COMPOSITE ENVISIONS KNOWLEDGE HUB
PRACTICAL AND INSIGHTFUL COMPOSITES INFORMATION

QUALITY CONTROL METHODS & PROCEDURES

COMPOSITE ENVISIONS

INTRODUCTION

Large companies follow specifications given to them by a specific “customer”. Most of the time the “customer” is who is physically buying the part or putting it into use. Usually the specifications control every aspect of a given part and how a given customer expects the parts to be controlled in the process. Most of these things are “critical to quality” or what pieces or processes are integral for the product’s or composite structures function when made. After the specification of the parts being made, a quality plan is put in place to define what documents will be needed for achieving a certain specification. To break it down. Below is a list of the high-level processes in composite’s manufacturing and how quality is or can be controlled and is controlled at various levels of manufacturing environments.

Note: To run conforming quality control, there is a basis of knowledge that needs to be achieved. That is the reason “inspectors” are not generally just someone brought off the street to ensure quality functions are met. Most people writing a general quality procedure are engineers or quality experts experienced in the critical functions of composite lamination. Knowing how a given material acts, knowledge on process parameters and ensuring an inspection plan for a given part is the baseline in providing a product that is adequate to the customer’s expectation and specification.

A quality control procedure can be high level does the part meet the strength and visual requirements or down-right to knowing the resin’s batch tested Tg at the Factory that it was made vs when it got to the fabricator’s door upon receipt to that same figure and test being completed 6 months down the road. In aerospace, traceability is the biggest word to quality. In other industries life and death may not be on the line.

PROCESS SPECIFICATIONS

The specifications determine the parameters for a working environment in which processes may be completed. They will call out any pertinent information such as if a clean room is needed, temperature and humidity criteria for a layup environment, particle counts to ensure air quality for a given process. How the part(s) will be inspected from a dimensional standpoint, what are the tolerances surrounding certain points? What parameters and tools to use to inspect laminate quality? Whatever a customer may see fit to ensure quality in the parts may be done in a process specification. More will be covered for process specifications in each of the processes defined below.

Many aspects of composite processes are defined in a process specification. In industrial applications, specifications are made to ensure a clean and consistent layup area. Clean Rooms are coined as areas specific to layup. In these clean rooms, Temperatures are recorded into data logs and inspected as needed to ensure Temperatures, Relative Humidity, and even particle counts are met per customer need.

MATERIAL SPECIFICATIONS

These are the “material datasheets” so to say. These specifications will determine many things for process parameters, just on a material level. Criteria and Quality controls for things such as how a given material is to be stored, frequency of material testing, what material tests to perform per specific ASTM standard and the results needed to sell a part with that material in them. Material specifications may also determine where that material may or may not be purchased. A Material Specifications will further define the cure parameters of the materials, it’s Shelf life, and other physical and chemical material properties.

PART DRAWINGS

Part drawings define what is being made. This document is going to define the Part number, it’s name, what materials are in it, what process specification the part will be made to, its dimensions, ply structure, ply shape, anything and everything the part will need that is critical to quality will be defined in the part drawing. Usually the part drawing will supersede most any other document as the part is what is being sold.

QUALITY CONTROL PROCEDURES

Quality control procedures take the above information and define how each of the above criteria will be met. The control plan can take shape in many of the process’s documents and work instructions and the plan will work to ensure each criterion on a part drawing, process spec, or material spec are met. First part or process qualifications are usually more stringent on controlling each micro piece of a process to make sure it is a repeatable, traceable, and defined process. Once process capability is proven, some quality control is less stringent on its implications to a production environment as customer requirement allows.

TOOLING BUY-OFF / CONTROL PARAMETERS / QUALITY CONTROL

A good tool is measured ultimately by its ability to make an acceptable part. Tooling may be sometimes hard to deal with, expensive and tough to perfect. However, the layup tool is singlehandedly more important than a single part. Such that, its quality control must be held tightly. A tool is not ever deemed as “good” or “bought off” until a complete good part is made, and that part has successfully been through dimensional inspection for criteria critical to that from the mold surface. Throughout the layup and cure process, there is variation in handling and the temps a given tool will see during its lifespan. These things can affect its dimensional stability and thus, part quality. Tooling in aerospace is constantly being tested, just not always directly. Each part may be measured dimensionally, though dependent on the customer specification. But tools may also run into other issues throughout its lifespan. Sometimes tools develop cracks or leaks, have issues with drawing an adequate amount of vacuum pressure, do not get the proper type or amount of mold release during preparation for layup. The question is, how does a quality control procedure work to mitigate that? The control plan sets buy off by a good part. If good parts are being taken off the tools, then the tools are good. As for preparation, process parameters such as writing a tool cleaning record for each time the tool is cleaned.

PLY CUT & KITTING

Quality control from a kitting aspect would cover criteria such as the ply shapes themselves being cut specific to the part being made. A kit may be cut from an automated ply cutting machine or other CNC cutting device that may have capability to cut within a .030” tolerance or less in some cases. These machines cut a file based on the material width and input from a given “cut file”. This file is usually controlled by inputs from cad or other drawing software. This drawing file can be put into the cutting machine and it will tell the machine when to lift, when to cut, what tool to use for cutting, the works. Automatic cutting tables are remarkable machines that have revolutionized the composite industry. Cut and numbered plys can be placed into a bag or box and stored on an as needed basis. It should be noted that material specifications hold regard in these areas as out-times, shelf-life, and expiration dates all play must be met before a part can be laid up or cured.

LAYUP

Once plys are cut they can be measured for deviation from a “master” ply shape mylar for instance. There are a ton on different ways to ensure ply shape verification. Use of laser projection systems programming onto tooling so that the outline of each shape is visible for the specific ply being laid down. This ensures the ply itself meets the dimensional criteria and ply orientation as designed. There are usually tolerances on the plys for dimensional criteria and orientation, as nothing can be “perfect”. Things can get quite complicated when ply level traceability is a requirement. One effective way this can be done is through having a quality or layup technician physically sign off on each ply that has been laid down into a tool. This may be best completed by following a detailed work instruction written clearly enough to understand the sequence of which the plys should be laid down.

Simpler ways to do this is after the part is made, a per ply thickness can be measured by most prepreg materials and even wet layups. Certain sections may be thicker than others based on the part’s drawing. Layup quality control may be executed in different ways but is ultimately dependent on customer requirement. Most of the control happens at ply cut but certain aspects have had a quality inspector physically stamp off on each ply laid down onto a tool. Quality assurance does not stop at the ply shapes either. The sequence in which the plys are laid up may be critical to the quality of the part. Especially when mixing in extra pieces such as core and film adhesives into the mix. Quality control parameters are set to ensure the order of operations are met throughout the entire layup. Plys may be labeled in the order of which they should be laid up (1,2,3...etc) which is a commonsense sort of quality control parameter that works wonders on ply shapes that are often nearly identical.

In more complicated layups, debulks and pre-bagging may be required. As an example, after "x" of plys have been laid down, a certain vacuum level must be placed onto the plys for a certain amount of time, using a vacuum bagging scheme. This ensures part quality stays at its highest throughout the layup process. This debulks may be recorded for pressure reached, time started and stopped and can follow the part all the way through production processing. If the part is to be left unattended for a long period of time, the part may be placed under debulk.

Once a part is laid up or all needed plys have been placed, final bagging processes may be scrutinized heavily based on part cost and / or process specification. For example, it would really be a bummer for a large part with $50K in material costs, another $10K in labor hours charged into the part... and to top it all off, meeting a tight production schedule...... for a vacuum bag to have a leak in it during the cure cycle, blow out, expose the part to the atmosphere during cure, resulting in the part being scrapped out due to porosity issues as the composite would be airshot. For that reason, final bagging processes are carried out with diligence and patience. Special attention is paid to the type of bagging material, the separating films, the entire scheme may have quality requirements based on the part's need. The main objective is to achieve the highest quality laminate and satisfy the customer, whomever that may be. The quality procedures will ensure that all aspects that are critical to achieving a conforming part are met.

CURE

Cure parameters are generally carried out per the given part's material specification. It will guide a cure cycle. Cure cycles will work to control aspects such as cure temperature, pressure in various aspects of the cure, ramp rates for getting to cure temperature, time at cure temperature and ramp rates back to atmospheric conditions. Quality procedures are written to ensure that the needed aspects of the cure cycle are met, and the part's chemistry will in fact meet the needed standard. In addition to meeting cure cycle parameters, a flat panel may be cured with parts to buy-off a cure cycle. Physical tests may be performed such as TG or tensile testing to represent the cure cycle. This ensures the rest of the parts cured during the cure are up to par.

STRIPPING

Ensuring mistakes are not made during the stripping process are usually complete by a visual inspection and / or a Non-Destructive testing means as described below. Main quality assurances are often as simple as making sure the mold was properly cleaned with the specific mold release needed, the time that it was completed for preparation to the next layup cycle. If these simple things are not taken care of properly, a tool could be down for weeks as some parts will stick if improper techniques are used to prep a tool. In industry, small mistakes can have huge implications and consequences.

TRIM & DRILL

Some parts may be simply cut from a template from a master part. Other parts may have more stringent requirements and need to be cut by machine. For these parts a CNC machine with multi-dimensional cutting technologies may be used. These machines are set to ensure cut quality is met based on part thickness, material types and dimensional tolerances can be met. Cutting tools used, speeds / feed rates are often controlled as part of a quality control plan to ensure parts are not damaged and consistent programs are running to meet the needed part's machining requirements. After the parts are ran through machining processes, they may be checked on a CMM (Coordinate Measuring Machine) to buy off the machining or cut work performed and also to measure any layup tool defined features that are design controlled.

NDI

Non-Destructive Inspections are performed after the part has been stripped and trimmed. These non-destructive tests (NDT / NDI) are performed using sound waves to project resonance into a pass / reject criterion based on the wave's return. Basically, these tests say if the part has air trapped within in plys or if it is solid. It may also check for delamination caused by machining or handling processes. This procedure will ensure a conforming part is solid from the inside out.