Automatic loading & unloading systems for freeze-drying processes

By Xavier Gómez
Lyophilization Portfolio Manager at Telstar

This article has been published in Industrial Pharmacy magazine (May/June 2020). Ed EUROMED Communications
ABSTRACT

In the freeze-drying market, especially in the pharmaceutical sector, there is an increasing requirement for automatic loading and unloading systems. The production of highly toxic and sensitive products is demanding better operating solutions. Productivity, flexibility, product care and operator safety are the key elements when considering a solution.

An automatic loading and unloading system, using a magnetic driven slider, can allow greater levels of technical precision and robustness, and also actively contribute to maintaining the integrity of the freeze-drying process under full aseptic conditions, assuring a more reliable GMP production.

Introduction

Current loading and unloading systems in freeze-drying can be divided into two groups: Push-push and Push-pull.

1. Push-push: This option is composed of a loading and an unloading “pusher” at the front and rear sides of the machine respectively. The pusher technology can be diverse amongst business manufacturers, but all require significant space layout. Different market solutions vary in technology showing clear differences in terms of GMP design, robustness and compactness. Several drawbacks include the presence of bellows or telescopic mechanisms and the need for large space, a big issue when the system is installed in isolators or Restricted Access Barrier Systems (RABS). Bellows are spring type components made of plastic or stainless steel that compress and extend during normal operation and are required to fully cover linear movement which can potentially generate particles and require periodic maintenance.

2. Push-pull: In the Push-pull configuration, there is still a front pusher, but instead of a rear pusher, there is a belt or chain mechanism in charge of the unload operation. This system is more compact than the rear pusher, but in terms of cleanliness, it has some drawbacks. Other market slider type push-pull systems are battery operated and cannot be cleaned and sterilized inside the chamber.

Cold shelf loading

New parenteral drug developments require loading of products into the freeze dryer where shelves are much colder, sometime at temperatures as low as minus 20°C and even minus 40°C. These cold loading temperatures can cause issues such as condensation and even frost on the shelves, creating an insulation layer between the product container and the shelf. This means there is no direct contact with the shelves, generating longer loading times and possible fallen vials due to the ice formation and longer freeze-drying cycles, as the extra trapped water has to go through the freeze-drying process.

It is well known that the most efficient way to load vials onto precooled shelves is to place the filled vials at the loading position and transport them to the final shelf position as quickly as possible. This solution will save time because while some rows are being transported into the freeze dryer, other rows are being prepared to be loaded.

Figure 1a and 1b – Slider type system
Integration with barrier systems

A slider type solution can load and unload vials with a much more compact layout avoiding the need of bellows or chain/belt mechanisms (see Figure 1). Current developments allow automatic steam sterilization and Clean In Place (CIP) inside the chamber. This solution does not require any battery or wiring such as a power or signal cable and it can stay within the chamber when the door is closed. It is composed of material such as stainless steel and FDA approved plastic parts that have good temperature and corrosion resistance characteristics.

Magnetic lead screws

Lead Screw transmission is widely used for automatic transport systems in order to position an object linearly with high accuracy.

However, in the case of a system which requires high cleanliness during operation, such as pharmaceutical manufacturing processes there is a GMP restriction on using this technology as it generates particles through the contact between screw and nut, and with the use of grease there is a high risk of contamination. With Magnetic Lead Screw transmission there is no direct contact and thus no particle generation. There is also less rigidity than with the mechanical Lead Screw, and thus it can cope with misalignments and still be capable of finishing the loading or unloading procedure.

Figures 2a and 2b show the structure and movement of the Magnetic Lead Screw. It is composed of a Screw shaft and a Nut. The Screw shaft is made of ferromagnetic steel, covered by a stainless steel pipe, and has screw threads with a certain pitch and shape. The Nut is made of Nickel coated Neodymium magnet and is magnetized spirally with the same pitch as the screw threads. There is a yoke at the periphery of the Nut (magnets) in order to form a closed loop of magnetic circuit. The Screw shaft is supported by bearings at both ends to enable rotation. The Nut is supported by an extremely low friction guide mechanism so as not to rotate but to be movable in an axial direction. When the Screw shaft is rotated it generates a relative displacement between the magnetic poles and the screw threads. It then generates a restoring force enabling it to return to the stable position by magnetic coupling. The Nut moves linearly following the rotation of the Screw shaft. During operation there is a gap between the screw shaft and the magnetized Nut avoiding any friction and generation of waste particles.

According to the calculation there is a peak restoring force at a relative displacement of 45 degrees and a peak on the opposite direction at a relative displacement of 135 degrees. There is no restoring force at a relative displacement of 0, 90 or 180 degrees. A double threaded screw is used in the screw shaft, so if the relative displacement reaches 180 degrees a magnetic pole of the
Nut couples with the next thread of the Screw shaft. Therefore, it is assumed that this will repeat within a cycle of 180 degrees. When using this mechanism for a transporting system it is important to note that the peak has enough thrust force for the transportation and for securing rigidity and positioning accuracy.

**Conclusion**

The contactless magnetic driven slider can solve some of the issues which operators encounter on a day to day basis. It allows efficient loading under cold shelf loading conditions and it can handle many vial types with minimum format change. In addition, it can recover from a system failure, even when using manual mode through glove ports, and thus avoiding the loss of the production batch. Finally, it can be automatically cleaned and steam-sterilized within the chamber and thus ensuring aseptic conditions are maintained.

**References**

- Lyogistics Zero brand

**About the Author**

Xavier Gómez is a Lyophilization Portfolio Manager at Telstar. He holds a bachelor’s degree in Industrial Engineering from “UPC Terrassa” Spain and a master’s degree in Mechatronics from “UPC Barcelona” Spain. Xavi started his career at CTM, a technological center located in Manresa. Since 2015, firstly as a freeze-drying Mechanical Engineer and then in the R&D department, he has been involved in the development of different projects related to the Life Science industry. Xavi has participated in key roles in the development of many breakthrough projects, including the Lyogistics Zero.
About Telstar

Telstar, part of the azbil Group, is a company specialized in the development of engineering & construction projects, integrated process equipment and GMP consultancy solutions, including turnkey projects and critical installations, for companies associated with Life & Health Sciences (pharmaceutical & biotechnology, healthcare, cosmetic, veterinary and food & beverage industries, hospitals, laboratories & research centers). Acknowledged as one of the 10 major suppliers for the pharmaceutical industry, Telstar is one of the few international manufacturers able to offer integrated process solutions for the biopharmaceutical industry with in-house sterilization, freeze drying, containment, process water & waste treatment, clean air and cold storage technologies.

www.telstar.com