AMT 2106 –AIRCRAFT MATERIALS CONSTRUCTION AND REPAIR II
(Composite)

PRELIM PERIOD

MODULE III

Matrix Materials

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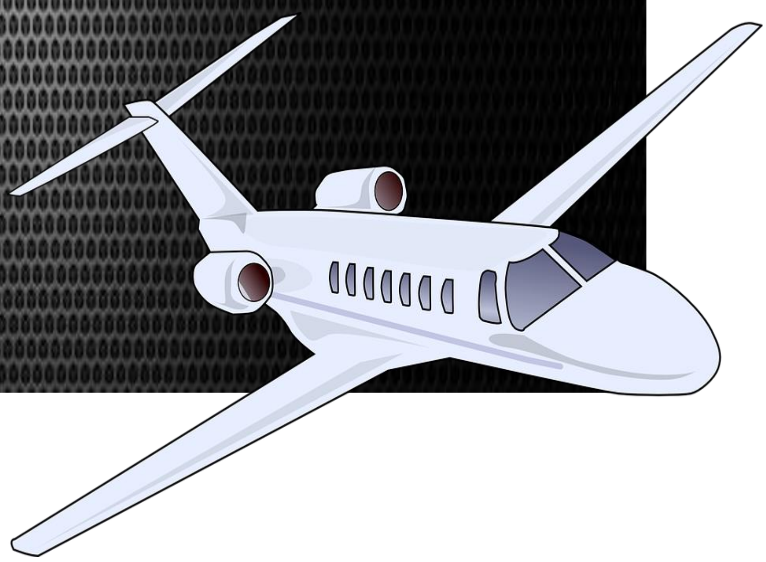

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David Cripps, Gurit(2019) citation Resin System retrieved from https://netcomposites.com/guide/resin-systems/	1
A&P Technician Airframe Textbook - Jeppesen	2
FAA Handbook CHAPTR 7- ADVANCE COMPOSITE MATERIALS	3

This module briefly discusses, one of the element of the composite focuses in the matrix materials, descriptions and its corresponding advantages when apply to selected reinforcing materials. This module also deal with the types of resin and its corresponding properties and advantages when apply. Also the safety consideration in working with solvent and Matrices as well as the pre- impregnated materials is also discussed.

TIMEFRAME

You should be able to complete this module including all the self-assessments, research works, assignments, and other performance tasks within **3** hours**.**

LEARNING OUTCOMES

Course Learning Outcomes (CLO)

CLO 1. Understand the development of the composite structure and classify its element in terms of properties , advantages and characteristics of each elements.

CLO 4. Execute and apply the techniques/ methods applicable to understand the different materials in composite.

CLO 9. Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria, methods and techniques.

Module Learning Outcome (MLO)

MLO 1. Demonstrate understanding of facts and ideas by comparing, the different materials falls under reinforcing material, their properties and corresponding advantages and disadvantages.

MLO 2. Show and familiarized the parts and style of fabric used in composites.

MLO 3. Define and explain the ff. types of hybrid in terms of aircraft composite and fiber placement .

Topic Learning Outcomes(TLO)

TLO 6. Overview of Matrix Materials and identifying by comparing and familiarizing each properties and responds effectively to this element of composite .

TLO 7. Adapt and Demonstrate by exhibit safety reminders when working with resin and catalyst.

TLO 8. Identifying and discuss the pre-impregnated materials in composite

MODULE III : MATRIX MATERIALS

Introduction

While the principal strength and stiffness of the composite is provided by the fibres, the matrix material also has a large part to play in the overall mechanical properties. The matrix is not designed to bear much of the load. Instead, the matrix binds the fibres together and distributes the load. It also provides ductility and protects the fibres from surface damage. It separates the fibres and prevents propagation of cracks from one fibre to the next. Also, unless the matrix chosen is a particularly flexible one then it will assist in prevention of the fibres buckling under compression.

The requirements of a good matrix material are that it can infiltrate between the fibres and form a strong interfacial bond. It is also essential that there is no chance of chemical reaction between the matrix material and fibres and that the matrix material does not cause damage to the fibres. *(UNSW, School of Materials Science and Engineering*

Any resin system for use in a composite material will require the following properties:

1. Good mechanical properties
2. Good adhesive properties
3. Good toughness properties
4. Good resistance to environmental degradation

MATRIX MATERIALS

The **matrix** is a bonding material that completely surrounds the fiber , giving it extra strength . The strength of the composite lies in the ability of the matrix to transfer stress to the reinforcing fibers

Polyester resin is an example of an early matrix formula used with the fiber glass for many non-structural applications such as fairings, spinner and trim. The old polyester /fiberglass formulas did not offer sufficient strength to be used to fabricate primary structural member , it can be somewhat brittle.

The function of the matrix in a composite is to hold the reinforcing fibers in a desired position. It also gives the composite strength and transfers external stresses to the fibers. The ability of the matrix to transfer stress is the key to the strength of a composite structure.

The newer matrix materials display remarkably the ff: characteristics:

- Improved stress distributing characteristics
- Heat resistance
- Chemical resistance
- Durability

Resin matrix are two-part systems consisting of the ff:

- Resin
- Hardener - which acts as the curing agent

MATRIX SYSTEMS

Resin matrix are a type of plastics, thus some of the companies refer to composite as a **fiber reinforced plastics**

Resin matrix systems are a type of plastic and include two general categories: thermoplastic and thermosetting. Thermoplastic and thermosetting resins by themselves do not have sufficient strength for use in structural applications. However, plastic matrixes reinforced with other materials form high-strength, lightweight structural composites.

There are two general categories of plastics:

- Thermoplastics
- thermoset

1. **Thermoplastics**

- Thermoplastic resins use heat to form the part into the desired shape
- If a thermoplastic is heated a second time, it will flow to form another shape
- Thermoplastic can be used in more places, as long as the temp. does not exceed to **75F**
  - Thermoplastics can provide composites with a greater fracture toughness than is possible with thermosetting resins.
  - A disadvantage of thermoplastics for use as matrix materials for continuous fibre reinforcements is that, due to the high viscosity of polymer melts, it is very difficult to achieve sufficient infiltration of the fibre bundles by the polymer. Fibre preforms consisting of the reinforcing fibres co-mingled with fibres of the matrix polymer are commonly used to make thermoplastic matrix composites. The preform is then hot pressed to shape. This causes the matrix polymer to melt and flow into the spaces between the reinforcing fibres.

ex,. **Plexiglass** which is used to form light aircraft windshields. The shape of the windshield remains fixed after it is cooled at the factory. However, if the windshield is sufficiently reheated, the plastic will melt, which in turn changes its shape. Overhead storage bin & non structural applications.

2. **Thermoset**

- Thermosetting plastics are usually formed from low viscosity liquids that undergo significant cross-linking through the application of an external energy source such as UV light or heat or through the addition of a catalyst.
- Thermosets used heat to form and set the shape of the part permanently.
- The plastic once cure, cannot be reformed even if it is reheated.

Ex. Structural airframe applications

The most important thermosetting resins for the use in composites are:

- Epoxies
- Unsaturated polyesters
- Phenolics

- Unsaturated polyester resins were the first type of matrix material to be used with glass fibres to make polyester GRP (glass reinforced plastics) materials. Polyester resins are still the most widely used matrix materials. They are cheap, easy to work, and cure at room temperature.
- Epoxy resins are superior to polyester resins in a number of important ways. They are stronger and stiffer, bond more effectively to fibres, have very little cure shrinkage, and have much higher service temperatures.
- Phenolics are not only strong but they also have one of the highest elastic moduli of common plastics and also have good fire resistance

KINDS OF A RESIN SYSTEMS

- ✓ Polyester resin systems
- ✓ Epoxy resin systems
- ✓ Polybutadiene resins

1. Polyester resin systems

Polyester resin, an early thermosetting matrix formula, is mainly used with fiberglass composites to create nonstructural applications such as fairings, spinners, and aircraft trim. While fiberglass possesses many virtues, its greatest limitation lies in its lack of structural rigidity. Polyester resins give fiberglass cohesiveness and rigidity. However, polyester resin/fiberglass composites do not offer sufficient strength to fabricate primary structural members.

Like other plastics, polyester shrinks when cured. While this inherent characteristic helps in some ways, it hurts in others. For instance, when bonding a metal structure to a fiberglass structure, the shrinkage can be helpful. As the polyester resin shrinks, it produces an increasingly tight grip on the embedded metal. However, when installing metal hinges on top of a large, flat surface using long strips of fiberglass and polyester resin, shrinkage may warp the surface. Bonding shorter strips of fiberglass to the fasteners or using a resin with a smaller shrinkage factor such as an epoxy resin usually prevents this type of warpage.

The reason for the widespread used of polyster resin are simple , these are the ff:

1. Very stable at room temperature
2. Can be store for a year w/o affecting the quality of the materials
3. It easily cure at room temperature in just few minutes when an inexpensive peroxide is added
4. Low cost and very versatile
5. Not very resistant to alkali however they are strong enough to used as matrix material for structural components

Epoxy Resin System

Most of the newer aircraft composite matrix-formulas utilize epoxy resins, which are thermoset plastic resins. Epoxy resin matrices are two-part systems consisting of a resin and a catalyst. The catalyst acts as a curing agent by initiating the chemical reaction of the hardening epoxy.

Epoxies are a type of a thermosetting plastics resin well known for their :

- outstanding adhesion,
- strength,
- and their resistant to moisture
- and chemicals
- They are very useful for bonding nonporous and dissimilar materials

Reason why Epoxy resins are among the most common matrix systems used in composite fabrication and repair :

1. Extremely flexible
2. Exhibits good adhesive characteristic
3. Resistant to deterioration
4. Easily cured at room temp.
5. Very dimensionally stable
6. Exhibits the strongest adhesive characteristic of any known polymeric materials
7. Economical to used for fabrication and repair than other matrix materials

Some of the properties of epoxy which make it useful for bonded structures are its low shrinkage percentage, high strength-to-weight ratio, exceptional chemical resistance, and ability to adhere to an almost endless variety of materials. Epoxy forms an extremely tight bond between glass and metal. However, if epoxy is used to bond glass to a metal window frame, the glass will crack from temperature changes because of the different expansion rates of the metal and the glass.

Epoxies may be used in place of polyester resins for almost any application. They also have a long shelf life. Unmixed, epoxies generally keep for almost a year at 728 F. Once they are mixed, however, they have a very short **pot life,** which is the amount of time a catalyzed resin remains in a workable state.

Polybutadiene Resins

Polybutadiene Resin are the thermosetting resins that offers the ff characteristics:

1. Good electrical properties
2. Outstanding chemical resistance
3. Very low water absorption
4. Stable at relatively high temperature

3 curing temperature ranges of the Polybutadiene Resins

1. Low temperature cure (room temp to 200F)
2. High temperature cure (250f to 400F)
3. Peak thermal Cure (450F to 750F)

WORKING WITH RESINS AND HARDENER

The matrix formula for most advanced composites is very exacting. A slightly improper mix ratio can make a tremendous amount of difference in the strength of the final composite. Because the mixing procedures are so important, they are always included with the resin containers. The aircraft structural-repair manual also outlines proper mixing procedures.

Manufacturers often produce pre-measured matrix packages. The advantage to using prepackaged resin systems is **that they eliminate the weighing process and therefore remove the possibility of a mixing ratio error**. Disposable cartridges that store, mix, and apply two-component materials are also available and convenient to use. They are available in many sizes and can be tailored to specific uses. Like the pre-measured packages described before, cartridges also eliminate mixing ratio errors In addition to prepackaged resin units, epoxy ratio pumps reduce mixing errors. Epoxy ratio pumps enable the technician to precisely measure varying Some resins systems are weighed verses measured to determine the proper mix ratio. Precision scales are used to weigh the two parts of the resin. **The scale surfaces should always be clean, and calibrated periodically to ensure accuracy.** If the type of resin system used requires refrigerated storage, allow each part to warm up to room temperature before weighing and mixing. When cold, a resin will weigh more than an equal quantity of the same resin at room temperature.

The resin and catalyst must be mixed thoroughly in order to achieve maximum strength. Mix resin systems together in a wax-free container. If a waxed container is used, the solvents in the resin and catalyst dissolve any wax on the inside of the container, which then contaminates the mixture. Though wax is used for heat control purposes in some resins, the wax from a container may cause the repair to cure incorrectly, or possibly not cure at all. Follow the manufacturer's mixing instructions, which often entails three to five minutes stirring or agitation time to completely mix the components.

Resins that are not mixed properly will not cure to the maximum strength obtainable. If resins are mixed too quickly, small bubbles may rise into the air and could get on your skin or in your hair. Do not be concerned if you have bubbles in the cup because they will be worked out with a roller or squeegee during the lay-up process. Vacuum bagging, which is a process of applying pressure to a lay-up, further ensures that no air bubbles remain in the final composite. If more resin is mixed than necessary to complete a project, any unused amount is wasted. If too much resin is mixed, allow it to cure before throwing it away. In most cases, resins in a cured condition are not considered hazardous materials for disposal.

A large volume of resin and catalyst causes an acceleration of the chemical reaction when curing. When this happens, it starts to cure in the mixing cup, possibly becoming too thick to work completely into the fabric. The pot life is also reduced if large amounts are mixed at one time. If a resin exceeds its pot life, it must not be used. Smaller mixed quantities are generally easier to work with and are more cost effective. One of the best ways to ensure that a properly prepared batch of matrix resin has been achieved is to mix enough for a test sample.

If the work is extensive and takes a long time, the pot life of the resin mixture may be exceeded if too much is initially prepared. Find out the length of the pot life, or working life, of the resin before preparing a resin batch. Some resin systems have very short pot lives (15 minutes), while others have long pot lives (4 hours].

The **shelf life** of a resin is the time that the product is still good in an unopened container. Like the pot life, the shelf life varies from product to product. If it has expired, the resin or catalyst must be discarded. Using a resin that has exceeded its shelf life does not produce the desired chemical reaction, and the strength of the finished product may be insufficient.

If too much resin is applied to the part, it is called **resin rich.** Traditional fiberglass work is used in nonstructural applications, so extra resin is not that critical. However, the use of excessive resin in advanced composite work used for structural applications is very undesirable. Excessive resin affects the strength of the composite by making the part brittle in addition to adding extra weight, which defeats the purpose for using composites for their lightweight characteristics.

A **resin starved** part is one where not enough resin was applied, which weakens the part. The correct amount of fiber to resin ratio is important to provide the structure with the desired strength. In advanced composite work, a 50:50 ratio is generally considered acceptable. However, a 60:40 fiber to resin ratio for advanced composite lay-ups is generally considered the best for strength characteristics. Actual ratios utilized should be in accordance with the manufacturer's instructions.

When working the resin into the fibers, care should be taken not to distort the weave of the fabric. If too much pressure is applied when using a brush or squeegee, the fibers could pull apart, altering the strength characteristics of the fabric. The curing of the resins must also be accomplished correctly to achieve the maximum strength. Be sure to follow the manufacturer's directions concerning curing requirements.

CAUTION: If two batches of resin and catalyst are mixed equally, leaving one batch in a jar and spreading the other in a thin layer, the one in the jar will harden rapidly because of the heat trapped by the glass. This cure rate takes place so quickly that it will cause minute fractures within the plastic. The thin sheet, on the other hand, will not cure as fast because it has a large surface area exposed to the air, which allows the heat to escape

1. When working with materials, always follow the procedures specified in the ***STRUCTURAL REPAIR MANUAL***
2. Mix resin in the proper ratios, the matrix formula for most advanced composite is very exacting.
3. 3 to 5 minutes is usually requires the completely mix the components.
4. Do not mix large amount together
5. In advanced composite work, 50:50 ratio is good however a 60:40 fiber to resin ratio is better.

Mastery Check

Self-Assessment A: Before we proceed with our module, let's check how well you have understood the discussion so far. Using the table below, try to identify the following:
Time frame: 3-5 mins

	Statement
	1. What category of the plastics is being used in primary structure of an aircraft?
	2. What is another term for hardener?
	3. This referring to the elements of matrix that serves as the bonding substance for the composite structures?
	4. This referring to plastics that can reshaped when subjected to heat twice.
	5. The materials that act as a curing agent when mix in any matrix system.

Self-Assessment B: Time frame: 5 mins – 10 mins

	1. A kind of resin that are low price and very versatile.
	2. What do you call when a reinforcing fibers was subjected to deep or mix with the solution of resin?
	3. A type of resin with three temperatures ranges base on its curing point.
	4. This referring to the strongest adhesive characteristic.
	5. What manual that the composite technicians used for their guide in any work on structures.

HONESTY CLAUSE

My signature below constitutes my pledge that all of my writing is my own work, with the exceptions of those portions which are properly documented

SHEILA MAY D. MOTOS,MEAM
Subject Instructor

Student Signature	**Parent Signature**