MILLS PRODUCTS INCORPORATED ENGINEERED WITH IMAGINATION

*Case Study*

# HYDROFORMING TECHNIQUES FOR STAINLESS STEEL APPLIANCE HANDLES

## SYNOPSIS

In 2000, a major appliance manufacturer had been using cast zinc handles for its stainless steel appliance line because they did not have a way to manufacture appropriately contoured handles out of stainless steel. Using computer modeling, Mills Products developed a way to make the handles from stainless steel by taking hydroforming techniques to a new level. For nearly a decade, Mills Products produced 5.3 million handles for the client's product line and reduced the cost of the handle to the client by 40 percent.

*In the early 2000s, stainless steel appliances featuring graceful, ultramodern curves became popular. A big challenge for achieving this look was creating curved handles made from stainless steel.*

## THE CHALLENGE

In the early 2000s, stainless steel became a growing trend in finish choices for kitchen appliances. One of Mills Products' clients introduced a sleek line of stainless steel appliances to answer the demand.

In developing the line, the client's design staff had encountered a problem: There was no existing way to make the types of handles they wanted out of stainless steel. But the company wasn't willing to compromise on the streamlined contours of the handles, which had been designed to complement the ultramodern look of the appliances. The only feasible option was to make the handles out of zinc, using casting techniques that could replicate the graceful curves of the design. Despite the design consistency, the different material made the handle look out of place. Consumers noticed and commented.

Metal fabricator Mills Products had been working with the client on other projects, and became aware of the difficulties the client was having with the handles. Mills was heavily invested in R&D on the evolving technology of tube hydroforming and felt strongly that it could assemble a hydroforming system that could re-create the handle designs out of stainless steel tubes.

The key to success would be bleeding-edge hydroforming techniques that would require pressures and forces that could expand the tubes by as much as 35 or even 40 percent without compromising the integrity of the metal. At the time, anything greater than a 30-percent expansion was considered pushing the limits, but hydroforming was clearly the only way to do it.

In the face of these limitations, Mills had exhaustively tested the concept of increased metal expansion, but only through computer simulations. Their virtual models told them time and again that it could be accomplished — at least in theory. Though the Mills engineers were convinced about the possibility of making the stainless steel handles a reality, and were even experimenting with new hydroforming equipment that held out the promise, the customer was less sanguine. They had concerns for the very sound reason that no one had actually done it — including Mills.

*The oven range in the client's appliance product line received the first hydroformed stainless steel handles manufactured by Mills Products.*

But the client was motivated to find a solution to eliminate customer dissatisfaction over the non-stainless handles. It took Mills nearly a year to convince the client that Mills could overcome the technical hurdles and deliver true stainless steel handles, not only in exact conformance with the cast metal designs, but at a reduced cost.

Once the client was convinced that there could be significant cost savings involved, Mills received permission to prototype the handles for a stainless steel oven range.

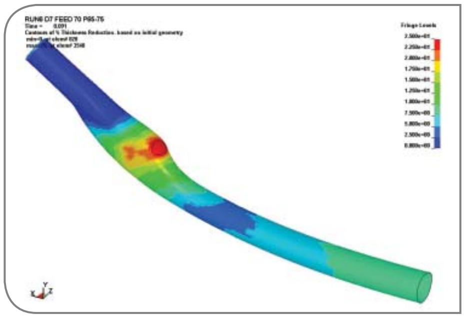
## TOOLING UP — MORE CHALLENGES

Once Mills began the trial run, the theoretical challenges became real-world problems to solve, including some that Mills could not have foreseen.

The client was adamant about keeping the exact same mounting method that had been being used with the cast-metal handles. That way, they would not have to change the rest of the appliance design. This meant Mills had to devise several different parts, including two small zinc pieces that were needed to achieve a fit identical to that of the cast handles. There also were embossed marks in the cast metal handles that facilitated lining them up for mounting, something that would be difficult, or impossible, to reproduce when hydroforming of stainless steel tubes.

Complication number two was that one of Mills Product's competitors was bidding for the same contract. The competitor had insisted that the only way to successfully hydroform the handles would be by using annealed stainless steel tubes. Annealing would soften the metal, making it easier to work with but also increasing the chance of breakage and adding to the cost. All of the computer simulations Mills had done convinced them that it wasn't necessary to use annealed stainless steel, but the client required Mills to have 10,000 annealed tubes as a backup in case its non-annealed test run was not successful.

As an added complication, the competitor was also asked to do a run of the handles as a side-by-side comparison, using annealed tubes. Mills was under the gun not only to match performance with the annealed tubes, but also to prove their theory that it could be done as well or better using non-annealed tubes.



*Finite Element Analysis of the hydroforming process.*

A crucial component of the Mills hydroforming model was the application of force in exact measure to the axial ends of each tube as it was being filled with high-pressure fluid, which would "in-feed" the material of the tube from each end, allowing the metal to expand outward into the mold. The tolerances were extreme, and the initial trial-and-error period produced nearly 10 percent waste. That can get awfully expensive with stainless steel.

Mills was utterly confident that it had done its homework right with the computer simulations, though, so it kept tweaking and refining its tooling.

## OPTIMIZED HYDROFORMING

Drawing on decades of experience in metal forming, the Mills engineers were soon able to get an exact duplication of the form factor of the cast handle — but in pristine stainless steel — and they were vindicated in finding that the non-annealed stainless steel produced better results than the more expensive annealed material their competitor had told the client would be needed.

Mills also got a leg up on its competition by experimenting to find the best possible lubricant to use in the hydroforming process. The forces exerted in hydroforming and the expansion of the metal results in a lot of friction. It can cause the stainless steel to rupture if it isn't correctly lubricated. The competition had been using a dry lubricant, which first had to be sprayed on the unformed tube and allowed to dry, adding time to the production process. The dry lubricant also made final polishing of the part more difficult, and could cause small defects in the metal. Mills came up with an alternative process using a putty lubricant that required no drying time, and that also eliminated problems with defects and polishing.

Once things were in full swing, Mills continued to make improvements to its fabrication process. One significant innovation was the elimination of the zinc fasteners. While the early units that Mills produced relied on a two-part fastening system to match the legacy cast-metal handles, Mills soon devised a design solution that eliminated all extra parts and saved the appliance manufacturer more money in the bargain by reducing both material costs and labor time.

*In 2007, the optimized Mills Products hydroforming assembly line produced roughly a million stainless steel handles a year for its client.*

## A GOOD, LONG RUN

During the first year of production, 2003, Mills ran 4,000 range handles per week.

Once all the fastening considerations had been solved to the client's complete satisfaction, Mills was able to drive waste percentages down to a manageable 3 percent for the entire production flow, including cutting, welding, and polishing. Ultimately, Mills was able to reduce the overall cost to the client by 40 percent when compared to the original cast-metal version.

Soon, the client contracted Mills to create handles for the entire suite of stainless steel appliances, including the range, refrigerator and dishwasher. By 2007, Mills was producing a million parts per year. As of the end of 2012, it had produced 5.3 million handles for the suite.