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COMPOSITES AND NON-METALLICS

COMPOSITES AND NON-METALLICS

COMPOSITE MATERIALS

"composite" material is:defined as a mixture of diff rent materials or things.

composition of composite materials is a combination of reinforcement, such as:

1, fiber

2, whisker

3, particle

- surrounded and held in place by a resin, forming a structure.

reinforcement and the resin

- are very different from their combined state
- Even in their combined state:
- they can still be individually identified and mechanically separated

ADVANTAGES/DISADVANTAGES OF COMPOSITES

The advantages for using composite materials are:

- High strength to weight ratio.
- Fiber-to-fiber transfer of stress allowed by chemical bonding.
- Modulus (stiffness to density ratio) 3.5 to 5 times that of steel or aluminum.
- Longer life than metals.
- Higher corrosion resistance.
- Tensile strength 4 to 6 times that of steel/aluminum.
- Greater design flexibility.
- Bonded construction eliminates joints and fasteners.
- Easily repairable.

The disadvantages of composites include:

- Inspection methods difficult to conduct, especially delamination detection (Advancements in technology will eventually correct this problem).
- Lack of long term design database, relatively new technology
- Cost.
- Very expensive processing equipment.
- Lack of standardized system of methodology.
- Great variety of materials, processes, and techniques.
- General lack of repair knowledge and expertise.
- Products often toxic and hazardous.
- Lack of standardized methodology for construction and repairs.

COMPOSITE SAFETY

Composite can be very harmful to the

- skin
- eyes
- lungs
- people can become sensitized to the materials with serious irritation and health issues.

Personal protection is often

- uncomfortable
- hot
- difficult to wear

however

- can prevent serious health issues or even death

Personal PPE and precautions

- Respirator particle protection (for the lungs to protect them from tiny glass bubbles and fiber pieces)
- dust mask approved for fiberglass
- respirator with dust filters (better than the mask point 2)
- vapor protection (when working with resins)
- charcoal filters (in a respirator last less than 4 hours)

Precautions:

- If you can smell the resin vapors after placing the mask back on after a break, replace the filters immediately.
- Store the respirator in a sealed bag when not in use
- If working with toxic materials for an extended period of time, a supplied air mask and hood are recommended.
- Avoid skin contact with the fibers and other particles by wearing long pants and long sleeves along with gloves or barrier creams.
- leak-proof goggles (no vent holes) when working with resins or solvents because chemical damage to the eyes is usually irreversible.

FIBER REINFORCED MATERIALS

The purpose of reinforcement in reinforced materials is:

- to provide strength
-

There is three main forms of fiber reinforcements are :

- particles
- whiskers
- fibers

particle:

1, is a square piece of material
2, Glass bubbles (Q-cell) are hollow glass spheres,
3, and their dimensions are equal on all axes

whisker:

1, piece of material that is longer than it is wide.
2, Whiskers are usually single crystals
3, They are very strong and used to reinforce ceramics and metals

Fibers:

1, single filaments that are much longer than they are wide.
2, Fibers can be made of almost any material,
3, not crystalline like whiskers
4, Fibers are the base for most composites
5, Fibers are smaller than the finest human hair and are normally woven into cloth-like materials. So thine

LAMINATED STRUCTURES

Composites can be made with or without an inner core of material.

Laminated structure with a core center is called a sandwich structure

Laminate construction is
- strong
- stiff
- but heavy

The sandwich laminate is equal in
- strength
- and its weight is much less

The core of a laminate can be made from nearly anything

The decision is normally based on use
- strength
- and fabricating methods to be used.

Various types of cores for laminated structures include:
- rigid foam
- wood
- metal
- the aerospace preference of honeycomb made from paper
- Nomex
- carbon
- fiberglass
- metal

very important to follow proper techniques to construct or repair laminated structures to ensure the strength is not compromised.

sandwich assembly is made by
1, taking a high density laminate or solid face
2, and backplate and sandwiching a core in the middle
(translate)

The selection of materials for the face and backplate are decided by
- the design engineer
- depending on the intended application of the part

It is important to follow manufacturer's maintenance manual specific instructions regarding testing and repair procedures as they apply to a particular aircraft.

ADVANCED LAMINATED COMPOSITE MATERIALS
Aircraft parts made from composite materials, such as
fairings, spoilers, and flight controls, for :
weight savings over aluminum

New generation large aircraft are designed with all composite fuselage

repair of these advanced composite materials requires an :in-depth knowledge of composite structures, materials, and tooling

Some applications of composites on aircraft include:
- Fairings.
- Flight control surfaces.
- Landing gear doors.
- Leading and trailing edge panels on the wing and stabilizer.
- Interior components.
- Floor beams and fl or boards.
- Vertical and horizontal stabilizer primary structure on large aircraft.
- Primary wing and fuselage structure on new generation large aircraft.
- Turbine engine fan blades.
- Propellers.

The primary advantage of composite materials are;
Strength
Low weigh
Corrosion resistance

MAJOR COMPONENTS OF A LAMINATE

isotropic material has uniform properties in all directions.
The measured properties of an isotropic material are: independent by the axis of testing.
Ex Metals such as aluminum and titanium are examples of isotropic materials.

- fiber is the primary load carrying element of the composite material.
- The composite material is only strong and stiff in the direction of the fibers
- Unidirectional composites have predominant mechanical properties in one direction and are said to be anisotropic

Components made from fiber reinforced composites can be

- designed so that the fiber orientation produces optimum mechanical properties, (will have mechanical properties if fiber is used)
- but they can only approach the true isotropic nature of metals

matrix

A matrix supports the fibers and bonds them together in the composite material.

The matrix transfers (Matrix is resin)

- any applied loads to the fibers,
- keeps the fibers in their position and chosen orientation,
- gives the composite environmental resistance,
- and determines the maximum service temperature of a composite.

Structural properties, such as STRENGTH CHARACTERISTICS
stiffness, dimensional stability, and strength of a composite laminate,
depend on
the stacking sequence of the plies

The stacking sequence describes:
the distribution of ply orientations through the laminate thickness

As the number of plies with chosen orientations increases:
more stacking sequences are possible.

FIBER
Fiber Orientation:
The strength and stiffness of a composite buildup depends on the orientation sequence of the plies

- The part might require 0° plies to react to axial loads,
- ±45° plies to react to shear loads,
- and 90° plies to react to side loads.
- Because the strength design requirements are a function of the applied load direction, ply orientation and ply sequence have to be correct.
- It is critical during a repair to replace each damaged ply with a ply of the same material and ply orientation.

unidirectional
The fibers in a unidirectional material run in one direction and the strength and stiffness is only in the direction of the fiber.

bidirectional
- The fibers in a bidirectional material run in two directions, typically 90° apart
- These ply orientations have strength in both directions but not necessarily the same strength

Preimpregnated (prepreg) tape is an example of a unidirectional ply orientation

plain weave fabric is an example of a bidirectional ply orientation

Ex: The plies of a quasi-isotropic layup are stacked in a 0°, –45°, 45°, and 90° sequence or in a 0°, –60°, and 60° sequence. (Figure 3-3) These types of ply orientation simulate the properties of an isotropic material. Many aerospace composite structures are made of quasi-isotropic materials.

Warp Clock

Warp indicates the longitudinal fibers of a fabric

The warp is the high strength direction due to the straightness of the fibers

A warp clock is used to describe direction of fibers on a
- diagram
- spec sheet
- or manufacturer's sheets

If the warp clock is not available on the fabric:
the orientation is defaulted to zero as the fabric comes off the roll
Therefore, 90° to zero is the width of the fabric across. guess

Fiber Forms

All product forms general ly begin with spooled unidirectional raw fibers

An individual fiber is called a filament

The word strand is also used to identify an individual glass fiber

Bundles of filaments are identified as :
- tows
- yarns
- rovings

Two types of yarn:
- Fiberglass yarns are twisted
- while Kevlar yarns are not

Tows and rovings do not have any twist.

Most fibers are available as dry fiber that needs to be:
impregnated (impreg) with a resin

before use or prepreg :
materials where the resin is already applied to the fiber

Roving

- roving is a :single grouping of filament or fiber ends, such as 20-end or 60-end glass rovings All filaments are in the same direction, and they are not twisted
- filaments are in the same direction and they are not twisted.
- Carbon rovings are usually identified as 3K, 6K, or 12K rovings, K meaning 1 000 filaments.
-

Most applications for roving products

- utilize mandrels for filament winding
- then resin cure to final configuration

Unidirectional (Tape)
Unidirectional prepreg tapes:

- the fiber is typically impregnated with thermosetting resins
-

The most common method of manufacture is to

- draw collimated raw (dry) strands into the impregnation machine
- where hot melted resins are combined with the strands using heat and pressure.

Strength :
1, Tape products have high strength in the fiber direction
2, no strength across the fibers

(The fibers are held in place by the resin.)
Tapes have a higher strength than woven fabrics(book)

Bidirectional (Fabric)
Most fabric constructions off r more flexibility for layup of complex shapes than straight unidirectional tapes off r (Suca)

Fabrics off r the option for resin impregnation either by
- solution
- the hot melt process

Generally, fabrics used for structural applications use like
- fibers or strands
- of the same weight or yield
- in both the warp (longitudinal) and fill (transverse) directions
-

tightly woven fabrics are usually the choice to
- save weight,
- minimizing resin void size,
- maintaining fiber orientation during the fabrication process.

Woven structural fabrics are usually constructed with
- reinforcement tows
- strands
- yarns

interlocking upon themselves with over/under placement during the weaving process.

The more common fabric styles are
plain or satin weaves.

The plain weave construction results from
- each fiber alternating over and then under each intersecting strand (tow, bundle, or yarn)

common satin weaves, such as:
5 harness or 8 harness:
the fiber bundles traverse both in warp and fill directions changing over/ under position less frequently.

These satin weaves have:

- less crimp
- are easier to distort than a plain weave

With plain weave fabrics and most 5 or 8 harness woven fabrics:

- the fiber strand count is equal in both warp and fill directions

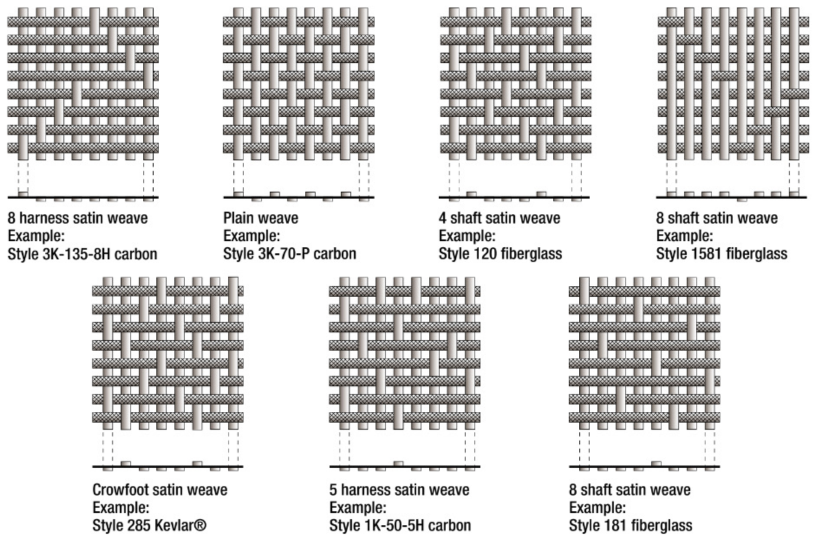

Figure 3-6. Typical fabric weave styles.

Non-woven (Knitted or Stitched)

- Knitted or stitched fabrics can offer many of the mechanical advantages of unidirectional tapes.

Fiber placement

- can be straight or unidirectional without the over/under turns of woven fabrics

fibers are held in place by:

1, fine yarns

2, dry plies

Non woven:

- These types of fabrics offer a:wide range of multi-ply orientations.
- Although there may be some added weight penalties or loss of some ultimate reinforcement fiber properties,
- some gain of interlaminar shear and toughness properties may be realized.
- Some common stitching yarns are polyester, aramid, or thermoplastics

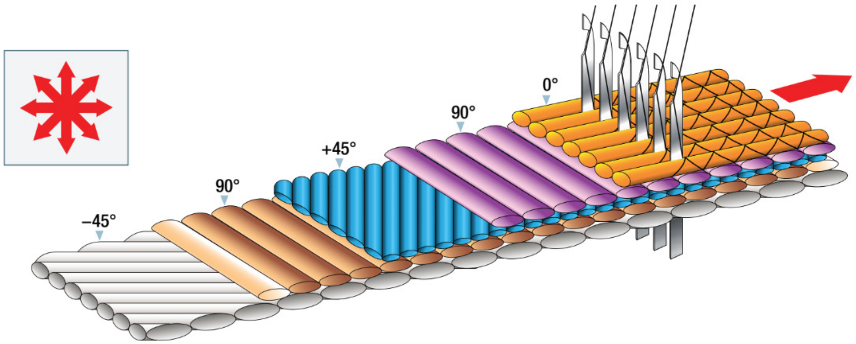

Figure 3-7. Nonwoven material (stitched).

Types of Fiber

1,) Fiberglass

Fiberglass is often used for :
- secondary structure on aircraft

such as :
- fairings, radomes, and wing tips

types of fiberglass:

1, Electrical glass is identified as such for :
- electrical applications
- Has high current flow

E- glass is made from:
- borosilicate glass

2, S-glass and S2-glass

identify structural fiberglass that have a higher strength than E-glass.

S-glass is produced from:
- magnesia-alumina-si licate

Advantages of fiberglass are:

1, lower cost than other composite materials
2, electrical properties (fiberglass does not conduct electricity)
3, chemical or galvanic corrosion resistance

Fiberglass:
- white color
- available as a dry fiber fabric or prepreg material.

2,) Kevlar named as aramid fibers

Aramid fibers are light weight, strong, and tough

Two types of Aramid fiber are used in the aviation industry.

Kelvar have 2 types:

- 49 has a high stiffness
- 29 has a low stiffness

An advantage of aramid fibers is their:

- high resistance to impact damage
- they are often used in areas prone to impact damage.

main disadvantage of aramid fibers is their

- general weakness in compression and humidity
- Kevlar® is difficult to drill and cut.

Kevlar® absorb up to 8 percent of their weight in water
Therefore, parts made from aramid fibers need to be protected from the environment

The fibers fuzz easily and special scissors are needed to cut the material

Color: has a natural yellow color

Bundles of aramid fibers are distinguished by :
the weight. Not by the number of fibers

available as :

- dry fabric and
- prepreg material

3,) Carbon/Graphite

There is different between carbon and graphite

Way of identification:

Carbon and graphite fibers are based on graphene (hexagonal) layer present in carbon

Graphene layers, or planes, are stacked with :
three dimensional order, the material is defined as graphite

The process of graphene is:
Expensive
Time consumer

Carbon
Bonding between planes is weak:
Only in 2 dimension

Carbon fibers are
- very stiff and
- strong, 3 to 10 times stiffer than glass fibers

Carbon fiber is used for structural aircraft applications, such as:
- floor beams,
- stabilizers,
- flight controls,
- and primary fuselage and wing structure.

Advantages include its :
- high strength
- corrosion resistance

Disadvantages:
- lower conductivity than aluminum
- high cost

Carbon fiber is: gray or black in color
is available as dry fabric and prepreg material.

4,) Boron
Boron fibers are very:

- stiff
- have a high tensile compressive strength

Boron fibers:

- have a relatively large diameter
- do not flex well; therefore;

they are available only as a prepreg tape product

An epoxy matrix is often used with the boron fiber.

- there is no galvanic corrosion potential.

The boron fiber is difficult to use if the:
parent material surface has a contoured shape.

The boron fibers are:

- very expensive
- can be hazardous for personnel

Boron fibers are used primarily in: military aviation applications.

5,) Ceramic Fibers

Ceramic fibers are used for high-temperature applications, such as

- turbine blades in a gas turbine engine
- temperatures up to :1 204°C

6,) Lightning Protection Fibers

- Carbon fibers are 1 000 times more resistive than aluminum to current flow,
- and epoxy resin is 1 000 000 times more resistive (i.e., perpendicular to the skin).

The surface of an external composite component often consists of a

- ply
- layer

of conductive material for lightning strike protection because composite materials are less conductive than aluminum

normal structural repair, the technician must also recreate the electrical conductivity designed into the part.

These types of repair generally require a

- conductivity test to be
- performed with an ohmmeter
- to verify minimum electrical resistance across the structure

When repairing these types of structures, it is extremely important to use only the approved materials from authorized vendors, including such items as :

potting compounds, sealants, adhesives, and so forth

6,) Dry Fiber Material

Dry fiber materials, such as :

1, carbon

2, glass

3, Kevlar®

used for many repair procedures.

The dry fabric is :

impregnated with a resin just before the repair work starts.

This process is called: wet layup

The main advantage of using the wet layup process is that

- the fiber and resin can be stored for a long time at room temperature.

- The composite can be cured at room temperature

or

- an elevated temperature cure can speed up the curing process and increase the strength

The disadvantage is that the:

- process is messy
- reinforcement properties are less than prepreg material properties.

THERMOSETTING RESINS

Resin is a generic term used to designate the polymer

The resin:

- its chemical composition

physical properties fundamentally affect the :

- processing
- fabrication
- ultimate properties of a composite material

Thermosetting resins are the most diverse and widely used;

- formed into any shape
- are compatible with most other materials,
- cure readily (by heat or catalyst) into an insoluble solid.

Thermosetting resins are also excellent adhesives and bonding agents

1,) Polyester Resins

Polyester resins are

- relatively inexpensive,
- fast processing resins used for low cost applications

Low smoke producing polyester resins are used for :
interior parts of the aircraft.

Fiber-reinforced polyesters can be processed by many methods:

- matched metal molding
- wet layup
- press (vacuum bag) molding
- injection molding
- filament winding
- pultrusion
- autoclaving

2,) Vinyl Ester Resin

the same as those of conventional polyester resins.
the corrosion resistance and mechanical properties of vinyl ester composites are :
much improved over standard polyester resin composites.

3,) Phenolic Resin

Phenolic resins are used for
interior components
because of their :
low smoke and flammability characteristics.

4,) Epoxy

Epoxies are :polymerizable thermosetting resins
available : in a variety of viscosities from liquid to solid.

There are many diff rent types of epoxy

the technician should use the maintenance manual to :
select the correct type for a specific repair

Epoxies are used widely in :
resins for prepreg materials
structural adhesives.

advantages of epoxies

- high strength
- modulus
- low levels of volatiles
- excellent adhesion
- low shrinkage
- good chemical resistance
- ease of processing

Their major disadvantages

- brittleness
- reduction of properties in the presence of moisture

The processing or curing of epoxies is ;slower than polyester resins

Curing:
The most common cure temperatures range between 120–180°C

5,) Polyimides
excellent in high-temperature environments

Their primary uses are:
- circuit boards
- hot engine
- airframe structures

A polyimide may be either a
- thermoset resin
- thermoplastic

Polyimides require high cure temperatures, usually in excess of 290°C.

6,) Polybenzimidazoles (PBI)
- resin is extremely high temperature resistant
- used for high temperature materials
- These resins are available as adhesive and fiber.

7,) Bismaleimides (BMI)
- resins have a higher temperature capability
- higher toughness than epoxy resins,
- provide excellent performance at elevated temperatures.
- similar process to that for epoxy resins
- used for aero engines and high temperature components

BMIs are suitable for
- standard autoclave processing,
- injection molding,
- resin transfer molding,
- Sheet Molded Compound (SMC) among others.

8,) Thermoplastic Resins

- Thermoplastic materials can be softened repeatedly by an increase of temperature

- hardened by a decrease in temperature.

primary advantage
Processing speed of thermoplastic materials.

Chemical curing of the material does not take place during processing, and the material can be shaped by molding or extrusion when it is soft.

9,) Semicrystalline Thermoplastics
possess properties of :
- inherent flame resistance
- superior toughness
- good mechanical properties at elevated temperatures and after impact, and low moisture absorption

used in
- secondary and primary aircraft structures

Combined with reinforcing fibers; they are available in:
- injection molding compounds,
- compression moldable random sheets,
- unidirectional tapes,
- prepreg fabricated from tow (towpreg),
- and woven prepregs.

Fibers impregnated in semicrystalline thermoplastics include
- carbon
- nickel-coated carbon
- aramid
- glass
- quartz

10,) Amorphous Thermoplastic’s
available in several physical forms, including
- films,
- filaments
- powders

Combined with reinforcing fibers, they are also available in
- injection molding compounds,
- compressive moldable random sheets,
- unidirectional tapes,
- woven prepregs

The fibers used are primarily carbon, aramid, and glass

The specific advantages of amorphous thermoplastics depend upon:
the polymer

the resins are noted for their processing :
- ease and speed,
- high temperature capability,
- good mechanical properties,
- excellent toughness and impact strength, chemical stability

The stability results in unlimited shelf life:
eliminating the cold storage requirements of thermoset prepregs.

11,) Polyether Ether Ketone (PEEK)
is a high temperature thermoplastic.

This aromatic ketone material offers
- outstanding thermal and combustion characteristics
- resistance to a wide range of solvents and proprietary fluids.

can also be reinforced with glass and carbon.

Curing Stages of Resins

Thermosetting resins use a chemical reaction to cure. There are three curing stages, which are A, B, and C

A stage:

- The components of the resin (base material and hardener) have been mixed
- the chemical reaction has not started.
- The resin is in the A stage during a wet layup procedure

B stage:

- The components of the resin have been mixed and the chemical reaction has started
- The material has thickened and is tacky
- The resins of prepreg materials are in the B stage
- To prevent further curing the resin is placed in a freezer at -18°C. In the frozen state,
- The curing starts when the material is removed from the freezer and warmed again.

C stage:

- The resin is fully cured
- Some resins cure at room temperature and others need an elevated temperature cure cycle to fully cure.

Thixotropic Agents:

Thixotropic agents are

- gel like at rest but become fluid when agitated.
- These materials have high static shear strength and
- low dynamic shear strength at the same time to lose viscosity under stress.

PRE-IMPREGNATED PRODUCTS (PREPREGS)

Prepreg material consists of a combination of

- matrix
- fiber reinforcement

available in

- unidirectional form (one direction of reinforcement)
- fabric form (several directions of reinforcement)

All five of the major families of matrix resins can be used to impregnate various fiber forms.

The resin is then no longer in a low-viscosity stage, but has been advanced to a B stage level of cure for better handling characteristics

The following products are available in prepreg form:

- unidirectional tapes
- woven fabrics
- continuous strand rovings
- chopped mat

Prepreg materials must be stored in:

freezer at a temperature below -18°C to retard the curing process.

Prepreg materials are cured with :

an elevated temperature.

Prepreg materials are cured with an

- autoclave
- oven
- heat blanket
- sealed plastic bag to avoid moisture contamination

ADHESIVES

1, Film Adhesives

Film adhesives are available using
- high temperature aromatic amine or
- catalytic curing agents with a wide range of flexibilizing and toughening agents

Rubber-toughened epoxy film adhesives are
- widely used in the aircraft industry.

The upper temperature limit of :121–177°C

The upper temperature limit usually dictated by the
- degree of toughening required
- the overall choice of resins and curing agents.

toughening of a resin results in a lower usable service temperature

Film materials are frequently supported by
- fibers that serve to improve handling of the films prior to cure

control adhesive
- fl w during bonding,
- and assist in bond line thickness control.

Commonly encountered fibers are
polyesters,
polyamides (nylon)
and glass

Inflation

Adhesives containing woven cloth may have :
slightly degraded environmental properties because of wicking of water by the fiber

---

Paste Adhesives

used as an alternative to film adhesive.

often used to :

- secondary bond repair patches
- damaged parts
- used in places where film adhesive is difficult to apply

Paste adhesives for structural bonding are made mostly from :epoxy

The advantages of paste adhesives are:
they can be stored at room temperature and have a long shelf life.

The disadvantage is:
the bond line thickness is hard to control, which affects the strength of the bond.

Due to the disadvantage
A scrim cloth can be used to maintain adhesive in the bondline when bonding patches with paste adhesive.

Foaming Adhesives

Most foaming adhesives are

- 0.025 inch to 0.10 inch thick sheets of B staged epoxy

During the cure cycle:

- foaming adhesives expand.

Foaming adhesives need to be stored

- in the freezer just like prepregs,
- they have only a limited storage life.

Foaming adhesives are used to

- splice pieces of honeycomb together in a sandwich construction
- bond repair plugs to existing core during a prepreg repair.

SANDWICH STRUCTURES

- is a structural panel concept that consists in its simplest form of
- two relatively thin, parallel face sheets bonded to and separated by relatively thick, lightweight core

The core supports the

- face sheets against buckling
- resists out-of-plane shear loads.

The core must have:
high shear strength and compression stiffness.

Composite sandwich construction is most often fabricated using :

- autoclave cure
- press cure
- vacuum bag cure

Skin laminates may be

- precured and subsequently bonded to core,
- co-cured to core in one operation,
- combination of the two methods

Examples of honeycomb structure are:

- wing spoilers, fairings, ailerons, flaps, nacelles, floor boards, and rudders

Properties of a sandwich

- high bending stiffness at minimal weight in comparison
- Most honeycombs are anisotropic; that is, properties are directional

il lustrates
the advantages of using a honeycomb construction:

- Increasing the core thickness greatly increases the stiffness of the honeycomb construction, while the weight increase is minimal

Facing Materials

Most honeycomb structures used in aircraft construction have :
aluminum, fiberglass, Kevlar®, or carbon fiber face sheets.

Carbon fiber face sheets cannot be used with aluminum honeycomb core material because:
It causes the aluminum to corrode

Titanium and steel are used for :
specialty applications in high temperature constructions

The face sheets of many components, such as;
spoilers and flight controls,

- are very thin
- sometimes only 3 or 4 plies.

Core Materials

- Each honeycomb material provides certain properties and has specific benefits
- The most common core material used for aircraft honeycomb structures is aramid paper (Nomex® or Korex®)
- Fiberglass is used for higher strength applications.
- Kraft paper

1, relatively low strength,
2, good insulating properties,
3, available in large quantities, and has a low cost.

Foam

Foam cores are used on homebuilts and lighter aircraft to give :
strength and shape to

- wing tips
- flight controls,
- fuselage sections,
- wings,
- wing ribs.

REINFORCED PLASTIC. PLASTICS

Reinforced plastic is a thermosetting material

used in the manufacture of :

radomes, antenna covers, and wingtips, and as insulation for various pieces of electrical equipment and fuel cells.

has excellent dielectric characteristics which make it ideal for radomes

But

its high strength-to-weight ratio

resistance to ;

mildew, rust, and rot,

ease of fabrication make it equally: suited for other parts of the aircraft

Reinforced plastic components of aircraft are formed of either

- solid laminates
- sandwich type laminates

TRANSPARENT PLASTICS

Plastics cover a broad field of organic synthetic resin and may be divided into two main classifications:

- thermoplastics
- thermosetting plastics.

Thermoplastics—

- may be softened by heat and can be dissolved in various organic solvents.
- Acrylic plastic is commonly used as a transparent thermoplastic material for windows, canopies,

Thermosetting plastics—

- do not soften appreciably under heat but may char and blister at temperatures of 240–260°C.
- Most of the molded products of synthetic resin composition, belong to the thermosetting group. such as

1, phenolic
2, urea-formaldehyde
3, a melamine formaldehyde resins,

- Once the plastic becomes hard;
- additional heat does not change it back into a liquid as it would with a thermoplastic.

STORAGE AND HANDLING

sheets soften and deform when they are heated

Store them in

- a cool,
- dry location away from heating coils,
- radiators,
- or steam pipes,
- away from such fumes as are found in paint spray booths or paint storage areas

Keep paper masked transparent sheets

- out of the direct rays of the sun,
- because sunlight accelerates deterioration of the adhesive,
- causing it to bond to the plastic, and making it difficult to remove.
-

Store plastic sheets with the masking paper

- in place in bins that are tilted at a 10° angle from the vertical to prevent buckling.
- the sheets are stored horizontally, take care to avoid getting dirt and chips between them

MANUFACTURING DEFECTS INCLUDE:

- Delamination
- Resin starved areas
- Resin rich areas
- Thermal decomposition

IN-SERVICE DEFECTS In-service defects include:

- Environmental degradation
- Impact damage
- Fatigue
- Cracks from local overload
- Debonding
- Delamination
- Fiber fracturing
- Erosion

NON-DESTRUCTIVE INSPECTION OF COMPOSITES

Visual Inspection

Audible Sonic Testing (Coin Tapping)

Automated Tap Test

Ultrasonic Inspection

Radiography

Page 3.24 for more information

important

LAYUP MATERIALS AND TOOLS

Prepreg and dry fabrics can be cut with hand tools, such as :

- scissors
- pizza cutters
- knives

Materials made from Kevlar® are

- more difficult to cut than fiberglass or carbon and tools wear quicker

to impregnate dry fibers with resin for wet layup use :

1, squeegee

2, brush

to make a repair layout use :

- Markers
- rulers
- circle templates

VACUUM BAG MATERIALS

Process:

Step 1: plastic bag is sealed around the repair area

Step 2: Air is then removed from the bag which allows repair plies to be drawn together with no air trapped in between

Step 3: Atmospheric pressure bears on the repair and a strong, secure bond is created.

These materials do not become part of the repair and are discarded after the repair process;

1, Release Agents:

used so that the part comes off the tool or caul plate easily after curing.

2, Bleeder Ply :

creates a path for the air and volatiles to escape from the repair

Excess resin is collected in the bleeder.

3, Peel Ply :

used to create a clean surface for bonding purposes

4, Layup Tapes:

used to seal the vacuum bag to the part or tool

- Always check the temperature rating of the tape before use to ensure that you use appropriately rated tape

5, Perforated Release Film:

- used so that the prepreg or wet layup plies do not stick to the working surface or caul plate.
- used to prevent the resins from bleeding through and damaging the heat blanket or caul plate if they are used.

6, Breather Material:

used to provide a path for air to get out of the vacuum bag.

7, Vacuum Bag

provides a tough layer between the repair and the atmosphere

- Most vacuum bag materials are one time use,

But

- material made from flexible silicon rubber is reusable.

TYPES OF LAYUPS

1, Wet Layups

wet layup process:

1, dry fabric is impregnated with a resin

2, Mix the resin system just before making the repair

3, Lay out the repair plies on a piece of fabric and impregnate the fabric with the resin

4, the fabric is impregnated, cut the repair plies, stack in the correct ply orientation, and vacuum bag

Wet layup repairs are often used with:

1, fiberglass for nonstructural applications

2, Carbon and Kevlar® dry fabric could also be used with a wet layup resin system

Many resin systems used with wet layup cure at : room temperature

Because :

- its easy to accomplish,
- the materials can be stored at room temperature for long period of times

The disadvantage of room temperature wet layup is that:

it does not restore the strength and durability of the original structure

2, Prepregs

- is a fabric or tape that is impregnated with a resin during the manufacturing process
- The resin system is already mixed and is in the B stage cure
- Store the prepreg material in a freezer below -18°C to prevent further curing of the resin.

Prepregs

Prepreg is a fabric or tape that is impregnated with a resin during the manufacturing process. The resin system is already mixed and is in the B stage cure. Store the prepreg material in a freezer below -18°C to prevent further curing of the resin. The material is typically placed on a roll and a backing material is placed on one side of the material so that the prepreg does not stick together. The prepreg material is sticky and adheres to other plies easily during the stack-up process. You must remove the prepreg from the freezer and let the material thaw, which might take 8 hours for a full roll. Store the prepreg materials in a sealed, moisture proof bag. Do not open these bags until the material is completely thawed, to prevent contamination of the material by moisture. After the material is thawed and removed from the backing material, cut it in repair plies, stack in the correct ply orientation, and vacuum bag. Do not forget to remove the backing material when stacking the plies. Cure prepregs at an elevated cure cycle; the most common temperatures used are 120°C and 200°C. Autoclaves, curing ovens, and heat bonders can be used to cure the prepreg material.

Consolidation is necessary if parts are made from several layers of prepreg, because large quantities of air can be trapped between each prepreg layer. Remove this trapped air by covering the prepreg with a perforated release film and a breather ply, and apply a vacuum bag. Apply the vacuum for 10 to 15 minutes at room temperature. Typically, attach the first consolidated ply to the tool face and repeat this process after every 3 or 5 layers depending on the prepreg thickness and component shape.

The maximum time allowed for storing of a prepreg at low temperature is called the storage life, which is typically:

- 6 months to a year

WET LAMINATED LAYUP TECHNIQUES:

Step 1: Read the stuctural repair manual

Step 2: determine the correct repair material, number of plies required for the repair, ply orientation

Step 3: Dry the part, remove the damage,

Step 4: taper sand the edges of damaged area

Step 5: Use a piece of thin plastic, and trace the size of each repair ply from the damaged area

Step 6: Indicate the ply orientation of each ply on the trace sheet.

Step 7: Impregnate the repair material with resin,

Step 8: place a piece of transparent release film over the fabric,

Step 9: cut out the plies, and layup the plies in the damaged area.

The plies are usually placed using the smallest ply first taper layup sequence.

but an alternative method is to use the largest ply first layup sequence In this sequence:

Step 1: the first layer of reinforcing fabric completely covers the work area

Step 2: followed by successively smaller layers,

Step 3: finished with an extra outer layer or two extending over the patch and onto the sound laminate for some distance

Bleedout Technique

The traditional bleedout :

- using a vacuum bag technique places a perforated release film and a breather/bleeder ply on top of the repair
-
- The holes in the release film: allow air to breath and resin to bleed off over the entire repair area.

- The amount of resin bled offdepends on :

1, the size and number of holes in the perforated release film
2, the thickness of the bleeder/breather cloth
3, the resin viscosity and temperature
4, the vacuum pressure

- Controlled bleed allows a limited amount of resin to bleed out in a bleeder ply

Steps :

1, Place a piece of perforated release film on top of the prepreg material
2, bleeder ply on top of the perforated release film
3, solid release film on top of the bleeder
4, Use a breather and a vacuum bag to compact the repair
(The breather allows the air to escape)

- The bleeder can only

1, absorb a limited amount of resin,
2, the amount of resin that is bled can be controlled by using multiple bleeder plies

Always consult the maintenance manual or manufacturer tech sheets

No Bleedout

- Prepreg systems with 32-35 percent resin content are typically:

no-bleed systems

prepregs contain exactly the amount of resin needed in the cured laminate:

- resin bleedoff is not desired not needed

No bleeder is used: the resin is trapped/sealed so that none bleeds away

Ply Orientation Warp Clock (To provide strength)

In order to minimize any residual thermal stresses caused during cure of the resin: the orientation should be balanced

Examples of balance laminates :

Example	Lamina	Written As
1	±45°, –45°, 0°, 0°, –45°, +45°	(+45, –45, 0) S
2	±45°, 0°/90°, ±45°, 0°/90°, 0°/90°, ±45°, 0°/90°, ±45°	(±45, 0/90)2S
3	±45°, ±45°, 0°/90°, 0°/90°, ±45°, ±45°	([±45] 2, 0/90) S

examples of the effects caused by non-symmetrical laminates (not balanced)

Type	Example	Comments
Symmetrical, balanced	(+45, −45, 0, 0, −45, +45) orientation	Flat, constant midplane stress
Nonsymmetrical, balanced	(90, +45, 0, 90, −45, 0)	Induces curvature
Symmetrical, nonbalanced	(−45, 0, 0, −45)	Induces twist
Nonsymmetrical, nonbalanced	(90, −45, 0, 90, −45, 0)	Induces twist and curvature

These effects are most pronounced in laminates that are cured at :

1, high temperature in an autoclave

- or

2, oven

due to the thermal stress developed in the laminate as the laminate cools down from the cure temperature to room temperature

Laminates cured at room temperature using

- typical wet layup
- do not exhibit the same degree of distortion due to the much smaller thermal stresses.
- The strength and stiffness of a composite buildup depends on the ply orientation

General information:

- The practical range of strength and stiffness of carbon epoxy extends from values As low as those provided by fiberglass to as high as those provided by titanium

It is critical during a repair operation :

to replace each damaged ply with a ply of the same material and orientation or an approved substitute

Mixing Resins

- must be thoroughly mixed.
- Some resin systems have a dye added to aid in seeing how well the material is mixed
- Since many resin systems do not have a dye:

the resin must be mixed slowly and fully for three minutes

- Air enters into the mixture if the resin is mixed too fast the resin may not cure properly.
- make sure to scrape the edges and bottom of the mixing cup to ensure : that all resin is mixed correctly Do not mix large quantities of quick curing resin
- These types of resins produce heat after they are mixed: Smoke can burn or poison you when the resin overheats
- Mix more than one batch if more material is needed than the maximum batch size. (ex: batch 1 / batch 2 / batch 3. etc)

Saturation Techniques equal distribution

It is important to put the right amount of resin on the fabric.

- Too much or too little resin aff cts the strength of the repair
- Air that is put into the resin or not removed from the fabric reduces the repair strength

VACUUM BAGGING TECHNIQUES

layup is cured under :

- pressure generated by drawing a vacuum in the space between the layup and a flexible sheet placed over it and sealed at the edges

In the vacuum bag molding process:

the plies placed in the mold by hand layup using prepreg or wet layup

High fl w resins are preferred for vacuum bag molding so that:

1, resin can be destrepuoted equally and The extra resin come out

2, If low flow resin is used Won't be equal

CURING OF COMPOSITE MATERIALS

A cure cycle is the:

1, time

2, temperature

3, pressure

cycle used to cure a thermosetting resin system or prepreg

composite repairs require the technician to manufacture the material This includes all :

1, storage

2, processing

3, quality control functions.

An aircraft repair's cure cycle starts with material storage:

- Materials that are stored incorrectly can begin to cure before they are used for a repair

- All time and temperature requirements must be met and documented.

This includes: Date /Storing documents /All documents should be done

Consult the aircraft structural repair manual to determine the correct cure cycle for the part that needs to be repaired.

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Types of curing :

- Room Temperature Curing

- Elevated Temperature Curing

For more information about the process and properties refer to the book page 3.41