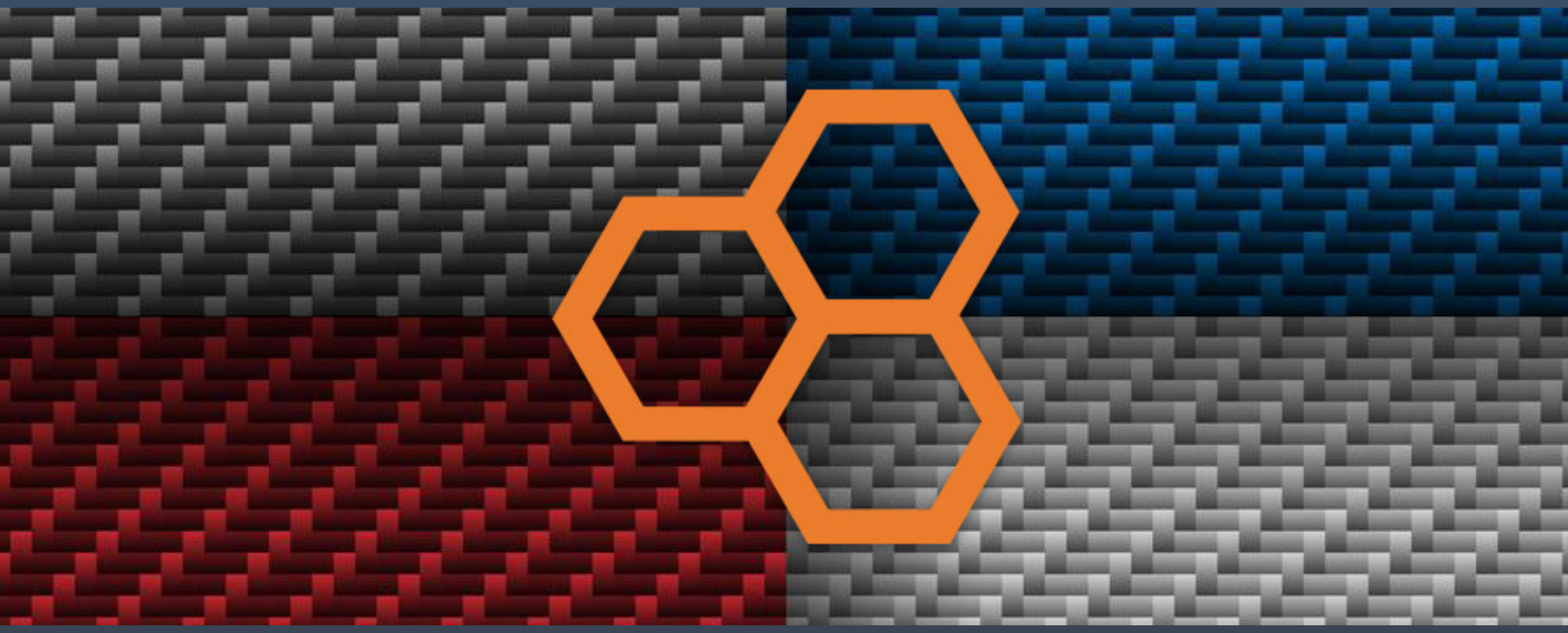
COMPOSITE ENVISIONS KNOWLEDGE HUB
PRACTICAL AND INSIGHTFUL COMPOSITES INFORMATION



BENEFITS OF VARIOUS SUBSTRATES FOR TOOLING

COMPOSITE ENVISIONS

INTRODUCTION

There are many options in front of any fabricator when it comes to choosing a substrate for tooling. Options for tooling is probably just as complicated as parts themselves. Selection is highly dependent on the traits in performance of the part that is needed. There is a lot of detail that goes into selecting or choosing effectively... How many parts? How complex or tight dimensional tolerancing for a part is? Temperatures for the cure? CTEs of tooling.... The list goes on. Luckily, there are some very easy ways to narrow the search for selecting the correct substrate for given tool.

CHOOSING METAL OR COMPOSITE TOOLING

How many parts are going to be made?

Industrial practices include some complex ways of computing or choosing whether to use composite or metal tooling. Metal tools are generally much more expensive than most composite options. If it is less than 40 parts, there probably won't be much advantage to a metal tool. Metal tooling's advantage lies in making a high volume of parts and turning the tools around quickly and effectively to make more. A metal tool's life cycle will generally be much longer with proper care. For someone just starting composite fabrication or even some light production work, composite tooling may be the best option.

What is the temperature that the tool will be subjected for the future part's cure parameters?

Make sure a tooling material system can take the heat and be able to keep dimensional stability while doing so. It is best practice in composite tooling to pair the part's thermal properties with those of the tool. Research technical data for comparing heat distortion temperatures, max service temps, and CTEs that closely match that of the part. This helps ensure the final part meets the dimensional characteristics needed and promotes tool longevity.

One of the most important features of a tooling material is its CTE. (Coefficient of Thermal Expansion) This characteristic shows how a given material expands as temperatures increases. CTE has major implications on the dimensional stability and quality of cured laminates. **Closely matching a part's CTE with the tooling materials CTE is best practice for selecting a tooling material.** This is especially true for complex surfaces as mismatching CTEs will have a negative impact on dimensional stability of the part and may cause part warpage. Flat panels and other simple laminate surfaces may not be held to the same criteria.

Aluminum for example would be a great tool to use if the final part does not have an

elevated cure temperature. However, if it is heated to 350F, dimensional stability of that part goes out the window.

COMPOSITE TOOLING

Composite tooling is generally created by laying up over a prepared plug surface. Starting by laying down a good base coat of tooling gel / resin to conform to the ranging surfaces of the plug, then applying layering buildups of fabric and resin matrix. Composite tooling has an advantage over metal tooling because it is generally much cheaper to make. They do not require CAD drawings, CNC machining ($), and can be made in a garage / workshop type environment that many DIY fabricators are accustomed to. Composite tools are also much lighter and more maneuverable for ease in layup and are generally easier to repair and modify for other layup methods.

Composite tooling choices begin with choosing a resin system or prepreg for the job. Epoxy, Polyester resins, and prepregs are popular choices for composite tooling. There are notable differences on the performance of the tools due to the resin chosen. A general layup resin could be used for a tool; however, most tooling resins are developed to be “harder” than general laminating resins. This promotes the stiffness needed for providing a rigid, repeatable fabrication of laminate parts. Of traditional layup mold making options, CF & Epoxy will yield the more rigid yet lightweight tools, just as a laminate part would do. It will usually cost a little more to produce and it should be noted how many parts one may plan to get from a tool when selecting it vs a standard gelcoat, chopped strand, polyester-based tool.

Composite tooling is also made from tooling specific prepreg materials, ranging in options of carbon fiber for thickness and conformity, depending on the tools need. Use of prepregs in tool making gives the same advantages as it would in regular part, increasing the efficiency of a layup and help provide the utmost tool quality. After all, a perfect tool may create a perfect part.
It should be noted that all tooling options can yield very good surface finishes regardless of the resin or fabric type used.

Polyester / Gelcoat / CSM Tooling: Cheap, effective, good for multiple parts
Epoxy & CF Tooling: More rigid option, used for higher dimensional stability
Prepreg Tooling: Increased fabrication and layup efficiency, best option for repeatability and rigid composite tooling, carries a higher cost

METAL TOOLING

Metal tooling is best used substrates when making many parts, like hundreds or even thousands. The lifecycle of metal tools is high, they are less susceptible to the wear and

tear that can be placed on composite tools. Selecting a metal substrate is highly dependent on CTE, as stated above. Higher costs are associated with metal tooling substrates due to material costs, design, machining and welding processes required to fabricate the commonly complex surfaces of a given part. However, most metal tools can be made highly precise, providing repeatable parts and quick turn arounds in layup. They are part of making layup processes highly standardized in manufacturing environments. Options include but are not limited to Invar, Carbon Steel, Nickel, Aluminum

Invar: Great with Carbon Fiber laminates cured at elevated temperatures. Disadvantage lies in high cost and being very heavy. Often molds are not easily moved by hand. Invar is a commonly used tooling material in high production prepreg layups with elevated cure temps > 350F

Carbon Steel & Nickel: Promote a good surface finish, these tools must be prepped as soon as possible as carbon steel will rust even in the presence of high humidity. CTEs more closely match general laminate materials than aluminum. Generally providing a close match to a desired surface.

Aluminum: Used mainly for assembly tools, Lightweight option of metal tools but it is a softer metal. Life expectancy in layup is not as high as invar or carbon steel. Aluminum is also not good with complex shapes at high cure temperatures given its high CTE.

TOOL CARE

Life expectancy is highly dependent on the care a layup tool gets during layup and in storage. **Tools will last much longer when proper care is given to properly prep with given release agents, tools are not used as cutting surfaces, stored wrapped or covered in bubble wrap (at least the layup surface).** Ensure sure not to run into or drop tooling. It seems like common sense, but these overlooked mishaps are often the most common failures in any type of tooling.

There are all kinds of different tooling options, metal vs composite tooling scratches the surface and are generally the most popular options. However, 3D printed plastic tools are rising in popularity, especially in one-off productions or prototyping. The surface finfish may leave something to be desired, but it can be worked around. Foam covered composite tooling is also another option that can provide multi use tooling. It goes to say that tooling options go as far as the imagination if the price is right and the temperatures vs expansions match.

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