Technical White Paper

Rotary Claw Technology in Soil Remediation

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1.0 Introduction: Rotary Claw vs. Liquid Ring

The rotary-claw pump/compressor, a well-established standard in many industries due to its inherent efficiency, has long been cost-prohibitive for soil remediation vacuum and pressure applications.

Now innovative new designs like the 'Mink' from Busch Vacuum Technics are bringing this technology into the mainstream and stealing the spotlight from that venerable old workhorse; the liquid-ring pump (LRP).

Figure A: An inside view of the rotary-claw pump chamber

1.1 What is a rotary claw blower?

Rotary-claw blowers are not new; they have been used in commercial applications in North America since the early 1990's, and since the mid-80's in Japan.

At first glance, the inner-workings of a claw pump appear quite similar to those of a rotary-lobe or Roots-type blower. Like the rotary-lobe, the claw is a 'dry' positive-displacement pump meaning that there is no lubricant or sealing fluid in the pumping chamber; only close mechanical tolerances between the chamber casing and the precision-machined rotors or 'claws' provide the seal required.

In contrast however, each of the two claw rotors has a unique profile so that as they counter-rotate separate expansion and compression chambers are created. Dry-operation and internal compression are the key ingredients of the highly efficient claw principle.

2.0 The Rotary Claw Operating Principle

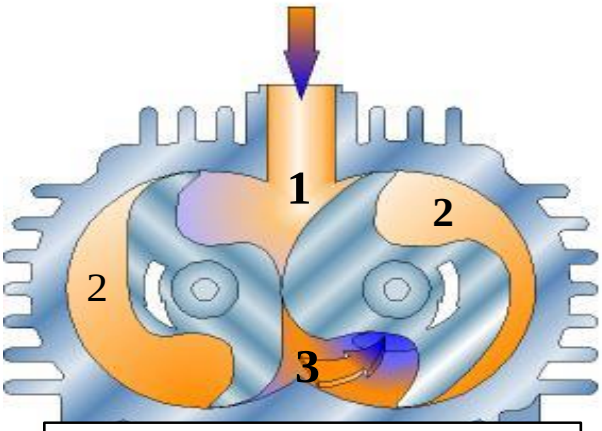
Driven through a set of exterior precision gears mounted on parallel shafts, two claw rotors rotate in opposite directions within the pumping chamber. There is no lubrication required in the chamber. The claws do not

touch each other, nor do they touch the chamber walls. Figure B captures the key steps of the process as described below:

Position 1: A volume of air is captured at the inlet by the expanding space created as the claws rotate.

Position 2: Each claw effectively traps a fixed volume of air for part of the rotation.

Position 3: The two volumes of air are recombined and compressed until the exhaust port is exposed. Tolerance is very tight at the 'would-be' contact point of the claws to prevent backflow from the pressure side to the vacuum side.



Double Click above for animation. (ESC to exit)

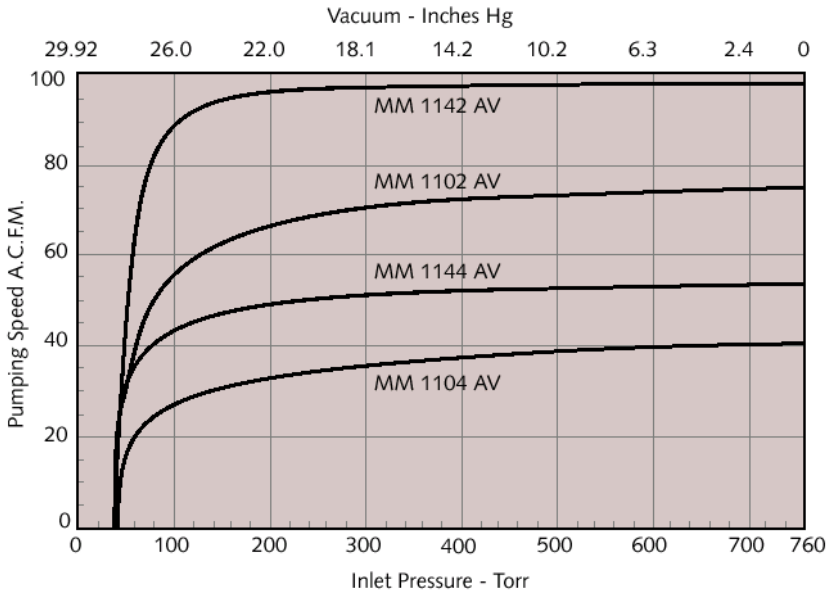
Figure B: Cut-away view of the claw process.

One full rotation of the claws is equivalent to two expansion/compression cycles.

While one charge is being compressed and expelled, a fresh charge is being simultaneously drawn in.

3.0 Range of application

Airflow and vacuum capacities vary according to manufacturer and model. The Busch Mink series single-stage pump is capable of continuous operation at 22 in. Hg vacuum (28.2 in. Hg max.) at flow rates, depending on the specific model, from 30 acfm to 300 acfm. Larger airflows can be attained by connecting two or more units in parallel. In soil remediation terms, this constitutes a range of operation formerly dominated by liquid-ring pumps.



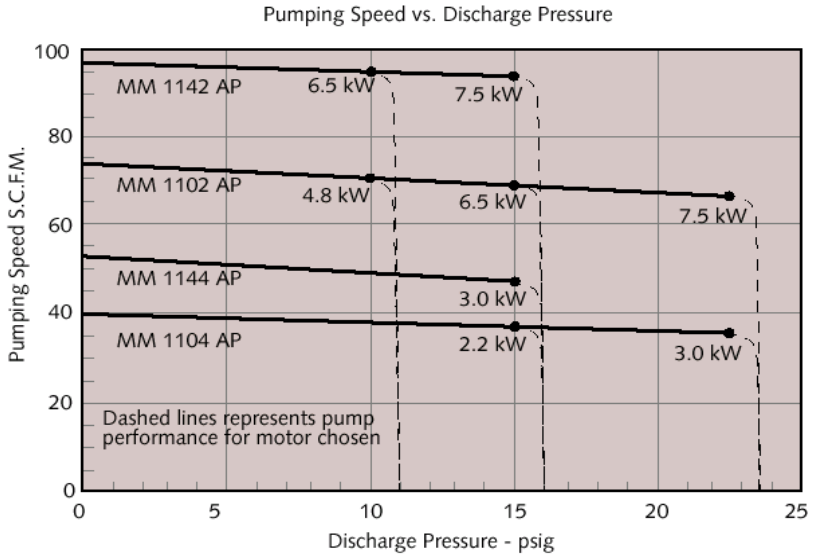
Technical Data Mink Model		MM 1104 AV	MM 1144 AV	MM 1102 AV	MM 1142 AV
Nominal pumping speed	ACFM	40	53	74	97
Free air displacement	CFM	43	58	86	116
Ultimate pressure	torr	37.5	37.5	37.5	37.5
Motor size	kW	1.5	2.2	3.0	4.0
Nominal motor speed	RPM	1800	1800	3600	3600
Sound level	dB(A)	78	79	84	85
Weight (approx.)	Lbs.	320	330	330	352

Figure C: Busch Mink 'MM' Vacuum and flow capacity
(Not all models shown)

3.1 Sparging capability

It is worthwhile noting that as compressors, the models shown below can produce flows of over 90scfm at 15psig, or 60scfm at pressures as high as 22psig. Some models can achieve pressures as high as 30psig.

This makes the rotary-claw a suitable alternative technology for many air-sparging applications.



Technical Data Mink Model	Nominal pumping speed SCFM	Free air displacement CFM	Motor size kw (HP)	Maximum pressure psig	Relief valve cracking pressure psig	Motor rotational speed RPM	Sound level db(A)	Weight approx. lbs.
MM1104 AP	40	43	2.2 (3.0) 3.0 (4.0)	16.0 23.5	15 22.5	1800	82	323 330
MM1144 AP	53	58	3.0 (4.0)	16.0	15	1800	83	337
MM1102 AP	74	86	4.8 (6.5) 6.5 (8.7) 7.5 (10)	11.0 16.0 23.5	10 15 22.5	3600	86	350 361 383
MM1142 AP	97	116	6.5 (8.7) 7.5 (10)	11.0 16.0	10 15	3600	87	367 389

Figure D: Busch Mink 'MM' Pressure and Flow capacity
(Not all models shown)

4.0 Advantages of Rotary Claw Pumps vs. Liquid Ring Pumps

4.1 Affordable

Rotary claw technology is now competitive with LRP systems on a capital-cost basis thanks to simplified and effective modern designs.

As an example, the Busch Mink model line has been redesigned to reduce the number of parts and to create a more modular unit. Additional benefits include increased efficiency, ease of maintenance, and quieter operation.

4.2 Clean

The rotary claw is a dry pump. There is nothing in the pumping chamber to contaminate the air stream. Unlike liquid ring pump systems, there is no fear of oil-carryover or leaks.

<u>Figure E</u>: Cut-away view of a liquid-ring pump. Air flow necessarily contacts the sealing ring (blue) causing cross-contamination.

Energy is wasted as the impeller acts upon the liquid to maintain a seal.

4.0

Advantages…(cont'd)

4.3 Efficient

In comparison to a liquid ring pump, the efficiency advantage of the rotary claw process is obvious. Liquid-ring pumps consume significant energies in maintaining the liquid ring or seal. One can imagine each vane of the impeller pushing a volume of liquid, be it oil or water, around the pump housing on each revolution. Also, there are losses associated with reclaiming, cooling, and returning liquid that is carried over from the exhaust flow into downstream piping.

Additionally, a heat exchanger must be installed in return line, consuming additional energy with no direct benefit to the actual pumping process.

The rotary-claw pump has no seal liquid to push around, and air-cooling is easily achieved with a small, integrated fan. As a result, a rotary-claw pump can produce a vacuum-flow at typically 25% less horsepower than an equivalent liquid-ring pump, which translates directly into significant operational-cost savings.

As an example:

Based on published pump flow and power data, a flow of 425acfm at 22”hg one could be achieved with a 40hp LRP, or with two 15hp claw pumps operating in parallel. This does not take into account additional horsepower required for cooling the sealing liquid in an LRP system.

4.4 VFD compatible

Many soil vapour extraction vacuum systems employ dilution lines on the influent side of the blower, providing a simple method of adjusting the extraction flow rate at the well. Unfortunately, it is a considerable waste of energy to have a blower working to pull (for example) 300cfm when only 150cfm is actually required. With a variable frequency drive (VFD), the blower motor speed can be adjusted to achieve the desired flow rate so that wasteful dilution can be reduced or eliminated. (Similarly, a VFD can be applied in sparging applications to eliminate bleed lines.)

Claw vacuum pumps are suitable for use with variable frequency drives. Vacuum-flow verses motor speed is almost linear so that capacity can be easily adjusted to suit the application.

Additionally, with a suitable VFD-capable motor some pumps can be operated at up to 3800 rpm to take advantage of reserve design capacity of the blower.

4.5 Low maintenance

Typical LRP system employ a myriad of connections and components, each of which represent a potential for future problems. Liquid levels must be regularly adjusted, monitored and maintained. Seal fluid must be changed as part of a regular maintenance routine. LRP systems may utilize a collection of level switches and solenoids as controls; each of which adds complexity and another opportunity for failure.

The claw compressor has two small gears in a closed oil bath; regular maintenance is as simple as periodically checking the oil. The pump rotors and chamber are non-contacting, and that means no wear. In a typical soil vapour extraction system, the knock-out water separator and inline filter upstream protect the blower from particles or liquid slugs that would otherwise damage the mechanism.

To prepare the claw compressor for extended shutdown periods, it only requires a cool-down run with clean dilution air for several minutes, or long enough to evaporate any moisture from the pumping chamber. A special water repellent coating is available as an option to further protect the pumping chamber and claws in high humidity applications.

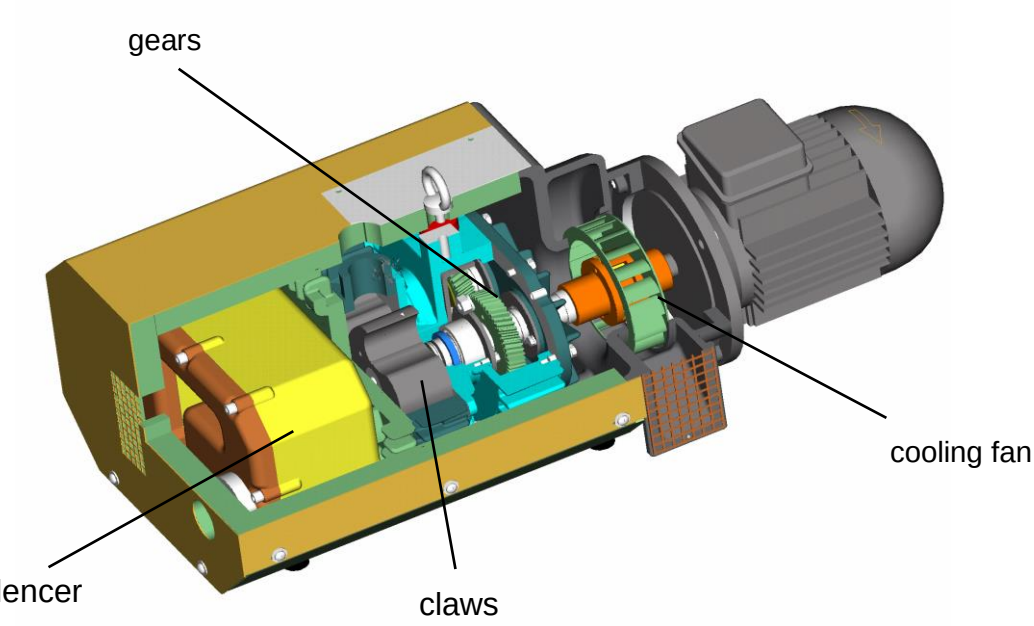


Figure F: Cut-away view of a Busch Mink MM series rotary claw

4.6 Compact

In comparison to the liquid-ring pump, the rotary claw is dramatically space efficient. Although a liquid-ring pump is compact in itself, there is the supporting system componentry to consider. A complete LRP system including pump, motor, seal-fluid tank, and heat exchanger can easily occupy four or more times the floor space of the pump and motor alone. There is also the vertical space and added weight to consider, both of which can be of significance when considering site layout or shipping costs.

A claw pump is self-contained, occupying a fraction of the space of an equivalent LRP system.

Figure G: For vacuum applications this is a representative size comparison of a liquid ring pump with supporting components (right), verses the equivalent self-contained rotary claw pump (below)

Note: When used for pressure or sparging applications, a heat exchanger may be required downstream of the claw compressor to lower the discharge temperature.

5.0 Setting a new standard for soil remediation

The modern rotary claw is the product of an established technology that has come of age.

Liquid-ring pumps may still have a place in soil remediation. However, for applications requiring flows up to 300 acfm and at continuous vacuum levels up to 22”Hg, the rotary-claw blower offers competitive cost and none of the problems commonly associated with the LRP process. Additionally, the rotary-claw compressor has noteworthy air sparging capability.

The rotary claw vacuum pump/compressor can be expected to quickly move to the forefront of popularity in the soil remediation industry.

6.0 About Newterra

Newterra designs, builds, commissions, and supports systems for soil remediation. The systems range from single well pumping systems to large combined soil vapor extraction/groundwater pump and treatment systems. Systems are highly customized, designed specifically to provide innovative solutions for our customer’s unique requirements. Newterra also distributes a range of environmental products that includes: pumps, sampling equipment, air strippers, and carbon filters. Key customers include leading environmental engineering consulting firms and large environmental contracting firms. Sales and support in Canada and the United States are provided through an established network of outstanding rep. firms. Newterra is known in the industry for its professional, long-term approach to the business, delivering quality solutions to support our customers’ success.

Figures are courtesy of **Busch Vacuum Technics Inc.**, Boisbriand Quebec. **Busch** is a world leader in industrial vacuum/pressure technology with manufacturing facilities Germany, Switzerland, Denmark, and USA. The Mink rotary-claw pump is part of the broad Busch product portfolio.