A Huge Success

Sivyer Steel casts 62' bull gear in seventeen weeks from purchase order to shipping.

Nancy Bartels

Sivyer Steel Corporation, Bettendorf, IA, an ISO-9002-certified casting specialist, is familiar with tackling tough jobs. The company has built an international reputation as a supplier of high-integrity castings, especially those which require engineering and/or full machining. It's not unusual for Sivyer's customers, especially those in the mining, recycling, power generation, valve and nuclear fields, to ask the foundry to produce a one-of-a-kind casting—often something revolutionary—but AmClyde Engineered Products' request was a special challenge, even for Sivyer.

AmClyde, a designer and manufacturer of large specialty equipment for lifting, pulling, moving and mooring the heaviest loads in the offshore oil and gas market, asked Sivyer to create a gear to turn large platforms or similar structures. Though the basic specs—a high-strength alloy steel per ASTM-A-148, Grade 115/95, with minimum 115,000 psi ultimate tensile strength, minimum 95,000 psi yield strength, minimum 14% elongation and minimum 30% reduction of area—were well within the ordinary, the size was not. The cast tooth bull gear required a diameter of 62 feet.

Fig. 1 — A close up view of the gear shows how the toothed sections were assembled during the roundup. Sections had to fit together with a very tight tolerance of ±5 mm on the 62' diameter.

Project Constraints

Other project constraints, though common to gearing, became crucial, because of the massive size of the gear. The 2" profile teeth had to be cast into each segment with zero draft angle allowed. The casting tolerances were extremely tight, and during roundup, all twenty segments had to be leveled and bolted together. When shipped, the gear had to meet Level 1 requirements—the casting industry's highest quality standard.

As Sivyer's design engineers looked at the project, they broke it down into several phases:

- Redesign for efficient manufacture at Sivyer's large, no-bake facility.
- MAGMAsoft® simulation modeling of mold filling and solidification.
- Building of new pattern equipment.
- First article approval.
- Production pouring.
- Heat treatment.
- Machining.
- Full radiography.
- Roundup.
- Shipment on time.

As Sivyer's engineers originally looked at the project, the biggest concerns were with the solidification modeling, heat treatment, machining and roundup. There were special customer requests on the last three, and the first was crucial to the success of the entire project.

However, once the purchase order was signed, there was an overriding concern: The process, which would normally take twenty-eight to thirty weeks, had a mere seventeen-week schedule. Scheduling, managerial and teamwork skills would really be put to the test.

Despite the fact that the foundry schedule in the floor molding area was extremely tight, Sivyer's engineers were sure the job could be completed on time if everything worked smoothly. But success hinged in the early days on their ability to

use computer modeling to design the patterns and related process parameters.

The final design called for casting in twenty segments, each 6" high x 6" wide, with a 2" cast tooth profile, cast onto the outside diameter. Sivyer's previous cast tooth gear projects had involved an identical number of teeth per segment. But because of the design of the 114.86" circular arc (based on the inside radius), this project would be different. In the final design, the 62-foot gear had a total of 558 teeth, 0.75 DP, 20° PA stub tooth form. It would be manufactured in eighteen segments containing 28 teeth per segment and two segments with 27 teeth per segment. Each segment would weigh 1600 lbs. and be 117 inches long. The designers were aware that any final adjustments would have to be handled at roundup stage.

Modeling

Producing the gear in the traditional manner would have involved weeks of trial and error, even with Sivyer's skilled and experienced staff—weeks they didn't have. In order to determine more efficiently where to best place the chills and related process components for successful pouring, company engineers turned to their computers and a software program known as MAGMAsoft.

MAGMAsoft is an extremely accurate mold-filling and solidification modeling software. With it, the design engineer is able to simulate a prototype of the actual mold and casting prior to its creation. By manipulating the location of the process particulars on screen, the software can accurately predict where faults, failures and shrinkage will appear in the actual casting process. Because of the program's 3-D capabilities, this computerized trial run shows trouble spots and allows for redesign of the mold to eliminate them, effectively ensuring the integrity of the actual casting.

While that work was being processed, other departments prepared for the pouring and the crucial steps that would follow. When the castings were ready for heat treatment, they would require normalization, as well as quench and temper processes. Arrangements also had to be made for special fixturing during loading to prevent warpage.

Machining

The specs called for top and bottom faces ground to dimension, milled ends machined to proper radial angle and milled pilot holes drilled for the splice joints. During machining, nine holes were drilled through the height of the gear for bolt-down. No machining was necessary on the teeth, thanks to exceptional dimensional accuracy and surface quality.

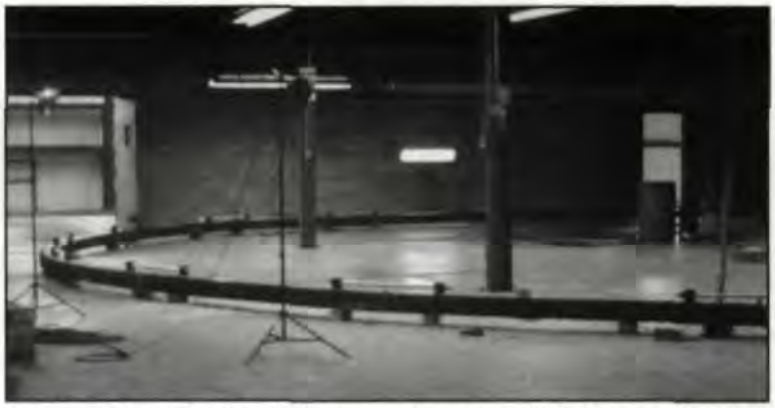

Fig. 2 — A view of the floor as the gear was being assembled gives some idea of the magnitude of the gear. A special site had to be found for the assembly process, and every piece fit together and leveled properly.

Roundup

The last step was roundup. The specs called for the radius to have an extremely tight tolerance of ± 10 mm. Sivyer engineers arranged a site for the roundup and the necessary equipment. With specifications as tight as they were, each segment of the 62' diameter gear had to be individually leveled, then bolted together to ensure overall uniformity of roundness. Highly accurate measurements were made using laser technology to verify that the critically important assembly dimensions were held to ± 5 mm.

At roundup, the customer asked for only one alteration. Because of the final shipping weight—over 34,200 pounds—he requested that lifting holes be drilled into each segment to make transportation easier. This done, the project shipped on time.

Project Management Skills Crucial to Success

A special combination of skills was required to make a success of the AmClyde project. Sivyer's technical know-how, project management expertise and its experience in handling short turnaround times and turnkey projects were essential. So was the company's recognition that sometimes, in order to keep a project on schedule, parts of it may have to be jobbed out—even if they are tasks the organization is normally capable of handling. In the AmClyde project, a local machine shop handled the machining under Sivyer's supervision. According to Patrick J. Comparin, Sivyer's vice-president, it was this combination of background, skills and teamwork that made the AmClyde gear project doable and account for Sivyer's success in the castings market. ○

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