Flowformed Components

Precise, Economical, and Flexible

Flowforming. PMF Industries photo.

Flowforming is a cold forming process that creates seamless, dimensionally precise, hollow cylinders (or other shapes with a rotational axis of symmetry). Because of the high degree of accuracy achieved from flowforming, it has become widely accepted for the production of tube-like components for aerospace and military applications. The Navy Metalworking Center (NMC) and its industry partners have made strides in further advancing the world's knowledge and use of this metal-forming process.

Background

During flowforming, compressive force is applied to the outside of a cylindrical component called a pre-form, which is attached to a rotating mandrel. A combination of axial and radial forces from two or more computer-controlled rollers, which are evenly spaced around the pre-form, shape the material and reduce wall thickness.

The quality and design of the pre-form is key to successful flowforming. The pre-form must be engineered to ensure that the appropriate amount of material forms into the final shape; the accuracy and finish of the final shape directly reflects the precision of the pre-form. Pre-forms, which are created using deep drawing, stamping, press forming, or any number of other processes, can be made from a variety of metals, including titanium, aluminum, steel, and superalloys. NMC has conducted most project work on high-strength, corrosion-resistant titanium alloys.

There are three methods of flowforming. Forward flowforming is used when the component being made has one closed or semi-closed end, such as a cylinder. Clamped by hydraulic force, the bottom of the pre-form rests against and rotates with the mandrel. As rollers are fed from right to left, the flowformed material moves in the same direction.

Reverse flowforming is used for components that have two open ends, such as tubes. The pre-form is placed over the mandrel and pushed to the end against a serrated drive ring. The axial thrust of the rollers forces the pre-form against the drive ring. The longitudinal feed moves from right to left; however, the flowformed metal moves in the opposite direction of the rollers.

Flowformed five-inch cartridge casings. CTC photo.

Flowforming Process

The process (left to right) begins with a pre-form attached to a rotating mandrel. Diagram shows roller applying compressive force to the pre-form, creating the finished shape. PMF Industries photo.

Shearforming, the third flowforming method, is used to form conical, radial, or parabolic geometries. Generally, the pre-forms are shaped like circular discs. With the pre-form held firmly against the nose of the mandrel by hydraulic force from the tailstock or other means, the carriage moves from right to left. The rollers plastically deform, or "shear," and flow the available metal against the mandrel.

Benefits

Flowforming is an innovative, cost-effective solution for creating complex, hollow metal components and is a viable alternative to traditional machining and deep drawing. The flowforming process generates seamless components with a superior finish and increased metallurgical strength and hardness. Its flexibility allows for design versatility and tolerance control as well as variable wall thickness with increased tensile strength, accuracy, and refined grain structure. Flowforming can result in improved physical properties and improved response to heat treatment due to the refined grain structure.

Cost savings is an essential consideration when discussing the benefits of flowforming. For instance, this metalworking process can reduce the number of parts necessary to perform a particular function, thereby reducing assembly costs and decreasing the number of component parts that must be outsourced or kept in inventory. Flowforming also can reduce or eliminate welding, finishing, and testing costs and ultimately may require less material than other manufacturing processes.

Applications

NMC has worked with leading partners in the United States, including Dynamic Machine Works and Precision Metal Forming Industries, to evaluate flowforming for the cradle tubes on the M777 Lightweight Howitzer. The demonstrations resulted in a Ti-6Al-4V seamless tube that meets all dimensional and mechanical property requirements for the program.

Another project has enabled the production of affordable, flowformed, five-inch cartridge casings that reduce life-cycle expenses and improve the performance of U.S. Navy five-inch guns. Traditionally, the steel cartridge cases had been manufactured using a deep-drawing process that is no longer cost effective. In conjunction with the Naval Surface Warfare Center Division at Indian Head, Dynamic Machine Works, and Owego Heat Treat, Inc., NMC identified flowforming processes that worked with a new alloy and new heat treatment to achieve all project objectives.

Future advances in flowforming will occur as new machines are built that have more power, greater stiffness, and better numerical control for path management. In addition, new applications are made possible as numerical process models are developed that allow simulation of material flow behavior and interaction with factors such as machine feed rates, machine speeds, tooling configuration, pre-form shape, and material characteristics.

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