The evolution of duplex fabrication: a fabricator’s view

Author: Barry Heuer (Chief Metallurgist, NFI)

Abstract

United States fabricator’s view of the history of the materials and the demand for such duplex materials in the United States from the 1970s until the current time.

1 History

In the early 1970s, the first generation of duplex stainless steels were accepted into ASME Section VIII, Division 1 Code as a code case. This ASTM specification A669 was for seamless, ferritic-austenitic alloy steel tubing. Throughout the 1970s, we saw little demand for duplex stainless steels in the United States. Our earliest experiences were with the SA669 material in heat exchangers. The first two heat exchangers that we fabricated using this material consisted of heat exchangers with rolled-only joints. Additionally, one exchanger was fabricated in this time frame that required both welding and rolling. The tubesheet on this particular exchanger required an ER308 overlay on the face of the tubesheet, and the tubes were welded with no filler metal added. All these units were designed for a tubeside pressure of 1590 psi.

In 1981 we were involved in the fabrication of four large vessels, two at 15’ (4.6m) diameter and two at 18’ (5.5m) diameter, that required the use of a duplex stainless steel known at that time as 44LN. We were involved in securing a code case for this material which was ASME code case 1893 which was approved in December 1981. Since we helped in securing the code case for this grade, we were also interested in the development of welding procedures to fabricate this particular material. Our chief metallurgist at that time, Mr Rudy Dirscherl, and one of our welding engineers, Mr Stan Barth, generated the procedures both for welding and fabrication of this particular material in our shop. A paper was presented at the ASM Metals Congress in St Louis, Missouri, in October 1982 documenting the research and development that went on with this particular alloy. This material was significantly improved over the SA669 material. It had a much lower carbon and nitrogen addition. Fortunately, at this early date, we chose to use 2209 consumables for this alloy and have continued to use these for our UNS 31803 and UNS 32205 materials to this day. Figure 1 shows the shop assembly being performed. The units were shipped by barge to the job site. Their installation is shown by figure 2.

Also, in 1981, we were committed to build two heat exchangers utilizing SA669 tubing. Again, one unit was rolled-only and the other unit required a weld overlay of type ER316 stainless steel on the tubesheet face. This overlay was applied by the PAW hot-wire process. The tube-to-tubesheet
joint on this particular exchanger was welded without filler metal added by the gas tungsten arc process. The tubeside pressures on these units were 1,070 psi. The maximum design temperature was 600ºF (316ºC).

In 1984 we fabricated two large thin-walled drums approximately 9/16" (14.2mm) thick ranging between 12.5 and 13 feet (3.8–4m) in diameter by 36 to 38' (11–11.6m) long. As you can see by the wall thickness, these vessels were relatively low pressure, but they were full X-ray vessels. They were fabricated out of, at this point in time, UNS 31803 which was covered by ASME code case 1978.

In 1988 we fabricated some thin drums and reactors which were to be utilized in the north slope of Alaska. These units were the thinnest units that we have ever fabricated, approximately 1/4" (6mm) thick and relatively low pressure.

In 1991 we fabricated at our one subsidiary fabricated four lots of scrubber duct work. The welding of these units was completed in the shop and then they were erected in the field. This duct work was 3/16" (4.5mm) thick and made with UNS 31803 material. Production weld tabs from the long seams on these units were submitted to the customer for ferrite determination and corrosion testing prior to acceptance for shipment.

Also in 1991, we became involved with a very large project for header boxes for fin-fan type heat exchangers. Due to our experience in duplex fabrication, we fabricated a total of 58 UNS 31803 header boxes. These units were assembled in a Tulsa exchanger shop and were destined for offshore service in the Far East.

In 1992 we fabricated two 14' (4.3m) by 59' (18m) strippers for use at an oil company complex in the southern United States. One half of these units was constructed of UNS 31803. These units were to be used in the treatment of on-site ground water.

Also in 1992 we fabricated a high pressure heat exchanger 7' (2.1m) in diameter by approximately 40' (12.2m) long utilizing UNS 31803 tubing. This material was selected for its high strength. It was possible to use thinner gauge tubes with this material than austenitic stainless tubes.
This allowed a more compact design due to the better heat transfer of the thin wall tubes as compared to an austenitic stainless design.

In 1993 we fabricated loop reactors that utilized extruded heavy wall pipe and forged connections of UNS 31803 material. This project also had a carbon steel jacket around the piping. Duplex stainless steel return bends were induction bent and solution annealed after bending. These units were hydrotested in our shop at a pressure of 7,060 psig in the horizontal position. These units had carbon steel jackets. The carbon steel to duplex welds were made with 2209 consumables. Figures 3 and 4 show some of the parts of the loop reactor ready for shipment. The hydrostatic testing of the assembled unit is shown in figure 5. Figure 6 shows one of the high pressure heat exchangers used in conjunction with the reactor.

In 1994 we received an order for two large 17 by 12’ (5.2 by 3.7m) by 3/8” (9.5mm) wall vessels. These vessels were to be used to replace existing 300 Series units. The forming of the heads for this project caused a great amount of difficulty. With the enhanced yield strength of the duplex material, forming pressures for the cold spinning of the head caused material problems. We were severely work hardening the external surface. We had to initiate an intermediate solution anneal to restore properties. Final sizing could then be accomplished.

Also in 1994 we fabricated four duplex stainless steel jacketed tanks. These tanks were polished on the inside and utilized a duplex half pipe on the outside. Figure 7 shows the interior surface of the vessel. The higher hardness of duplex stainless steels as compared to austenitic stainless gives a better finish. They were a replacement for 304 stainless steel vessels that had failed due to excessive chlorides in the jacket side. We fabricated the half pipe with a gas tungsten arc root followed by gas metal arc welding. The loading of the vessel is shown in figures 8 and 9. At that same time, we also fabricated two additional low pressure rectangular tanks for the same customer replacing 316L material with UNS 31803. One of these tanks is shown by figure 10.
In 1997 we had a variety of duplex jobs on the shop floor. We had three 12' (3.7m) diameter UNS 31803 batch digesters that were our first experience into duplex stainless steel for the pulp and paper industry. These units used hot pressed heads that were re-solution annealed at our facility. The vessel is shown in figure 11 ready for shipment.

We also fabricated a 114" (2.9m) diameter by 28' (8.5m) long heat exchanger with seamless UNS 31803 tubes. These units were welded with the automatic gas tungsten arc process with ER2209 welding consumables. The tubesheet thickness on this exchanger was 5 1/4".

Our final job in 1997 that used duplex stainless steel was a 5' 6" (1.7m) by 111' 5" (34m) column out of UNS 31803, which again was replacing an existing 316L column. The truck shipment is shown in figure 12.

2 Conclusion

To this day we continue to see additional applications for duplex stainless steel. Whenever chlorides and the possibility of stress corrosion are predicted, the chemical processing industry is turning to duplex stainless steel more and more often. The pulp and paper industry is also embracing UNS 31803 and UNS 32205 for their applications.

Higher strength duplex stainless steels are being developed and marketed. With the ever-increasing demand for these new developments and the existing ones in the world market, it forces the fabricator to constantly reinvent himself and prepare for the future of duplex stainless steel in the year 2000 and beyond.