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Centrifuge Rotor Selection and Maintenance

by Tammy Goodman

Laboratory centrifuges are common, everyday instruments. Yet selecting the proper centrifuge and rotor system for a specific application can sometimes be a challenge. Understanding the various types of rotors available and the applications they are best suited for requires a solid understanding of centrifugation requirements. Furthermore, since rotors are a significant investment for the laboratory, it is also essential to provide the proper level of rotor care and maintenance.

This article examines the different types of centrifuge rotors available and the applications they are designed to support. Proper rotor maintenance procedures are outlined to ensure not only the maximum performance and longevity of the rotors, but also the safety of the laboratory personnel handling these systems.

Three types of centrifuge rotor

Centrifuge rotors fall into three categories: swinging-bucket rotors, fixed-angle rotors, and vertical rotors. Each category is designed to address three key factors: 1) type of centrifugation (differential, rate-zonal, or isopycnic), 2) speed, and 3) volume range.

Of these categories, fixed-angle and swinging-bucket rotors are the most common styles for benchtop, low-speed, and high-speed floor-model centrifuge applications. Vertical rotors are used primarily in ultracentrifugation.

Rotors can be fabricated from a range of materials including carbon fiber, aluminum, and titanium. Each material has different characteristics that lend themselves to particular applications. Selecting and caring for the different types of rotor materials are addressed later in this article.

Swinging-bucket rotors

Swinging-bucket rotors are ideal for separating large-volume samples (up to 12 L) at low speeds. A swinging-bucket rotor system consists of three parts: 1) the rotor body attaches to the centrifuge drive and has four or six arms to support the buckets, 2) the buckets are placed onto the arms of the rotor body, and 3) trunnion pins are used to hold the buckets in place.

The above components form the basic swinging-bucket rotor framework; additional accessories can be added as needed to tailor the rotor for a specific application or sample format. For example, large-volume rotors frequently offer a wide variety of adapters (plastic inserts) that can be placed into the buckets to hold the desired tube size (see *Figure 1*). Certain buckets offer sealing lids, which provide biocontainment for potentially hazardous samples.

Figure 1 Sorvall® STEPSAVER™ rotor system (**Thermo Fisher Scientific**, Asheville, NC).

Swinging-bucket rotor applications

The most common benchtop and superspeed centrifuge applications requiring a swinging-bucket rotor include: 1) high-throughput protocols such as batch harvesting of whole cells from growth media, 2) high-capacity processing of blood collection tubes, and 3) large-volume tissue culture processing. For these applications, the user can start with volumes as large as 1000 mL and scale down to smaller volumes of 1.5-mL conical tubes.

For ultracentrifuge applications, a swinging-bucket rotor typically supports sample volumes ranging from 36 mL to 2.2 mL (adapters are not normally used). An ultracentrifuge equipped with a swinging-bucket rotor can support two types of separations: rate-zonal (i.e., based on mass or size) or isopycnic (i.e., based on density). For rate-zonal separations, a swinging-bucket rotor is advantageous because the pathlength of the gradient (i.e., distance from Rmin [inside top of meniscus] to Rmax [outside bottom of tube]) is long enough for separation to occur. Also, since the buckets are positioned at 90° during the run and returned to a vertical position at the end of the run, the sample retains its orientation, which minimizes any pellet or band disturbance.

Fixed-angle rotors

Fixed-angle rotors are the most ubiquitous rotors used in centrifugation. The majority are used for basic pelleting applications (differential separations), either to pellet particles from a suspension and discard the excess debris, or to collect the pellet. The cavities in these rotors range in volume from 0.2 mL to 1 L, with speeds ranging from single digits to 1,000,000 × g (relative centrifugal force, RCF).

Two factors determine the type of fixed-angle rotor required: desired *g*-force (RCF) and desired volume. Generally speaking, the size of the rotor is inversely proportional to its maximum speed capability (i.e., the larger the rotor, the lower the maximum speed). An important specification when selecting a fixed-angle rotor is the K factor, which indicates the pelleting efficiency of the rotor at top speed, taking into account the maximum and minimum radius (pathlength) of the rotor cavity. A low K factor indicates a higher pelleting efficiency; therefore, the K factor can be a useful metric for comparing the speed at which particles will pellet across a range of rotors.

Vertical rotors

Vertical rotors are fairly specialized—their most common use is during ultracentrifugation for isopycnic separations, specifically for the banding of DNA in cesium chloride. In this type of separation, the density range of the solution contains the same density as the particle of interest; thus the particles will orient within this portion of the gradient. Isopycnic separations are not dependent on the pathlength of the gradient but rather on run time, which must be sufficient for the particles to orient at the proper position within the gradient. Vertical rotors have very low K factors (typically in the range of 5–25), indicating that the particle must only travel a short distance to pellet (or in this case form a band); therefore run time is minimized. Once it is determined that a vertical rotor is appropriate for the end-user application, volume and speed become the deciding factors for which rotor to use.

Rotor care

Proper rotor care is essential for ensuring safety and longevity. In addition to reducing the risk of accidents, regular rotor maintenance can save time and money and greatly extend rotor life span. A simple and effective set of rotor maintenance steps is outlined below.

Rinse

Whether using a carbon fiber, aluminum, or titanium rotor, rinsing with water after each use to remove any residual sample or dirt, followed by a thorough drying, yields dramatic results in rotor longevity. If debris is firmly lodged to the rotor, a mild detergent and soft cloth or brush can be used to remove it. Metal tools should never be used to remove lodged debris. It is important that rotors are completely dried following any rinse or wash.

Disinfect

When working with potentially infectious agents, a disinfection step is recommended after each use. There are many disinfection products available through major laboratory suppliers. Because different rotor materials require different disinfection products, it is important to select the appropriate cleaning agent for the rotor material. For example, bleach can be used on carbon fiber rotors but not on aluminum. All rotor manufacturers provide guidelines regarding the acceptable active ingredients in a disinfecting agent; therefore it is valuable to review the literature provided.

Sterilize

In some cases, rotors must be sterilized using autoclaving or UV exposure to kill highly infectious agents. All rotors, whether made from aluminum, titanium, or carbon fiber, are autoclavable, making this the most common and easiest method of sterilization. In cases in which autoclaving is not an option, users should consult the manufacturer's guidelines to identify the active disinfecting ingredients that are safe to use on the rotor.

Additional maintenance—rotor parts

In addition to the body of the rotor, most rotors contain other parts that also require regular attention, including O-rings, lid threads, and locking mechanisms.

O-rings

O-rings provide the main source of protection against sample leakage, but they are often completely neglected. O-rings must be lubricated prior to installation on a new rotor. More importantly, since most detergents and many disinfecting agents remove the lubricant, the O-rings need to be dried and relubricated after washing or disinfecting. O-rings degrade after repeated cleaning and autoclaving; therefore it is important to replace them when they begin to show signs of cracking or stretching.

Lid threads

The threads on bucket or rotor lids must be cleaned regularly with a soft, lint-free cloth to remove built-up debris. Applying a light coat of manufacturer-approved grease on the rotor lid threads ensures easy opening and closing; it also helps to prevent inadvertent cross-threading and general corrosion.

Locking mechanisms

Locking mechanisms, which hold the lid to the rotor or bucket, wear with time and can also become damaged when attaching and removing the lids. If the locking mechanism is threaded, it should be checked regularly for damage to the threads (either nicks or wear on the edges of the threads). The locking mechanisms can usually be replaced by a field service technician. By regularly checking and cleaning the threads with a soft cloth to

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remove debris, the life of the mechanism can be extended substantially. Lubrication for these parts is not typically required.

Manufacturer support

Whenever a factory-certified technician is on site, it is worth asking for a quick inspection of all rotors. Most manufacturers will also conduct rotor-inspection clinics upon request. Over time, rotors will begin to lose their finish or show telltale signs of damage to the surface, such as small pits in the surface of the rotor, rust, or metal corrosion. These are all strong indicators that a rotor needs careful inspection. If left unchecked, microcracks can form at the bottom of the pits, and corrosion can spread until the rotor fails. Carbon fiber rotors do not corrode; however, the finish can wear off over time and after repeated exposure to chemicals. This type of rotor can be refinished by the manufacturer before the exterior surface becomes a handling hazard.

Low-speed and superspeed centrifuge rotors that have been in use for 10 years or longer should be closely inspected and considered for replacement, especially if they show any of the symptoms described above. Ultracentrifuge rotors all have recommended life spans based on the number of hours in use or cycles completed.

Summary

As in most endeavors, gathering the right information is key. When selecting a rotor, it is important to know the type of separation required—differential, isopycnic, or rate-zonal—as well as the volume and RCF requirements. This will help identify which of the three rotor types to choose.

Once the rotors are in the laboratory, it is important to establish a regular rotor maintenance program. This will increase laboratory safety, extend rotor life span, and reduce centrifugation and contamination problems. Users should follow the manufacturer's recommended schedule to have rotors inspected, and retire them when they show wear. Being preemptive will ensure that centrifuges and rotors perform the vital sample preparation function they are designed to provide.

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