ROSS INLINE SLIM THEORY AND OPERATING PRINCIPLES

Introduction:

The Ross Inline SLIM is an innovative powder induction and mixing device based on the Ross Inline Mixer Emulsifier.

The Inline SLIM consists of a rotor and stator mixing arrangement, specially designed to create negative pressure (vacuum) behind the rotor, which can be used as the motive force to suck powdered (or liquid) ingredients directly into the stream of the incoming liquid. The resultant powder/liquid mixture then is expelled centrifugally through the openings in the fixed stator before exiting the tangential discharge connection.

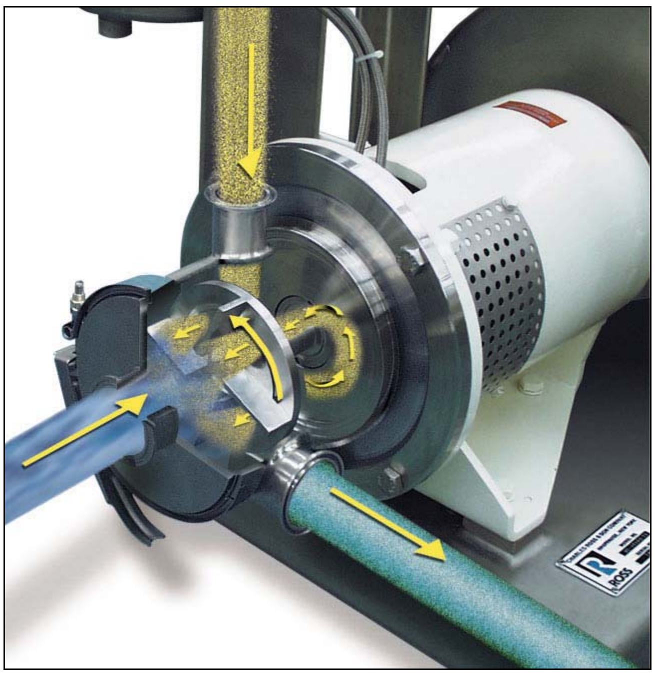


Fig. 1: The graphic above illustrates the general principle of combining liquid and powder streams with the Inline SLIM

Powdered ingredients may be introduced to the powder inlet via a hand-held wand arrangement, or a hopper arrangement. Each approach has its specific benefits that will be addressed below.

The Inline SLIM differs from other powder induction systems in that:

- It does not usually require the use of a centrifugal pump on the inlet or outlet side to create the suction for the induction of powders.

- It does not use an eductor to create the suction, thereby making the Inline SLIM more tolerant of flow and viscosity changes.

Operation and Performance Criteria:

Despite the many advantages of the Inline SLIM over other commercially available powder induction systems, there are nonetheless several important guidelines that must be considered to achieve its maximum performance. The criteria that affect the Inline SLIM's performance can be broken down into three (3) distinct categories:

- **Product specific variables**

- **Machine specific variables**

- **Interconnection specific variables**

Product specific variables include characteristics of the raw ingredient streams, as well as the final product obtained through the mixing of the liquid and powder.

These variables are considered independent of machine and interconnection variables and are described as follows:

- **Starting and final viscosity.**

  The Inline SLIM will perform to its maximum potential at low viscosities. As the viscosity of the recirculated liquid increases, the powder suction performance will decrease. To illustrate this point, see the data in the following table, which indicates the powder induction rates for successive 10 lb. bags of fumed silica inducted into a light mineral oil, using a Ross Model ME-405SB-25:

Total Amount of Fumed Silica Added	**Rate / 10 Lb. Bag**
10 lbs.	20 sec. / bag
20 lbs.	22 sec. / bag
30 lbs.	33 sec. / bag
40 lbs.	45 sec. / bag

- **Density of the product.**

The Inline SLIM was designed to handle liquids with a wide range of densities (specific gravity).

Liquid raw ingredients and the resulting end products having a specific gravity greater than 1.00 will increase the power demand of the motor driving the Inline SLIM System. These higher densities are not a major concern, as they will not adversely affect the powder induction performance, however, the increased powder demand needs to be considered by your Ross engineer.

Liquid raw ingredients and the resulting end products having a specific gravity significantly less than 1.00 will negatively affect the powder induction performance. Other than the physical properties of the raw ingredients, the most significant source of low densities is the aeration of the recirculated product. It is therefore important to minimize sources of air incorporation when using an Inline SLIM System.

The main sources of product aeration are through the powder inlet connection, and during the return flow of product into the recirculation vessel.

To minimize air entering the system from the powder inlet connection, it is advisable to utilize the hopper arrangement, instead of the wand arrangement (see section below entitled, "**Hose & Wand vs. Hopper**").

To minimize air entrainment from the return flow of product into the recirculation vessel, consider a sub-surface return connection and minimize the chance of vortex formation in the recirculation vessel (see section below entitled, "Return of discharged product to the recirculation vessel").

Machine specific variables include operating parameters of the Inline SLIM System.

These variables are considered independent of product and interconnection variables and are described as follows:

- **Rotor speed**

  Under most conditions, the Inline SLIM should be run at its maximum speed, even when it appears that the performance is adequate at lower speeds.

  Often, Inline SLIM systems are provided with AC variable frequency inverter drives. Speed control can be a useful parameter to vary in order to control the shear rate of the rotor/stator, **before or after** the powder induction phase. It is highly recommended that the speed not be reduced during the powder induction phase.

- **Stator configuration**

  The Inline SLIM is available with several stator configurations. The most common stators are the “Slotted” head and the “Large Square Hole Disintegrating” (LSHD) head.

  Due to its higher flow and lower restrictive characteristics, it is usually recommended to use the LSHD for most powder induction requirements.

  The Slotted head provides acceptable performance (but less than the LSHD), however, due to its higher shear characteristics, it may be preferred where a very high degree of dispersion is required.

Interconnection specific variables include all aspects of the Inline SLIM installation, exclusive of the product and machine variables.

Interconnection specific variables have the most significant effect on Inline SLIM performance and thus, require the most attention from the personnel responsible for installing and operating this equipment.

It is vitally important to understand that the full potential performance of the Inline SLIM System is highly dependent on the velocity of the fluid as it passes through the Inline SLIM. Any factor that adversely affects the inlet or outlet flow of liquid will have a negative effect on the Inline SLIM performance.

The interconnection specific variables are described below:

- **Inlet and outlet line diameter**

  When selecting the tubing or hose diameter, use the largest diameter tube or hose possible. If the inlet of the Inline SLIM is 2", than the diameter of the inlet-side tubing or hose should be 2" minimum. If possible, it would be even better to use 2-1/2" or 3" diameter tubing or hose up to the inlet, and then reduce the size to 2" right before the inlet.

  The same points above apply to the discharge tubing or hose.

- **Inlet and outlet restrictions to flow**

  Keep the restrictions and disturbances to flow to a minimum. Valves should be full- ported ball valves where possible (butterfly valves are more restrictive to flow). Minimize the amount of elbows and "Tee's" in the line.

  If hose is being used, make certain that there are no bends or kinks in the hose.

- **Distance from the source of the incoming liquid (vessel)**

  Locate the Inline SLIM as close as possible to the source of the incoming liquid. This usually means locating the Inline SLIM near the outlet of the feed vessel.

- **Distance to the point of ultimate discharge**

  Keep the length of the discharge tubing or hose to a minimum. Try to run this tubing or hose directly to the closest point of discharge into a return vessel. If the return hose is excessively long, obtain a hose that is the shortest appropriate length.

- **Return of discharged product to the recirculation vessel.**

The return of the discharged product to the recirculation vessel should not create any aeration of the bulk. Product that becomes aerated will result in a performance decrease in the Inline SLIM.

If possible, submerge the return flow under the surface of the liquid in the recirculation vessel to minimize aeration.

The return flow should not create a strong vortex in the recirculation vessel. A strong vortex will entrain air in the product, resulting in a performance decrease in the Inline SLIM.

For information on how to overcome the negative effects of long inlet/outlet piping, , restrictions to flow, and increasing viscosities, see the section below entitled, "Pumps and the Inline SLIM".

Hose & Wand vs. Hopper

The Inline SLIM will work with either a hose & wand arrangement, or with a fixed hopper mounted atop the powder induction connection of the mixing chamber. The decision whether to use the wand or the hopper depends on your process conditions, and your desired goals.

Fig. 2: Ross Model ME-405SB/25 with hopper arrangement

All factors being equal, the **hopper** is preferred as it:

- Minimizes operator dependent variables
- Ensures a more consistent feed of powder to the Inline SLIM system (minimizing aeration of the liquid)
- Minimizes static electricity discharge issues
- Eliminates issues of powder clogging the hose
- Eliminates issues of cleaning the hose and wand

The use of the **hose & wand** arrangement will require your operator to manipulate the wand in the box, bag, or container of powder, to help ensure a constant flow of powder to the SLIM system. This makes the hose & wand arrangement susceptible to operator influences, and to potential fatigue.

Fig. 3: Ross Model ME-405SB/15 with hose & wand arrangement

Consider using the wand only when:

- There are issues with transferring your powders to the hopper

- You are adding considerably more powder than the hopper will accommodate

- Your powder is extremely free-flowing

- Your powder is of a relatively low bulk density (<30 lbs./cu.ft.)

Pumps and the Inline SLIM:

Although the typical operation of the Inline SLIM does not require the use of pumps, the use of certain types of pumps can enhance its performance under certain conditions.

- **Centrifugal Pumps:**

  Centrifugal pumps can be used to feed the liquid inlet of the Inline SLIM and/or to aid in the return of the discharge flow to the recirculation vessel. The use of a centrifugal pump on the inlet or outlet (discharge) side can often overcome many of the performance deficiencies caused by the factors described in earlier sections (i.e. long inlet/outlet piping, restrictions to flow, increasing viscosities).

  When using a centrifugal pump on the inlet side, it is important to adhere to the following installation and operational guidelines:

1. Always install an adjustable valve between the outlet of the centrifugal pump and the inlet of the Inline SLIM (as close to the Inline SLIM liquid inlet connection as possible).

2. In order to optimize the SLIM performance, connect a vacuum gauge to the powder inlet connection.

3. Close the valve completely between the pump and the Inline SLIM

4. Start the Inline SLIM first and then the centrifugal pump.

5. With both the Inline SLIM and centrifugal pump running, open the valve slowly. Observe the vacuum gauge on the powder inlet. As soon as liquid begins to flow, you should start to see a vacuum reading on the gauge. Keep opening the valve as the vacuum level increases.

6. Continue to open the valve until the vacuum level peaks and begins to decrease. This should be considered the optimum setting for the valve. You should now shut down the system in the reverse order and remove the vacuum gauge.

7. Please note that, as conditions (such as viscosity) change, the valve setting may also need to be readjusted.

When using a centrifugal pump on the outlet (discharge) side, it is important to follow these suggestions:

1. Install a pressure gauge between the outlet of the Inline SLIM and the inlet of the centrifugal pump (as close to the Inline SLIM liquid outlet connection as possible).

2. Install an adjustable valve between the outlet of the centrifugal pump and your recirculation vessel.

3. In order to optimize the SLIM performance, connect a vacuum gauge to the powder inlet connection.

4. Open the valve completely between the pump and the Inline SLIM

5. Start the centrifugal pump first, then the Inline SLIM.

6. The purpose of the centrifugal pump is to reduce the discharge pressure of the Inline SLIM, as determined from the gauge on the outlet side. However, the centrifugal pump should not be starved of flow. If this occurs, close the valve on the discharge side of the centrifugal pump until the flow is constant.

7. Once a steady state is achieved you can observe the vacuum gauge on the powder inlet. Adjust the valve on the discharge side of the centrifugal pump to optimize the vacuum reading on the gauge.

8. Please note that, as conditions (such as viscosity) change, the valve setting may also need to be readjusted.

- **Positive Displacement Pumps:**

The Inline SLIM is a centrifugal device with a relatively high pumping rate. The use of positive displacement pumps to feed the Inline SLIM is usually **discouraged** for the following reasons:

- The high feed rates required by the Inline SLIM would necessitate the use of an unusually large positive displacement pump.

- Any blockage in the mixing chamber, or outlet piping, due to undispersed powders, could result in a dangerous pressure increase in the mixing chamber, or the discharge of liquid back through the powder inlet connection.

The only scenarios where positive displacement pumps should be considered are:

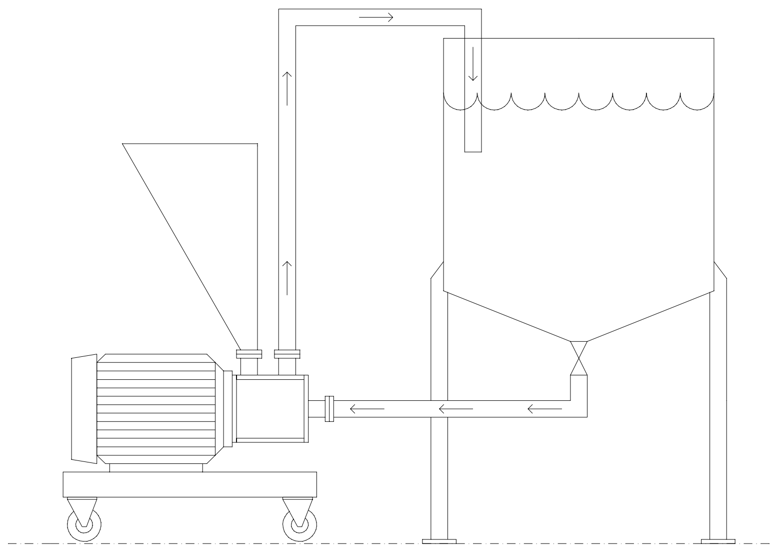
- The product is extremely viscous **and** it is possible to provide a positive displacement pump with the appropriate flow rate. In this case, the use of rupture discs or other pressure relief devices downstream of the pump is strongly recommended.

- A recirculation buffer vessel is used as described in Example #5 (below).

Installation Guidelines:

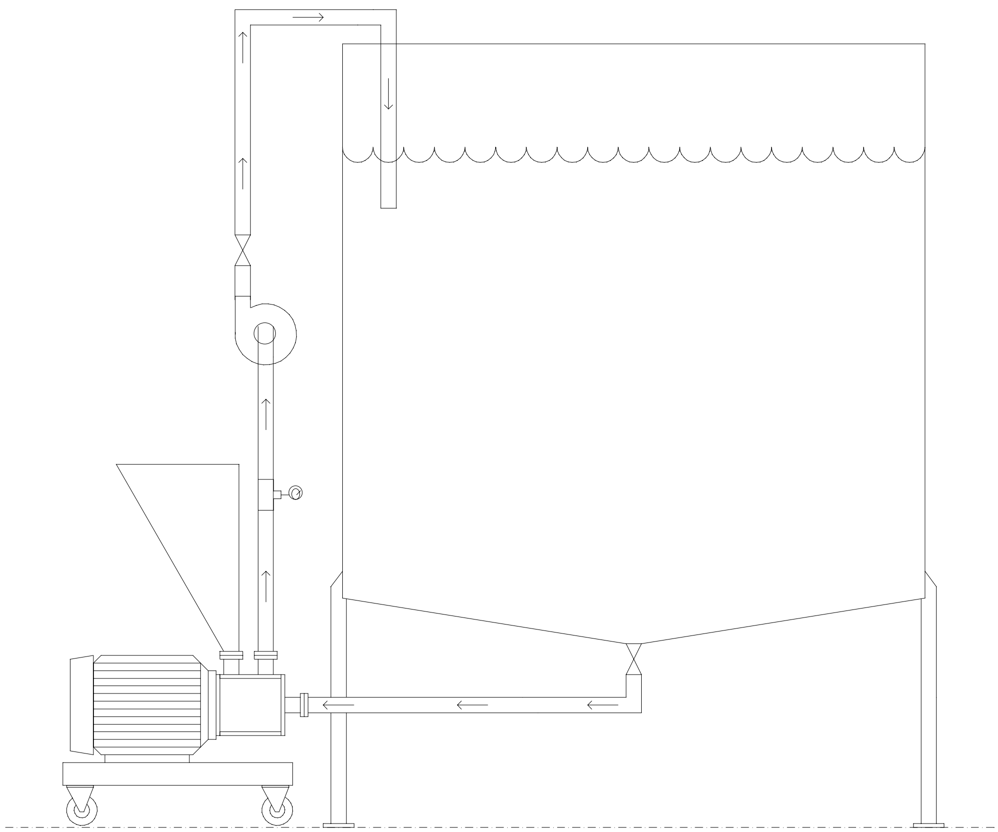
This section describes several installation scenarios and details the preferred installation techniques for each case.

Example #1:



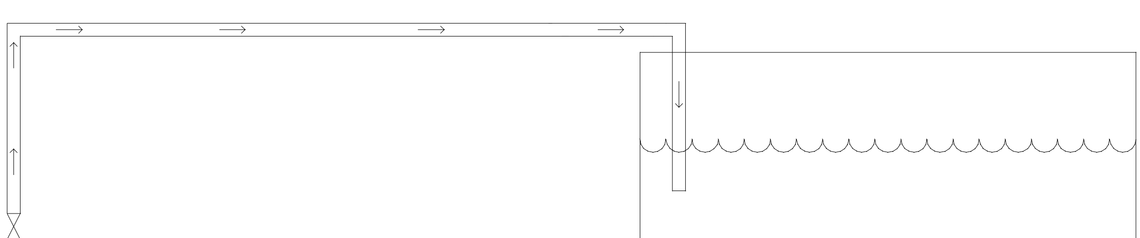
Example #1 describes the Inline SLIM System being used with a small (50 – 1000 gallon) recirculation vessel. The Inline SLIM unit is located on ground level and is as close to the outlet of the tank as possible. Discharge tubing length is kept to the minimum possible length.

Example #2:



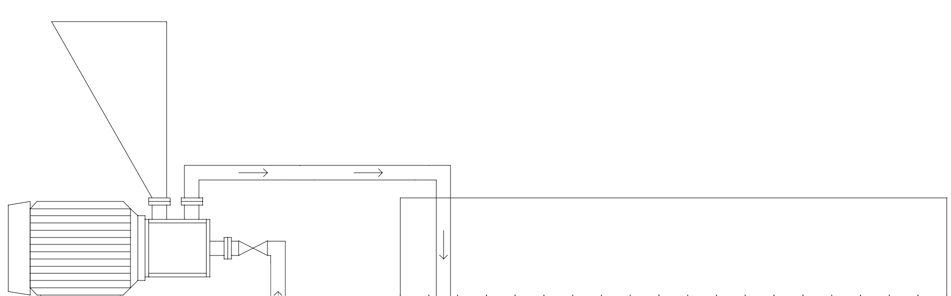
Example #2 describes the Inline SLIM System being used with a large (1000+ gallon) recirculation vessel. The Inline SLIM unit is located on ground level and is as close to the outlet of the tank as possible. Since the discharge tubing is long, a centrifugal pump is used to minimize the back pressure on the discharge side.

Example #3:



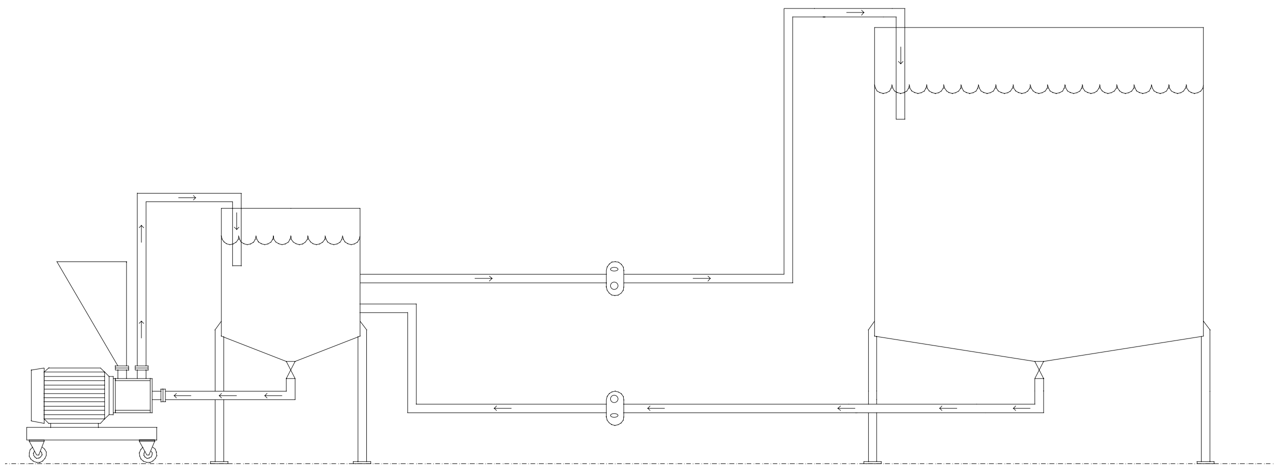
Example #3 describes the Inline SLIM System being used with a large (1000+ gallon) recirculation vessel. The Inline SLIM unit is located on ground level and is not close to the outlet of the tank, therefore, a centrifugal pump is used to feed the inlet side. Since the discharge tubing is long, a centrifugal pump is used to minimize the back pressure on the discharge side.

Example #4:



Example #4 describes the Inline SLIM System being used with a large (1000+ gallon) recirculation vessel. The Inline SLIM unit is located on an elevated mezzanine or upper level floor. The inlet of the Inline SLIM is not close to the outlet of the tank, therefore, a centrifugal pump is used to feed the inlet side. Since the discharge tubing is short, the discharge side does not require a pump.

Example #5:



Example #5 describes the Inline SLIM System being used with a large, remote storage tank. A small (50 – 500 gallon) recirculation buffer vessel is mounted near the Inline SLIM unit. The Inline SLIM unit is located on ground level and is as close to the outlet of the recirculation vessel tank as possible. Discharge tubing length is kept to the minimum possible length.

Liquid from the large storage tank is pumped to and from the small recirculation vessel at constant rates. It is possible to use either positive displacement or centrifugal pumps in this scenario, as the rate of transfer from the large storage tank to the small recirculation vessel is not critical. It is important to note that this scenario may require level control and an advanced control system.