FINITE ELEMENT ANALYSIS OF BENDING DELAMINATION IN MULTILAYER CIRCUIT BOARDS PCBs

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by

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ABSTRAK

Selama beberapa dekad, papan litar berbilang lapisan sering digunakan dalam industri elektronik, dan aplikasinya dalam peranti elektronik telah menjadi penting dan meningkat sejak beberapa tahun kebelakangan ini. Ia mempunyai kelebihan mobiliti, berat dan fleksibiliti. Walaupun analisis lenturan delaminasi telah lama wujud, hampir penyelidikan yang dibuat berkemungkinan memfokuskan kepada faktor suhu dan tekanan. Disebabkan kepentingan kefungsiannya, adalah penting untuk memahami dan meramalkan analisis kegagalan bahan gelagat kohesinya akibat lenturan delaminasi. Kertas kerja ini disasarkan untuk meramalkan beban lentur delaminasi papan litar bercetak komposit berbilang lapisan dan untuk mengkaji kesan kekakuan papan kadar beban pada laluan retak. Daripada model zon kohesif simulasi (CZM) menggunakan perisian ABAQUS, kaedah terbaik pemodelan delaminasi telah dicipta untuk melakukan analisis terhadap struktur. Kaedah ini menggunakan pendekatan zon kohesif dan pemisahan cengkaman untuk memodelkan ikatan campuran yang dibuat antara prepreg kohesif dan bahan homogen kuprum dan substrat. Di lain-lain untuk menguji delaminasi lentur, simulasi dilakukan dengan menggunakan tiga prepreg berbeza, jenis kekeaun dan kesan berat bahan. Keputusan menunjukkan bahawa lebih besar ketebalan prepreg, lebih besar daya yang diperlukan untuk memisahkan papan berbilang lapisan yang padu. Analisis struktur akan dibandingkan untuk mendapatkan hasil yang terbaik. Kesimpulannya, simulasi ini pada asasnya boleh meningkatkan pengetahuan tentang penembusan PCB, mengukur daya/beban yang terlibat dalam PCB dan boleh membandingkan keputusan dari segi medan tegasan. Dalam kerja akan datang, terdapat keperluan untuk membuat lebih banyak disertakan dalam simulasi untuk memastikan struktur PCB yang lebih fleksibel dan terbaik.

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ABSTRACT

For decades, multilayer circuit boards have been often used in the electronic industry, and their application in electronic devices has been crucial and rising in recent years. It has the advantages of mobility, weight, and flexibility. Although the analysis of delamination bending has long existed, almost the research made is likely focusing on factor of temperature and pressure. Due to the importance of its functionality, it is crucial to understand and predict the failure analysis of its cohesive behaviour materials due to delamination bending. This paper is targeted to predict the delamination bending load of multilayer composite printed circuit board and to examine the effect of loading rate board stiffness on the crack path. From a simulation cohesive zone model (CZM) using ABAQUS software, the best methods of delamination modelling have been created to do analysis on the structure. This method using cohesive-zone approach and traction separation to model the mix bond made between cohesive prepreg and homogeneous material copper and substrate. In other to test the bending delamination, simulation done by using three different prepreg, difference PCBs stiffness and using impact load. The results showed that the difference type of test have difference impact on delamination strength and fracture. The structural analysis will be compared to get the best results. In conclusion, the simulation can basically improve knowledge about PCBs delamination, measure the force/load involved in PCBs and can compared the result in term of the stress field. In future work, there is a need to make more include in the simulation to make sure more flexible and best structure of PCBs.

CHAPTER 1

INTRODUCTION

1.1 Research Background

This study involves the designing of multilayer circuit boards (PCBs) that will be used to predict the delamination bending effect. Nowadays, as electronics progress toward multi-functional possibilities for internal components, multilayer PCBs give a comprehensive alternative, while single and double-sided PCBs have limitations in their capacity to balance size and functionality. It offers the characteristics of light weight, high strength, great erosion resistance, and superior design flexibility. It has been used in both secondary and load-carrying components. Simple electronics with limited functionalities are normally consisted of a single layer, but more complicated electronics are composed of numerous layers and are referred to as multilayer PCBs.

An experienced designer is necessary to build link between layers of PCBs circuit board as it is tough to be produced, and also takes much more design time and is easy to become unusable if there is even a tiny defect. Composite laminates cannot function due to matrix cracking, delamination, or other factors. Delamination is the separation of two laminar layers, which appears to be a simple process but has various characteristics that make it difficult to be handled. It can diminish the load-carrying capacity and structural integrity and can be readily triggered by a variety of factors during the composite's life. If the board structure has gaps and is not properly laminated, delamination bending can produce mode of failure structure on the multilayer board and can make the objects PCBs more deformed.

Multilayer circuit boards are widely employed in a wide range of industries. When compared to single-sided PCBs, double-sided multi-layer PCBs can handle more sophisticated chips and are widely used. These multi-layer PCBs are often made up of numerous layers of woven glass fibre placed between copper foils to ensure that the electronic product components do not fail. As technology advanced, the multilayer structure of PCBs boards became increasingly complicated and layered. The fabrication of multi-layer PCBs enabls the distribution of traces over multiple layers known as vias. The approach greatly reduced design constraints, allowing for more sophisticated and powerful boards. The multi-layer build-up of diverse materials given rise to novel failure mechanisms. During the reflow process, the contact between the dielectric material is frequently found to break. As a result, there is a greater chance of delamination as a result manufacturing and failure.

Delamination or inter-laminar damage is a common failure mode in PCB composite laminates. Delamination can occur especially when using lead-free solders, which require greater reflow temperatures than leaded solders. The locations with of high interlaminar stresses also can be as a factor thar derive delamination due to their relatively weak interlaminar strengths. Bending can also promote delamination due to stress on certain areas of PCB boards and can be more prone to deformation, particularly on thinner PCB board effect of loading rate and board stiffness on the crack path of PCB board. Delamination simulation in composites is often separated into two stages: delamination initiation and delamination propagation. In high performance composite laminates, the fracture process is highly complicated, involving not just delamination but also intralaminar damage processes. Delamination caused by impact, or a manufacturing problem can significantly reduce a structure's compressive load-carrying capability.

Even though the layered design is fully laminated and has no gaps, delamination on multilayer circuit boards can occur due to the thickness of the PCBs board itself and its condition. The stress on the multilayer circuit boards can be generated by an applied load or bending on a specific section of the circuit board. Because of the stress, the partial split on the PCBs board structure has become more gaping. As an outcome of ABAQUS software analysis, the impact of delamination bending may be detected and acquired. Generally, ABAQUS Software analysis for delamination bending has several main elements: pre-processing, segmentation, feature analysis and recorded data. Pre-processing is stage where to identify structure of PCBs.

Next is segmentation where the layered PCBs arranged layer by layer material to become a structured model. For this analysis, the design created using ABAQUS software and it is an effective technique to determine the delamination bending of PCBs structures. Finally result data of delamination bending will be obtained when the layered circuit board is tested by bending.

1.2 Problem statement

This study mainly focuses on exploring mode fracture of failure based on analysis of cohesive materials delamination bending on multilayer circuit board PCBs. Furthermore, there are a few researches have been done on the analysis of cohesive method of delamination bending load multilayer composite printed circuit board (PCBS). Although the analysis of delamination bending has long existed, almost the research made were mostly focusing on factor of temperature and pressure. The delamination on circuit board also can be cause by the bending of PCBs board. Hence, a study based on result data obtained enables us to examine the effect on the multilayer circuit boards PCBs.

This project will focus more on the simulation and modelling of PCBs structure. Simulation and modelling can be done in two ways which are two dimensional (2D) and three dimensional (3D) using ABAQUS software. In this project, the 2D simulation is chosen because it can lower the simulation time.

By doing the simulation, the PCBs delamination bending characteristics can be measured without using a higher cost and time efficiency. Higher cost means less work need to be done in simulation than using the fabrication technique. The different thicknesses of prepreg and loads also can be experimented with using finite element simulation because, the simulation, the thickness of prepreg and load can be easily adjusted in the software.

The comparison will be made to gain more insights about the delamination cause by bending. The simulation is chosen because to predict the delamination bending load of multilayer composite printed circuit board (PCBS) and examine the effect of loading rate and board stiffness on the crack path.

1.3 Objective

The objectives of the project are:

1. To examine the influence of cohesive size, PCB stiffness and impact load on delamination force of a multilayer PCB subjected to bending.
2. To examine the influence of cohesive size, PCB stiffness and impact load on fracture energy in delamination of a multilayer PCB subjected to bending.

1.4 Thesis Outline

Chapter 1 covers the research background, problem statement, objectives, and thesis outline. The research background explained the thin PCBs background and it advantages and disadvantages in current technology and as well as provides an overview of ABAQUS software overview.

The literature review in Chapter 2 is based on various publicity available publications or articles that are relevant and important to this project. This chapter will cover the fundamental history and theory of delamination, cohesive and bending PCBs board.

The procedures and study measures carried out in this project are outlined in Chapter 3. The flowchart depicts the idea flow for each point. ABAQUS software is used to program the simulation with all significant processes.

The result and discussion of the work are explained in Chapter 4. This work is compared with previous work and calculated work.

The conclusion and future recommendations are included in Chapter 5. The best performance of delamination bending, and cohesive and future recommendations are discussed in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are five main sections in this chapter that will be reviewed based on existing publications or journals that are relevant apply to this present study. First, the basic principle laminated structure is covered in Section 2.2

Section 2.3 discusses the bending delamination causes delamination failure mechanism caused by bending

Section 2.4 covers the cohesive model causes by delamination of PCBs board structure and implementations to make modelling of delamination more accurate and efficient.

The last section, which is section 2.5, would summarize the mechanism of predicting the cohesive delamination caused by bending.

2.2 Laminated structure

Fiberglass (FR4) epoxy laminate is traditionally used for core layers of printed circuit boards [2]. The Grapheme film was incorporated into the sandwich construction of a flexible print circuit board to dissipate heat. As shown in Figure 2.1, a sandwich layer was formed by laminated grapheme and polyimide films.

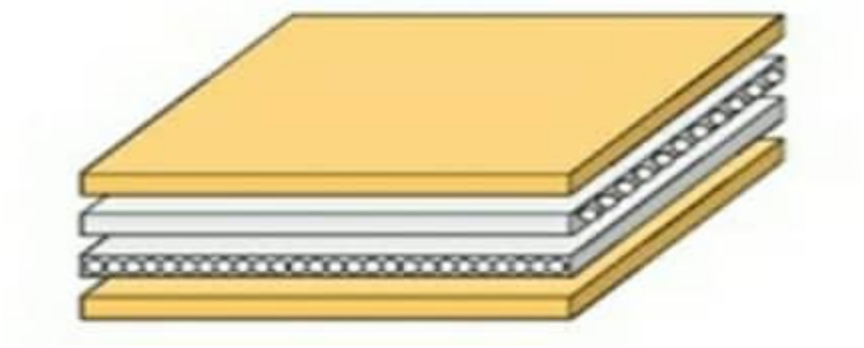

Figure 2.1 laminated multilayer structure

With epoxy resin as adhesive, flexible circuit board are reliable,stable and have thermal conductivity that can withstand bending. FR4 used in substrate will offer a flexible print circuit board that can be an ideal choice for adaptable and wearable electronics in the present years [1]. Increasing the resin content boards can reduce the fracture of multilayer board [4].

Multi-layer PCBs typically consist of many layers of fiberglass reinforced epoxy resin composite substrate sandwiched between copper foils.The woven glass fibre/epoxy layers were divided into two thin layers and a shell section was used to determine their structure, material type, and orientation. The shell section was extraordinarily smaller than the other dimensions [3]

Multilayer bonding prepregs are often made of fibre glass to strengthen the low signal loss fluoropolymer. The coefficient of thermal expansion is controlled by a surface-coated thermosetting resin and ceramic filler. The thickness of the prepreg sandwich structure has a significant impact on the joining property. Prepreg efficiently fills the gap generated by plate deformation and improves joint dependability. Figure 2.2 shows that prepreg layers significantly affect the shear strength of joints.

Gradually increasing the prepreg layer thickness increased the shear strength of the joints. When prepreg thickness increases, resin content in the sandwich structure increases, effectively filling the gap between laminate and structural sheet and improving structural [5].

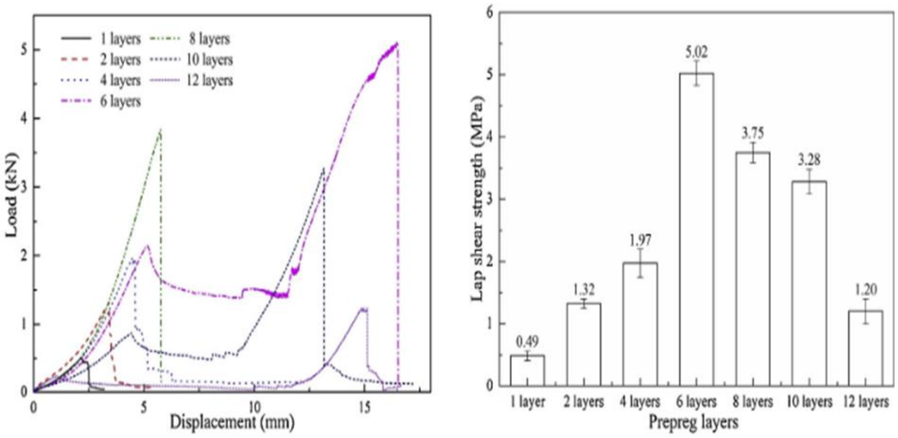

Figure 2.2 The shear strength of the joints

Prepregs are semi-finished materials that are woven into continuous fibre reinforcement. Fibre reinforced thermoplastic plastic prepreg is a quick method of production that eliminates the need for a lengthy polymerization step. In addition to their excellent mechanical properties, fabric composites possess relatively high stiffness and are excellent for having a light weight [6]. Despite this, forming in hyper elastic techniques can roughly approximate the strain energy required to deform prepregs until the unloading process is engaged [7].

The critical strain energy indicates that multilayer PCBs do not have uniform thickness, with variable conducting and insulating layers linked at interfaces with varied strengths. Microelectronics uses underfill adhesives to improve the reliability of solder connections between complex components and composite printed circuit boards. The resin-containing underfill had lower resistance under thermal mechanical stress tests compared to the free-resin underfill [8].

Due to the increased elastic modulus, the solder connections and the PCB sandwich are subjected to deeper stresses during temperature cycling. Solders are also stiffer than leaded solders, which increases the strain on the PCB. Even minor fractures in the PCB caused by soldering might shift the primary failure mode from solder joint fatigue cracking to PCB cracking. A study has shown that pre-stressing PCBs before thermal cycling can cause hidden fracture that isn't visible in cross sections but increases the probability of damaging in future thermal tests [38].

For lead-free BGA packages, PCB cracking has previously been detected. When cracks are created in the PCB beneath the solder joints, they enhance the thermal fatigue life of the solder joints, enhance PCB compliance, and reduce strain and stress in the solder joint. It seems that BGA packages' thermal cycle dependability is affected by PCB rupture, especially near solder joints [40].During testing, PCB fractures are more likely to occur because hot cyclic parameter used are often harsher than in regular work conditions. As a result of the partial unreliability of the failure processes and the function of PCB cracking in reducing strain in solder junctions, accelerated testing may overestimate solder fatigue life [39].

Higher moisture absorption rate reduces resin strength, toughness, solidity, and durability. Laminates containing filler particles offer stronger fatigue resistance than no laminates. Moisture is known to dramatically increase fatigue fracture formation in glass fibres; however, it is unknown if that was the cause. In many cases, strength and fatigue resistance show quite divergent trends and are sensitive to factors such as underfill and pre-damage. After several reflows, the effects of curing and damage usually cause an initial improvement in performance, but then performance starts to degrade. Multiple reflows lowered fatigue resistance as well [41].

In order to investigate inter-laminar damage in composite materials, a stress-based method has been used to estimate toughness and optimize different elements of cohesively bonded joints. It has been demonstrated that rupture mechanics can be used to forecast static characteristics of prepreg bonded joints as well as to study fatigue and durability. However, some methodologies have significant drawbacks that prevent their use in fracture propagation analysis [42, 43]

Frequently, laminate manufacturers/suppliers will include broad drying guidelines and restrictions. To eliminate accumulated moisture, laminate makers demand that PCBs be baked for a short period in devices with low humidity levels, particularly before soldering procedures. In order to prevent soldering pad corrosion and other unfavourable thermal events, moistness and steady heat must be maintained. Despite this, the fabrication process cannot be too long, not only because of increased cost and duration, but also because combination layers may be formed, which result in a lack of humidity in the soldering area, hindering solderability. By maintaining suitable production, packing, and storage conditions, as well as regularly monitoring all activities, circuit board makers and assembly businesses can minimize the risk of warning up. Due to the fact that all these variables cannot always be satisfied at the same time [44], drying should be carried out using specific machines that control heat, moistness, and process duration.

The researchers examined samples of sandwich prepreg FR4 and copper. After further baking for 20 hours, the dry weight was calculated. Additionally, copper layers have been shown to significantly affect humidity transport. According to [45], high moisture-saturated epoxy materials require high temperatures to remove excess moisture content. However, it is not necessary to reduce humidity from the PCB during assembly. For the current technical abilities, such as high-efficiency dry vacuum, PCBs can be prepared for assembly or storage before soldering without affecting the stored circuits.

Plastic deformation in composite materials is highly restricted, resulting in a greater damage area upon contact. The structure's loadbearing characterization after the impact event is difficult due to the damage zone's complexity. Matrix toughening is one approach to increase damage resistance. These strategies, on the other hand, have produced very little progress and have implications in the production process. Researchers discovered that stitching enhances composite laminate damage tolerance by lowering delamination pressures and distortion in the damaged area [46].

2.3 Bending delamination

Damage cause by delamination is one of the most common crack types in PCB composite laminates. The thicker the structural the easier to delaminate. By understanding the mechanism of cohesive delamination working principle, the overview of the common causes and factor that influence the structure can be determined.

Prepreg FR4 resin is used to cover the space in between the bottom of a component, such as copper and the surface of the PCB, it might cause delamination. It was discovered that as the modulus and volume rose, the bend performance improved. The bonding of these cohesive help to strengthen the relation with the PCB structure. When mechanical damage occurred, the edge bond resin enhanced crosshead displacement, strength, and force, resulting in the highest performance. It has a stiffer look and can withstand greater deformation under the same conditions since it has a higher modulus and adequate adhesive volume. It has been shown that PCB pads are the most common fracture mode, regardless of whether resin is used. Even though the reinforcing appears to be insufficient, it may be sufficient to allow it to pass the bend test.

Figure 2.3 illustrates how the curvature change between PCB and the extends of corner most solder junctions. A sticky joint at the edge of the substrate and at the corner of the printed circuit board reduces the inconsistency in the curvature of the substrate and distributes the load across the PCB. Additionally, sticking on the edges and corners of the printed circuit board may create a significant amount of stress near the cured glue's closest location to the PCB's board.

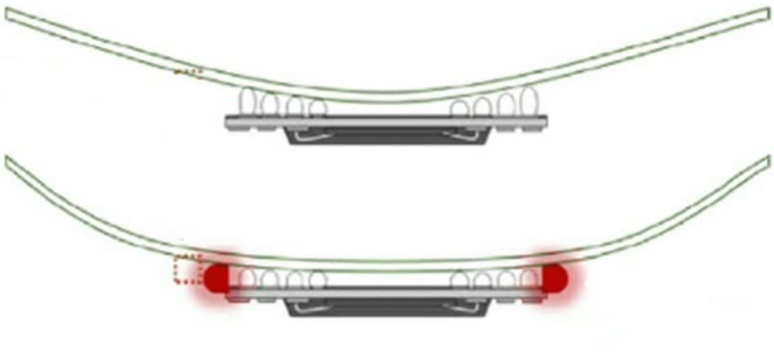

Figure 2.3 PCB extends the corner most solder junctions

For various assemblies' operation in the constant loading scenario, the stress and strain distribution might well be compared. When using corner joint for composite laminate the important patch connections move from traditional package corner to the edge central, as demonstrated in Figure 2.4. The largest tension occurs at the juncture of the PCB pad and the lamination in the single solder joints, which is consistent with the failure study results. Figure 2.5 demonstrates indicates, with the exception of the semiconductor connections, the incorporation of resins seems to have no impact on the tension distribution of board-level assembly. However, utilizing bonding raises the package tension, particularly for assemblies that use significant elastic modulus corner resin.

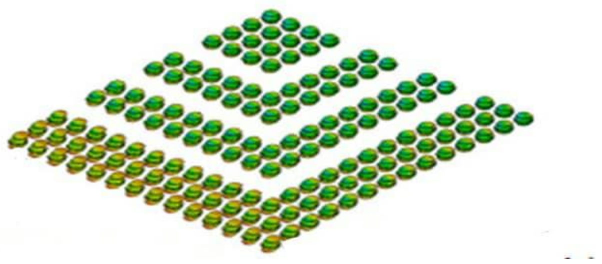

Figure 2.4 Corner joint of composite laminate

The use of resin has less of an impact on the shear force of board assembly than solder connections do (Figure. 2.5). Applying adhesive, on the other hand, increases package stress, particularly for assemblies utilizing from elastic modulus corner and edge bond epoxy [9].

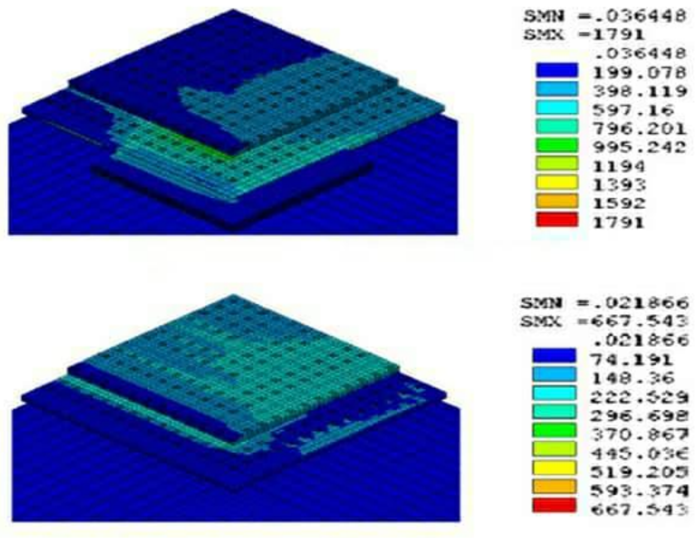

Figure 2.5 Stress distribution of board level assembly

The shape of the sticky prepreg determine the bonding durability in between microelectronic components and composite circuit boards filled with and without under-fill epoxy. The under-fill caused a significant tension pressure on the PCBs, which resulted in fracture initiation. Cracks originated and spread at the PCB contact for relatively modest fillets. Larger fillets lowered tension density at the PCB juncture and relocated fracture of the prepreg layer. Furthermore, the existence of a thick fillet boosted the strength under-filled solder junctions substantially [10]. Compared to the condition when there was no filling, the fracture initiation load increased significantly.

Small modifications in the area design towards the edge of the contact region have been demonstrated in several studies to have a considerable impact on the strength of an adhesive connection. The rising usage of composites in a variety of safe-fail constructions has resulted in material failure mechanisms, particularly the delamination failure mode. Delamination decreases a structure's global stiffness and compressive strength greatly. Remote loadings on composite components are usually translated into inter-laminar delamination and applied load at discontinuities, resulting in delamination even though numerous specimens have been proposed for measuring the mode inter-laminar fracture toughness quality [11].

When modelling delamination or debone with plate of shell, certain factor such as material sequence and distortion parameters, kinematic limitation in vicinity of the crack front is taken into consideration. Matrix fractures and various delamination also need to be model at distinct interfaces. Therefore, it is necessary to enhance techniques for calculating breakage variables in built-up structures.

In higher - performing laminates board, the fracture process is highly complicated, featuring not just interlaminar crack but also inter-laminar fracture processes. When inter-laminar shear stresses are present, criterion such as non-linear contact of the inter-laminar tension of combination with a feature interval are commonly utilized [12, 13]. This method has been used to forecast delamination initiation stresses in composite bolted joints. [12]. The Fracture Mechanics technique is used in most evaluations of delamination growth to determine the energy release rate [13].

It is necessary to specify an initial delamination. The exothermal frequency and delamination damage toughness are commonly employed to forecast fracture dispersion under stress state problem. The inter-laminar fracture toughness, penalty stiffness, and strengths appropriate to formulate the constituent basic equation. When a crack stretches, energy produced is similar to the total energy necessary to close the rupture to its basis length. The position of the delamination front may be difficult to establish for some geometry and load scenarios. When the local exothermal frequency exceeds a significant level threshold modelling of delamination development may need the use of extensive dynamic mesh methods to advance the fracture tip [14].

The front strength of a circuit board PCBs specimen is affected by curved delamination. The interlaminar damage strength of a circuit board materials is determined not only by the sandwich structure or interaction parameter variable. Force acting to sandwich structure layer are often transform into inter-laminar tension and delamination forces at gap, resulting in diverse forms of delamination. Because of the focused buckling events, this degradation process is especially harmful to compressive strength. As a result, the evaluation of composite delamination resistance is of great interest [15].

The breaking pattern of the PCB engaged at leat two competing fracture mechanisms as shown in Figure 2.6. The maximum stress criteria used to predict the delamination interfaces at consequent crack of the PCB fractured sandwich laminate. The PCB's outer plane fracture toughness was much less compared to its internal toughness.

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Figure 2.6 cracking sequence of the PCB

Interlaminar damage can happened in a difference type of condition, including slow motion rate crash, and stresses in laminate bond. The fracture damage mechanism is crucial for the laminate boards constructions since it hard to identify during check-up. In absence due to pre-existing fractures, zero-joint fracture damage is a common form of beginning crack. The fracture induction is expected when a mix of the exothermal (energy out) element equals a peak number [16]. The toughness in zero joint interlaminar fracture damage is starting 0 and grows approximation to a constant value at around twice the ply thickness, as demonstrated by the edge delamination issue. It is steady crack development if the load increases as the cracking spreads [17]. Thus, both interlaminar fracture damage induction and tension dispersion rise practically straight with rupture ratio.

There is a significant delamination effect in many composite systems, and brittle materials, such as resin, can be hardened by adding comparatively brittle fibres. Deflection at several inter-laminar contacts causes energy to be dissipated via the delamination process. Crack refraction at confluences in various layer of coatings offers the same characteristic for preserve substrates, which is very helpful in daily applications (Figure 2.7). Deflection can occur even though the juncture is substantially harder compared to substrate. Deflection of fracture can be generated in the process with moderately surfaces [18]

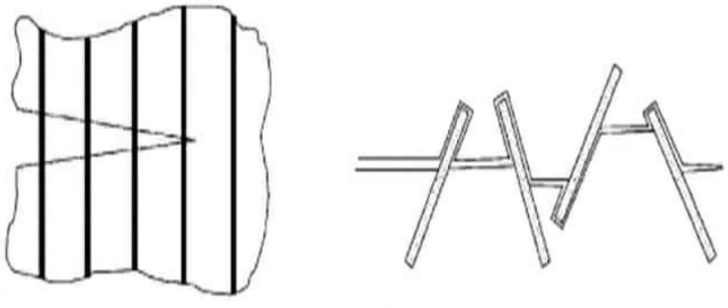

Figure 2.7 Crack refraction

2.4 Cohesive Zone model (CZM)

Composite delamination has been extensively studied experimentally and computationally. Cohesive zone models (CZMs) are frequently utilising of simulation crack induction and dispersion in sticky resin and circuit boards. Nevertheless, since delamination of PCBs was the most common fracture damage, the traction-separation law was chosen to define the CZM.

In the majority of cases, stable cohesive typically fails, but under loading test, unstable fracture featuring stick-slip crack growth often occurs [25]. Calculating the tension forces created in impact load composite and comparing this value to the composite arms' measured strength properties explains the proclivity of a joint to display such a crack path via demage of the multilayer circuit board. Joints that were loaded with mixed-mode loading exhibited a higher rate of inter laminar fracture paths in composite substrates than joints loaded with pure mode loading.

A strong adhesive zone model is likely to be useful in designing adhesive joints under static loads, but relatively high loads make the adhesive a practical choice for automotive applications. A critical point to consider is how adhesive properties may vary with velocity and, what the effect might be on vehicle collisions when the speed is suitable for catastrophic loss of toughness. As sheet metal deforms due to an accident, it is that the attachment retains a considerable amount of strength and rigidity in order to completely disperse the force of the accident [23].

The attempt to describe adhesive energy management in an accident necessitates a knowledge of fragile fracture formation in the context of elasticity. In this way, bonded joints can be assessed using shattered part with simple fracture measure of toughness. The traditional fracture mechanics tools are inadequate when a sheet has large plasticity at break, similar to the expected behaviour when glued with an adhesive with a practical toughness. This kind of cohesive zone model allows the adhesive layer to be characterised based both on strength and toughness. The average rate of destruction determines the energy dissipation of the adhesive layer. Depending on the failure rate of the failure mechanism, the shift among the vary growth of state appears to have underlying frequency aggregation properties. [22].

In the process zone, the adhesive exerts normal traction on the adherend, which increases triaxiality, causing yield to be less reliable as shown in (Figure 2.8).

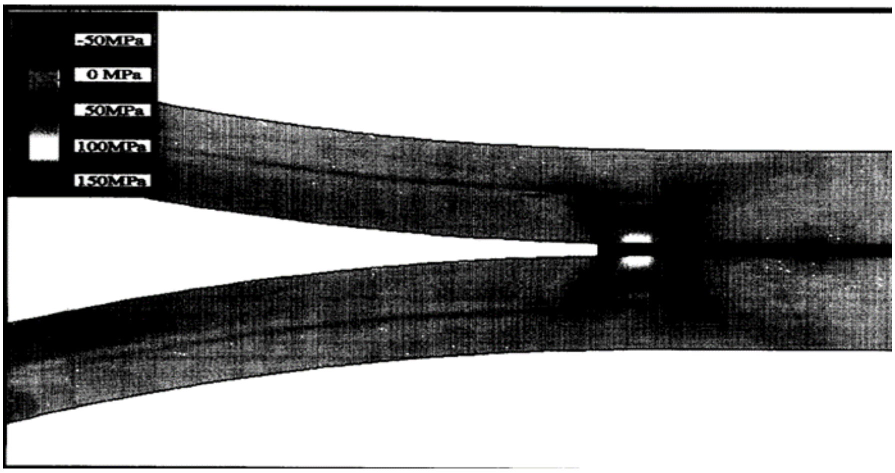

Figure 2.8 Cohesive zone delamination

Behind the initial separation portions, a beam with no surface tractions, on the other hand, deforms independently, allowing the beam bending theory to accurately describe the deformation and predict crack growth [19]. If deformation tractions produce extra plasticity in the joint interface, the R-curve exhibited predicted behaviour. The induced force needed for fracture rises as the crack grows. Therefore, for the effect to occur, the cohesive tension must be larger than 3 times the fracture toughness of the adhesion. [20].

A composite substrate exhibits lower mixed mode values. Cracks propagate from the cohesive precrash to the pattern inside the sandwich laminate board to damage the joints [24]. There is more variation in this regard due to fracture toughness of the composite that controls delamination tendency than composite interlayer value.

Delamination resistance is not affected by the test rate. Stick slip growth was observed in the static fracture behaviour, and the specimen showed delamination when the woven composite was used. Fracture behaviour patterns in various phase joints were conquered by fracture in composites. Several crack patterns were notice in the difference measurement, so a prototype describing the tensile stresses were proposed that was based on the impact load, material properties, and adhesive strength [21].

An energy strength toughness is used as the breakdown measure in interfacial mechanical cracking to analyse adhesive joint fracture. The linear-elastic deformation of the adherents dominates the system deformation in adhesive joints with well-defined cracks. As a result of implementing cohesive laws for adhesive joints, it can be determined the strength of the joint under various loading conditions using mixed-mode fracture mechanics [27].

An optimization of strength can be achieved theoretically by designing the micro-structure to create a cohesive area which can optimizes the toughness of an separated parts. Creating and designing of cohesive law parts is no longer directly predicted by models, but rather related based on test determined cohesive laws. The cohesive law of a multilayer circuit board sandwich laminate loaded with natural bent was determined provisionally using a J integral-based access. The cohesive stress increased as separation increased. A model may be used to anticipate the form of a cohesive state when it is employed as the basic break characteristic, whereas a traction-separation law determines the crack operation stage. [28].

It is possible to assume mode crack of glued resin joints quantitatively using cohesive-zone models. It is observed that the stability phase rupture parameter variable with the thickness of the irregular zone in joints where there are non-reversible stress-strain characteristics in the sandwich layer. As an extension to the interfacial fracture mechanics, the concept of a cohesive zone utilizes energy and strength variables to define the indentation phase along the fracture plane [29].

Cohesive zone law describes how tractions and separations within cohesive zones are governed by the stress and deformation area of the parameters [30]. The parameter variable of crack induction and development makes it difficult to predict fatigue variables such a fracture influence force and strength of basic concept.

According to research, a condition of the cohesive area correlates with a variety of microstructure processes in material rupture modelling [30]. A top-down analysis of embedded process zones has been used primarily to relate microscopic damage processes to macroscopic failure behaviour. Cohesive energy, which indicates crack progress, is the area beneath the traction separation relationship. Since damage build-up under cyclic stress is taken into account in the cohesive zone law, its functional form is considerably more important in the case of fatigue crack propagation [31].

Researchers used cohesive zones with clearly defined impact and impacted load routes. As fatigue cycles increased, the cohesive traction or unloading stiffness decreased, which in turn simulated subcritical crack formation. Eventually, this impact loading resistivity was introduced in the cohesive zone law for testing the effect of destructive methods like mechanical rupture of joint bonds and frictional interactions between cracks. Due to history cyclic deformation area around fatigue crack tips, the accompanying elastic deformation area can be much more complex than those around monotone rupture [32].

During the deformation process, fracture is produced as a real result. Because crossing components can be placed along the fracture path, precise predictions can be made. Cohesive constitutive relation incorporates the material's failure properties and defines the separation process in the formulation of the cohesive surfaces. When fracture occurs at distinct confluence, such as in a structure of solid, it is difficult to place a cohesive surface because fracture orientation has a constraint pre-set angles. [33].

In general, the cohesive zone technique is used to assure stress transmission between two successive plies at the interface layer. When compared to the thickness of the ply and the in-plane dimensions, the cohesive zone thickness is insignificant.

Thus, the cohesive zone move significantly can move in different direction as shown in Figure 2.9

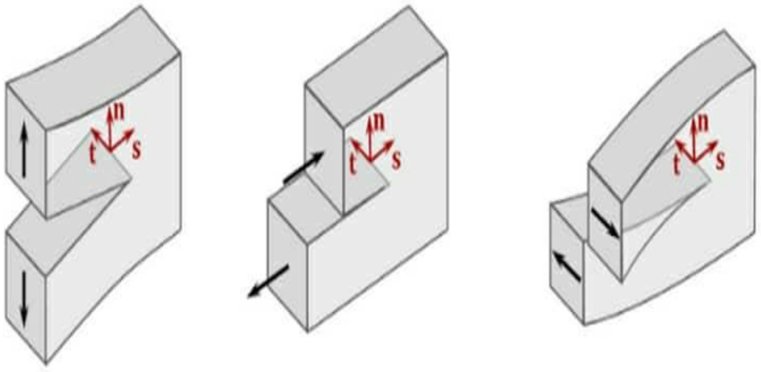

Figure 2.9 cohesive zone slides different way

2.5 Summary

Several simulations have been reviewed, and all the essential information regarding causes of delamination bending has been simplified. The most common factor that generated to delamination are temperature and pressure. Higher temperature can significantly affect the laminated structure of PCBs. The delamination also can be caused by the bending. Bending can fracture the structure of PCB and damaged certain part in the cohesive zone model. The main aim of this study is to develop a CZM to predict the initiate and growth of delamination by bending.

To conclude, the aspect of traction and elastic material properties of FR4 must be included in the simulation process to ensure that the simulation result will fit the experiment result, although this project only focuses on numerically evaluating the effect of prepreg thickness and loading load variation on the bending laminate PCBs.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Figure 3.1 shows overall project development flow delamination bending using cohesive method of PCBs board by simulation. Firstly, the project will start with research on objectives and the scope of the project. The project needs the researcher to have basic to come out with accurate calculations and results. Secondly, the researcher to undergo information and segmentation which need to collect data to have detail about the PCBs boards structures.

Next, the Project will go through pre-processing and modelling step using ABAQUS software. In this step designing and modelling based on the real structure will created. The parameter/dimension use specify by material. The material properties will define their basic material structure then follow up with mesh, define load, create step and job. This step will generate the structure that will be used in analysis the structure of PCBs structure. Reference points were used as set that would act asymmetric on distribution force to measure the force, stress and displacement.

After that, job that created would be submitted to run the simulation on the structure. The result and data collected after the simulation run end. This section summarizes the fabrication procedure of the PCB assemblies as well as the preparation of the fracture specimens. The experiments using various PCB bending specimens, aimed at determining and predicting the effect of prepreg size, impact load and PCB stiffness, are described in greater detail in Section 3.3, 3.4 and 3.5.

3.2 Project development flow

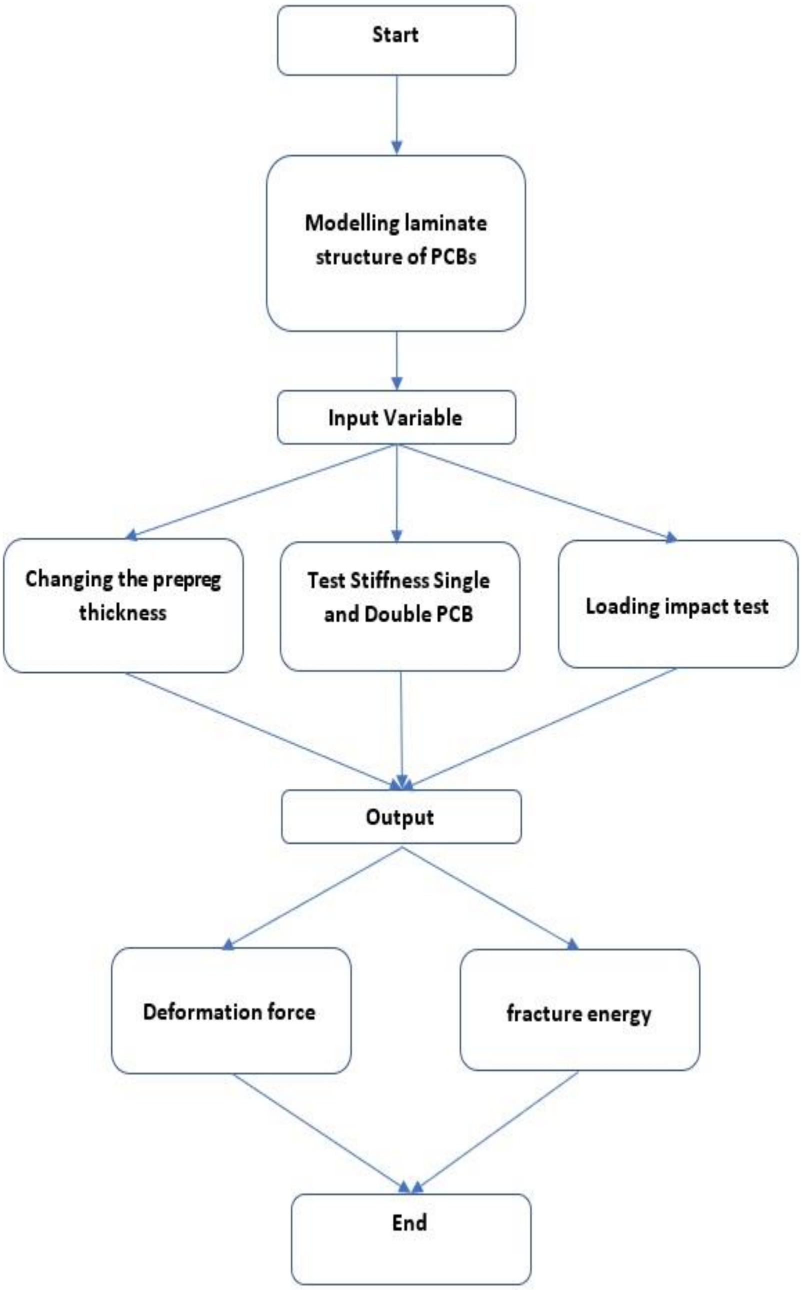

Figure 3.1 project development flow