POKA YOKE FOR SOLVING HIGH DISPOSAL SCRAP PROBLEM AT HAND LAY-UP PROCESS AT AEROSPACE COMPOSITE MALAYSIA

by

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LIST OF ABBREVIATIONS

FOD	foreign object debris
ACM	Aerospace Composite Malaysia
BAA	Boeing Aerostructures Australia
DMAIC	Define Measure Analyze Improve Control
RWP	Residence Work Plan
CSV	Class Sample Vector
CWM	Class Weight Matrix
CWV	Class Weight Vector
EDC	Euclidean Distance to Centriods

LIST OF SYMBOLS

A	Number of PLS or PCA components in the model
a	Number of the PLS or PCA component
b	PLS regression coefficient
b	Number of blocks (b=1,2,3.....,K)
C	Coarse APM block
$\boldsymbol{C}_p$	Pooled covariance matrix for the two classes

Poka Yoke untuk Menyelesaikan Masalah Skrap pelupusan Tinggi pada Proses Layanan Tangan di Aerospace Composite Malaysia

ABSTRAK

Objektif penyelidikan ini adalah untuk menunjukkan penggunaan metodologi Lean Six Sigma dalam mengurangkan sekerap pelupusan yang tinggi dalam proses layanan tangan. Selain itu, matlamatnya adalah untuk membangunkan penyelesaian kerja bagi syarikat sasaran untuk mengurangkan masa kerja semula melalui meminimumkan kecacatan serpihan objek asing (FOD). Latar belakang teoritis dicapai melalui kaedah Lean dan Six sigma. Asas bahan komposit dan kaedah fabrikasi komposit dikaji kerana projek ini dijalankan di Perusahaan Komposit Aerospace Malaysia. Masalah kecacatan FOD yang dicadangkan oleh syarikat sasaran, dengan mengikuti proses penambahbaikan mengunakan Tentukan Pengukuran Analisis Meningkatkan Kawalan (DMAIC), Lean and Six Sigma dan menganalisis data proses dari perusahaan sasaran. Tumpuan penyelidikan ini adalah dalam memperlihatkan bagaimana menggunakan proses pergunaan DMAIC, lean and sig sigma . Untuk mengesahkan keadaan semasa sistem perkilangan, potensi peningkatan dan penyelesaian, alat statistik seperti carta Pareto dan histogram digunakan. Untuk memastikan bahawa semua keputusan adalah berdasarkan data sebenar yang mungkin, data sebenar telah dianalisis melalui gambarajah sebab dan akibat. Sebagai hasil daripada kajian ini, beberapa set rekabentuk penyelesaian dan kaedah menggunakan alatan telah dibuat.. Teknik kualiti ini dipilih dan digunakan untuk meminimumkan sekerap pelupusan yang tinggi

Poka Yoke for Solving High Disposal Scrap Problem at Hand Lay-Up Process at Aerospace Composite Malaysia

ABSTRACT

The objective of this research is to demonstrate the use of Lean Six Sigma methodology in a reduce high disposal scrap in hand lay-up process. Moreover, the goal is to develop working solutions for the target company to reduce the rework time through minimize the number of FOD defect. The theoretical background is achieved through exploring the literature of Lean and Six sigma. The fundamental of the composite material and composite fabrication method are studied due to this project conducted at the Aerospace Composite Malaysia Company. The FOD defect problem suggested by the target company, by following the Lean and Six Sigma improvement process DMAIC and by analysing the process data from the target company. The focus of this research is in demonstrating how to use Lean and Six Sigma improvement process DMAIC in practice. In order to validate the manufacturing system's current state, improvement potential and solutions, statistical tools such as Pareto chart and histogram were used. To ensure that all the decisions were as heavily based on actual data as possible, the actual data had been analysed through cause and effect. As a result of this study, some designs have been done using tools. As a result of this research, a set of solutions were developed by poka yoke tool.. These quality technique are selected and applied to minimize in high disposal scrap

CHAPTER 1:INTRODUCTION

1.1 Background of the Study

Quality is now involved in a various business which included manufacturing, business, hospital, school, food industry, public utilities, etc. and it is not only focusing in the field of production but the service sector. It has become the core competitiveness for many companies to improve their competitive advantage and it is essential perspective in all the field. This is because, quality of the products or services leading to commercial success, enhance competitiveness, improve customer loyalty and reduce costs. (Lachajczky, Dudek-Burlikowaska, 2006)

On this reason, the costs which occurred from providing the high quality of product and services. The cost can be impacted by the low-quality product or unnecessary work procedure such as scrap, rework and retest and all these are more than the cost of the produce or doing it. The cost of poor quality can be divided into four classes: prevention cost, appraisal cost, failure cost (cost of internal fault and external failure costs) and discarnate costs. Internal failure costs which include failure analysis, scrap, rework, retest, and downtime while external failure cost is a compliant adjustment, return products and supplies, warranty costs, liability costs and indirect costs. Thus, to ensure the cost is minimized, it is required to find out the potential problem and identify the related problem that cause the cost of poor quality. Since the project focuses on the aerospace manufacturing industry and the company individual involved in the various aspects of producing, testing, selling, and shipping the aircraft part. The main manufacture process of the company is hand lay-up. Hand lay-up is the basic processing

procedure for composite material and it is a main material for aerospace structure. There are a lot of various type of defect able to be found in the hand lay-up process. The most significant defects in monolithic structure is porosity, cause by incorrect manufacture, and impact damage during in-service. Besides, there are still have another potential defect which can affect mechanical properties of the aircraft structure which is foreign object debris (FOD) defect. FOD is one of the potential defects that affect the quality of the aircraft. So, from FOD can cause high disposal scrap problem.

Competitor is not only from domestic or local companies but also from the international companies. Therefore, customer needs are low prices, high quality products, good services, fast delivery, etc. Continues Quality Improvement Theory (CQI) or Kaizen is one of the strategies that can help organization to satisfy customer needs and to have greater performance. To improve the quality of the product; kaizen the production and operation management for defect reduction, there are some strategies able to establish on the production process or organization, which are Six Sigma and Lean. Both of these tool is a methodology that depend on the collaborative team effort to improve the performance systematically removing the waste. Therefore, it is suitable to implement these tools on this project due to the main goal for this project are to reduce/eliminate the waste caused by the FOD defect.

1.2 Target Company and background

The target company of this project is Aerospace Composite Malaysia Sdn Bhd (ACM) owned equally by The Boeing Company and Hexcel Corporation and is located in Bukit Kayu Hitam, Kedah, Malaysia. ACM distributes and manufactures fibre

reinforced composites for wing of aircraft and flat and contoured primary (Aileron Skins, Spoilers & Spars) and secondary (Flat Panels, Leading Edges, Trailing Edges & MISC: Components) structure composite bond assemblies and sub-assemblies for aerospace industries. ACM Company is one of the manufacturer aerospace company that supplies high technology composite products to the aerospace industry and employs around 1300 people. (Boeing, 2017).

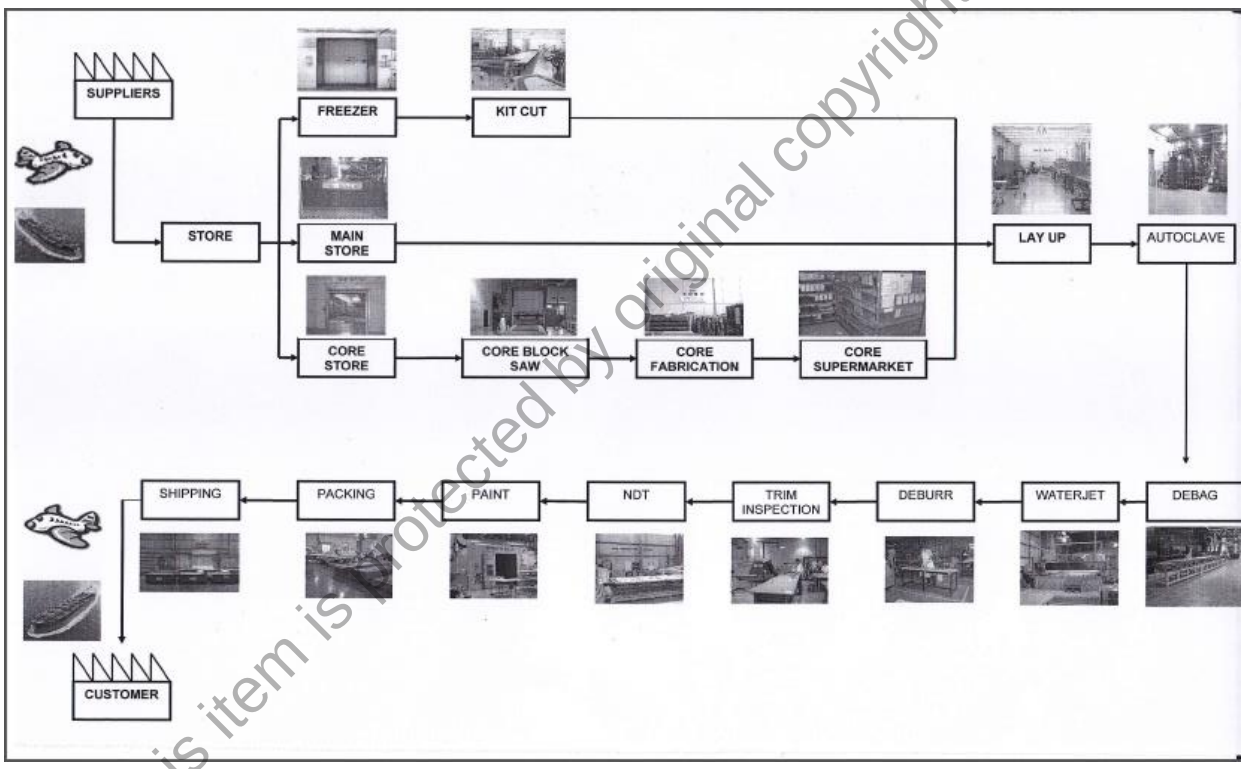

Figure 1.1: ACM Manufacturing Process Flow.

Figure 1.1 shows the ACM manufacturing process flow which Honeycomb core is the material used as a central layer material in sandwich structured composite materials. There are many type of honeycomb in market such as aluminium, aramid fibre, stainless steel and thermoplastics. In ACM manufacturing used aramid fibre, which can be classified in two categories, Nomex, and Flex core, which is bought from Hexcel Casa Grande. Always make sure to cut the honeycomb according to ribbon direction. Main defect in honeycomb is depression there are Grade 3, 4 and 5. Gred 3 is soft and Gred 5 is the hardest. Torit will absorb dust during sanding

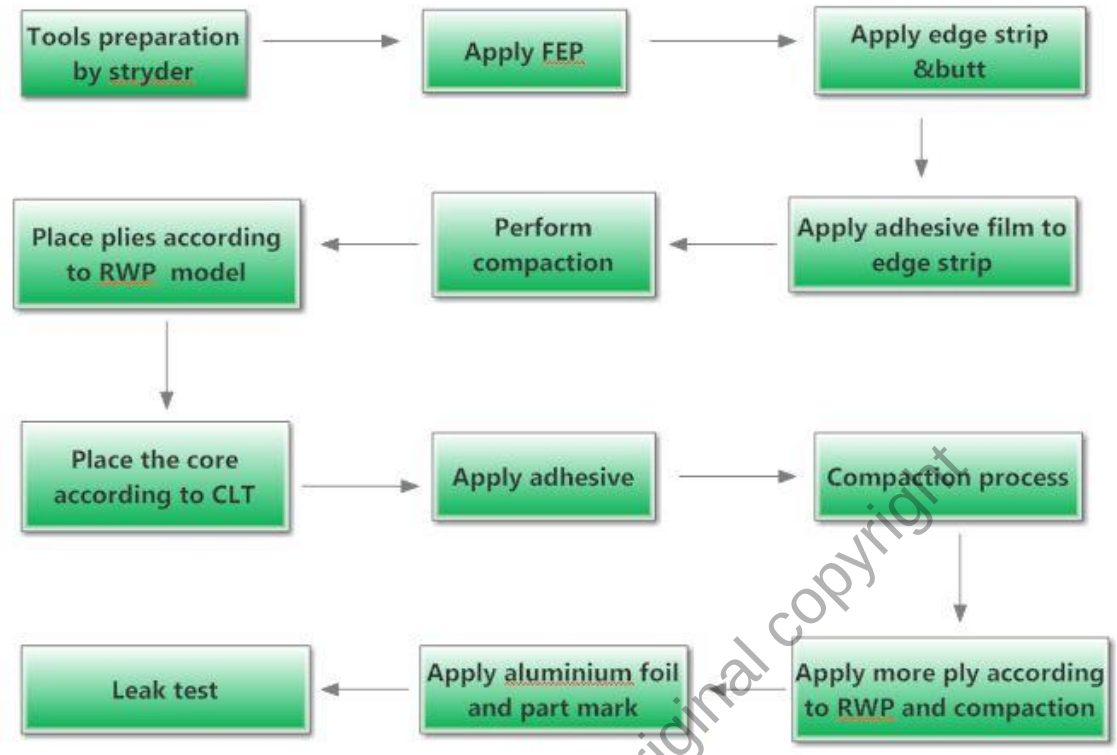

Figure 1.2: Flow chart honeycomb core

Figure 1.2 shows ACM manufacturing process flow process layout all workers are following the step to do honeycomb core according to Residence Work Plan (RWP). Strider, person in charge as runner, makes the tools preparation. Before starting process, always make sure that the tools or Lay-up Mould is match with the ply received according to the P-copy. There are five program in ACM, which are Hexcel, Boeing, BAA, CCAC and FACC. Core Locating Template (CLT) is use to locate the position to place the honeycomb core. Filler is place around the core location. Vacuum compaction is done to compact the ply and avoid delamination.

This research was initiated by ACM company desire to be able to reduce the FOD's cases due to FOD can directly threaten safety of flight crews and integrity of the aircraft. This also increase the wastes, increase rework time and spontaneously increase

the cost of the company production. The research and the related project was at the same time cooperated with the ACM team to establish Lean and Six Sigma approaches on the production area. Due to the company's request, the execution of this project depends heavily on the different ideas and tools combined under the six sigma and Lean methodology.

1.3 Problem Statement

The data collected from the target company through visiting and observation on the current situation of a production line. There was 58 pieces of FOD defect in 2014 and had dropped dramatically on 2015 which only had 28 pieces of defect on the product. The FOD defect in 2016 is 28 pieces and defect FOD in until September 2017 is 23 pieces forecast that the number of FOD defect will be maintained or will be no improved in following year. Thus, the project problem statement which is to improve the product quality through the reduction of the FOD defect. This project set a goal which reduce 20% of FOD defect from 23 piece FOD defect in 2017.

At all time, foreign object defect FOD is a potential hazard to aircraft safety. FOD cause damage and this costs are in millions of dollars every year. The type of FOD can be divided into two major part: FOD on the physical of aircraft and FOD on the structure of aircraft. FOD on the structure of aircraft are focused on this project due to it affect the mechanical properties of the aircraft, and it is one of the defects of composite material that is difficult to detect and control. FOD can inadvertently be produced or involved in composite materials, either during the manufacturing process or others work process in the industry. The manufacturing process –hand lay-up process has the potential for

causing a wide range of FOD due to this process is manual and required human workforce. In either case there is the potential for the inclusion of foreign bodies ranging from backing film to just greasy mark from a finger. The defect not only cause the rework's process, a cycle time of the production and also increase the expense/ cost of the production. Thus, the research proposed to demonstrate how poka yoke approaches in the manufacturing process to reduce the number of FOD defect.

1.4 Research Objectives

The outline of aim which wants to achieve from the project;.

a) To identify the root cause of FOD defect in hand lay-up process.
b) To design a poke yoke tool to reduce high disposal scrap problem in hand lay-up process

1.5 Research Scope

This research focused on the manufacturing production process hand lay-up which is the traditional and manual method for manufacture of fibre enforced These composite material is the main material for making the wings of the aircraft and is the main production in ACM Company. The reason of studied the manufacturing process-hand lay-up which for understand the procedure, technique, common defect, and basic concept when operating the hand-layup process. In this research, the tools and frameworks used are all linked to Lean and Six Sigma, in other words, the paper will discuss Lean and Six Sigma methodologies. Lean and Six methodologies relies on a collaborative team effort to improve performance by systematically removing waste and

reducing variation. The goal of this research is to demonstrate how these Poka yoke tools can be used in an improvement project in term of reduction the FOD defect of an industrial and to present a set of solutions for the target company's manufacturing.

In this research, the tools and frameworks used are all linked to Poka yoke, in other words, the report will discuss Poka yoke methodologies. Poka Yoke methodologies relies on a collaborative team effort to improve performance by systematically removing waste and reducing variation. Hence, the goal of this study is to demonstrate how these tools can be used in an improvement project in term of reduction the FOD defect of an industrial and to present a set of solutions for the target company's manufacturing. The choose poke yoke tool to reduce the defect in the part.

The goals and scope for this research can be summarized in the following way:

- Demonstrate how Poka Yoke can be used in a project and improvement the quality of the product through reduction of FOD defects.
- Create a set of working solutions through which the target company can reduce its high disposal scrap problem.

1.6 Significant of Study

FOD is a potential defect that causes of aircraft damage. It is involved in the safety case and quality control concept in any aerospace, manufacturing, warehouse, shipping, military or similar environment such as small debris, loose objects, and even fingerprint from human also have the potential to cause.

As to overcome this problem, this study is to propose the solution for reducing the FOD defect on the hand lay-up process. So, the research focused on design poka yoke tool of Poka yoke improvement process DMAIC for FOD defect reduction. Quality is about making a product to meet the personal satisfaction of a customer about the quality or value. Therefore, in what regards Poka yoke, the concern is not only to "do the things right" but also to "do the right things right". The key elements it aims at are achieving the best quality, the lowest cost, stressing on waste elimination. The requirements of a company for its implementation and the strategy to obtain the maximum practical outcome investigated.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter 2 discussed the study/research that main finding and as well as some additional finding which respect study research problem and objective. More over this chapter is devoted to the review of literature, which include concept of material composite in structure of aerospace, the properties of the material composite, and the manufacturing process in structure of material composite.

The construction of the material in aerospace structures are becoming more important. Aircraft part, such as fairing, spoilers, and flight controls, spark, aileron skins, spars were made from composite material and this was developed during the 1960s for the weight saving purpose. New generation of large aircraft structure design and all the fuselage and wings, and the repair of these advanced composite materials requires a lot of understanding of composite structures, material, and tooling. Besides the reason of composite material is chosen for construction of material in aircraft which is their high strength, and corrosion resistance, relatively low weight. All these properties are main requirement in structure of aircraft.

2.2 Foreign Object Debris (FOD)

In generally, foreign object debris (FOD) is a kind of material, debris or foreign vehicles or system, may cause damage, especially in aerospace settings. FOD appeared

in the airport's air operations area (AOA) constitute a major threat to the safety of air travel. FOD possible damage to the aircraft during the critical phase of flight, which could lead to miserable loss of life and fuselage, and also it can increase the maintenance and operating cost (Bachtel, 2017). Moreover, (FOD) can cause damage that costs airlines, airports and all these costs is in millions of dollars every year. FOD is any object that does not belong in or near airplanes and, as a result, can injure airport or airline personnel and damage airplanes (Burch, 2010).

FOD can severely damage the airport and airline personnel or damage the equipment. Potential damage types include: reduce aircraft tyres, drawn into engines or becoming fixed in mechanisms and affect the flight operation. Injuries or even death can occur when jet blast propels. FOD through the airport environment at high speed (R.Smitch, 1997). On the other hands, FOD includes a wide range of material, including loose hardware, pavement fragments, catering supplies, building materials, rocks, sand, pieces of luggage, and even wildlife and also FOD is found at terminal gates, cargo aprons, taxiways, runways, and run-up pads (Burch, 2010).

There are several of source that cause the FOD. FOD can be generated from personnel, airport infrastructure such as pavements, lights, and signs; the environment such as snow; and the equipment operating on the airfield likes aircraft, airport operations vehicles, maintenance equipment, fuelling trucks, other aircraft servicing equipment, and construction equipment. Besides, weather can also be the cause of FOD due to movement. For example, wind can blow dry debris, such as sand or plastic bags, from relatively non-critical areas onto the flight area. Rain water and drainage can stream mud, pebbles and other small items along the path of least resistance (Bachtel, 2017). All these are considered FOD defect but happened in the physical of the aircraft