Know Your

Photos courtesy of Clifford-Jacobs Forging Co., except where noted.

Forgings

William R. Stott, Managing Editor

With fluctuating material prices and often long delivery times, getting your hands on a reliable supply of quality gear blanks can be one of the biggest challenges gear manufacturers face.

Many gear manufacturers are looking at alternatives—shopping around for new suppliers, even looking overseas. Of course, what they're looking for is a better price or faster delivery. But cheaper and faster aren't always the right solution. A lot goes into a quality gear blank, and judging good from bad isn't always easy—until it's too late.

Experts at Clifford-Jacobs Forging Co., a low- to medium-volume producer of hammer forgings, and Presrite Corp., a state-of-the-art high-volume producer of press forgings, have offered their advice on what questions gear manufacturers should be asking, what factors they should consider before switching suppliers and what goes into a quality forged gear blank.

Raw Material

Perhaps the biggest factor affecting the quality of a gear blank is the quality of the raw material from which it's forged.

"Depending upon the design parameters and subsequent heat treat required, gear engineers specify a variety of carbon and alloy material grades to achieve optimum performance in service," says Justin McCarthy, vice president of sales and marketing for Clifford-Jacobs Forging Co. "It is up to the forging supplier to select raw material in compliance with all of the quality requirements specified on the customer's print, and input raw

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material represents at least half of the quality of gear forgings."

A forging company judges the quality of the materials by the material certifications it receives from the steel supplier, says Dale Debeljak, director of technical services for Presrite Corp.

Often, particularly when you're trying out a new supplier or specifying gear blanks from overseas, some of the details can be lost in translation. One customer of Presrite's had tried sourcing gear blanks overseas. The supplier provided all the appropriate certifications for material, heat treating and inspection, but the parts were still bad. The problem was with the raw material, Debeljak says.

"The goal is to have a qualified supplier," says Norm Fisher, Presrite's director of international sales, adding that it really is up to the forging company to make sure the blanks are right. It shouldn't be the customer's responsibility. "They don't want to have incoming inspection."

Quality forging suppliers go out of their way to ensure the quality of the raw material. "At Clifford-Jacobs, we believe in purchasing the highest-quality raw material available," says McCarthy. Clifford-Jacobs routinely specifies the "H-band" on its material, which guarantees a certain level of hardenability.

Clifford-Jacobs also specifies a "DI" rating on its steel purchase orders. The DI value is the maximum diameter bar that can be quenched to a core microstructure of 50% martensite under ideal conditions.

"Specification of H-band steels and DI values is a good way of assuring that you have a metallurgically good product and that you are minimizing variation from lot to lot of steel," McCarthy says.

"As an additional quality step in our pre-forging process, we inspect all incoming raw material," McCarthy says. Clifford-Jacobs requires that all bars on a shipment are received banded together from the mill, and the company verifies that each bar is stamped with the mill heat code.

"We also perform a chemistry check analysis from drillings taken from each incoming heat of steel," McCarthy says. "We compare our chemistry

analysis to the mill certifications and make certain that the material complies with our customers' requirements."

The keys are that the forging company follows the material specifications on the customer's drawing and that he can provide material certifications, says Debeljak.

Some gear blank buyers will even ask to review the mill's material certifications prior to forging, McCarthy says.

The Forging Process

There are a number of quality control measures a forging supplier should follow during the forging process in order to guarantee consistency in results.

A critical element in forging quality gear blanks are the dies and associated tooling used to form the part. "The first time—and every time—we sink the dies for a first production run, we inspect every dimension in the impressions by means of CMM or plaster-cast," says McCarthy.

In addition, the dies used in forging tend to wear out with use, especially features like corner radii. Therefore, forging suppliers should check the tooling prior to forging to ensure that the dies are still to print tolerances.

Also, when a new part is ready to be forged, it generally goes through a short development phase. For example, at Clifford-Jacobs, new parts go through a "tryout" run in order to make sure the size of the pieces of cut steel, or "mults," is optimized for the part being produced. "We cut several mults at the weight estimated by our forging engineers, then a little heavier and lighter," McCarthy says. "We forge these sample gear forgings to determine which cut-weight is optimum for each particular gear. Once that weight is established, we cut steel for the production run."

Checking the weight of the mults while saw-cutting prior to a forging production run is an important method of process control, says McCarthy. The reason is a billet that is hot-rolled at a steel mill can vary in thickness, so the weight of cut mults could vary enough to either underfill an impression or be too heavy, resulting in thickness variation in the gear blanks.

Because the parts are heated prior to forging, controlling furnace temperature is also a critical issue.

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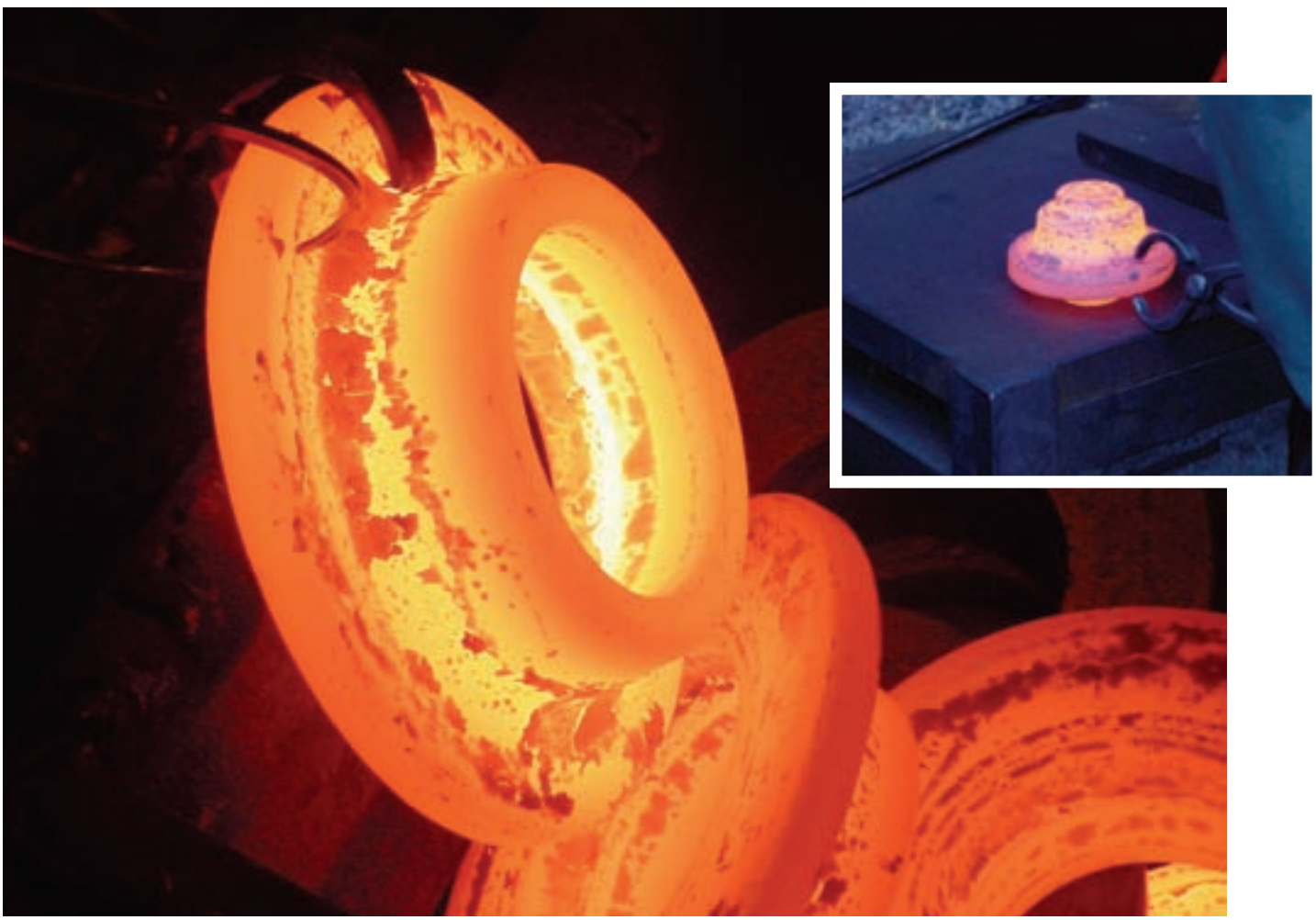


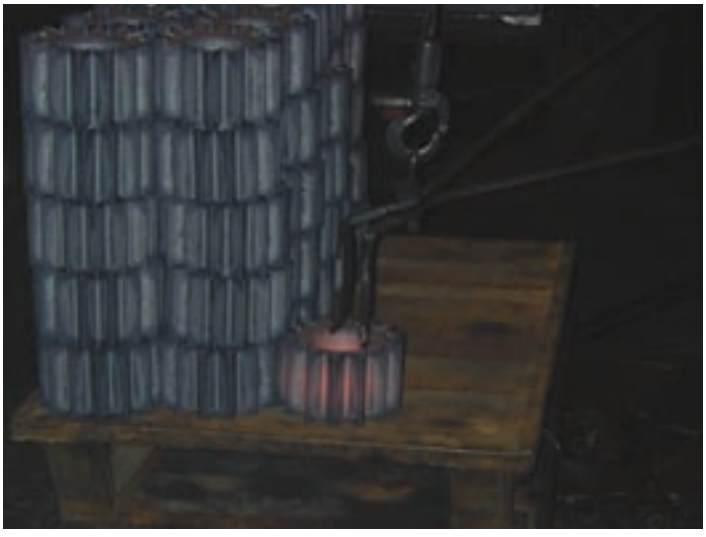
"If the furnace temperature is not controlled, you can 'burn' steel, and that could negatively affect the quality of the gear's mechanical properties or affect the microstructure," McCarthy says.

Excess forging scale on the parts can be a dead giveaway that the forging temperature was too high.

At Presrite, mults are heated by an induction heater rather than by a gas-fired furnace prior to forging. This allows for precise control of the heating process, says Fisher.

Inspection of the parts is also important for producing quality forgings, McCarthy says. Clifford-Jacobs performs a first-article inspection as well as "hot" inspection during the production run. The hot inspector checks for critical dimensions, thickness, mismatch and markings and makes sure there are no defects, such as cold-shuts, cracks or laps.

After the parts have cooled overnight, each gear forging is visually inspected, McCarthy says. Any sharp edges are ground off. Gear forgings are cleaned of forging scale by shot-blast. Some customers require magnetic particle inspection to check for interior defects prior to heat treating.



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Most forging companies will heat treat the blanks for you as well, or send them out for heat treating. Of course, control of this process is critical. Just as customers should expect material certifications from the steel mill, they should also expect to receive certifications of the heat treat process.

"Quality heat treat completes the overall quality of the forging that is shipped to the gear shop," McCarthy says.

How Forgings Can Save You Money

Presrite's business is often driven by trying to save its customers money, says Debeljak. In many cases, the company's goal is to try to get the forging as close as possible to the finished product.

Aside from heat treating, many forging shops have begun to offer additional services, such as turning or other machining processes. Both Clifford-Jacobs and Presrite can turn the inside and outside diameters of gear blanks for customers.

"For our largest customer, we turn every gear blank we make," says Debeljak. "They want to put it right into the gear machine."

But Presrite has special capabilities that allow it to go far beyond just turning the gear blanks for customers. The company's specialty is forging gear teeth into the blank, in many cases to net or near-net shape.

What this means is that many gear manufacturing customers save time and money on rough hobbing. Presrite can leave different amounts of stock on the blank, depending on a customer's requirements.

"We try to match our finished forging to the customer's finishing capability," Fisher says. In some cases, that means the customer will just finish hob the gear. But the fact that the teeth are already forged into the part means that he only has to remove a small amount of material. Other customers will take Presrite's near-net forged gear blanks and finish them by grinding.

In cases where the customers will be just grinding the parts, Presrite performs a secondary cold sizing operation after hot forging, Fisher says.

For a couple of customers, Presrite forges net-shaped parts. In other words, the customers do no further processing on the gear teeth. One of those parts is a gear, the other a spline, Fisher says.

Although it costs more to forge gear blanks with teeth in them, the idea is to save the customer enough money in the time and equipment it takes to perform machining operations that the extra cost of the gear blanks is worthwhile.

The amount of savings depends on the geometry of the part and what additional processes would be required (i.e., hobbing, shaving, grinding). It also depends on the size of the gear and how much stock is left for removal by those processes.

On some of its customers' coarser-pitch gears, hobbing times have been cut by as much as 50% using a near-net gear forging, Debeljak says. The reason is that in those cases, rough hobbing has been eliminated altogether.

Also, when you forge blanks with teeth in them, you save on material costs. For example, Fisher says, a large railroad pinion might require a 55-lb. gear blank if forged without teeth. But the same part, with the teeth forged, might weigh only 37 lbs. That material savings helps offset the additional cost of forging the gear teeth.

On larger parts, particularly those 30 lbs. and up, the material savings can be enough to make the forged teeth pay for themselves, Debeljak says.

But even on smaller parts, forged gear teeth can provide cost savings through reduced machining operations at the gear manufacturer's factory. Also, Fisher says, forged-tooth gears have stronger teeth due to the material's grain flow properties.

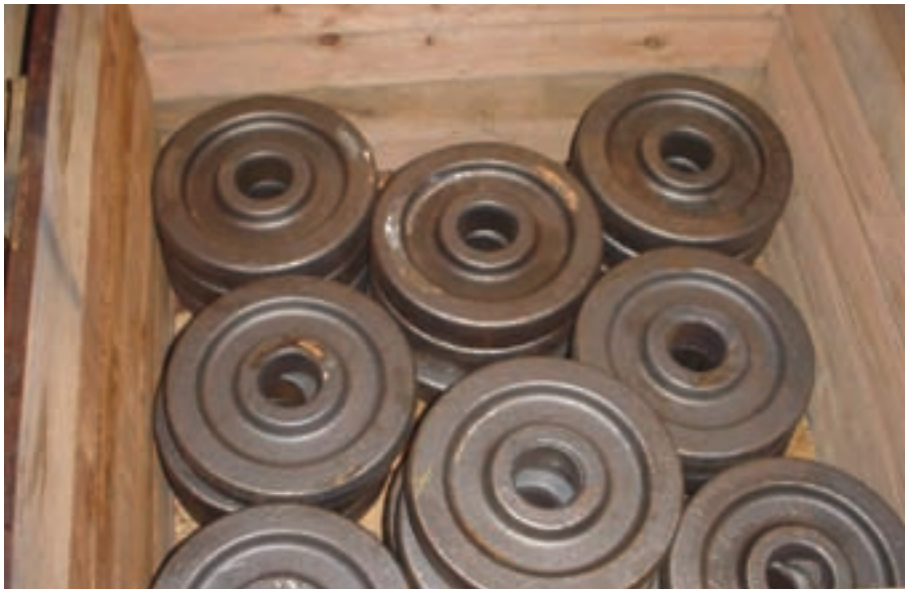
Shopping Around

Even when you have a qualified gear blank supplier, material costs and delivery times often tempt gear manufacturers to shop parts around and look for new suppliers.

In particular, the amount of international competition for forgings has increased dramatically in recent years, Fisher says. American gear manufacturers are now using or considering forging suppliers in India and China.

But the important thing to do when shopping for gear forgings is to make sure you know what you're getting. Material certifications are crucial, as are certifications and other documentation for any processes performed on the gear blank, most notably heat treating certifications and inspection reports for any machining operations.

What appears to be a cheaper gear blank may not be in the long run. For example, Debeljak says, if you end up having to machine more stock off the part, what does it cost you? When comparing one gear blank supplier to another, make sure they're



both offering you the same stock allowances. Also, it's important to get a proposal drawing from any new supplier and compare it with what you're getting from a current supplier. A proposal drawing will spell out how much stock is added to your original drawing.

Moreover, it's important to make sure all the processing is equivalent. Will the part be normalized? Is heat treating included in the cost of the blank? Will the parts have any rough machining already done, such as turning diameters or faces? All these questions should be asked and the answers compared before choosing a forging supplier.

McCarthy sums it up: "There are no shortcuts to producing quality gear forgings. Selecting and purchasing high-quality raw material is probably the most important factor. Working with a forging supplier that maintains the dies and tooling to print tolerances, and then controls all aspects of the forging process is what contributes to the best gears produced for the most demanding applications—and which contributes to the gear company's reputation for quality and performance." ■

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