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FRICTION WELDING FOR FOOD INDUSTRY MANUFACTURING

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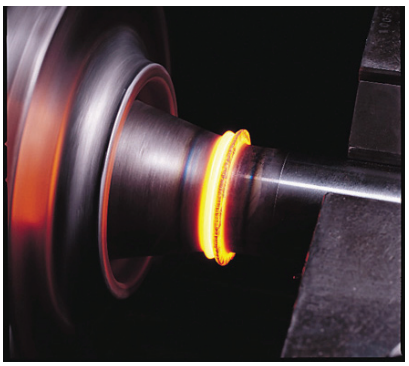

How Friction Welding Can Save Food Manufacturing OEMs on Material Costs.

The challenges of material price versus performance in food manufacturing equipment have gotten tougher with each price increase for raw materials. Friction welding as a way to reduce costs is a viable option for design engineering and new product development.

Although the term welding is used in defining the friction welding process, it bears no resemblance to conventional welding since no filler material is involved. Instead, two components are rubbed together at a controlled rotational speed, which creates the friction and heat that allows both components to reach a plastic state and forge together into a bond. Friction welding involves the use of unique technology incorporating state-of-the-art monitoring controls. This process is in widespread use by large OEMs throughout the industry.

Friction welding allows manufacturers to use bimetallic or multi-piece assemblies rather than single piece assemblies, providing more ease in selecting the best materials to suit an application with less concern for raw materials costs. A balance is achieved in the selection of optimum materials without the heavy price tag for pump shafts, impellers, mixers and other components.

Cost versus performance criteria—abrasion or corrosion resistance, mechanical strength for operating loads, FDA-mandated sanitary characteristics, etc.—are realized without sacrificing performance. With 60 percent of the component made with lower cost materials, significant savings can be realized for virtually any size and quantity of pieces, considering today's costs of $4 to $34 per pound for commonly used stainless steels and high nickel alloys.

Shafts—Dry End Versus Wet End

For example, in the case of pump shafts, two distinct ends, the dry end and the wet end, have different considerations. The dry end is sealed and encased (typically in oil) within the housing itself and the wet end—outside the pump enclosure—comes in contact with the application. The dry end plays a less critical role in a given application, so less costly materials such as low carbon steel can be used for this portion of the shaft, providing sufficient strength.

The wet end of the shaft is where "the rubber meets the road" due to its direct contact with the external, ambient conditions of the specific application. The critical needs reside here and much more costly, exotic high nickel alloys—such as Hastelloy and high strength stainless—are often required.

The wet end of the shaft requires more costly materials because of its direct contact with the conditions of the specific application.

Cost savings are realized by constructing the composite shafts with the typical two-thirds of the shaft's less critical dry end replaced with lower cost steels. Due to the current challenges of both price volatility and surcharges to nickel-based materials (often exceeding the material's base cost), these savings can be substantial for OEMs while also promoting significant cost and profit stability on the end product. With proper selection of the two materials for dry and wet end, strength properties of the original material can typically be met or exceeded.

For all food related friction welding applications, close control—via monitoring and visual graphing during the weld process and post-weld ultrasonic inspection procedures—ensure consistent weld joint integrity. Production controls monitor RPM, axial load and displacement of material during welding. In addition to internal quality control, finished parts are regularly shipped to accredited laboratories for metallurgical evaluation and/or a variety of mechanical testing including torsion, tensile and normal bend testing over particular radii for specific applications. Parts are typically rated for loads far exceeding the intended applications.

Metallurgical Integrity of Friction Welding

Craig Brown, metallurgical engineering manager at Stork Technimet, has performed extensive analysis of friction welded joints. Comparing friction welded to conventional welded joints, Brown states, "In general, the heat affected zone (HAZ) is less extensive and has a narrower width than the HAZ of a conventional weld that incorporates a filler material. HAZ mechanical properties are similar to the base metal, but depending upon the temperature achieved during welding, the cooling rate and the post-weld thermal treatment, all three can change the weld properties. If all are controlled correctly, welds will have the necessary integrity."

According to Brown, the successful friction weld will be free of porosity, lack of fusion and oxide inclusions. If done right, none of these will be present. On rare occasions, one might see very fine oxides that are dispersed through the center of the joint. The primary risk and challenge is temperature control at the weld interface. If it is too cold, there may be a poor bond between the materials. If too hot, the weld may be brittle, and—depending upon the alloy content—cracking could occur. The principal challenge is evaluating the quality of the weld below the surface, which is why ultrasonic inspection is so essential.

Key Material Considerations

A wide variety of stainless steels and nickel-based alloys are typically used in the food processing industry based upon particulars of the application. For instance, 304 stainless, 316 stainless or 17-4 PH stainless can also be incorporated in friction welding for higher mechanical properties, providing a balance between strength and corrosion-resistance.

In an area of an assembly where a component does not come in contact with the product, the options are virtually endless. Medium and low carbon steels, as well as stainless, on this end can be incorporated for corrosive resistance, if needed. Even with the use of stainless on this end, cost reductions are often realized. As far as weld integrity is concerned, the 1100 and 1200 series carbon steels with their re-phosphatized and re-sulfurized content (typically manufactured for enhanced machinability) needs to be avoided since the addition of higher sulfur or lead can create complications in the welding process. Although these materials can be welded, mechanical strength cannot be guaranteed but still may be within the user's requirements.

Many alternatives exist to avoid such complications while new weld developments using exotic combinations are being devised constantly with great success.

A Broad Range of Options

Friction welding provides manufacturers who are designing solutions for food processing applications a savings option in the cost of materials and choices for material properties such as strength and corrosion-resistance. Specific wear-resistance, longevity in length of service with related fatigue and the types of loads the component will receive are all important factors where an ideal material choice can be more easily integrated into a solution. Manufacturability benefits can also be realized with friction welding. Shafts can be designed for optimum machinability with a significant reduction in machining labor. This minimizes perishable tubing costs with faster feeds and speeds, longer life on perishable tools, more uptime on machines and higher output due to faster times on existing equipment. At times, up to 15 percent savings can be realized, buying manufacturers 15 percent to 20 percent more capacity on expensive machine tools and cells.

For practically any selected blank on a component, endless opportunities exist within friction welding regarding size, type, length and configuration, including the use of two different diameters.

Friction Welding and Cost Savings

Based on application particulars, savings of 50 to 60 percent on raw material costs can be realized using friction welding after factoring in the cost of the weld. For instance, with a 2.5-in diameter high-strength alloy shaft having material that weighs 16 or 17 pounds a linear foot, a 3-ft shaft will weigh around 45 to 50 pounds. At $5 per pound, this shaft can cost in the range of about $200. If friction welding can allow replacement of around two-thirds or 2-ft of the shaft's dry end with lower cost (perhaps 60 cents per pound) carbon steel material, this shaft could cost around $125.

Although friction welding has been a viable option for more than 50 years, it continues to be one of manufacturing's best kept secrets. Specific to today's cost challenges for high strength, nickel-based materials, the ability of friction welding to replace large percentages of this costly material without loss of strength or structural integrity is a strong consideration for cost conscious food processing OEMs. It is one of the most economical welding processes available—providing increased design flexibility, superior strength and significant cost savings.

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