Increasing the productivity of a glass plant involves more than technology and innovation. Although both are critical success factors, neither technology nor innovation is enough. The key to profitability is a combination of technology and innovation applied in proven, systematic methods, as in Pack+, a new Advanced Services product from Emhart Glass.

The Pack+ service involves the use of Six Sigma methodologies, together with the application of Emhart Glass-developed advanced technology, and its experienced staff of production and product specialists. By approaching production improvements in this systematic way, Emhart Glass works closely with the customer to find the root cause of problems and wastes less time chasing non-critical factors.

Because glass container forming involves many interrelated variables, there is seldom one factor that – if resolved or improved – will result in full optimization of the production process. A strict fact-based methodology is required to ensure that the root causes of problems are found and rectified, rather than trying to patch or quick-fix the process, which may result in wasted effort or only temporary, non-sustainable improvements.

Pack+ follows a six-step, Six Sigma-based methodology designed to make changes based on fact, not assumption:
1. set the scope and mission of the project;
2. conduct an audit to get facts and measure current performance;
3. review the findings and determine next steps;
4. confirm the hypothesis;
5. implement the improvements and verify success; and
6. sustain the improvements.

With this process, as well as new, proprietary advanced tech-
nologies, Emhart Glass has used the Pack+ service to improve the productivity of lines at a number of glass plants worldwide.

Emhart Glass' advanced technologies, such as Virtual Modeling and Cycle Optimization, provide more precise solutions, while the company’s experienced staff of service engineers, bottle makers, tradesmen and outside contractors, provide the means for implementation. By means of Pack+, Emhart Glass now is able to offer an expanded array of Advanced Services to the glass container industry.

**FOREHEARTH MODELLING**

The Forehearth Modelling service can improve efficiency in the working end and forehearth by computationally testing the system to optimize firing and control strategies to increase performance. Emhart Glass engineers generate a three-dimensional computational fluid dynamic model that can simulate the glass conditioning process in the systems used to manufacture containers. The model is then used to optimize operation by anticipating temperature distribution, pressure losses, and velocity profiles, while simulating the effects of internal and external radiant effects, steady state, and transient vortex rolls, as well as the heat losses through the refractory and insulation surrounding the channels.

**MOULD DESIGN VALIDATION**

The Mould Design Validation service helps reduce the time needed for proofing the parison shape on the IS new generation machine. Computer modelling techniques allow bottle makers to predict the performance of new mould designs. Ideas for improvement of the parison shape or mould cooling methodology are computationally tested before final test and application on the machine. This program allows the optimization of the mould cooling system and blank mould design, resulting in a container that is capable of meeting strength requirements while utilizing the least amount of glass.

**CONTAINER STRESS ANALYSIS**

The Container Stress Analysis service uses computational techniques to evaluate the response of a container design to thermal shock, impact loads, internal pressure, and vertical loads. Design attributes of a container, such as wall thickness distribution, height, push-up height, and inside knuckle dimensions, all affect the inherent strength of a container. By coupling forming simulations with strength analysis models, it is possible to develop solution strategies to identify problem areas and regions of potential container failure. This enables the bottle maker to optimize the blank and blow mould designs based on the final container strength requirements. In addition to identifying problems with a current container design, final product strength analysis can identify regions where a container has been over designed. This can lead to significant savings of energy and raw materials through light weighting. Combined with Emhart Glass forming modelling, strength analysis provides a powerful tool that can be used to design a container to meet all strength specifications with the minimum amount of glass.

**BLANK MOULD COOLING**

Computer based forming modelling programs. In this example, numerical modelling programs were used to optimize blank mould cooling by changing the focus from cooling the mould to focusing on cooling the glass.

---

**ALAN FENTON “EXAMINING” A BOTTLE**

Project Engineer, special projects, “examines” a bottle from a production line during a Pack+ line audit.
MOULD COOLING
The Mould Cooling service recommends the optimal mould-cooling configuration, based on the container being made, by changing the mould-cooling paradigm from a focus on cooling the mould to a focus on cooling the glass. Depending on the size of the container and the forming process, Emhart Glass can recommend and supply a cooling system that will take advantage of the thermal times inherent in the forming process, and produce a parison temperature distribution that gives the strongest container for a given weight. Combined with the Emhart Glass forming modelling capabilities, specifying the correct mould cooling strategy for containers can lead to significant container weight reduction without the loss of container strength.

FEEDER MODELLING
The Feeder Modelling service can show variations in gob properties and computationally determine the link between the forehearth exit plane and the gob. Control algorithms are then developed to compensate for these variations. Once a link has been developed for a particular feeder/forehearth configuration, forehearth control algorithms can be developed to push the forehearth exit plane temperature toward a distribution that minimizes thermal, viscosity, and gob weight variations.

MOULD COOLING
The Mould Cooling service recommends the optimal mould-cooling configuration, based on the container being made, by changing the mould-cooling paradigm from a focus on cooling the mould to a focus on cooling the glass. Depending on the size of the container and the forming process, Emhart Glass can recommend and supply a cooling system that will take advantage of the thermal times inherent in the forming process, and produce a parison temperature distribution that gives the strongest container for a given weight. Combined with the Emhart Glass forming modelling capabilities, specifying the correct mould cooling strategy for containers can lead to significant container weight reduction without the loss of container strength.

CYCLE OPTIMIZATION
The Cycle Optimization service helps solve the bottle maker’s ultimate problem: the balancing act of compromises made indirectly by adjusting individual event angles to manage blank contact, mould contact, and all other thermal forming steps to achieve the desired results. Trained bottle makers, with the use of the new Emhart Glass Cycle Optimizer software program, can directly manipulate key thermal forming durations to find the best possible, correctly sequenced, and collision-free job timing. The results are forming processes that are optimally tuned, machine cycles that are minimized, and speeds of non-critical servomechanism motions that are reduced. Typically, the effects of the optimized job are better ware quality, increased per cent pack, improved production rate, all of which are accomplished while preventing mechanism collisions, reducing downtime, and cutting maintenance costs. The Cycle Optimizer, a key tool that can be used as part of Pack+, can help increase bottle makers’ productivity and allow them to focus on solving higher-level production problems.

GOB FORMATION
The Gob Formation service uses existing computational methods to investigate how various feeder design and operating parameters affect gob shape and weight. The numerical simulations show the formation of the gob at the feeder and the transfer of the gob to the blank mould. A key area of interest in these studies is the effect of the feeder plunger motion and
a high level of defects associated with “stuck glass.” By using the new fact-based problem-solving approach of Pack+, the team was able to precisely determine the root cause to batch composition and resolve the issue. If the team had taken a more traditional approach, focusing on trying to adjust the machinery and forming process, they would have wasted days and not definitively solved the problem.

At a second site, the goal was to increase pack rates above 92 per cent and decrease downtime to less than 1.5 per cent. This plant had been experiencing pack rates of 88 per cent and downtime of almost three per cent. After the Pack+ team investigated the line, they found a number of critical machine and process issues that could then be systematically resolved. Pack+ rate and downtime statistics dramatically improved, surpassing the initial goals, outperforming the performance of sister lines making same or similar containers.

At another site, the joint customer/Emhart Glass Pack+ team determined that there were no machine or equipment-related issues, but rather a combination of mould design and set-up issues. With assistance from an Emhart Glass bottle maker and validation of mould design via computer-based modelling, pack rates were significantly improved beyond target levels.

Pack+ is more than a product or a service. It is both. Unlike a single product or a particular service, Pack+ is a custom-designed package of products, technology, advanced services, and systematic methods, configured to resolve specific problems, optimize the container forming process, and increase profitability. Pack+ is another way Emhart Glass is applying a customer first, quality first focus to the products and services it supplies to the glass container industry.

**PROVEN RESULTS**

The new Pack+ service is a package of all or some of the above programs, each employed as determined by the systematic investigation that is integral to this new service. To date, combinations of these services have been used at various customer sites resulting in significant gains in productivity.

At one site, Emhart Glass production specialists were able to resolve a chronic defect problem. The customer was experiencing gob transfer equipment on gob shape. By evaluating the extent and manner to which feeder and transfer equipment design affect gob shape and weight, a systematic methodology to control these parameters is developed. Insights gained from the models are used to develop new gob forming and transfer equipment that allow greater gob shape and weight control. This system helps eliminate container weight and thickness variations, and reduces the number and severity of defects created during the container forming process.

**CYCLE OPTIMIZATION SOFTWARE, ONE OF THE TOOLS AVAILABLE IN THE PACK+ SERVICE**

**VIRTUAL FORMING**

The Virtual Forming service uses proprietary numerical models to analyze blow & blow and press & blow processes to determine the sensitivity of the final container-to-process parameters, thus improving the container design at reduced cost and time. All stages of the process are modelled, and the result of each unit is transferred and used as an input for the next unit to predict the final bottle thickness distribution. In addition to specific thermo-mechanical coupling capabilities, “mesh-to-mesh” interpolation and remeshing techniques are available to allow a continuation of the calculations in spite of very severe mesh deformations. These powerful modelling capabilities successfully address all critical stages of the glass forming process.

**EMHART GLASS SA**

Hinterbergstrasse 22
CH-6330 Cham
Switzerland
Tel: +41 - 41 - 7494200
Fax: +41 - 41 - 7494271
E-mail: info@emhartglass.com
www.emhartglass.com
www.glassonline.com/emhart