

HOW TO BUY FORGINGS

Close cooperation between buyers and producers of forgings has always been a vital part of achieving the best possible product at the lowest possible cost. With major advances in forging methods and materials improvements, this collaboration is more critical than ever before. By keeping abreast of these advances, and working closely with the forger, the engineer or buyer can ensure delivery of high-quality products with important cost savings.

Despite its long history and the many technological developments that have taken place in recent years, forging still involves a good deal of artistry. Even as product designers and industrial buyers learn more about shaping of metals, there is still much to be gained from bringing the forger into the design and specification phases of product development.

Of course, such basic questions as whether a given part can or should be forged must be addressed at an early stage. There are many instances when any of several processes can be used to product the component in question.

Once it has been determined that a product or component requires the strength, toughness, dimensional accuracy and overall integrity of forging, there is still the question of which forging process—open die, impression die, ring rolling, etc.—is most appropriate. Usually, this decision is straightforward, based on part, size, configuration and quantity required. However, to help in those situations when the choice is not so clear cut, the forging buyer should have at least a general knowledge of methods and equipment used in the industry.

Besides a general knowledge of forging, buyers should also have a clear idea of what they specifically require and how readily individual forgers can meet their needs. Capabilities can vary dramatically from one company to another. For instance:

- Does the forger have experience in applications similar to the one being considered?
- Is design assistance offered?
- Does the forger have the equipment required to produce the part?
- Is the forger able to provide related services like heat treating, machining, testing and so on?
- Is the forger accustomed to producing the volume required? Does the company specialize in long runs, short runs or quick delivery?

The answers to these and other questions will help narrow the field to a few qualified forgers. Then, the buyer can begin to take advantage of the valuable technical and design assistance available from these forging experts.

The Design Conference

An experienced and capable forging company engineer should be able to make design suggestions to consolidate components, simplify processing, reduce required machining, speed delivery and so on. It may be possible to achieve forging's high-level performance benefits without significantly increasing material or production costs over those associated with other processes.

The key is to get the forger involved early. The benefit derived from consultation will vary with the complexity of the part and the forging process involved. For instance, impression die forgings may benefit somewhat more dramatically than open die products. However, the ideal first step toward getting the most from a forged part is to form a team consisting of the product's designer, the purchasing manager and, possible, a quality-

control or manufacturing representative. Then this team should sit down with a technical representative of the forging company while the product or component design is still being evaluated.

The focal point in these early meetings with candidate forgers should be an engineering drawing. The part print should be fully detailed, showing finished dimensions and tolerances. If the forging is to be delivered in a rough-machined or as-forged state, the required machining envelope should be clearly specified. In many cases, it can be advantageous to provide a drawing that shows how the forged part will mate with other components in the finished assembly.

Another critical part of these early design meetings should be the service requirements of the application. The forger needs complete information on how the forging will be used, the operating environment, and critical mechanical properties. A thorough understanding of service stresses – load-bearing, power transmitting, impact, hydraulic pressure, high or low temperatures, corrosive conditions – and the stress location can allow the forging engineer to make design and process suggestions that can result in an improved product and reduced manufacturing costs. For instance:

Material Selection... Often, alternative carbon-and alloy-steel grades can produce similar mechanical properties, depending on forging design, heat treatment, and so forth. Specifying property levels beyond those actually required by the application can significantly increase costs. The best economy is achieved when tensile, hardness, impact and other mechanical properties are realistically based on the service requirements of the component being designed. Once these realistic property levels are established, the forger can help select one material from among the alternatives to achieve the optimum combination of performance, forgeability, heat treatability, machinability and economy.

Part Configuration... Special preforming operations, reheats or additional dies and equipment may or may not be required to achieve the specified part configuration and the desired grain flow pattern. Almost always, a knowledgeable forger can work with a product design and achieve material and production economies with no loss of part performance. Sometimes, slight changes in part shapes can simplify forging requirements, reduce die costs, and speed production.

The forging engineer studies a new design from the standpoint of its tooling and processing requirements. Reduced draft angles or sharper radii, for instance, can sometimes reduce machining requirements without affecting part function. If a simpler die can be used or if the parting line can be adjusted to allow use of a flat top die, it may be possible to produce the part more economically.

Dimensional Tolerances... The ability of forgers today to produce as-forged shapes to tight tolerances is improving, and most companies are striving to develop their net- and near-net shape forging capabilities. At present, however, there is still considerable cost involved in holding tight as-forged tolerances. The wise buyer will ask the forger to help evaluate the trade-offs between reduced machining and increased die and processing costs.

In open die forging, particularly, nearly all forgings require some machining. Determining where and how much machining stock or “envelope” should be specified is a complex decision best made in concert with the forger.

But no matter what tolerances are set, it is important to include them along with all dimensions on the part drawing given to the forging engineer. Based on this information, and on his experience and the experience of the steel supplier, the forger can accept or request modification of the specifications to achieve more cost-effective production.

Applying Guidelines...Over the years, the forging industry has developed a system of dimensional tolerances guidelines that set limits on size (length, width and thickness), die match and straightness. Guidelines for impression die applications, for instance, are found in Forging Industry Association's Tolerances for Impression Die Forgings.

Standards also have been developed to apply to such material considerations as chemistry, strength, ductility, impact resistance, conductivity, soundness and grain flow. These have been published by such organizations as ASTM, Society of Automotive Engineers, and the American Standards Association. Unless there is good reason to specify a special material or tighter tolerance controls, it is best to follow the established standards to avoid additional costs.

Surface Finishing...Most forging companies have machining capabilities and some offer extensive finishing services. Many buyers specify that rough machining be done by the forger so that any surface imperfections will be discovered before the parts are shipped. And there is a large growing trend toward specifying that the forger also does finish machining, for reasons of economy and to isolate responsibility. The buyer gets a finished, ready-to-install component. Intermediate steps in production are left to the forger.

With the added responsibility, the forger also gains some flexibility that can result in overall savings for the buyer. Armed with a drawing showing finished part dimensions and tolerances, the forger can design an ideal forging around the finished part. The parting line can be positioned for maximum part quality and production efficiency. The chief benefit, however, is that the machining envelope can sometimes be reduced to save material and machining time.

Inspection and Testing...Only those tests needed to establish the mechanical properties and quality required for reliable performance should be specified to minimize the costs involved. While the buyer will normally specify the type of tests and acceptance levels required for a forging, the forger can offer good advice on appropriate testing. Tests on representative bar samples are relatively simple. When the specification requires that additional tests be made on the forging itself, costs increase. Non-destructive testing – ultrasonic and magnetic particle inspection – is becoming increasingly important for critical service applications like generator or turbine rotor shafts. Because these tests can be time-consuming and expensive, however, they should be required only when absolutely necessary.

Statistical process quality control techniques are being applied in many forge shops. Such capabilities may reduce the need for some of the costly testing of individual forgings.

Delivery...While not necessarily important in early design discussions, it is helpful to discuss production volumes and anticipated shipping schedules with the prospective forger. This information allows him to take these factors into consideration when making tooling decisions.

In addition, production-run setup and material acquisition requirements will vary with anticipated volume. Substantial reductions in material and production costs are attainable through advance planning. And it is almost always more economical to forge and ship a quantity of parts at one time, rather than shipping to a monthly, weekly or daily schedule. However, any economies realized through bulk handling must be balanced against those that may be achieved through just-in-time material-control programs. The forger usually can help reconcile these conflicting objectives.

Advanced Technology

The forging industry continues to advance processing technology and techniques. Some of the developments underway in the industry today may have an impact on the production of many forgings, while others may affect only a narrow segment of the business.

No matter, it is important for the forging buyer to stay abreast of developments so as to be aware of options becoming available through advancing technology. This is another good reason to get the candidate forger involved early in product-development discussions. The competent forging engineer will be able to identify situations where new technology and processing techniques can benefit the buyer's particular project. And, because capabilities vary so widely from one forging plant to another, only the forger himself can determine how cost-effectively a particular new or more advanced procedure can be applied in his plant.

Here are a couple of areas where technology is changing the way forgings are made:

Net Shape Forging...Has been getting a lot of attention primarily because of the potential to dramatically reduce finishing costs. Not only should it be possible to reduce the amount of stock machined away after forging, but also the costs associated with machining time will be reduced.

That does not mean there are no benefits to be achieved by studying net-shape techniques. Given certain latitude in material selection and in forging design, the knowledgeable forger should be able to keep machining and associated costs to a minimum. The more input the forger has in the early stages of product development, the more likely near-net shapes can be achieved.

Microalloyed Steels...Are used to reduce or eliminate the need for heat treatment. These materials are used to forge such parts as crankshafts, connecting rods and front axles for trucks –with subsequent cost and energy savings

Close cooperation between forging producer and forging buyer is required to ensure that the performance properties of the finished product suit the application.

CAD/CAM, Process Simulation and Computer Control...has changed the forging process from an art to a science. Computers are now an integral part of the day to day operations of a forging plant, from quotations and process simulation to computer control of the forging equipment.

Bringing the forging engineer into the design process often results in reduced lead times, improved part-to-part uniformity, optimized heat treating and a reduction in the amount of material removed in machining.

The Service Industry

The custom forge plant is essentially a service organization. One of the most important aspects of the service provided is the assistance the forger can give in the design and development of a product to be forged. Today, competition among forgers in the global marketplace is allowing the buyer to demand – and get – ever-higher levels of service from the companies vying for the business.

As materials and process technologies advance, it is increasingly important for the forging buyer to involve the forger in decisions that ultimately affect the cost and performance of the part. Through close collaboration with forgers, buyers can gain the greatest benefits from forging industry innovation and can help spur further progress.

Success Stories Result from Buyer/Forger Collaboration

There are literally hundreds of situations in which a knowledgeable forger can help customers solve troublesome problems or simply help develop superior products. Here are some real-life examples of how buyer/ forger collaboration worked...

...To solve a unique design problem:

A cylindrical magnetic core piece for a wound electric coil required close control of straightness and diameter. An upset forging of silicon steel showed straightness in the long shank superior to the investment casting it replaced. In addition, because of electromagnetic property requirements, silicon steel was specified. The forger was able to supply steel with a silicon content in a range from 2.25 to 3.0 percent; for the application, the forging steel compared favorably to the wider 2.5 to 4.5 percent range provided by the investment casting supplier.

...Or to reduce secondary operations and costs:

A cast brass housing for a lock used to hold large doors in an open position was converted to a forging. A switch to forged brass resulted in a 60% reduction in polishing operations. Machining also was reduced when knurled teeth and four counter-bores were forged directly into the part.

...Or to solve and unexpected emergency:

When cracks appeared in the cast hub of a large mining shovel, delivery of a replacement hub casting was projected at four weeks. The high cost of a mine shutdown made this lead-time unacceptable. A custom forged hub, produced by the open die process, put the shovel back in operation within two working days.

...Or to react to a change in service conditions:

When an increase in viscosity of a fluid plastic material began causing failures of forged pump impellers during pumping operations, the forger and buyer evaluated the problem carefully. The solution: switch from a medium-carbon low alloy steel to a 15 Cr-5 Ni steel.

...Or to guide a buyer away from a serious specification error:

Despite a lack of detailed processing knowledge, the buyer of open die forged rolls issued a specification that included inappropriate heat treatment, an error that would have resulted in undesirable surface properties. The problem was discovered in a conference with the forging engineer. After the forger discussed the situation and suggested a more appropriate heat treatment program, the buyer agreed to amend the specification to achieve the correct level of hardness.

Forging Design Conference Checklist

The following information should be exchanged between buyer and forger during conferences held prior to final design and specification of a forged part. This information is the key to identifying ways to improve part performance and reduce costs.

Identification

- Name of component
- Drawing number
- Part number
- Company name and address
- Name and title of person initiating the inquiry or order
- End use

Engineering drawing-forging print and machining print

- Name of component
- Drawing number
- Part number
- Position of locating points and/or chucking bosses for subsequent machining operations
- Surfaces to be machined and finish allowance desired
- Type of finishing operation to be used
- Location and nature of part numbers and trademarks (raised or indented numbers and letters)
- Identification of drawing as to issue status or number
- Test bar location, analysis, and specification number
- Heat treatment (if required)

Quantity

- Total quantity required (in pieces) for initial orders
- Number of pieces per release (if subject to release)
- Estimated annual quantity requirements
- Any limitations on application of FIA quantity tolerances. (Special quantity tolerances are usually quoted separately)

Delivery schedule

- Initial delivery date and number of pieces
- Subsequent schedule (pieces required per delivery –monthly, daily, weekly, etc.)
- Date order is to be completed.

Service data

- Maximum design stress (ksi)

- Description of stresses in service (impact, cyclic loading, or pressures)
- Nature of wear or abrasion to be encountered
- Operating environment (corrosive agents, maximum service temperatures)

Surface condition

- Surfaces to be machined (marked on drawing)
- Nature of finish (polish, plating, paint, other)
- Whether alternate quotation is desired, with machining and other operation included

Material

- Metal by name, composition, and specifications
- Alternate materials permitted

Properties

- Standard specification which applies (additional requirements and/or exceptions)
- Minimum tensile strength (ksi)
- Hardness (maximum and minimum at specified locations)
- Other applicable properties.

Heat treatment

- Nature of heat treatment
- Property levels required

Dimensional tolerances

- Tolerances guidelines (FIA)
- Critical dimensions where special tolerances apply

Special inspection requirements

- Inspection methods required (dye penetrant, magnetic particle, sonic)
- Customers incoming inspection (complete, 100%, statistical, average quality level, AQL, or other)
- Government agency inspection
- First-piece inspection samples required

Shipping

- Special packaging specifications or crating requirements
- Type or name of carrier preferred

Government, customer, or technical society specifications