Tips:

# Using a vacuum-deaeration feed system to minimize powder leakage during roll compaction

**Making your roll compaction process more efficient and economical for a powder with a 0.3-g/cm³ or lower bulk density can be a challenge. Typically, as bulk density reduces to this level, the powder leakage increases and throughput efficiency drops. Read this tip for information on using a vacuum-deaeration feed system to increase throughput and reduce leakage.**

In dry powder densification, chemical, pharmaceutical, agricultural, food product, or other granules are formed by compacting feed powders in a roll compactor (also called a *roll press* or *roller compactor*). The powder is typically fed by gravity or a force-feed screw from a conical hopper to the unit's counter-rotating rolls, as shown in Figure 1. The powder rubs against the roll surfaces and is drawn into the gripping zone. The powder moves into the nip angle region where it begins to predensify and precompact. The powder then travels into the roll gap, where the particles are rearranged and densified. The resulting compacts fall by gravity from the roll gap to a mill or screener for sizing.

### The powder leakage problem

In most roll compactor processes, as much as 20 to 30 percent of the feed powder can escape compaction because of uneven feeding and powder slippage between individual loose particles and the roll surfaces. These uncompacted particles leak from the compactor and are typically recycled back to the process, which requires additional equipment and processing time. Research has identified three conditions for optimizing roll compactor output and minimizing powder leakage:[1]

- An adequate feed supply must enter the gripping zone.
- All powder must flow into the roll gap's narrowest part.
- Compaction pressure must be uniformly distributed over the entire roll-gripped powder mass.

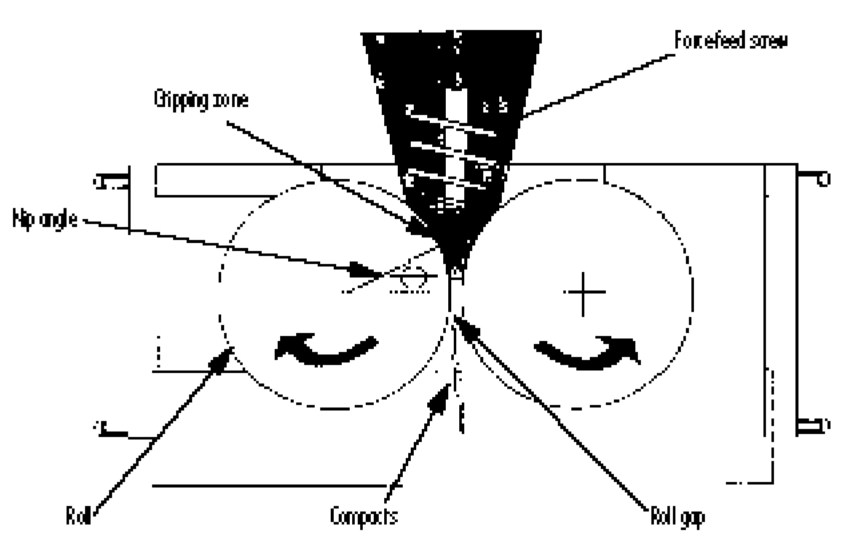
Several roll pair and feed system designs have been developed to satisfy these conditions. They include roll pairs with combination concave-convex (rather than flat) surfaces or different rim (raised roll edge) angles, various shapes of feed screws, combination horizontal-vertical screw feed systems, and variable-speed feed controllers. But such designs generally don't prevent leakage of powders with a 0.3-g/cm³ or lower bulk density, such as many pharmaceutical, toner, polyvinyl alcohol, and polymer powders.

### Minimizing leakage with a vacuum-deaeration feed system

One way to efficiently feed low-density powders is to apply a vacuum that deaerates the powder before roll compaction. Besides minimizing powder leakage, vacuum deaeration can:

**Figure 1**

**Typical roll compactor and feed system**



- Provide more uniform feed to the rolls.
- Produce a more uniform, better quality compact.
- Increase the compaction throughput rate and total yield.
- Reduce the amount of loose powder adhering to the compact prior to sizing.
- Minimize airborne particles.
- Maintain more consistent voltage and amperage on the roll pair.

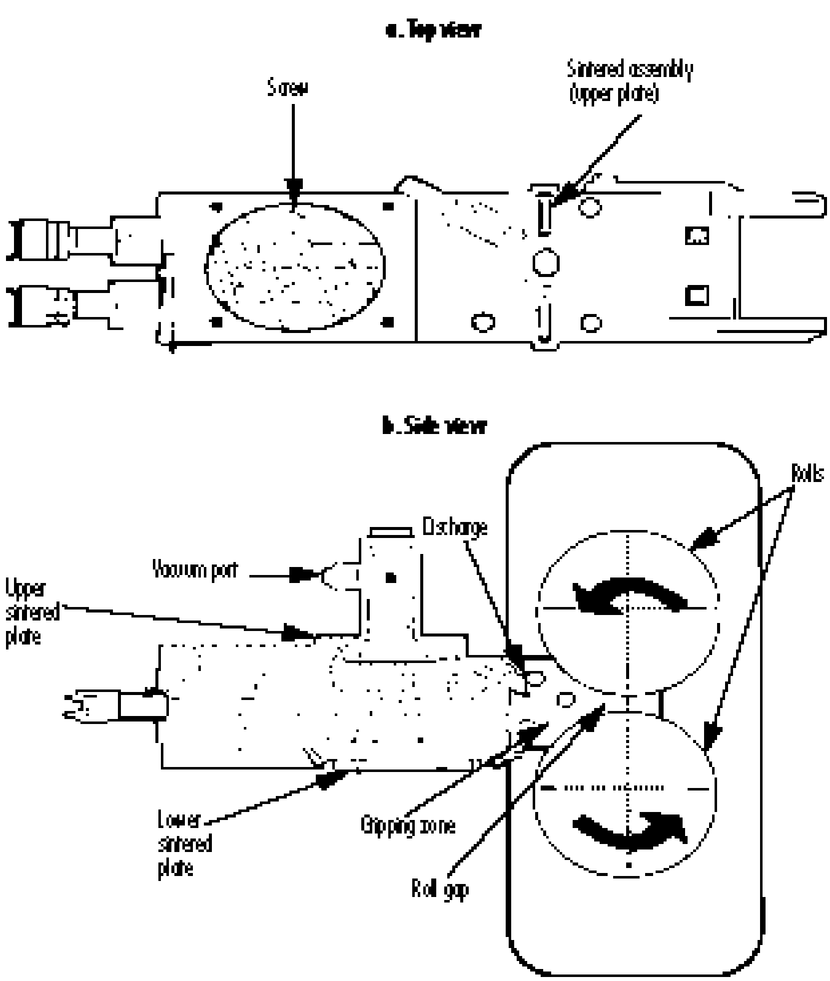
Various vacuum-deaeration feed system configurations are available. Most are integral to the roll compactor; some can be retrofitted to an existing compactor by the same manufacturer. Let's look at how one system works for low-density pharmaceutical feed powders. [***Editor's note:*** Operation and performance of other vacuum-deaeration feed systems vary; for more information on specific vacuum-deaeration feed systems and performance tests, contact the author.]

### Equipment close-up

The horizontal twin-screw vacuum-deaeration feed system, as shown in Figure 2, is integral to the roll compactor and includes a conical storage hopper containing a variable-speed agitator.[2] Below the hopper outlet are two horizontal variable-speed screws encased by upper and lower sintered stainless steel plates (Figure 2a). This sintered assembly permits the system to operate under partial vacuum, which can be adjusted from -0.1 to -0.8 bar. A small vacuum port, dry filter, and stainless steel line are located in front of the upper plate. The feed system's discharge is located near the roll compactor's gripping zone (Figure 2b). The rolls operate under variable hydraulic pressure to control the desired compact properties. The lower roll is fixed, while the upper roll is slightly movable in the vertical plane; the pair can operate at two speeds. Two sizing granulators — large and small — are located below the roll gap.

**Figure 2**

**Horizontal twin-screw vacuum-deaeration feed system**




In operation, a vacuum pump draws negative pressure through the vacuum port, dry filter, and stainless steel line into the sintered assembly. The twin screws counter-rotate, drawing feed powder from the hopper outlet into the screw flights and conveying the powder toward the discharge, where it enters the gripping zone. By deaerating the powder, the partial vacuum promotes consistent flow to this zone. The rolls' counter-rotation draws the powder into the roll gap, where the powder is compacted. The screw speed, roll speed, and roll hydraulic pressure all contribute to the compact quality. The compact falls by gravity from the roll gap into the sizing granulators. The large sizing granulator breaks the compact into coarse particles. These particles then flow into the small sizing granulator, which finely sizes the particles.

### Tests with low-density pharmaceutical powders

Two low-density active drug blends were used in roll compactor tests with the horizontal twin-screw vacuum-deaeration feed system.[3] For all tests, the weighed powder blends had bulk densities between 0.25 and 0.35 g/cm$^3$ and were fed at a 52-rpm screw feedrate, 8-rpm roll speed, and 60- to 65-bar roll pressure. One test condition was varied: engaging or disengaging the vacuum system. The compacted material wasn't sized but was collected on a 10-mesh screen to determine the compact and leakage quantities. The results, listed in Table I, show how much powder was compacted and how much leakage occurred in the tests.

***For the first drug blend:*** The powder was fed to the roll compactor with the vacuum system engaged. This produced a 100-kg/h throughput at a -0.78 to -0.80 bar vacuum. The leakage was about 2 kg/h — about 2 percent — as shown in the table. The minimal leakage required no recycling. In tests of the same drug blend with the vacuum system disengaged, the throughput typically dropped to 70 to 80 kg/h, and the leakage was 15 to 20 kg/h — about 20 to 30 percent. Powder flow to the rolls was uneven, and the compact exiting the rolls wasn't uniform. Processing this drug blend for a long period without vacuum deaeration would require recycling the uncompacted powder back to the rolls.

***For the second drug blend:*** The next test series used the same conditions and followed the same procedure but used a different drug blend with the same active drug substance and same active drug quantity per dose. When the vacuum system was engaged, the system produced a -0.78 to -0.80 bar vacuum and the roll compactor throughput was 150 kg/h. The powder leakage was 1.3 kg/h — just 0.9 percent. When the vacuum system was disengaged, the throughput was typically 100 to 110 kg/h with leakage of 20 to 30 kg/h — about 20 to 30 percent.

The results show that the second drug blend was compacted at a higher throughput rate, with or without the vacuum system engaged. But both test series show that deaerating a low-density feed powder increased the compact yield and reduced leakage.

## References


1. Ronald W. Miller, "Advances in pharmaceutical roller compactor feed system designs," *Pharmaceutical Technology,* March 1994, pages 154-162.

2. Vacuum deaeration system, Alexanderwerk, Horsham, Pa.

3. Tests conducted by Bristol-Myers Squibb Co., New Brunswick, N.J.



***—Adapted from a paper Ronald W. Miller presented at the 1995 Institute for Briquetting and Agglomeration conference. He is associate director of worldwide pharmaceutical technology, Bristol-Myers Squibb Co., New Brunswick, N.J.; 908/519-2510.***


**Table I**

**Vacuum-deaeration feed system tests**

| | Active drug blend 1 | | Active drug blend 2 | |
|---|---|---|---|---|
| **Conditions** | **Vacuum system engaged** | **Vacuum system disengaged** | **Vacuum system engaged** | **Vacuum system disengaged** |
| Feed powder density ($g/cm^3$) | 0.25 to 0.35 | 0.25 to 0.35 | 0.25 to 0.35 | 0.25 to 0.35 |
| Screw feed (rpm) | 52 | 52 | 52 | 52 |
| Roll speed (rpm) | 8 | 8 | 8 | 8 |
| Vacuum (bar) | −0.78 to −0.80 | 0 | −0.78 to −0.80 | 0 |
| Roll pressure (bar) | 60 to 65 | 60 to 65 | 60 to 65 | 60 to 65 |
| Throughput (kg/h) | 100 | 70 to 80 | 150 | 100 to 110 |
| Powder leakage (kg/h) | 2 | 15 to 20 | 1.3 | 20 to 30 |