Replacing Metals with Composites

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Engineers are challenged to find effective solutions to solve several problems associated with products traditionally designed and manufactured with metals. Some of the well known problems are: corrosion, weight, and cost. Design engineers are also addressing performance, ergonomics or human factors, and aesthetics of products manufactured with metals.

Historically ferrous and non-ferrous metals were the materials of choice in casting, machining, and fabricating durable products. Metals offered a low raw material cost, and forming parts and assemblies was well understood with predicable results. From the industrial revolution to today, metals were and are used to manufacture durable products. What are the problems that challenge design engineers today? Why have engineers embraced composites as a replacement for metals?

A number of engineering challenges with metals existed in the past, and remain present today. For most industrial use metals, corrosion continues to present problems. Advancements in metallurgy, plating, and paints have improved the corrosion protection, with the added penalty of increased cost. The exposure to environmental and corrosive materials has driven the need to protect metals from degradation. The cost to protect metal from corrosion continues to rise, while engineers are directed to reduce cost. The environmental and health impact of protecting metals with plating and coatings cause additional concerns and cost. This is a direct result of the ever increasing regulations in the painting and plating industry. Replacing metals with composites will solve the problem with corrosion, and can reduce cost by eliminating painting, coatings, and plating in certain applications.

Today engineers are also faced with reducing the weight of products. Reducing weight can reduce product cost, increase the performance, improve ergonomics, and lower transportation or shipping costs. Metals are isotropic materials, and this property can result in added weight were structural strength is not needed. It can be impractical in most designs to utilize multiple thicknesses or gauges of sheet metal. Thin sheets can utilize formed reinforcements, such as stamped ribs to improve strength, but this usually results in added cost. Material can be welded to improve strength where required, but again this adds cost. Composites allow the engineer to put strength where it is required, as the material is anisotropic. Designing thin walls where strength is not a requirement, thick walls or adding cores for reinforcement and strength where needed, is a unique property composites offer engineers.

Many products benefit from reducing weight by improving performance. Lower weight can increase the operational time of battery powered equipment by reducing the load. Machines can run longer between charges, or have a higher payload. Energy efficiencies are gained by reducing weight. Composites are replacing metals in aircraft, mass transit, automobiles and numerous applications where reducing the weight provides immediate gains in fuel efficiency. The performance improvements are realized without sacrificing strength. Cost can be reduced by molding shape in, and by eliminating secondary machining operations.

Products made of metal that are designed to be pushed, pulled, or lifted by a human present significant challenges to engineers. The heavier the product, the more difficult to handle, and the less ergonomic it becomes. The human factor is a design consideration that is more important today than in the past. Equipment designed to be handled by humans and made of metal is typically limited in both weight and size. Replacing metals with composites will improve ergonomics, and can reduce overall weight up to 60%. A lower weight product may provide a significant competitive advantage to manufacturers. Large heavy products can only be safely handled by a small percentage of people.

We now understand there are several benefits in considering composites as a replacement to metals: *Reducing weight, corrosion resistance, cost, ergonomics, performance, and in most designs the aesthetics can be improved.* To realize the benefits, there are numerous composite material options available. Engineers can specify thermoset composites, or the recent development of unidirectional fiber reinforced thermoplastic composite.

Thermoset composites have been available for decades. Over this time, thermoset composites have evolved to include resin and reinforcement combinations that have applications from consumer products to aerospace. These materials can be formed in a wide variety of processes to achieve the performance requirement of the application. Thermoset composites can be molded in a press, without the limitations of wall thickness like thermoplastic molding. The inherent strength of thermoset molded composites, and the ability of this material to be used in high temperature applications up to 500 F, offers the engineer material performance options that are beyond any available thermoplastic resin. Thermoset composite can be sprayed, hand formed, molded in tools, wound on mandrels, and pultruded in dies. The manufacturing process, resins, and fiber reinforcement are determined by the application requirements. The design engineer has multiple options available to achieve the desired results.

Thermoplastic composites are a recent technical development. This material uses a matrix of thermoplastic resin with continuous fiber reinforcement. Multiple resin and fiber options exist. This technology offers the engineer the design capability to manufacture lightweight parts that are impossible to produce with plastic injection molding technology. Continuous fiber reinforced thermoplastic is used to manufacture parts that have the highest strength to weight ratio of any composite material. Parts can be made from glass, carbon, or aramid fiber with several thermoplastic resin matrixes. The low tooling cost as compared to injection molding is a significant benefit. This composite material easily replaces metal stamped and formed parts, and is a cost effective solution.

Replacing metals with thermoset or thermoplastic composite materials is an option available to engineers that should be considered where reducing weight, improving corrosion resistance, lowering cost, enhancing ergonomics, improving performance and aesthetics are design requirements. To learn more visit Jobst Inc. at: http://www.jobstinc.com, or call 952.447.3904 to speak with an Application Engineer.