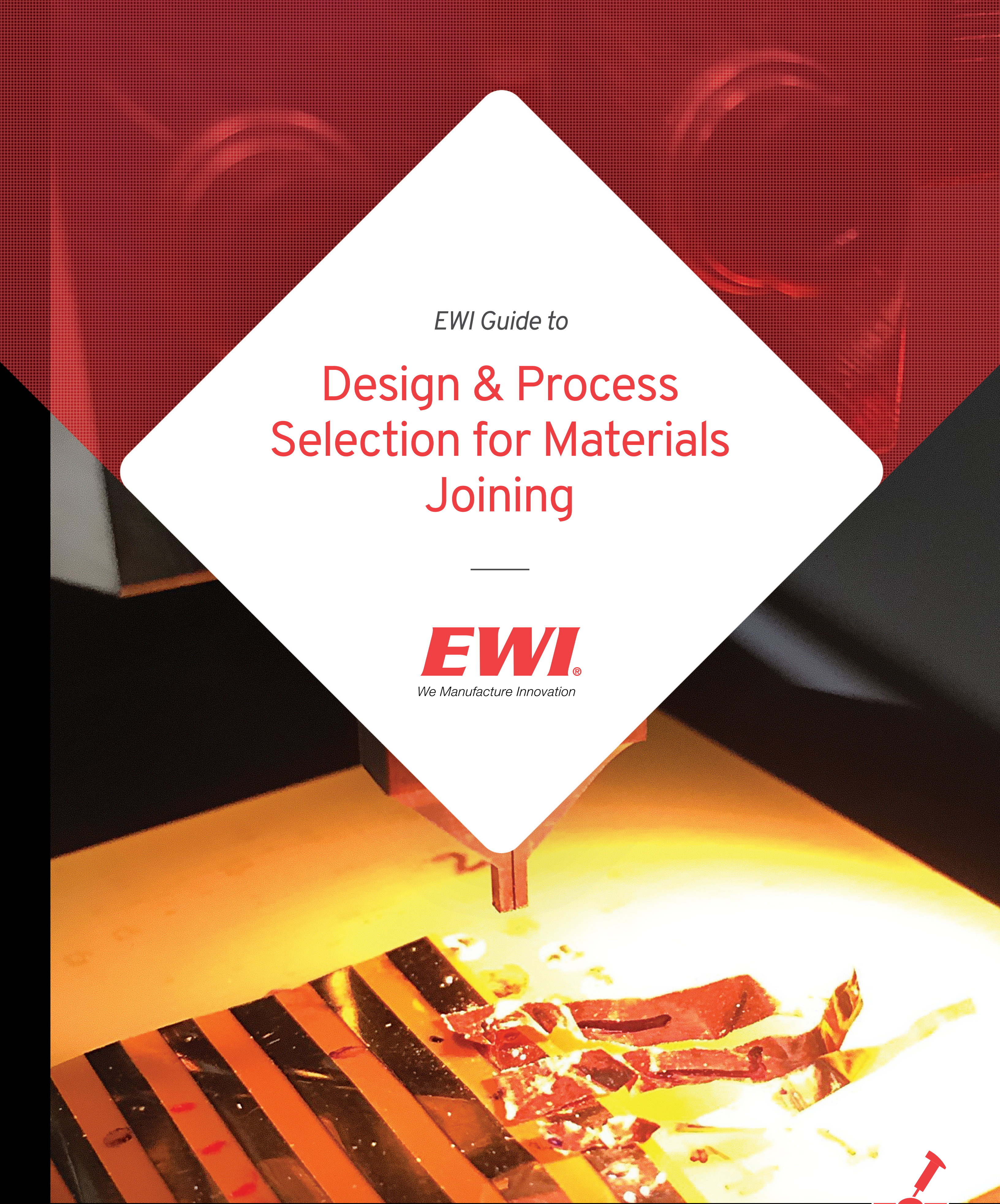

EWI Guide to

Design & Process Selection for Materials Joining

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Introduction

When designing a new product, or revising a current design, there is a growing trend to consider manufacturability in the design. Manufacturers recognize that margins on products can be improved by reducing the launch time, and they understand that the cost and time it takes to transition products from CAD through prototype to mass production can have a huge impact on the success of a launch. Some common considerations for efficient product development include:

- Reduce part count of assembly
- Standardize parts
- Minimize part handling
- Design for robust joining

It is not a coincidence that designing for robust joining is last in the list. The joining process is commonly overlooked until very late in the design process cycle. By the time the joining options are considered, major decisions in product materials and other upstream processes have often already been made. This can lead to a crisis in trying to evaluate and develop joining technologies with sub-optimal materials or designs. Considering joining process earlier can significantly impact the entire design and frequently has a favorable impact on material selection and manufacturability.

Product Performance Considerations

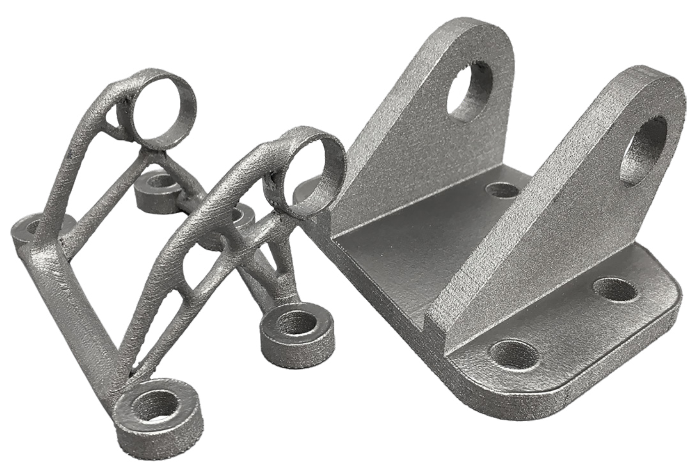
A natural place to start a design and process selection is by understanding what the component needs to do. What environmental constraints exist (for example, is corrosion a concern)? What strength is required? Does product weight matter? What are cost limitations? What can we learn from feedback from the previous product? What are the cost targets? Aesthetic requirements?

There are, of course, many trade-offs that need to be considered when defining your product. Asking the right questions and carefully evaluating the answers will provide valuable information to feed your product design. The key to making a realistic evaluation of the trade-offs in product considerations is having the expertise and experience to understand the magnitude of these trade-offs – thereby reducing what is unknown.

Design

The design concept methodology described above is, appropriately, called "Design for Manufacturing", or DFM. Once one understands what the product needs to do, the product design begins, keeping in mind those critical product considerations. The design stage of the product development cycle is where the product requirements are transformed into the first concept. At this stage, through advances in modeling and simulation power, it is easy to "try" many different ideas because the designer can make the changes with a few clicks of a mouse in a model space. This can allow us to predict behaviors of certain aspects of the design, easily increasing the part thickness for strength or durability.

The design stage is where some of the qualitative analyses can be evaluated in a quantitative way and the impact of the trade-offs begin to come into focus. For example, suppose a welding engineer suggested changing from a 7XXX aluminum to a 6XXX aluminum to facilitate arc welding in the assembly process. Is the 6XXX of component sufficient strength to satisfy the design requirements? The designer can quickly perform simulations to determine the answer.



Materials

Speaking of material considerations, making informed material decisions early in the design process will significantly reduce cost and time obstacles later in the process. When selecting materials for a component, the most common criteria include cost of the material, its physical properties (strength, corrosion resistance, etc.), and machinability (or formability, or forge-ability). This is especially true in the concept stages. Designers usually select the materials that are readily available and best meet their design intent. Prototypes are often manufactured with suboptimal manufacturing processes. If the immediate goal is to bolt or rivet the assembly together to prove the concept, then consider the cost / forming / machining / joining issues later.

While this approach works for prototyping, it will set you up for failure if your prototype material isn't weldable. The development cost of validating the suitability of the prototype is a loss if you have to change material, or the cost associated with riveting makes the component too expensive to produce. Taking time to sort through pros and cons of different materials can help designers select the material best suited for a volume-relative joining operation from the start – saving time and money in the design cycle.

Performance

The successful joining of materials is ultimately determined by how the joint performs in subsequent service. There are several factors that can affect joint performance in the service environment. Does the joint need to be stronger than the components it joins? Would comparative weakness be an advantage? A whole series of questions can be asked like this about resistance to corrosion, color match, hermetic sealing, accuracy of joined shape, precision of the joined shape, ability to accept subsequent manufacturing operations, resistance to cycles of loading, and resistance to growth of cracks during a sudden increase in loading and others. Designers should think of each of these as a point of choice for the process.

Process Selection

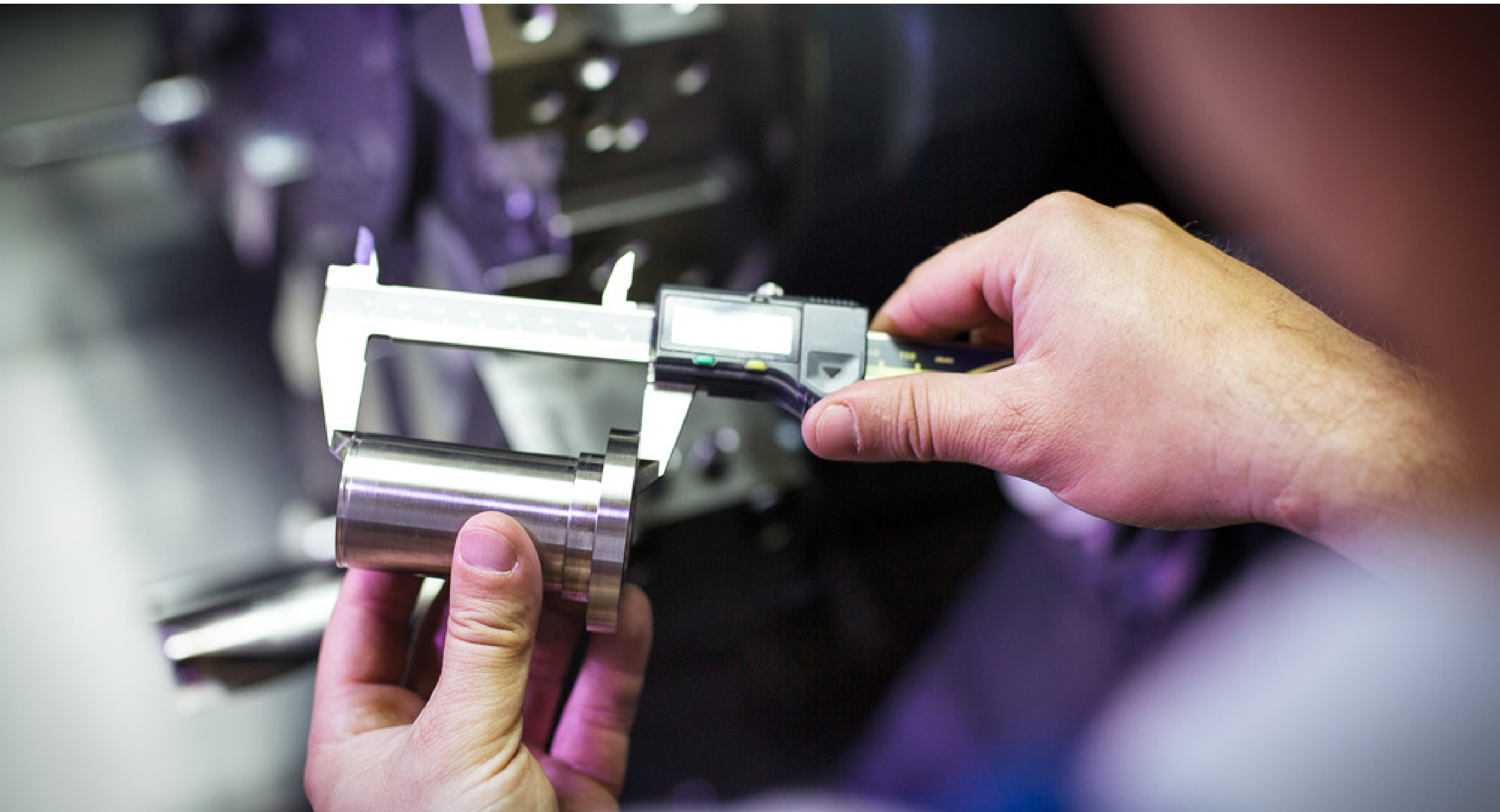
Understanding what joining processes are available for a given set of materials is important. Most published literature indicates aluminum and steel are not weldable to one another – but advances in technology and manufacturing techniques successfully join those materials every day in high-volume applications. What other dissimilar metals can be joined successfully? What is the required tolerance for laser welding versus arc welding? What are the access requirements for your spot weld gun? How large do weld flanges need to be? How easily can the process be automated? Understanding not only the answers to these questions, but also what other questions should be considered when choosing a joining process, will significantly improve the flow of process selection.

Testing

Once a product design is complete, and perhaps even after a first concept or prototype is built, understanding the product's performance characteristics is important. Depending on the product, there are many ways to accomplish this goal. For some simple widgets – building several and performing mechanical testing (either static or dynamic) is sufficient. For more complex parts with very specific performance targets, like good high-cycle fatigue, hermeticity, corrosion resistance, etc., the method to evaluating performance can be much more complex.

One approach is sub-scale or coupon testing. For example, if a component must withstand a marine environment (specific corrosion demands) in an arctic application (specific low-temperature mechanical property demands) under a range of stress conditions (specific fatigue demands), selecting or designing a test to evaluate all of these constraints is desirable. Often this can be done on sub-scale components to mock the final part geometry. Taking that a step farther, a computer model can be generated of the larger component and data from the sub-scale testing can be utilized to predict the behavior of the full system.

Understanding how to intelligently design a test that accurately reflects the conditions of the part in service allows the design to proceed with much less risk at a reduced cost. As with every other phase of the design cycle, this requires intimate knowledge of the material, joining processes, and other information.



Quality

Building quality into materials joining requires an understanding of the part's purpose in service. Codes, standards, and specifications provide a storehouse of information on methods of providing reliable quality, but often these are correlated to specific purposes that are explicit or even implicit in the history of the document. Requirements for service are typically described using a standard document, but that approach is often too simple. The designers need to consider whether the document fits or whether it would fit with some modifications. Inspection can also provide quality assurance as a step after a joining process.

Production

At the end of the day, economics must make sense in order for a design to go into production. This requires a team that understands the business drivers, production volume, target costs for capital and operating expenses, etc. Generally, an engineering development team does not have the expertise – or all the required data – to build this picture. A company's marketing and sales team can provide this input. However, they often lack a fundamental understanding of the effort that goes into the design and manufacture of a new part. The process should be collaborative and iterative. Having periodic information sessions between the groups is extremely valuable for alignment.

In addition, there must be a strong link between the new product design team and the manufacturing team. Having a member of the production team working closely with the designers will provide valuable information and create a bond and sense of ownership and teamwork that will help with the successful launch of the new product.

Conclusion

It is impossible to address every aspect of joining process selection in a brief overview. This guide, however, should help you understand that giving consideration to manufacturability – specifically assembly methods – in the early stages of a new design can save considerable cost (and headache) as the design process evolves. You are the expert in your product. EWI is the expert in manufacturing processes. We look forward to working with you to solve your most challenging applications.

James Cruz, *Principal Engineer for EWI's resistance and solid-state processes group, has extensive experience in most joining technologies and related manufacturing processes such as welding automation, nondestructive analysis, and metal forming. His diverse projects have ranged from tooling and fixturing development, welding automation, procedure optimization, and qualification of weld procedures for manufacturing applications. He has worked with a wide range of companies across industry including aerospace, consumer electronics, automotive, and heavy equipment.*

Get Started

For more information on design and process selection, talk to one of our experts by calling 614.688.5152. You can also learn more about our welding and joining capabilities and more technical resources by visiting ewi.org