Design and Development of 90 Degree Peel Test Setup

Darshan Awale[1], Shrushti Abhyankar[2], Suruchi Gujarathi[3], Gautami Keskar[4]
[1,2,3,4] *Student, Mechanical Engineering Department, Maharashtra Institute of Technology, Pune*

Abstract- **Delamination is failure in a laminated material, often a composite, which leads to separation of the layers of reinforcement or plies. Peel testing is one way to characterize adhesive bonds. It is used extensively to evaluate the bonding strength of tape, adhesives and flexible substrates. The peel test is used to determine the adhesion between soft (Adhesives & PVB) and hard (Glass, fiberboard, steel and liner material) materials.**

Peeling test is the practice of testing adhesion properties of film bonded to a substrate. The designed peel test setup uses Universal Testing Machine (UTM) as the measuring aid and the setup is assembled onto it. The setup ensures minimum friction during the sliding motion. The voluntary motion of the sliding plate eliminates the use of a motor or a separate mechanism to enable horizontal motion.

The support block and buck mechanism serve their respective purposes for the test to be carried out. The setup is connected to a computer that has 'Win UTM' software to convert the experimental results into numerical data required for further analysis.

Index Terms- Peel test, Crack Nucleation, Crack Propagation, Tensile modes of Delamination, Tribology.

I. INTRODUCTION

Interfacial delamination is the separation of two materials across the interface. In laminated materials, repeated cyclic stresses, impact, vibration loadings, etc. can cause layers to separate with significant loss of mechanical toughness. Delamination also occurs as a result of corrosion.

The adhesive strength of peel tests exist depending on the peel angle, namely 90° and 180° peel tests. The peel angle is the angle between the interface direction and the direction of the peel force (Refer Fig 1).

Adhesives are used to bond separate materials or small parts together. They are widely used in our daily life, industrial manufacturing, and scientific research. Adhesion interaction takes the dominant role in the performance of adhesives.

The adhesives diffuse into the holes of the substrate at the interface. After solidification or gelation, the substrate and adhesives interlocks. Some of the important factors influencing the adhesives include fatigue strength, impact strength, yield strength and durability.

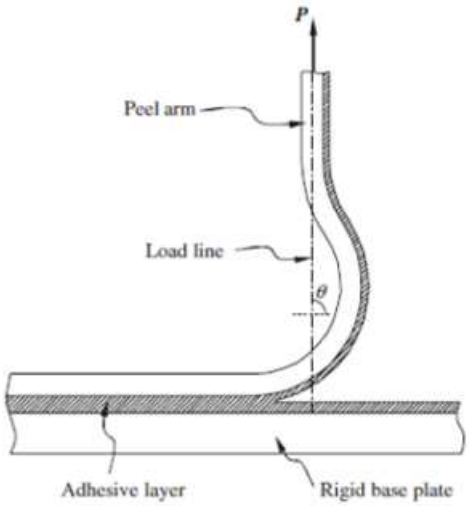

Fig 1: Geometry of 90 degree Peel Test

II. LITERATURE REVIEW

Crack Nucleation

Crack nucleation occurs when the radial stress acting at the interface between a rigid cylindrical inclusion and the matrix reaches a critical value. The radial stress is computed by considering both the stress accumulated due to the residual stress associated with strain concentration around the inclusion and the stress due to the applied load. When the normal load is higher than four times the critical shear stress of the metal, the rate of crack propagation per loading cycle as well as the crack nucleation rate. The size of the region over which cracks nucleate also increases with increased applied loads.

Crack Propagation

The crack propagation rate is always constant regardless of the total crack length, because only that portion of the crack which is in the tensile region contributes to the stress concentration and it thus controls the crack propagation rate. Studies show that cracks located at depth will propagate faster than those at other locations.

Modes of Delamination

Mode 1(Tensile mode):

In this mode, the failure occurs because of the tensile force applied in a direction. When a tensile force is concentrated at one edge of the adhesive, the adhesive layer will peel off from substrate. This tensile force is the peeling force. In other words, peeling force is the force required to remove adhesive film from a substrate. Peeling force is not a maximum load. Peeling force is the force at equilibrium state. This force is sensitive to experimental conditions, such as peeling rate and peeling angle.

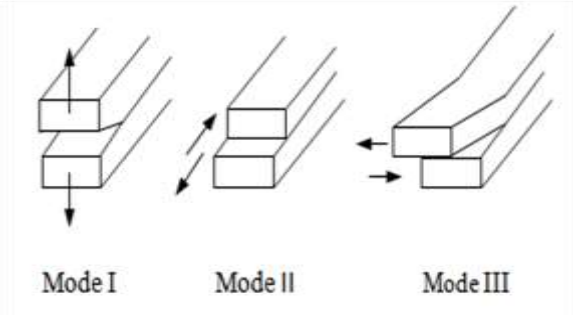

Fig 2: Modes of De-lamination

Mode 2(Sliding mode):

In the mode, the failure occurs because of the sliding of the upper substrate with the lower one.

Mode 3 (Tearing mode):

The failure occurs as a combination of all modes, it takes place when peeling occurs at an angle along with the sliding between the two substrates. Shear strength is another traditional characterization for adhesives. Shear strength is the maximum strength the adhesive joints can bear per area at parallel direction of the interface before failure. When shear stress is larger than the shear strength, adhesive and substrate will slide over each other within the adhesive layer or at the interface.

III. AVAILABLE SETUP

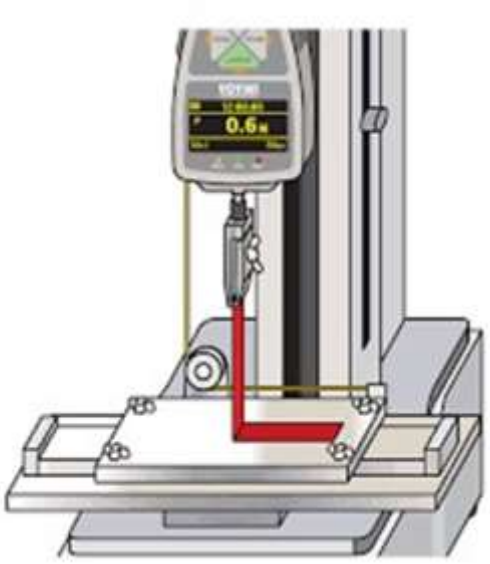

Fig 3: Available Setup

The setups available in market use the string mechanism. The Peel test setup consists of the upper jaw in synchronization with the sliding plate. This can be achieved by using either a string or a motor. The available setups are costly. The aim of designing a new fixture was reduction in cost and to carry out the Peel test without any modification to the UTM.

IV. DESIGNED SETUP

Tensile test setup of the UTM is chosen as the testing method where the lower Jaw of UTM is replaced by the custom designed setup. The flexible substrate is held in the upper jaw of the UTM.

UTM SPECIFICATION

Make: PANASONIC (MINAS A4 Series)

Traverse Speed Range: 0.05 to 500 mm/min

Maximum Capacity: 100kN (By load cell)

The below fixture is designed for 90 degree peel test. The design is done in accordance with the dimensions and specifications of UTM. As the fixture is designed for 90 degree peel test, the velocity of the peel arm and the platform on which the specimen is placed needs to move with the same speed so that 90 degree angle is maintained. Slider mechanism is used in the designed fixture for the same. The sliding plate is supported by the two side plates that are mounted on the base plate by using allen screws. The Universal Testing Machine has a solid cylindrical block. In order to mount any fixture, the hollow

cylindrical part can be mated with this solid block by using a pin.

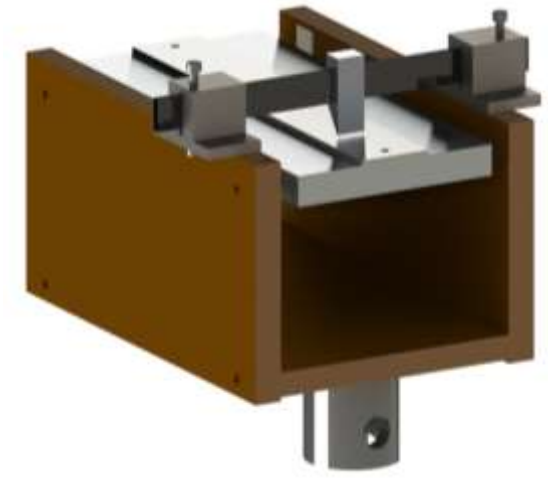

Fig 4: Designed Fixture

Jaws required for gripping the upper substrate have plane surface. The maximum opening and closing limits of the jaws is 0 to 7 mm. In accordance with the standards for 90 degree peel test (ASTM D330), the velocity of peeling is taken as 300 mm/min.

Parts of Fixture

Sliders

It is important to achieve effortless relative motion between the slider plate and the frame. The motion should be ideally frictionless in order to avoid errors in Load cell readings. To achieve this motion, Slider Railing is used as the connecting link between slider plate and frame.

Support Column

It is the bottom most part of the setup. The function of cylinder column is to support the entire setup and couple it with the fixture support provision on UTM. The inner cylindrical part of 'support column' hosts the male part of UTM fixture support. The relative rotational motion is prohibited by the transverse steel pin.

Frame

Frame is mounted on the support column and builds the skeleton of the setup. Three individual mild steel plates are assembled together using allen screws. It supports the sliders and subsequently supports the sliding plate. It forms the basic structure of the assembly. It provides the required stiffness to the body in order to resist the forces acting on it.

Slider Plate

Slider plate acts as the host for the test specimen. The slider plate is attached to the dynamic part of the slider and mounts the Specimen plate on itself.

Adjustable Mechanism

Mechanism consists of Support block, a steel plate and a wedge block. After experiments conducted on prototype a wedge block was introduced to maintain the 90 degree of the test specimen. It was achieved by bringing the wedge block as close as possible to the substrate plate and hence maintaining the angle close to 90 degree.

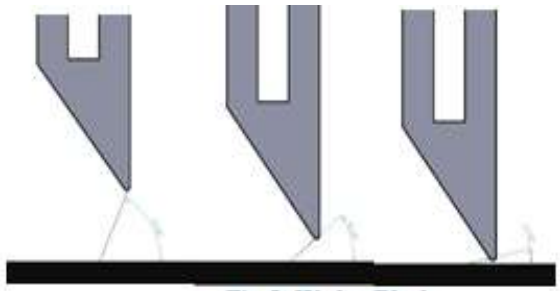

Fig 5: Wedge Block

A clearance distance of 0.2 mm is maintained between the wedge block and substrate plate. This achieves the angle of 89.4o.

For the specimens of different thickness the wedge block had to be re-positioned frequently to maintain the constant thickness of 0.2 mm for every specimen. This is achieved by using the screw mechanism. Vertical screws are used to position the wedge supporting block and move it up and down.

The following figure depicts the mechanism.

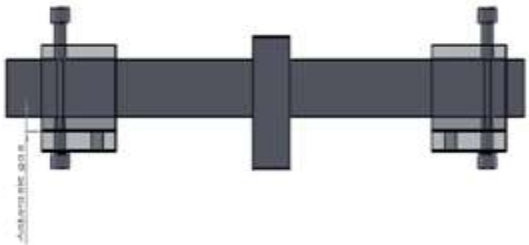

Fig 6: Adjustable mechanism assembly

Stress analysis of the designed fixture

To check whether the designed fixture can take up the stresses generated during the experiment, a FEA analysis of the same was carried out in ANSYS.

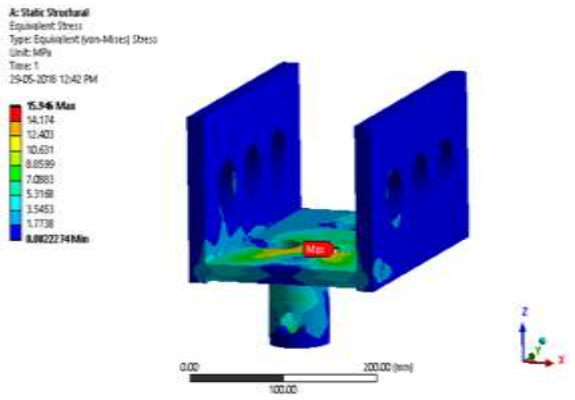

Fig 7: Stress analysis of the fixture

V. PERFORMED TESTS

Specimen Preparation

ASTM D3330 Standards are followed-

The specimen shall be 24 mm wide. If different, refer to note after 10.2. A tolerance of ± 0.5 mm shall be allowed. The length shall be approximately 300 mm.

Fig 8: Application of promoter to the Copper strips

Before applying the adhesive tape to the flexible substrate (here, copper foil), the surface must be cleaned with cleaning agent like acetone. The promoter, which enhances the adhesive strength between the foil and the adhesive, has to be applied with cotton. The double-sided adhesive tape has to be peeled off from one side and then applied smoothly onto the copper foil. Precautions must be taken in order to avoid air traps or wrinkles. Now, in a similar manner, the tape has to be applied on the fixed substrate (here, S.S. plate).

For even distribution of the adhesive throughout the specimen, the roller and squeezer have to be used.

For the performed test following parameters were maintained-

Specimen width -24 mm

Gauge length for % elongation – 200 mm

Cross Head Travel - 300 mm/min

VI. RESULTS

Table 1: Test Result for Various thicknesses.

Specimen No.	Adhesive	Specimen Thickness (mm)	Load at peak (N)
1	MP468 1	0.177	54
2	MP468 2	0.177	62
3	MP468 3	0.177	54
4	MP467 1	0.075	35
5	MP467 2	0.075	32
6	MP467 3	0.075	30

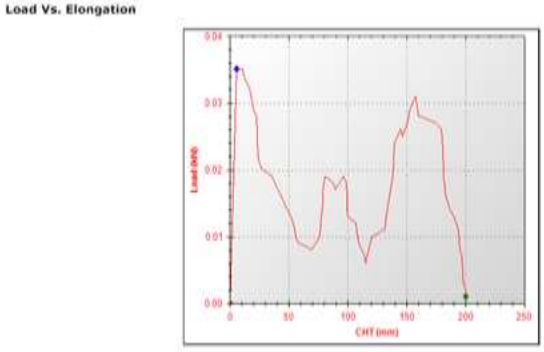

Fig 9: Graph 1. MP 467

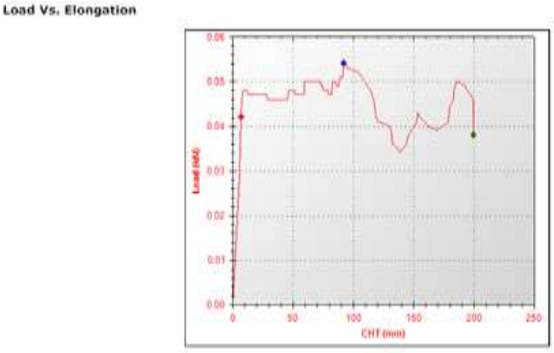

Fig 10: Graph 2. MP 468

VI. CONCLUSION

The proposed setup can be used as a cost effective tool for researchers working in initial stages of the development. Since the setup is an accessory to the UTM machine, any facility housing a UTM machine can make use of the designed setup with ease.

The repeatability in above results makes it reliable.

REFERENCES

[1] The Graduated Faculty of The University of Akron, A thesis on THE EFFECT OF PEELING RATE AND PEELING ANGLE ON THE PEELING STRENGTH
[2] NAM P. SUH Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 02139 (U.S.A.) AN OVERVIEW OF THE DEL~INA~ON THEORY OF WEAR
[3] Suat Malçikan, Numerical modelling of adhesive failure in delamination of laminated glass