Meeting sustainability requirements

BFS-produced vials and bottles eliminate the need for secondary packaging print

Sustainability is increasingly important and, considering the pharmaceutical industry's use of solvents, water and environmentally taxing reagents, producers need to seek out more sustainable processes such as blow-fill-seal, argues **Chuck Reed** of Weiler Engineering

Along with sterility assurance, process validation and regulatory compliance, sustainability is becoming a more high-profile component in pharmaceutical processing, and is considered a critical factor in the design of healthcare equipment, products and packaging. The concept of sustainability has been a topic of interest for many years, and has been more formally discussed and considered since the late 1980s. Current international focus has led to the development of regulatory guidance in many of the world's markets.

The US Environmental Protection Agency (EPA) has posted the following definition of sustainability on its website[1]: 'Sustainability is based on a simple principle: everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.'

The major emphasis with sustainable procedures in pharmaceutical manufacturing is directed to the reduction of environmental impact by decreasing consumption of raw materials and energy in manufacturing and packaging processes, and by increasing the use of recyclable materials.

There are many processes in pharmaceutical manufacturing that can be addressed with a view to improving sustainability, while at the same time reducing operating costs. One of the most critically important objectives in achieving sustainability is reducing process energy consumption. Implementing energy-efficient practices and technologies should be a priority at the component, process and system levels.

Energy monitoring systems and process control systems are key tools in energy management. Such systems, including metering, monitoring and system controls such as integrated programmable logic controllers (PLCs), minimise the time required to perform complex tasks and increase efficiency in process operations. Automated process technologies that reduce energy consumption can also improve product quality and consistency and increase production throughput.

The ASEP-TECHR BFS system

Embracing process sustainability and energy efficiency in the pharmaceutical industry is the aseptic blow-fill-seal (BFS) system for packaging pharmaceutical liquids, which has made significant strides in achieving sustainability objectives.

Aseptic BFS technology integrates the three processes of blow moulding, sterile filling and hermetic sealing into one continuous, highly automated operation. Where aseptic BFS systems differ from traditional aseptic processing is in their capability for rapid container closure and minimised aseptic interventions. BFS is a self-contained process, where the raw materials are virtually completely recyclable. The consolidation of process steps through the use of BFS results in a significant reduction in the carbon footprint for the entire liquid filling and packaging production process.

The products manufactured by aseptic BFS present a strong platform for sustainability from a variety of perspectives.

Pharmaceutical manufacturers possess a wide degree of latitude in selecting and implementing systems for achieving environmental sustainability and energy efficiency. But foremost is the necessity to have a structured methodology that clearly delineates overall sustainability initiatives and process improvements.

Two basic types of structured programmes are available to companies that manufacture pharmaceutical products: a) programmes that address multiple aspects of sustainability, such as Leadership in Energy and Environmental Design (LEED), which provides a step-by-step process to achieve certification and recognition of having reached specific levels of compliance; and b) programmes that provide assessment and planning tools for reducing energy consumption and plant process costs.

Both types of programmes use a set of guidelines for evaluating the environmental impact involved in manufacturing, packaging and distributing a product.

LEED is a certification programme developed by the US Green Building Council (USGBC) ▶

that can be applied to any building type and any building life cycle phase. It provides a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.

LEED promotes a whole-building approach to sustainability by recognising performance in key areas, such as sustainable sites, water efficiency, energy, materials, indoor environmental quality, location and building design. The programme's internationally recognised green building certification system provides third-party verification that a building was designed and built using strategies aimed at improving performance across these metrics.

Although LEED certification covers the actual physical facility and its habitable spaces, it does not provide benchmarks for manufacturing and packaging processes within the plant. For pharmaceutical manufacturers, whose plant operations represent an energy draw that significantly affects their sustainability, a more process-oriented sustainability programme would be needed to assess environmental impact accurately.

Similar to LEED is Green Globes, operated by the Green Building Initiative in the US. Green Globes is a building environmental design and management tool used throughout the US and Canada. It encompasses both sustainability and energy management criteria, such as integration of energy efficient systems, renewable energy, cogeneration and on-site wastewater treatment systems, in addition to sustainable environmental practices such as sustainable site development and indoor air quality.

Green Globes delivers an online assessment protocol, rating system and guidance for green building design, operation and management for light industrial applications such as pharma manufacturing. But the programme does not govern industrial processes – omitting the significant energy savings that can be achieved when taking these processes into account.

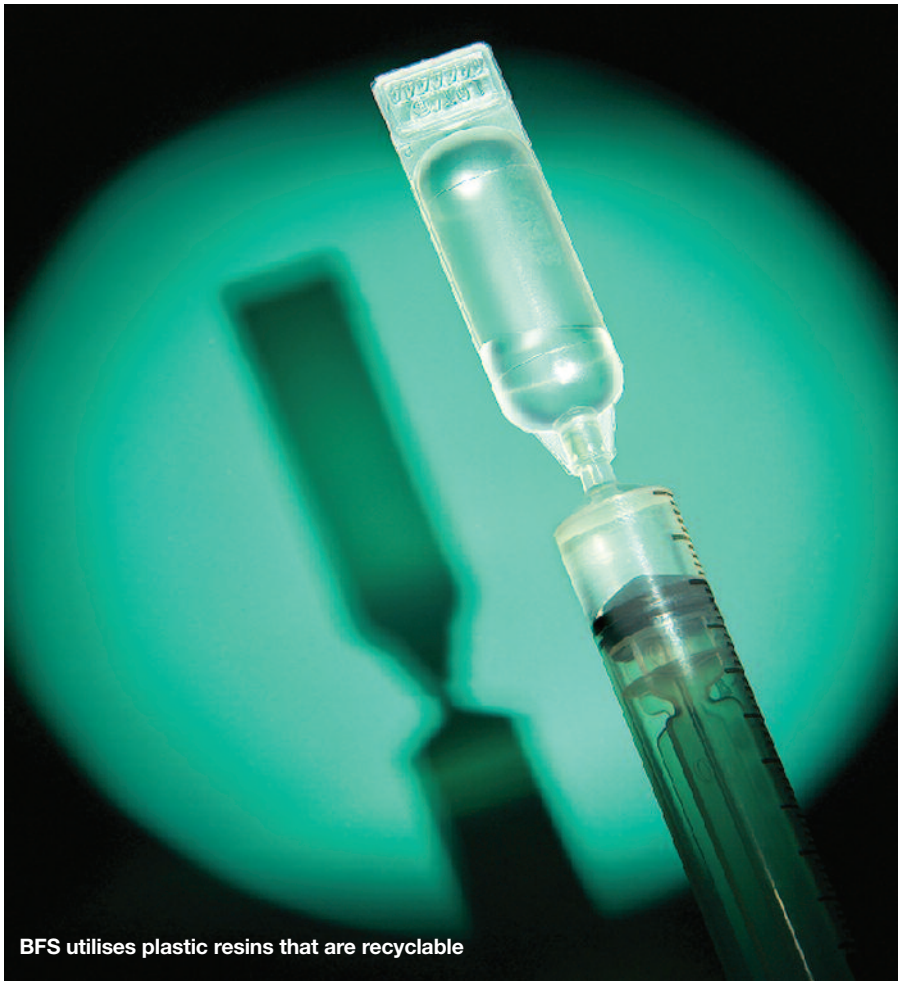
The Building Research Establishment's Environmental Assessment Method (BREEAM) is a leading European environmental programme for building practices in sustainable design. The programme can assess light industrial operations such as pharmaceutical plants, both at the design stage and after construction.

Factors considered are energy management, wastewater, land use, pollution, building materials, and other sustainability factors. Credits are awarded in each of these areas according to performance. A set of environmental weightings then enables the credits to be combined into an overall score.

But like LEED and Green Globes, process assessment is not covered in this programme, which means it is an incomplete system for the sustainability requirements of pharmaceutical manufacturers.

A programme that does address processes in pharmaceutical plants is Energy Star, sponsored by the US Department of Energy (DOE), and administered through the EPA. Its programme provides tools and resources to help improve the energy efficiency of manufacturing and industrial facilities, including plant manufacturing and packaging processes.

Energy Star supplies an energy guide specifically for the pharmaceutical industry, which helps manufacturers evaluate potential energy improvement options, and develop action plans and checklists for the energy programme. A major benefit is that it allows industrial companies to measure the energy use of their facility, and to benchmark it against other similar facilities. Companies input key plant operating data into an energy performance indicator to receive an efficiency score. It is a critical management tool for evaluating how efficiently a plant is using energy compared with other companies in their industry.



BFS utilises plastic resins that are recyclable

Also supporting energy efficiency in pharmaceutical processes is the DOE's Industrial Technologies Program (ITP), run by the Office of Energy Efficiency and Renewable Energy. This programme addresses process functions in manufacturing plants that use steam, compressed air, process heat, electricity and other systems that could potentially be a source of wasted energy. It focuses on the reduction of energy usage by integrating new technologies in industrial controls, automation and robotics, and provides concrete guidelines to achieve energy sustainability.

The ITP regularly conducts and makes available analytic studies to identify energy reduction opportunities within industrial processes, making these results available to participant manufacturers. Application of the ITP programme has resulted in significant energy savings, waste reduction, increased productivity, lowered emissions and improved product quality for US industrial manufacturers.

Choosing the right programme is critical to how quickly a pharmaceutical manufacturer's energy efficiency and sustainability goals can be achieved. A company's best strategy may be to use more than one of these programmes. A plant may decide to run with Energy Star or ITP for its process energy improvements, while simultaneously going with LEED or Green Globes for its other sustainability initiatives. Or a manufacturer may choose to integrate state energy efficiency programmes with LEED, Green Globes or ITP to capitalise on state energy credits or low interest loans and grants that the states may offer for energy-efficient solutions or equipment.

life cycle analysis

Life cycle analysis (LCA) has emerged as a recognised instrument to assess the ecological burdens and impacts connected with them. It assesses environmental impacts associated with all stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. LCA can be used to find the most ecological way to improve product manufacturing, and can be a useful decision-making tool for new products and process development. It can also be used as a guide for the optimisation of energy and raw material consumption.

Cradle-to-grave life cycle analysis, through mathematical modelling, makes it possible to determine and manipulate key metrics to provide a weighted average on total sustainability. Values

for energy and resource consumption, the extraction and processing of the raw materials, the pollution produced, recyclability and the effects of associated transportation on the environment are applied in a numerical equation. The weighted average then gives a clear evaluation of a sustainable solution for the product and manufacturing/packaging process being examined.

The LCA process is a systematic, phased approach and consists of four components:

1. Establishing the context and parameters of the analysis;

2. An inventory, consisting of an identification and quantification of energy, water and materials usage and environmental releases;

3. An impact assessment of these inventory factors, and the potential human and ecological effects;

4. The different environmental impacts are weighted relative to each other, then summed to get a single number representing the total environmental impact.

LCA allows a decisionmaker to study an entire product system and its processes, thereby avoiding the sub-optimisation that could result were a single process the only focus of the study.

In a comparison of different liquid pharmaceutical containers, for example, to determine which had the lowest releases to the environment and least affected the supply of natural resources, an LCA would quantify the raw materials used and the environmental loadings (including energy consumption) from the manufacturing and packaging processes used to produce each container. Also viewed would be comparative ecological impacts from distribution, consumption and disposal or reuse of each container.

When selecting between two packaging processes, for example, it may appear that one is better for the environment because it generates lower chemical emissions at the point of packaging. However, after performing an LCA, it could be determined that the preferred process actually creates larger cradle-to-grave environmental impacts when measured across its influence on air, water and land. The packaging process may use a film that is difficult or impossible to recycle. Therefore, the unselected process may now be viewed as producing less cradle-to-grave environmental harm or impact than the initial preferred technology.

From a life cycle analysis perspective, aseptic BFS machines that provide packaging of pharmaceutical liquids present much more streamlined and sustainable systems for production of sterile products compared with traditional aseptic processing in a number of critical aspects:

- **Energy management** – The most advanced aseptic BFS systems are quite automated compared with traditional aseptic processing. These BFS machines are designed to require minimum human access while operating in Class 100 environments. Various in-process control parameters using the latest generation of fully system-integrated PLCs control and monitor container weight, fill weight, wall thickness, isolation of visual defects and other factors, facilitating optimised system function.

These BFS machines allow very efficient processing speed and short machine cycle times. Aside from the obvious improvement in throughput volume, they provide more efficient energy usage.

According to the DOE's Energy Star programme, implementation of monitoring and control systems, such as PLCs and servo-drives, present well-documented opportunities for energy savings.

- **Recyclable plastic containers** – Aseptic BFS systems incorporate the use of recyclable plastic resins, as differentiated from glass containers used in traditional aseptic processing. Low density polyethylene (PE), high density PE and polypropylene, used to produce aseptic containers for injectables, ophthalmics, biologicals and vaccines, are generally considered inert by the FDA. These inert materials do not contain additives, have low water vapour permeability, and are easy and safe to handle in critical care environments such as hospitals.

These resins used in BFS processes are recyclable. Regulatory requirements permit reuse of the resin up to three times before it must be discarded. As much as 50% of the resin used in the BFS process can be reground and directly used again within the process when mixed with virgin material. The remainder of the waste can be captured and used for other applications. The entire production and recycle processes can be maintained on-site with minimal need for off-site disposal of waste material.

- **Reduced manual interventions** – Waste reduction should be viewed as an important objective in a sustainability programme. In aseptic packaging of pharmaceutical liquids, waste can manifest itself in compromised quality, labour-intensive processes and reduced efficiency.

Traditional aseptic procedures for packaging pharmaceutical liquids involves multiple steps in the handling and manipulation of the material, containers and sterilisation filling processes with human intervention and therefore have a higher potential for contamination during processing.

Additional processing steps for conventional aseptic processing include receiving, inspection and warehousing of incoming containers, washing and sterilising of containers, separate processing steps and equipment for filling and sealing, and end processing handling such as labelling.

The FDA's 2004 Guidance for Industry Sterile Drug Products Produced by Aseptic Processing states that the design of equipment used in aseptic processing should limit the number and complexity of aseptic interventions by personnel. Both personnel and material flow should be optimised to prevent unnecessary activities that could increase the potential for introducing contaminants to exposed product, container-closures or the surrounding environment.

The latest generation of BFS machines, as exemplified in the ASEP-TECHR BFS system from Weiler Engineering, are highly automated, thereby severely reducing manual interventions. The forming, filling and sealing steps are achieved in one unit operation – the cycle being completed within seconds. Such automation reduces the need for manpower and lowers and risk to product integrity.

- **Elimination of secondary packaging** – BFS-produced vials and bottles, by virtue of their opening features and simplified designs, such as twist-off tops, eliminate the need for secondary packaging. Labelling is not needed, since the moulds can be engraved with product information. This avoids an additional process step and eliminates material usage and the potential for additional waste generation.
- **Integrated packaging of inserts** – BFS allows pre-moulded, pre-sterilised components, called inserts, to be integrated into the basic container. These inserts, including items such as rubber and silicone stoppers and tip-and-cap dropper units for eye drop containers used to deliver a calibrated drop, are attached to the container after the blowing and filling process. These improvements streamline the packaging process.
- **Changeover flexibility** – When aseptic throughput is interrupted, or not running because of downtime, the entire process line is affected, which represents a significant production loss to the manufacturer. Many BFS machines are configured to produce more than one bottle shape or format. This makes it easy to change over from one container size to another. A blow-fill-seal machine might produce a family of 2, 3 and 5ml, then switch to a family of 5, 10 and 15ml, or to one of 10, 15 and 20ml, moving from one to the other with relative ease of machine set-up. BFS systems approach 99% uptime efficiency, significantly higher than traditional aseptic processing, which is subject to manual interventions and process interruptions.

The BFS system improves product integrity and better ensures patient safety over traditional aseptic processing procedures. As a result, the US FDA and the US Pharmacopoeia now characterise modern BFS technology as an 'advanced aseptic process', indicating its use as a preferred technology over other aseptic systems, and a better solution for the sterile, aseptic processing of pharmaceutical liquids.

Waste reduction, resource and energy management, improved process controls and throughput efficiency are key factors that have influenced the acceptance of aseptic BFS. These are critical functions for achieving sustainable practices in the packaging of aseptic pharmaceutical liquids. They save energy, increase productivity, and reduce environmental impacts.

Advanced aseptic BFS technology has emerged as an innovation in green technology within the pharmaceutical packaging sector. As government agencies and pharmaceutical manufacturers steadily, but surely, embrace the sustainability initiative, aseptic BFS technology will continue to occupy a prominent position in the evolution of 'Green Processing'. **mc**

Reference

1. www.epa.gov/sustainability/basicinfo.htm:

contact

Chuck Reed, Director, Sales & Marketing, Weiler Engineering, Inc
1395 Gateway Drive, Elgin
Illinois 60124, USA
- **T +1 847 697 4900**
- **solutions@weilerengineering.com**
- **www.weilerengineering.com**