This strong, tough, corrosion-resistant stainless steel improves performance of equipment in aerospace, medical instruments, oil drilling, firearms, and marine applications.

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Custom 465 stainless steel is a premium double vacuum-melted, martensitic, age-hardenable alloy that offers a unique combination of high strength, toughness, and corrosion resistance. It is capable of ultimate tensile strength in excess of 250 ksi (1722 MPa) when aged at 950°F (H950 condition). This strength is higher than that of any other historically available precipitation-hardenable stainless steel long product. Aging temperatures ranging from 950 to 1050°F can be selected to achieve the balance of strength, toughness, and resistance to stress-corrosion cracking needed for specific applications.

The H950 condition is the most common treatment for achieving higher strength together with good toughness and excellent notch tensile strength. The H1000 condition may be chosen for higher toughness at a slightly lower strength level. This condition provides a superior combination of strength, toughness, fabricability, and resistance to stress-corrosion cracking.

Figure 1 shows the relative strength and toughness of PH stainless steels, while Fig. 2 shows the relationship between yield strength and fracture toughness of conventional PH stainless steels.

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General corrosion resistance of Custom 465 stainless approaches that of Type 304 stainless. In both the H950 and H1000 conditions, exposure to 5% neutral salt spray at 95°F (35°C) (per ASTM B117) caused no rusting after more than 2000 hours. Double-cantilever-beam tests conducted in 3.5% NaCl (pH 6) show inherently good resistance to stress-corrosion cracking.

In addition, stress corrosion resistance improves with increasing aging temperature, making it comparable to that of Carpenter 13-8 stainless and Custom 455, but at significantly higher strength, and its resistance is superior to that of both when overaged to the same strength level. Fig. 3 shows the relative strength, general corrosion resistance, and stress-corrosion cracking resistance of traditional PH stainless steels.

Service conditions
In today’s competitive business climate, more manufacturers are focused on the lowest life-cycle cost, rather than lowest initial cost. This attitude has created a strong worldwide demand for materials with high strength and toughness that are also relatively easy to fabricate and that provide reliable, long-term service in corrosive environments. The patented alloy is a corrosion-resistant upgrade to high-strength alloy steels, and is a higher-strength upgrade to more conventional stainless steels. Composition is shown in Table 1, and typical properties are shown in Table 2. Unlike alloy steels, Custom 465 stainless requires no surface coating or metal plating to provide corrosion resistance. It thus eliminates the vulnerability of treated surfaces to cracking and subsequent corrosion attack.

In addition to the expense of coating or plating, the environmental issues related to such coatings and their waste solution disposal are an even larger problem. For example, the European Union is considering a ban on cadmium plating. Even if cadmium plating is not entirely banned, new restrictions and regulations could make the disposal...
cost of plating baths prohibitive.

A superior strength-to-weight ratio has driven the success of several new products beyond aerospace. The very high levels of strength that can be achieved provide the part designer with the opportunity to either add strength to an existing design, or to reduce its weight or size. Even with such high strength levels, Custom 465’s superior fabricability has been key to the success of critical products that could not be made from alternative high-strength materials.

The alloy is typically shipped from the mill in a solution-annealed and cold-treated condition. In this condition, Custom 465’s structure is a highly ductile iron-nickel martensite with low yield strength and a relatively low rate of work hardening. As such, it can easily be formed or shaped via conventional methods before the simple one-step hardening treatment.

Oil and gas drilling

Drill rigs for oil and gas exploration are subjected to severe costs due to lost production when they are shut down to repair or replace failed equipment. Examples of such critical components are the drive shafts for downhole drilling tools. Shafts made of EN30B or Astralloy alloy steel, traditional choices for this application, would typically last no longer than 150 hours in service before requiring replacement.

NQL Energy Services, a large independent drilling tool supplier in Nisku, Alberta, decided to make the drive shafts on its Black Max line of downhole drilling tools from Custom 465 stainless, as shown in the photo. As a result, the newly designed shafts and mud motors now last up to 1500 hours before replacement is required.

Aerospace applications

Custom 465 stainless was originally designed to help meet demands from the aerospace industry for materials that could keep aircraft flying for 30 years or more with minimum maintenance. Carpenter and partnering aerospace companies discussed and refined goals, and tested alloy samples for seven years before the alloy was fully accepted and qualified. It has since been approved and used for structural components such as flap tracks, slat tracks, actuators, engine mounts, and landing gear hardware. Custom 465 alloy is currently covered by the MMPDS-02, AMS 5936, and ASTM A564 specifications.

The alloy can be considered as a corrosion-resistant replacement for 300M, AISI 4340, and similar types of steels that must be plated or otherwise coated to provide corrosion resistance. It can also be considered as a higher strength replacement for stainless steels such as 15Cr-5Ni, 17Cr-4Ni, and Ph13-8Mo stainless steels that have acceptable corrosion resistance, but less-than-needed strength and toughness.

Medical instruments

Cold-worked Custom 465 stainless aged at 900°F (482°C) can provide maximum achievable tensile strengths approaching 300 ksi (2070 MPa) for parts with diameters less than 0.75 in. (20 mm). This capability has been useful for making surgical and dental instruments and needle wire. While the more conventional ferritic and martensitic...
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New surgical techniques require instruments of improved design that do not break, distort, or otherwise fail during surgery. The new alloy’s combined high strength and toughness has allowed instruments to withstand higher operational torque loads during surgery. These properties have facilitated the design of the longer and smaller-cross-section instruments that are typically required for minimally invasive surgeries.

Superior fracture and impact toughness are also key properties for surgical tools. At comparable strength levels, it provides more than twice the impact resistance of either Custom 455 stainless or 17Cr-4Ni stainless, two alternative precipitation hardenable stainless steels.

Instruments are autoclavable and resistant to oxidation in a steam environment. The alloy also has been found to be resistant to cleaning and sterilizing solutions as well as to body fluids, and is included in ASTM F899, which is the governing specification for Stainless Steels for Surgical Instruments.

Although not designed specifically for wear and edge retention applications, Custom 465 stainless is suitable for instruments such as scrapers and cutters with superior results when compared to Custom 455 and 17-4. In addition, the alloy has served well in suture needles due to its combination of high strength, ductility, and corrosion resistance.

Firearms industry

When firearms manufacturer Sturm Ruger & Co. Inc., Southport, Conn., developed the world’s first six-shot revolver in a .454 Casull caliber (the Ruger Super Redhawk), it selected Custom 465 stainless for the cylinder to withstand the enormous pressure generated when firing this powerful cartridge. Designers started with Ruger’s proven, rugged .44 Magnum platform, planning to modify it to withstand the approximately 62,000 psi pressure produced by the .454 Casull cartridge.

The highest chamber pressure produced by a typical .44 Magnum cartridge is about 42,000 psi. Since the diameter of the chambers in the cylinder had to increase to accommodate the larger .454 cartridge, the cross sections between the chambers were reduced in thickness. In other words, the design required thinner walls to withstand 50% higher pressure.

To determine whether this was possible, Ruger fabricated a cylinder from Custom 465 stainless, then fired hundreds of rounds at a proof stress of 92,000 psi, approximately 50% higher than the stress produced under standard .454 firing conditions. After this testing, the chambers exhibited no cracking, scratches, or other signs of fatigue.

The alloy’s full range of properties was required to actualize this design — high tensile strength, notch tensile strength, fracture toughness, and corrosion resistance. The clean micro-structure produced via premium melting and the inherent good machinability of the iron-nickel martensite matrix provided additional advantages in material savings and manufacture.

**Marine engine shafts**

Howard Arneson is known for groundbreaking marine racing designs such as the famous Arneson surface drive propulsion system. He knew he was pushing material limits when he harnessed a 4500-hp Lycoming gas turbine, like those in U.S. Army helicopters, to just one propeller shaft in his newest catamaran racing boat. This is three times the power load that is normally applied to a marine propulsion shaft.

Zeiger Industries of Canton, Ohio, was asked to fabricate the propeller shaft from 17Cr-4Ni PH stainless steel. The finished shaft measured 40 inches long by 2.5 inches in the center, tapering down to 1 1/4 inch at both ends. After careful installation of the shaft, the powerful racer was taken for a test cruise on the Pacific Ocean. Following 50 hours of running time at speeds around 100 mph, the shaft broke off, dropping to the bottom of the sea with its propeller.

A new shaft made from Custom 465 was produced and placed into the catamaran. The engine was tested under exceedingly severe loading conditions. The initial test involved accelerating the catamaran to 100 mph in just 12 seconds, which was accomplished successfully. The catamaran was then accelerated to 175 mph, and held for several hours at that speed. For approximately four months, the catamaran was cruised at sustained high speeds, 50 to 100 miles at a time, several times a week, without any trace of a problem.

After this extended period of intense service, the propeller was removed and no marks or signs of wear were found even where the propeller engages the spline. This serves to illustrate the advantages of 465 over other PH stainless alloys, as it matches them in resistance to stress corrosion cracking while providing markedly higher strength.

**Mill forms**

Despite its highly alloyed content, Custom 465 stainless can be produced with consistent properties, in most long forms: flat, square, and round bar; wire; rod; strip; and forged billet up to 16 in. round. The company is also investigating the manufacture of hot rolled plate, having rolled a number of trial plates. This development could facilitate the fabrication of parts close to stock size and reduce the cost of machining parts.