Laser Peening by CWST Contributes to Successful Nuclear Canister Storage Program

THE LASER PEENING PROGRAM at Curtiss-Wright Surface Technologies (CWST) has contributed to the successful launch of a new manufacturing process for Multi-Purpose Canisters that hold spent nuclear fuel. Their contribution was the result of extensive research, prototype testing, and validation at the CWST facility in Livermore, California on the prevention of Stress Corrosion Cracking (SCC) in the welds of the canisters. The Multi-Purpose Canisters are being laser peened by CWST at the Holtec Manufacturing Division's Pittsburgh facility.

The project was a collaborative effort between CWST and Holtec International—the company that designed, licensed, and manufactures the Multi-Purpose Canisters. Holtec is a global turnkey supplier of equipment and systems for the energy industry. The company provides solutions for managing the back end of the nuclear power cycle for commercial nuclear power plants. Holtec and Curtiss-Wright worked jointly to develop a peening process of Holtec's Multi-Purpose Canisters as a barrier against SCC.

The Challenge

Dry canister storage of spent fuel at nuclear plant sites is being used as an interim approach until a permanent dry storage site is available. The dry canisters are necessary because spent

The laser peening process in development and testing with a Holtec Multi-Purpose Canister at the CWST facility in Livermore, California.

fuel pool storage is reaching capacity at nearly all nuclear plants in the US. However, the corrosive nature of the moist air in costal or lakeside regions and humid environments can make the welded regions of the canisters susceptible to pitting and Chloride Stress Corrosion Cracking (CLSCC). These canisters are commonly made of 304 or 316L stainless steel and are roll-formed and welded to a cylindrical shape. After being loaded with spent fuel, the cylinders are then sealed welded and filled with an inert gas, such as helium. The canisters are placed vertically in concrete/metal overpacks to provide radiation shielding and reduce exposure to the environment.

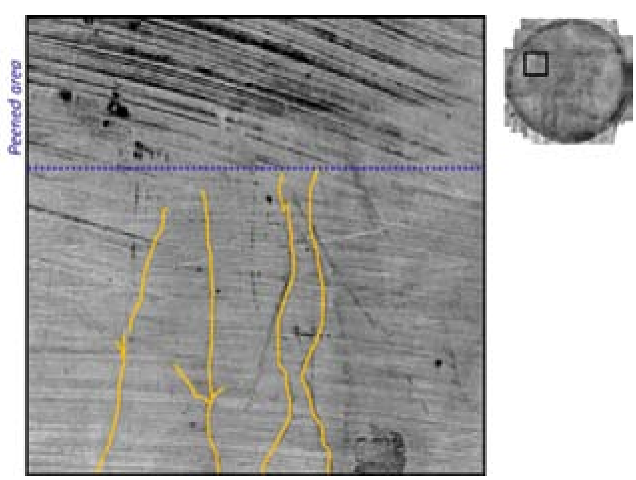
The laser peening team at CWST was eager to address the challenge of preventing stress corrosion cracking in the weld sites of the Multi-Purpose Canisters.

The Backstory

The groundwork for the nuclear waste storage program began 20 years ago when CWST participated in a Department of Energy study on the treatment to prevent corrosion cracking in nickel-based canisters for long-term storage at the Yucca Mountain Nuclear Waste Repository. Under a cooperative research and development agreement between CWST and the Lawrence Livermore National Laboratory, research on nickel materials and 316L stainless steel proved that laser peening would prevent stress corrosion cracking in welds. With funding provided by Holtec in 2016, CWST tested and verified a laser peening process on Holtec Multi-Purpose Canisters to meet a June 2017 deployment.

The Research

CWST performed a series of tests, demonstrating the benefit of laser peening to prevent chloride stress corrosion cracking (CLSCC) of dry canisters for spent nuclear fuel storage. The research centered on panels of 316L stainless steel from Holtec. The panels were fabricated with the same process the company uses to manufacture its Multi-Purpose Canisters.



Test plate of 316L stainless steel fabricated by Holtec with stress corrosion cracks highlighted. Observation was done after 57.5 hours exposure to $MgCl_2$ at 155˚C. Cracks developed in un-peened areas, but did not develop in peened areas and arrested as they propagated from un-peened into peened areas.

CWST presented its findings in a paper written by Dr. Lloyd Hackel, Vice President at CWST, titled *Preventing Stress Corrosion Cracking of Spent Nuclear Fuel Dry Storage Canisters*. The conclusion of the paper stated:

> It is generally accepted that corrosion pitting reaching a tensile field can initiate CLSCC that will continue to propagate. Literature analysis and verification show that pitting will self-terminate in 316L at a depth of about 200µm (0.008 inches) due to cathodic current limits. Thus deep levels of compressive stress are critically important to prevent corrosion pitting from reaching tensile stress and thereby initiating and propagating CLSCC. Our measurements conclusively show that laser peening generates compressive stress in canisters greater than 4 mm in depth that is well beyond the self-terminating pit depth. Our accelerated ASTM G36 (2013) tests conducted at 155˚C with $MgCl_2$ (Magnesium chloride) clearly show that CLSCC will not initiate in areas treated with high-energy laser peening and that CLSCC originating outside of a laser peened zone will arrest upon reaching the peened area. The high-energy laser peening thereby offers an excellent safety margin for structural integrity of dry storage canisters of spent nuclear fuel.

The Results

Due to the success of their laser peening research and development work, CWST became the laser peening service provider to Holtec for the Multi-Purpose Canister program for a specific client. Holtec International mentioned the results of the project in a November 2017 edition of their newsletter, *Holtec Highlights*:

> "Another recent noteworthy development is the pioneering effort by Southern California Edison and Holtec to further fortify the SONGS' multi-purpose canisters against attack from marine air by a *laser peening* process guided by the established science on corrosion protection of stainless steel."

Holtec's Program Manager, Dr. Fred Bidrawn, said, "This pioneering peening operation is a giant step in our industry's efforts to substantially inoculate MPCs from the threat of stress corrosion cracking."

Dr. Hackel added, "The benefits of deep compressive stress generated by laser peening are highly effective in preventing stress corrosion cracking in an ever-expanding range of applications including short- and longer-term storage of spent nuclear fuel, in sensitization cracking of 5000 series aluminum plaguing Navy and commercial ships, and in the upstream and downstream oil and gas industry. We are excited to be able to solve these problems."