CHAPTER I
INTRODUCTION

1.1 Background

In the present, composite materials are widely used in many industrial applications, such as automotive and safety parts. They received increasing attention in these applications because of their stiffness, toughness, light weight, and their resistance to tensile loading.

In fact, drilling holes in composite material cause damage around the hole edge, large stress concentration, and delamination at the entry and the exit of the hole. The existence of holes in composite structures is considered as the potential reason for crack initiation and growth location. This interdiction in structures (hole, notch, etc.) leads to a high stress concentration around the edges. Also, the stress concentration is the site of initial damage and it cause a wide range of effects, such as stress or strain gradients.

Reinforced composite is one of the most remarkable families of materials in this technological era. Their capability to be customized for use and endless possibilities provided by the combination of reinforcements with their aligning and fiber fraction, allow design engineers to have almost total freedom in the design of new parts. Unique properties such as low weight, high strength and stiffness are normally referred to whenever the advantages of these materials are listed. Despite that some problematical issues remain concerning the utility of composite laminates. Therefore, providing arguments for the selection of conventional materials instead of composites, mainly in structural parts. Some of those issues are cost-related, but considerations about reliability or fatigue resistance also cause some difficulties for a wider usage of those materials.

However, the importance of composite materials has been growing steadily over the last decade, which can be confirmed by their intensive use in the new Airbus A380 or Boeing 787 airplanes. In the latter, 50% of the heaviness of its primary body structure will be made of composite materials, an unprecedented ratio which was hard to imagine just some 35 years ago. One can now find composite materials not only in the aeronautical field, but also in other industries such as automotive, marine, railway or sports goods. There is no doubt that the level of confidence and reliability already achieved in metallic materials can also be reached for composites, it is just a question of time.

Considering the main problematic issues related to laminate parts into account, it is possible to find different arguments for the selection of conventional materials. One of them is correlated with the relative complexity and cost of the production process. In the later stage of parts production, machining operations like drilling are frequently needed in composite structures, as the use of bolts, rivets or screws is required to assemble the parts. Mostly, machined parts have poor surface appearance and tool wear is higher. One of the issues related with composites machining is the property of the fiber reinforcement, which is usually very abrasive and causes rapid tool wear and deterioration of the machined surfaces. As early as 1983, Koplev, Lystrup and Vorm examined the cutting process of unidirectional carbon fiber reinforced plastics in directions perpendicular and parallel to the fiber orientation. A series of quick-stop experiments was implemented to investigate the area near the tool tip. The author stated that the machining of CFRP consists in a series of fractures, each creating a chip. In the following years there were comprehensive contributions improving knowledge concerning composites and the most frequent associated issues.

One of the most common problems relates to the need of drilling without delamination. Several studies on this subject have been reported, and it is therefore now possible to envisage a drilling strategy that keeps delamination risk at a minimum. Davim and Reis, studied the effect of cutting parameters on specific cutting pressure, delamination and cutting power in carbon fiber reinforced plastics. The author deduced that feed rate has the greater influence on thrust force, so damage increases with feed. Hocheng and Tsao, conducted several practical experiments to support the benefit of using special drills instead of twist drills. In this experiment, the author deduced that thrust force varies with drill geometry and with feed rate which allows for the use of higher feed rates if adequate drill geometry is selected. Durão *et al.*, confirmed the influence of appropriate drill geometry selection on delamination reduction, as well as the advantage of the use of a pilot hole strategy. *Materials* 2014, *7* 3804.

Zitoune *et al*. investigated the effect of the machining performance during drilling of sandwiched composites using various dimensions of double cone drill. In the experimental work provided, the author concluded that it is possible to reduce the thrust force during drilling by using a double cone drill in a multi-material aeronautic component (copper mesh/CFRP laminate/carbon-epoxy fabric layer).

Another alternative frequently referred to in order to prevent delamination, is the use of a backup plate. The influences of using a backup plate on delamination are familiar in the composites industry. This drilling strategy is always a good option when the opposite side of the plate is accessible, which sometimes is not the case, mainly in field work as those involved in maintenance or repair are well aware. The utilization of a backup plate allows for drilling with higher feed rates, and consequently with higher thrust forces, as critical thrust force for delamination charge is also higher.

1.2 Problem statement

The main issue confronted during drilling process of composite materials is a delamination. The literature distinguishes the loss of cohesion between the various components of the composite (deboning) or between the layers of the laminate (delamination). Delamination happens because the changing of deforming temperature and forces. Another cause for delamination can be occur by technological errors in production process. Delaminated composite is characterized by significantly reduced stiffness and strength.

Composite repair is not profitable, but change the application of a less demanding after repairing damage is possible. An example could be rework the hull sailing yacht on a fishing boat – with a reduced load of the hull, despite the delamination can retain its own shape and integrity for many years. Delamination is disadvantageous and dangerous phenomenon, especially in locations where the safety of people and machines depends on the strength of a material.

Another issue encountered during drilling composite material is the temperature. The effect of temperature on mechanical properties of the composites is noticeable. For example, the PP composite with hemp, tensile strength at a temperature of 60ºC causing a decrease modulus of elasticity three times.

The next problem resulting from drilling is exceeding the glass-rubbery transition temperature. The glass transition temperature is defined as the point of transition from the plastic state to a glassy state and in the case of certain polymers, from glassy to plasticized one. Temperatures above the glass transition temperature (T_g) of the thermosetting matrix cause the formation of defects in the material which may lead to cracking and delamination, and after reaching very high temperatures, to melt or burn a polymer composite. Thermosetting polymers are the materials which the process of transition to a glassy state is irreversible right to the crosslinking process.

The problem investigated in this paper is to estimate characteristic temperatures occurred during drilling process of polymeric composites when various drill bits are used. Such an analysis allows evaluation of appropriate technological parameters during drilling in polymeric composites as well as specific thermal and thermomechanical phenomena occurred during treatment of polymeric composites. The study about it was performed by using passive thermography measurements and the obtained evolution curves were analyzed.

1.3 Problem limitation

In order on narrowing the problem limitation, here are some the problems to have more pre-cautions to avoid problem expenditure;

1. In drilling hole through composite must be carefully done in order to avoid excessive cracking in that material.
2. Composite is a material that need maintained temperature control during machining process especially drilling.
3. Delamination in drilling composite can reduce stiffness and strength of the material processed.

1.4 Objective of research

Regarding to background and problem statement in this report, the objectives of the research are;

1. To simulate the manufacturing operation towards composite material in drilling process.
2. To do machining towards composite material by concentrating on delamination phenomena using suitable software.
3. To analyze and observe the result of drilling product including chips shape and hole roughness.

1.5 Benefits

There are some benefits of research which is expected after doing the experiment, such as;

1. This could be the reference for other advanced research or experiment in order to have better performance on manufacturing especially drilling process.
2. This experiment could identify composite material in drilling process and improve production on industrial world.
3. To educate ourselves more about SIEMENS software, specifically in drilling programming and process simulation.

1.6 Preface

A stress centralization is a location in an object where stress is centralized. An entity is stronger when force is evenly disported over its area, so a reduction in area caused by a crack, results in a limited increase of stress. A material can fail, via a propagating crack, when a concentrated stress exceeds the material's theoretical cohesive strength. The original crack strength of material is lower compared with the theoretical level. Because most of materials accommodate small cracks or contaminants (especially foreign particles) that concentrate stress. Fatigue cracks always begin at stress raisers, so removing such defects increases the fatigue strength.

A counter-intuitive method of reducing one of the worst types of stress centralization of a crack, is to drill a large hole at the end of the crack. The drilled hollow with its relatively wide diameter, causes a smaller stress concentration than the pointed end of a crack. However, this is a temporary solution that must be corrected at the first time.

This is important to systematically check for possible stress concentrations created by cracks there is a critical crack length. When this value is surpassed, the crack proceeds to bound the catastrophic failure. This ultimate failure is definite since the crack will propagate on its own once the length is greater. (There is no additional energy required to increase the crack length so the crack will continue to enlarge until the material fails.) The origins of the value can be understood through Griffith's theory of brittle fracture.

Another method used to decrease the stress concentration is by creating the fillet at the sharp edges. It gives smooth flow of stress streamlines. In a threaded element, force flow line is bent as it passes from shank portion to threaded portion as a result stress concentration takes place. To reduce this, a small cutting is taken between threaded portion and shank. There are observational methods to measure stress concentration factors including photo elastic stress analysis, brittle coatings or strain gauges. While these approaches have been successful, all also have environmental, experimental, accuracy and measurement disadvantages.

There may be small distinction between the catalog, FEM and theoretical values measured. Each method has advantages and disadvantages. Many catalog curves were obtained from experimental data. FEM computes the peak stresses directly and nominal stresses may be easily found by integrating stresses in the surrounding object. The result is that engineering consideration may have to be used when picking which data applies to make a design. Some theoretical stress centralization elements have been derived for infinite or semi-infinite geometries which may not be analyzable and not testable in a stress experiment. Solving a problem using two or more of these approaches will allow an engineer to obtain a precise conclusion.