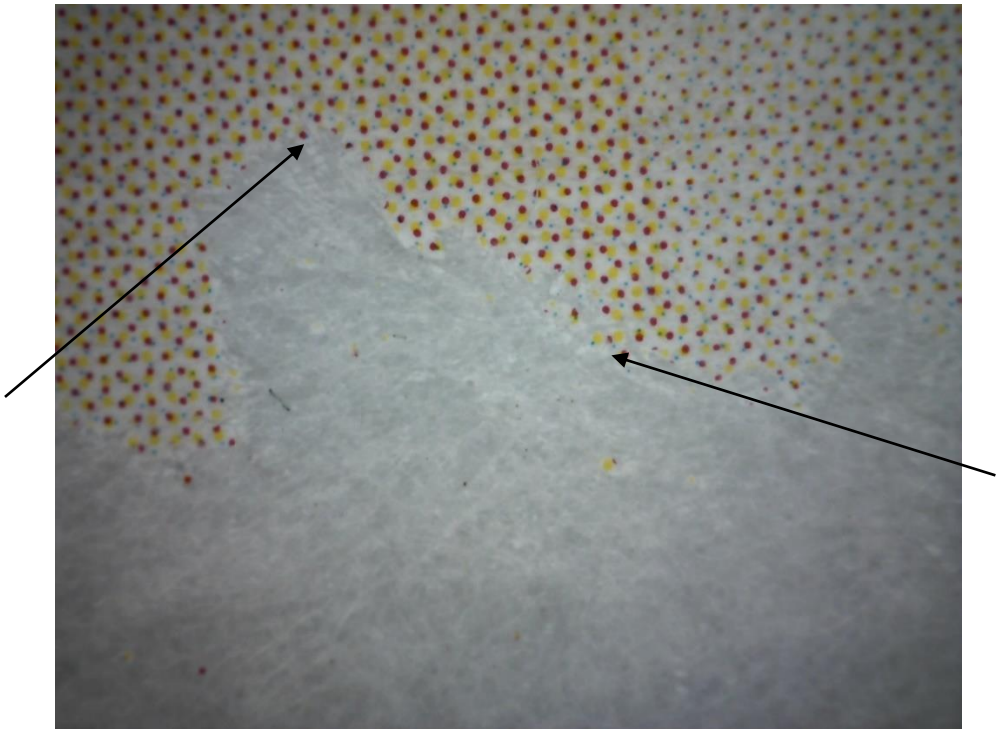


Figure.4.9. Failure mode of Break or Tear.

Here the above failure mode is same as the break mode where here it will either break or tear into pieces this type of failure mode occurs when high temperatures occur and the seal strength is high.

Usually theses specimens will get torn first when weight applied if the weight exceeds then the failure mode break will occur.(5)

4.6. THERMAL SEALING MICROSCOPIC IMAGES

1. ADHESIVE TYPE FAILURE MODE

This type of failure usually occurs when in less temperature because the seal is not that hard to get peeled. So, adhesive type failure modes occur in 120°c usually.

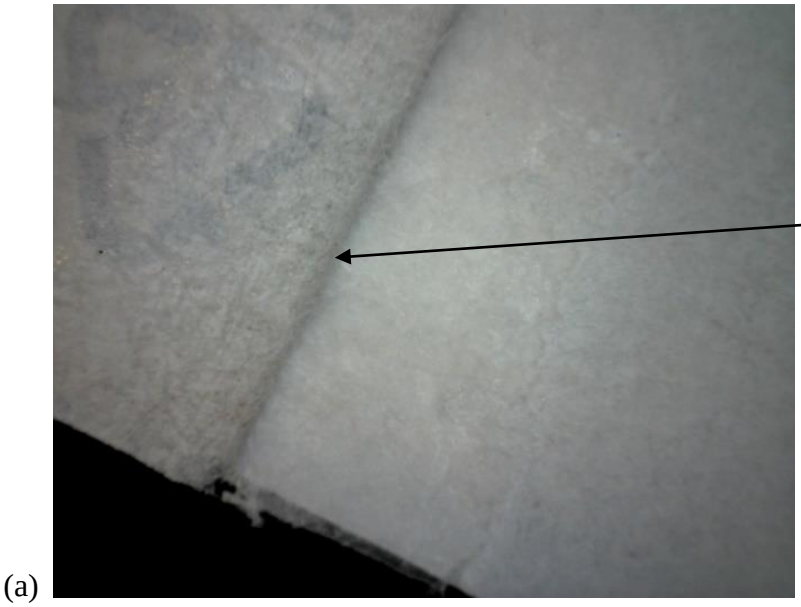
(a)

(b)

Figure.4.10. Failure type of Adhesive.

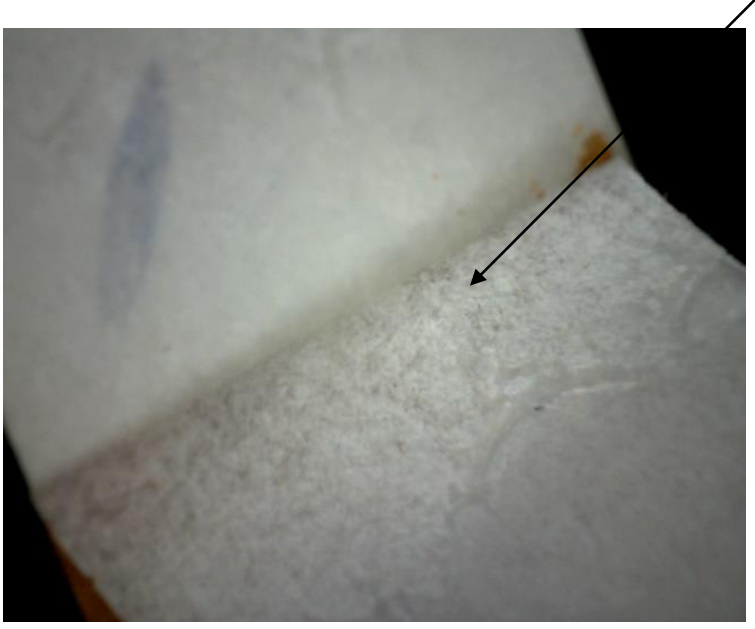
So, in this type adhesive failure type tells that the seal me peeled but no elongation or break. Happens usually at temperatures 120°c.

2. COHESIVE TYPE FAILURE MODE



(a)

Usually we found that in laminated seals in 130°c temperatures the failure mode is break or tear but in thermal out is cohesive where a small rupture or elimination



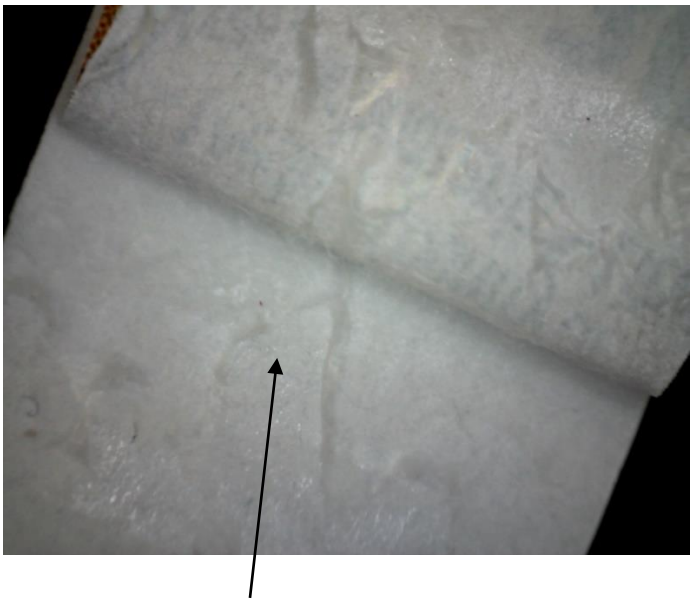
(b)

Figure.4.11. Cohesive failure mode.

This type of cohesive occurs at 130°c in thermal gluing test. Here the material will be failure mode where it leaves the polyethylene cover from the paper. And this failure mode is called cohesive failure mode.

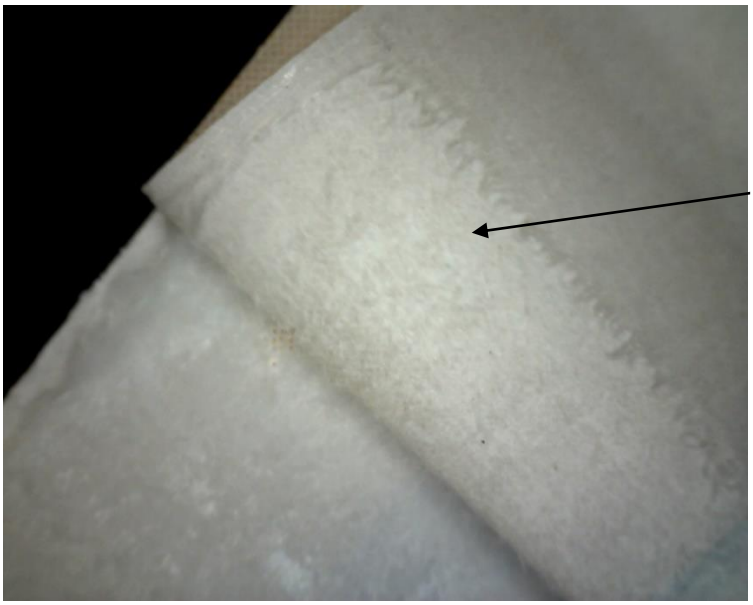
3. DELAMINATION TYPE OF FAILURE MODE

(a)



Here we can clearly see the material of the seal got torn and got stuck to the other specimen

(b)



Here also the same as above the material got stick to the other material.

Figure.4.12. Delamination type of failure mode.

As I have explained before here the delamination means the material will be eliminated from the specimen. And this will stick to the other co-specimen.

4.7. GRAPHICAL RESULTS OF PEELING TEST

1.FOR THE LAMINATED GLUING TEST,

1. At 140°c for laminated gluing test.

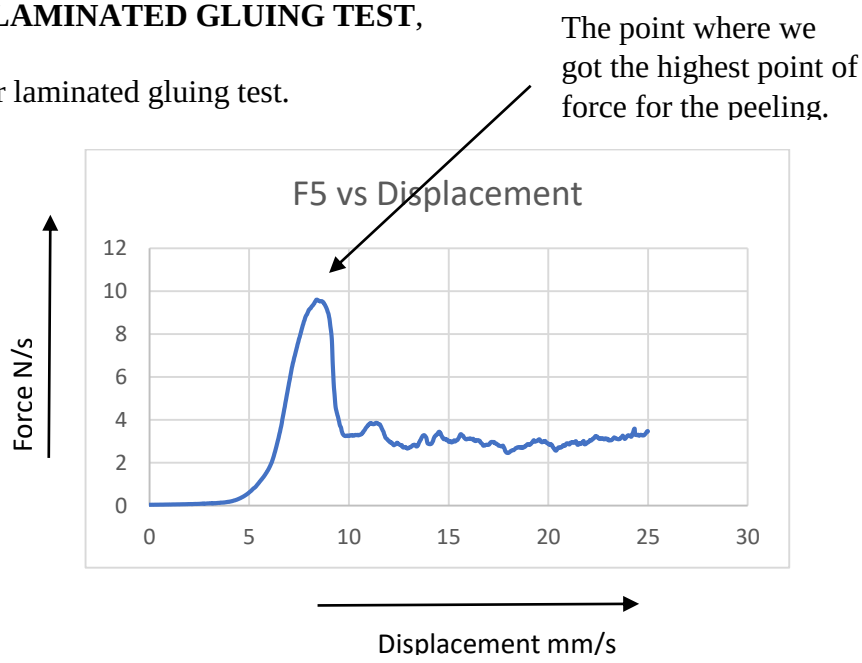


Figure.4.13. Force 5 vs displacement at 140 degrees

From the forces that we got for the 140°c for laminated test results, at the average displacement of 25mm/s, the force 5 have got the highest peel strength. As we can see the load applied on it helps is investigating the seal strength of a seal.

2. At 130°c for laminated gluing test.

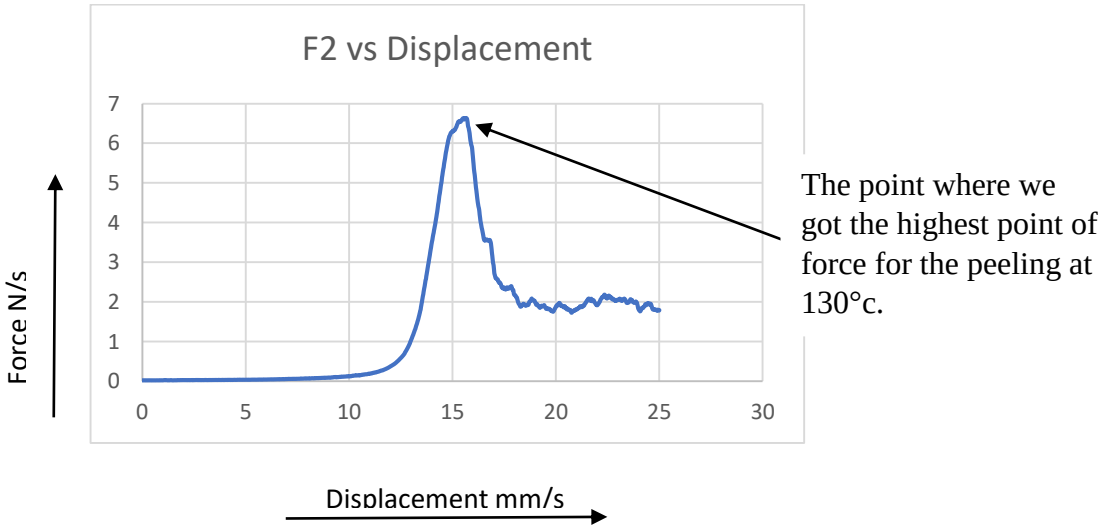


Figure.4.14. Force 2 vs displacement at 130 degrees

From the forces that we got for the 130°c for laminated test results, at the average displacement of 25mm/s, the force 2 have got the best peel strength.

For laminated gluing even at 130°c temperature also the seal strength is good compared to the thermal gluing results displayed below.

3. At 120°c for laminated gluing test.

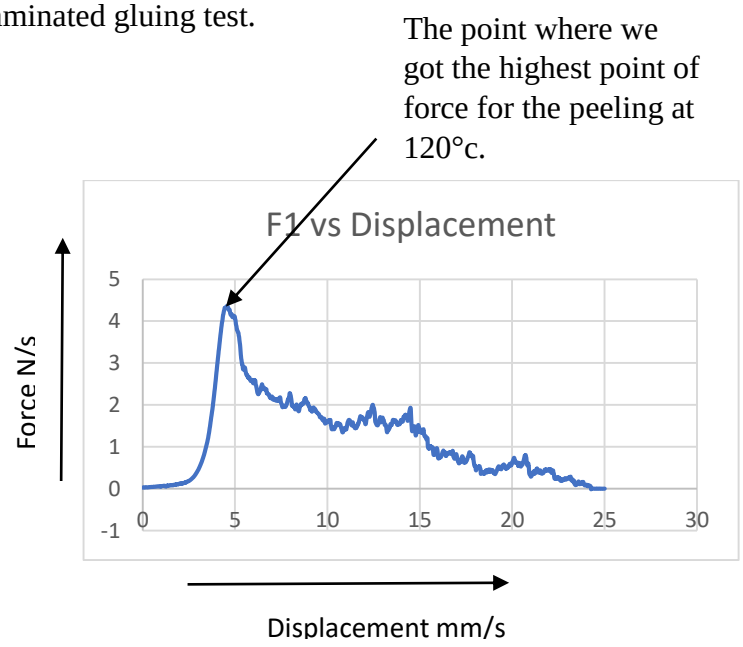


Figure.4.15. Force 1 vs displacement at 120°c

From the forces that we got for the 120°c for laminated test results, at the average displacement of 25mm/s, the force 1 have got the best peel strength.

So, with same average displacement we are getting different peel strengths at 120°c, 130°c and 140°c temperature.

2. FOR THE THERMAL GLUING TEST

1. At 140°c for thermal gluing test

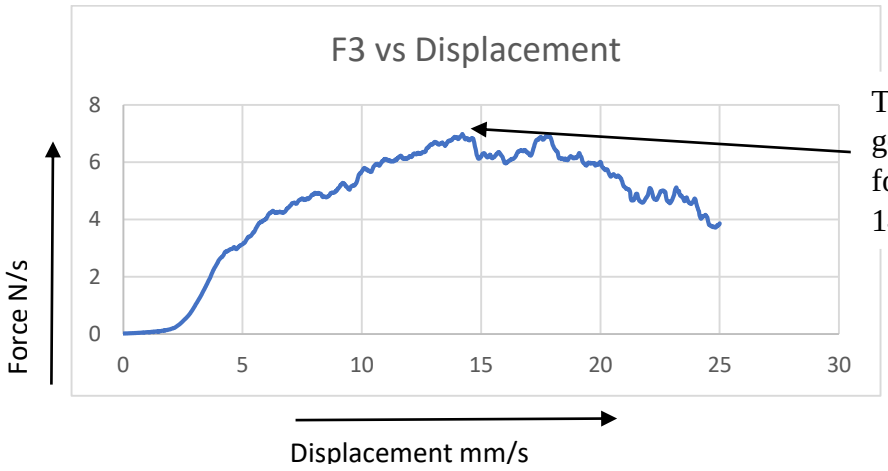


Figure.4.16. Force 3 vs displacement at average displacement of 25m/s at 140°c

From the forces that we got for the 140°c for thermal test results, at the average displacement of 25mm/s, the force 3 have got the highest compared to 130°c and 120°c of thermal peel strength. But not equal to the strength of the 140°c laminated peel.

2. At 130°c for thermal gluing test

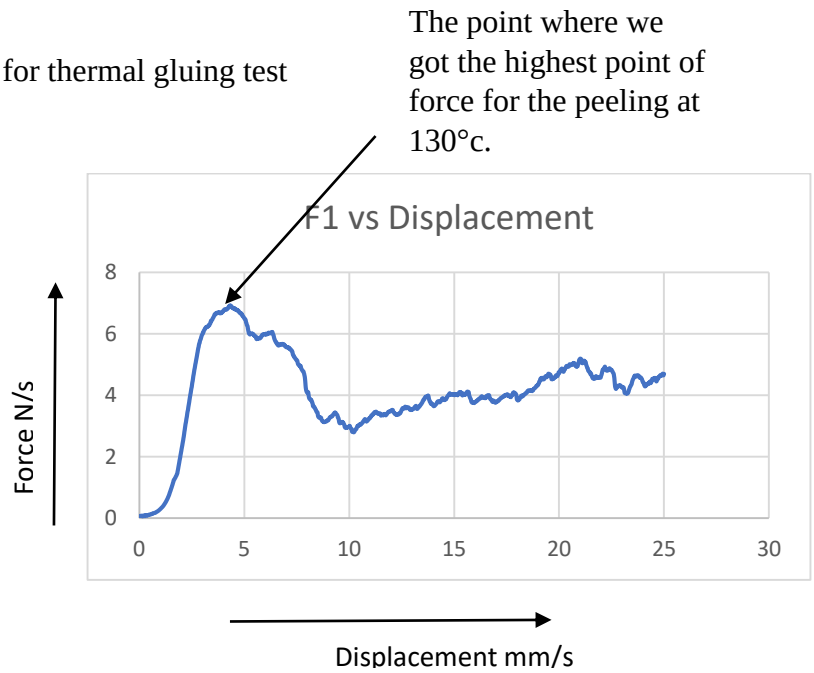


Figure.4.17. Force 1 vs displacement of 25mm/s at 130°c

From the forces that we got for the 130°c for thermal test results, at the average displacement of 25mm/s, the force 1 have got the best compared to 120°c of thermal peel strength. But not equal to the strength of the 130°c of laminated peel strength.

3. At 120°c for thermal gluing test

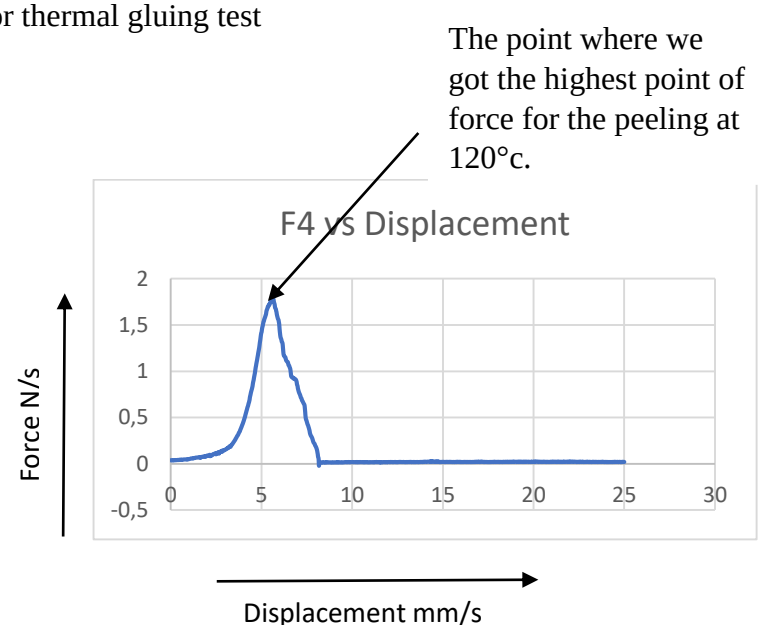


Figure.4.18. Force 4 vs displacement at 120°c temperature

From the forces that we got for the 120°c for thermal test results, at the average displacement of 25mm/s, we got the peel force very less as compared to all the other specimens in other temperatures.

I have chosen the best force of the all 6 forces done for each temperature and done the graphical representation and the results are like laminated seal force for failure mode have more strength as we can see from graphs.

4.8. COMPARISON OF GRAPHS OF THERMAL GLUING AND LAMINATED GLUING TEST RESULTS

We can see in the first laminated graphs the graphs were drawn by taking the average of all displacements and we got the average as 25m/s. The graphs shown that at 140°c temperature the seal got hard enough to meet the expectations because we can see the force applied on it is more so, thereby we can say that when the seal is hard only then the load will be more to peel.

Hence at 140°c the laminated gluing machine had the best seal compared to the thermal gluing seals at 140,130,120°c.

CONCLUSIONS

So according to the experiments done to the Thermal and Laminated sealing tests, the following results are investigated.

1. The polyethylene coated paper test is done and I have observed that the material loses its weight after the test. As we are putting all the specimens in water the paper on the polyethylene sheet got week and will be removed and cleaned for precision. So as this happens the paper will be removed and only the polyethylene cover is left. As here we got to know that paper weighs more that the polyethylene sheet.

2. The thermal gluing test is done with the specimens designed at 10cm and 0.8cm. So, the result is that the thermal gluing test is that the specimens tested at different temperatures at 120, 130,140°c temperatures. It is shown that at 120°c temperature the material is not hardly glued compared to 130 and 140 temperatures. And 130°c temperature the seal is somewhat better compared to the 120°c temperature. And 140°c seal is more better and précised for seal and hard enough for delamination.

3. The laminated gluing test we have done the same test with same temperatures and with same measurements. But the results show that 120 degrees is somewhat less sealed that 130 and 140 temperatures. And the 130 degrees temperature the seal is harder compared to the 120 degrees and the 140 degrees where the failure mode goes to break while peeling test is done.

4. So, after the seal test is done on both Laminated and Thermal gluing test the results are shown that time taken for both the peels are same and the weight is same. But here compared to the thermal gluing test the laminated test results shown that the test on laminated gluing text is more precise and harder compared to the thermal gluing test.

5.Compared to the laminated test the thermal test is more week according to the results. And, the graphs shown that the laminated results are having good seal with maximum force applied on the laminated specimens.

6.In Laminated results the specimen got the delamination even from the 120°c temperatures. this shows that the laminated seal is more precise and harder compared to the thermal gluing seal.

7. The overall investigation allowed to say that laminated seal films are more stronger and have the best strength property than compared to thermal seal films.

LIST OF REFERENCES

1.ASTM F2029-16, Standard Practices for Making Laboratory Heat Seals for Determination of Heat Seal ability of Flexible Barrier Materials as Measured by Seal Strength, ASTM International, West Conshohocken, PA,2016 [Accessed 10 November 2017]
Available from: http://www.astm.org/cgibin/resolver.cgi?F2029.

2. ASTM F88 / F88M-15, Standard Test Method for Seal Strength of Flexible Barrier Materials, ASTM International, West Conshohocken, PA,2015 [Accessed 14 November 2017]
Available from: www.astm.orghttp://www.astm.org/cgi-bin/resolver.cgi?F88F88M.

3. ASTM E171 / E171M-11(2015), Standard Practice for Conditioning and Testing Flexible Barrier Packaging, ASTM International, West Conshohocken, PA, 2015 [Accessed 17 November 2017]
Available from: http://www.astm.org/cgi-bin/resolver.cgi?E171E171M.

4. ASTM D882-12, Standard Test Method for Tensile Properties of Thin Plastic Sheeting, ASTM International, West Conshohocken, PA, 2012[Accessed 23 November 2017]
Available from: http://www.astm.org/cgi-bin/resolver.cgi?D882.

5.ASTM F1921-98(2004), Standard Test Method for Hot Seal Strength (Hot Tack) of Thermoplastic Polymers and Blends Comprising the Sealing Surfaces of Flexible Webs, ASTM International, West Conshohocken, PA, 1998, [Accessed 11 December 2017]
Available from: http://www.astm.org/cgi-bin/resolver.cgi?F1921-98(2004).

6. ASTM D638-14, Standard Test Method for Tensile Properties of Plastics, ASTM International, West Conshohocken, PA, 2014, [Accessed 15 December 2017]
Available from: http://www.astm.org/cgi-bin/resolver.cgi?D638.

7. ASTM D638-14, Standard Test Method for Tensile Properties of Plastics, ASTM International, West Conshohocken, PA, 2014, [Accessed 15 December 2017]
Available from: www.astm.org.

8.ASTM D2103-15, Standard Specification for Polyethylene Film and Sheeting, ASTM International, West Conshohocken, PA, 2015. [Accessed 16 December 2017]
Available from: http://www.mecmesin.com/astm-f88-standard-test-method-for-seal-strength-of-flexible-barrier-materials.

9. Source: http://en.labthink.com/en-us/literatures/heat-sealing-technology-and-important-testing-indexes.html.

10. Image Source: http://www.transbriteclean.com/wp-content/uploads/POLY-PAPER.jpg.