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The roll of vacuum in modern furniture manufacturing . . .



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AIR KNIFE DRYING BLOWERS CENTRAL AIR SYSTEMS VACUUM PUMPS



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Vacuum

How it works and why it's needed on CNC routers.

Canadian Furniture manufacturers have experienced unprecedented growth in both numbers and quality. From easy to assemble to ultra fine quality, our furniture manufacturers are world leaders. Helping to bring the elements of skill, design and craftsmanship to the era of high output, profitable production is the CNC router.

CNC router tables are not new to the industry. What is new is the use of vacuum to hold material in place, allowing the entire surface to be utilized, eliminating the costly waste associated with mechanical clamps.

The Becker Pump Corporation of Germany came to the Italian Woodworking machinery industry with a new idea, compact easy to maintain oil free vacuum pumps, 1 to 10 Hp for use on high speed CNC routers. As a result, Becker now dominates the industry with oil free technology. New to Becker is the variable speed drive 50 Hp oil free vacuum pump designed for large table routers or central systems.

Table Design

With many CNC manufacturers in the market, vacuum table design and operation varies greatly. The demands required to sizing a vacuum pump vary dramatically. Two similar size 5 x 7 tables may come originally equipped, one with a 2 Hp vacuum pump; the other with a 5 or 7.5 Hp. This is possibly due to the way the table is designed and how vacuum is introduced to hold the product.

Table designs follow two basic styles, modular moveable vacuum cells or an open grid. The modular vacuum cell design works on the basis that a given work area, i.e. a 4' x 8' space, will have as many as 20 individual vacuum cells or cups each attached to a common vacuum pump. Each cell can hold a specific product; example, cupboard door, or they can be grouped together to hold a spoil board or jig. The advantage of this design is that the vacuum energy can

be focused in regions as required, leaks from atmosphere through the wood can be minimized.

The open grid is one in which the table surface either wood, edpm or aluminum has a top surface of recessed grid lines or grooves.

The grid pattern centers around a recessed hole that connects to a common vacuum pump. The grid areas can be isolated with valves to a common distribution header or simply by inserting a plug or cap in the hole feeding a grid not being used. The advantage to this design is that it allows a flat machined surface to hold down a spoil board or backing board.

Both table designs have many variations. The high output design has two separate tables with one router to operate both. This facilitates unloading and loading one table while machining on the other. The requirement here is for two vacuum pumps of equal size.

Vacuum Pump Options

Four styles of vacuum pumps can be used in vacuum table hold down or vacuum chucking. Each has its merits. The type and size of vacuum pump should be decided on the following criteria;

1. Table size and design.
2. High speed production or custom design.
3. Material to be machined, eg. MDF, plywood, hardwoods, plastics or corian.
4. Router force or the energy the router will exert on the board in a linear direction while cutting.

Vacuum Terminology

Vacuum by definition is a void, an area in which air has been removed, resulting in a differential pressure between our atmosphere and the inlet to the pump. The change in the atmospheric pressure to the pressure at the pump inlet is the vacuum energy and is commonly measured in inches of mercury ("Hg). European

machines measure vacuum in negative bar or percentage vacuum. It is important to remember absolute vacuum is not possible at 30" Hg or negative 1 bar or 100% vacuum. For woodworking, we use coarse vacuum pumps which range in vacuum energy from 15 to 29" Hg.

Atmosphere

15"Hg	"0.5	500	50
18"Hg	"0.6	600	60
27"Hg	"0.9	900	90
30" Hg	-1 bar	-1000 mbar	100 % Vac

In order to create any vacuum, air must be removed. This is the job of the vacuum pump and the pump's ability to move air is commonly rated or measured in cubic feet of air per minute (CFM). European pumps are measured in cubic meters per hour (M³/H). In selecting a vacuum pump it is the volumetric efficiency in CFM at any given vacuum energy in "Hg that determines how well the pump will work. One important note regarding a pump's rating is the speed. In Europe, electrical energy is provided at 50 cycle or 50 Hz. This allows the typical woodworking vacuum pump to run at 1450 rpm. The pump name tag will say 100 M³/H (assuming it is running at 50 Hz or 1450 rpm). Deliver this same pump to North America where our electrical energy is provided at 60 cycle or 60 Hz, the same pump will run at 1750 rpm or approximately 20% faster, approximately 20% more volume.

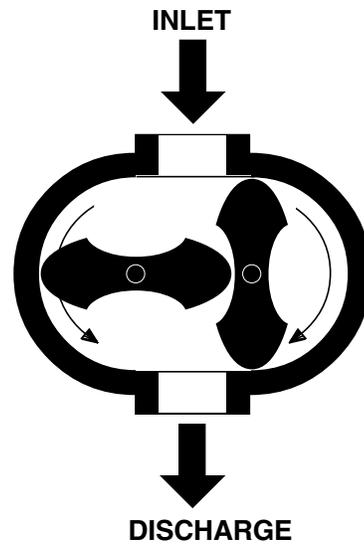
$$M^3/H \times 0.58861 = CFM$$

Use the following formula to convert to 60 cycle

$$M^3/H \times 1.2 \times 0.58861 = CFM$$

Rotary Lobe Vacuum Pump

This type of pump works on the oil-free principal and relies on two figure eight shaped rotors turning in opposite rotation to trap and move air from the inlet to the outlet of the pump. The need for large non-meshing clearances between the rotors limits this design to 15-20" Hg vacuum energy. This style can move large volumes of air and is relatively inexpensive on a first cost basis. The drawback to this style, as viewed from a woodworking application, is the limited vacuum energy, large physical size and extreme noise. The advantage is the large CFM per Hp ratio. On porous wood, this type of pump will move more air to compensate for leaks, however, it has limited holding power.



**ROOTS-TYPE PUMP
VACUUM BOOSTER**

Centrifugal or Regenerative Vacuum Pumps

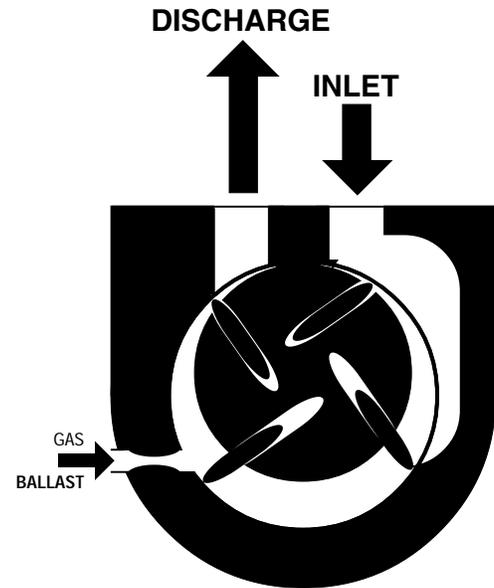
This type of pump works on the oil free principal and relies on turning at high speed an impeller or disk with many individual fins or pockets. Each pocket captures air and moves it from the inlet to the discharge of the pump. Internal tolerances required to allow the disk to work limit this design to high air volumes at limited vacuum energy of approximately 12" Hg. It is important to note that the volumetric inefficiency of this design limits the air flow considerably at vacuum levels from 6-12" Hg. This pump is best suited for use in applications where extreme board porosity will never allow for higher vacuum energy.

Rotary Vane Vacuum Pumps

This is the most common type of vacuum pump. They work on the oil free or oil lubricated principal and relies on the centrifugal force created by a turning rotor to cause the vanes held within slots in the rotor to move out forming a pocket which moves air from the inlet to the discharge of the pump. The oil lubricated version can produce a vacuum energy level of 29.9" Hg against a sealed inlet. The oil is used to lubricate but also to provide a seal between the sliding phenolic resin vane and the cylinder housing. This allows for optimum volumetric efficiency. The oil free version can produce a vacuum energy level of 25-27" Hg against a sealed inlet.

The vanes are a self lubricating carbon compound that uses the normal heat caused by friction to release the lubricant.

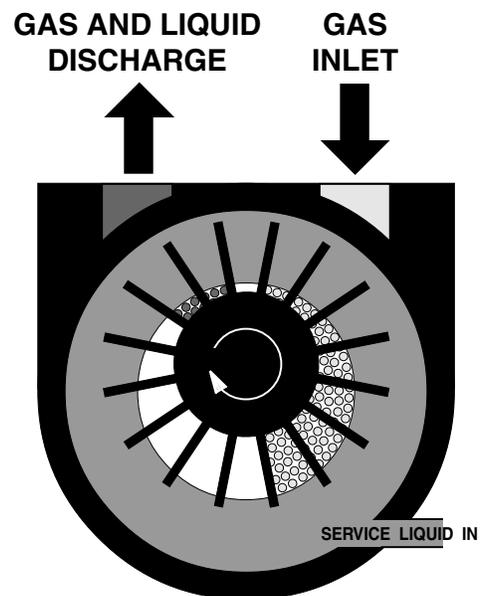
It is important to note, Becker Pumps have been selected by most CNC Router original equipment manufacturers because of the unique patented vane composition. The carbon is not hydroscopic and will not retain moisture caused by internal condensation. This ensures long vane life (2 years in a properly maintained pump). The advantage to rotary vane vacuum pumps is the relative ability to create a strong vacuum energy at a consistent volume. It is quiet and compact with sizes from 1 to 25 Hp, matching the requirements of most CNC tables. The oil free version requires very little maintenance, compared with the oil lubricated design and is more adaptable for use in a fine dust environment.



ROTARY VANE PUMP

Liquid Ring Vacuum Pump

This type of pump works on a water ring principal relying on a turning impeller to spin a volume of water from the center to the outer circumference. Air moves into the pockets created by the space made by the moving water. This design is available based on a very durable once through water principal. The large volume of water required passes from the inlet to the discharge only once before entering a municipal drain. This works very well at handling dust and debris as it is simply washed through the pump. However, the extreme cost of municipal water and sewage make its use prohibitive. The recirculating water design relies on more efficient injection of water, but requires cooling and filtering of the liquid which can be water, glycol, or oil. The advantage of this design is a low first cost and a low noise level. The complex recirculating design does not work well with mdf dust and debris. Frequent water ring maintenance is required.



LIQUID RING PUMP

All of the above mentioned vacuum pump designs will work. However, today's competitive environment has all but eliminated maintenance personnel in the average woodworking shop.

For this reason, OEM and end users consistently choose Becker Oil Free Rotary Vane Vacuum Pumps because of their rugged dependability and ease of infrequent maintenance.

Filtration

Filtering the wood dust from the inlet air before it enters the vacuum pump plays a vital roll in both production speed and pump life. The volume of air moved through a pump determines its ability to hold material in place, overcome any leaks in the wood itself or spoil board or from cutting into the vacuum cell as part of a necessary design. Filters must be clean to allow this to happen. The traditional inline cannister type vacuum filter has a 10 micron efficiency rating meaning the filter media whether paper, polyester or metal mesh will catch 99.9% of dust particles 10 micron in size or larger. MDF dust resulting from routers is commonly 5 micron in size.



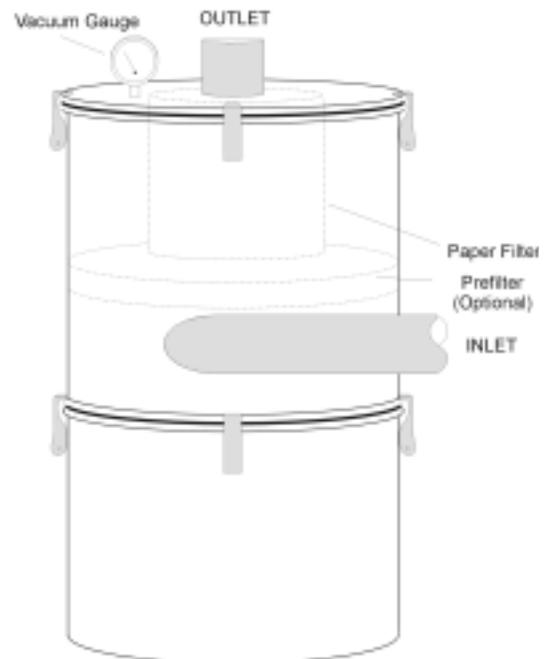
Metal filters with Snap-on Covers

The common filter only begins to filter the majority of the dust after it builds a layer of dust around the polyester pleats. The pumps ability to move air is drastically reduced by a clogged filter and the life of the pump is reduced by ingesting the dust that passes through. On an oil lubricated or liquid ring style pump the 5 micron dust clogs internal oil passages, oil filters and exhaust oil separators causing excessive heat and premature failure. The oil free carbon vane design can easily pass the fine dust. However, it is captured in the exhaust carbon filter causing the same reduced flow and high temperature. It is important to note that the exhaust filter on a Becker Oil-Free Vacuum pump is not required in a CNC Router Environment and can be eliminated thus increasing the pump's life. Another important note regarding filter cleaning is this; the fibers on a paper or polyester filter are woven to create the micron efficiency; if the filter is washed as a cleaning method its efficiency to capture dust is reduced by 40 per cent each washing. Sourcing a low cost supplier of original quality filters and disposing of them each time makes good maintenance practice when you factor in the labour cost to clean and the increasing pump damage due to dirt.

A cyclonic drum type separating filter extends the time between filter cleaning. This design spins the air cyclonically around the outer wall of the filter as the air stream slows the dust falls to the bottom. The clean air is then sucked up the center into a large pleated filter cartridge and on to the pump.

IN-LINE CYCLONIC DRUM FILTER

Model REM 20L-3-S



The advantage of this type of filter is that it will extend the interval between filter cleaning from once every three hours to once each week.

Filter cleaning, however frequent, ensures increased router productivity with fewer rejects by optimizing the volume of air moving through the system.

Production Techniques

There are many ways in which vacuum can be better used on a typical CNC Router Table. Now that we know that volume and vacuum energy are directly related to one another, we need to look for ways to focus all of the volume to the vacuum cell holding the parts, eliminating leaks.

Reducing Leaks on Production Runs

When faced with a common part multi-unit production run the most effective way to maximize the hold down force (vacuum energy) is to create a jig. On an open grid table O-ring gasketing can be placed in the grooves to create sealed cells under each part. The spoil board can be laid out in such a way that the parts position in the same orientation. The surface of the spoil board (jig) not in contact with the part can now be sealed to prevent air being leaked in from any surface except that under the part. The jig can be sealed with paint on the edge and top surface. It is important to note that gasket material is not consistent in its compressibility (wall thickness is inconsistent). In critical cuts, such as v-grooves, surgical tubing can be used as a grid seal as it has a consistent wall thickness to ensure the material is drawn down flat.

Reducing Leaks on Custom Parts

A jig cannot be economically made unless repeat production of the part is planned. Other sealing techniques can be used to reduce leaks. The edge of each spoil board should be sealed with paint. The top surface not in contact with the part can be sealed with random cut sheets of plastic, tinfoil, wax paper or tape.

The trade off, in terms of producing a reusable jig, is the set up time versus production time. If a jig is made, the production speed can be increased with fewer rejects. In production environments consider a designed jig.

A commonly asked question of a vacuum pump supplier is, "Can I get a bigger pump, I need more and I heard that 40 Hp works best". It's true that the larger the pump, with its greater displaced volume, improves the ability of the pump to overcome leaks. There is a high cost in "bigger". A 10 Hp vacuum pump running 24 hours a day will cost \$4,540.00 per year. A 40 Hp vacuum pump in the same duty will cost \$17,800.00

per year to operate. The variable per unit costs increase dramatically versus using the original pump and constructing a jig to maximize air flow (volume). There is a limit to how much air can move through a fixed diameter opening. If your table has a 1 1/2" hose connecting it to the vacuum pump, that 1 inch opening will only allow 86 CFM at 15–30 "Hg. A bigger pump can't change that, however, it can cause a higher vacuum energy. The results often do not justify the cost of electrical energy. If the table could be modified to allow a larger diameter vacuum connection with more table inlets then a larger pump would have resulted in significant improvements in both vacuum energy and volume. Bigger is always better. The decision must be how much bigger before the per unit costs increase with no resulting increase in production output or quality.

As woodworking shops increase in size the number of individual vacuum pumps can reach as many as 15–20 units. Centralizing the vacuum system becomes a common goal. There are many variables to designing a central system for CNC routers. The common criteria for a central system are as follows:

"If I have a 50 or 100 Hp system all of my machines will run better".

This is true, however a central system has a fluctuating vacuum energy depending on how many user points are operating. In multiple pump systems the pumps turn on and off based on a minimum / maximum vacuum energy setting. This means the energy holding boards in place throughout the shop will be constantly changing. The result many be rejects or ultimately slower cutting speeds defeating the benefit of centralizing. There is the variable cost scenario of a weekend shift on overtime using one router that used to have a 7.5 Hp pump now producing parts using a 50 Hp central vacuum pump. Per unit costs go up. There is an alternative in the New Becker Vari-Air Direct Screw Central Vacuum Pump System. This system uses a high efficiency oil free single stage screw compressor controlled by a variable speed motor. Variable product supplied by variable utility costs. The motor responds instantly in vacuum energy changes to change the speed of the direct connected vacuum pump ensuring a uniform vacuum energy regardless of the number of machines. This also makes cost effective the

weekend overtime shift because the Vari-Air Direct can slow-down to perform as a 7.5 Hp vacuum pump or speed-up to perform at 50 Hp. Two or more machines can be joined together for unlimited Hp systems.

“If I centralize I can eliminate the cost of repairing my many pumps”.

Lack of preventative maintenance results in costly repairs whether it be on individual pumps or a central unit. What normally happens is a number of old pumps are replaced by a new system eliminating the costs for a two year period. It may be cost effective to replace or upgrade the individual pumps with new as they require overhauls gaining the two year trouble free advantage.

“If I centralize I can eliminate noise and heat from the work place”.

Yes, not only can you remove heat, it can be captured and used to heat the entire building in the winter. Individual pumps can also be remote located to gain the same results at a fraction of the cost of central systems.

The design and installation of piping systems often equal the cost of the central system pumps and must be designed by a production vacuum company not using the theories and practices of janitorial or dust collection.

Vacuum Gauges

A final note on performance. The vacuum gauge on your CNC Router Table shows energy only. In a rest position the gauge will show the same as it did when everything was new. Rejects occur and you look back to the gauge, it hasn't changed. What has changed is the filters, piping, valves and pumps have slowly, over time clogged, reducing the volume of air permitted to move through the system so on critical cuts the volume cannot respond to maintain the vacuum energy.

Accountable qualified routine service will provide the best long term benefit to your vacuum system. Replacing filters and pumps as they become costly will bring life back to the system and overall keep costs down.

Becker is a chosen world leader in supplying woodworking OEM equipment. It's what we do and we do it to the satisfaction of Biesse, Morbedelli, Weeke, SCM, Anderson, Ligmatech, and Azzia. The following page provides a comprehensive list of Becker Vacuum Pumps supplied as original equipment on CNC router machines.



When it's vacuum you need you really should give us a call.

1-800-668-8736



Guaranteed Solutions

Becker pumps supplied as original equipment on CNC router machines.

ANDERSON

EXAACT 51 VTLF 250
MAGNUM VTLF 250 / 500
VANDI EXXACT 51 / RAN VTLF 250 SK

AXYZ VTLF 250 SK
MILLENNIUM KVT 3.60

AZZIA VTLF 250

BIESSE

ARROW VTLF 250
MILLENNIUM U 4.100
PROTEC 2 KVT 2.140
RBO TORNADO 1300 STACKER VT 4.40
ROVER 13S VT 4.40
ROVER 15 VT 4.40
ROVER 18 VT 3.40
ROVER 20 VT 4.40
ROVER 23 KVT 3.100
ROVER 30 (2) KVT 3.100
ROVER 321 KVT 2.100
ROVER 321R KVT 3.100
ROVER 336 (2) KVT 2.140
ROVER 336 KVT 3.100

C.M.S.

ZOGNO KVT 2.100
IMA VT 3.6

COSMEC VTLF 250

FLEXICAM KVT 3.100
KVT 3.140

HOMAG

LIGMATECH ZQP 10 KVT 3.80
LIGMATECH ZDE 20 (2) VT 3.40
MASTERWOOD PROJECT 330-T KVT 3.100
MASTERWOOD PROJECT 317 KVT 3.100
NIANDI SPRINT 48 \ 2 \ D VTLF 250
WEEKE OPTIMAT BP 45 KVT 3.100
WEEKE OPTIMAT BP 150 KVT 3.100

HOLZHER KVT 3.100
VTLF 250

MAHROS VT 3.10 / 3.60

MASTERWOOD KVT 3.100

MIKON
MULTICAM VTLF 250

MORBEDELLI

AUTHOR 502 VT 4.25 / KVT 3.100
AUTHOR 503 (1997) KVT 3.100
AUTHOR 503 VT 3.40
AUTHOR 504 KVT 3.100
AUTHOR U550 KVT 3.100
AUTHOR 660 VT 4.25 / VT 4.40
AUTHOR 700 VT 4.40 / KVT 3.100

NORMAND

V. ALBERTI FORMAT 90 KVT 3.80

ONSRUD VTLF 250

PHOENIX

RG 48 KVT 2.100

REICHENBACKER

DORFLES U 2.165 TANK MOUNTED
RAN C230 U 2.100 -250 TANK MOUNTED

SCM

RECORD 120 VT 4.40 / KVT 3.100 / VTLF 250
RECORD 120S KVT 3.80
RECORD 2 KVT 2.100
RECORD 220 VTLF 250
ROUTOMAT KVT 3.100 / VTLF 250
ROUTRONIC KVT 3.100 / VTLF 250
ROUTRON KVT 3.100
ROUTECH VTLF 250
TECH 99L VT 4.40

STANDARD VTLF 250

TECHNO-ISEL VTLF 250



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