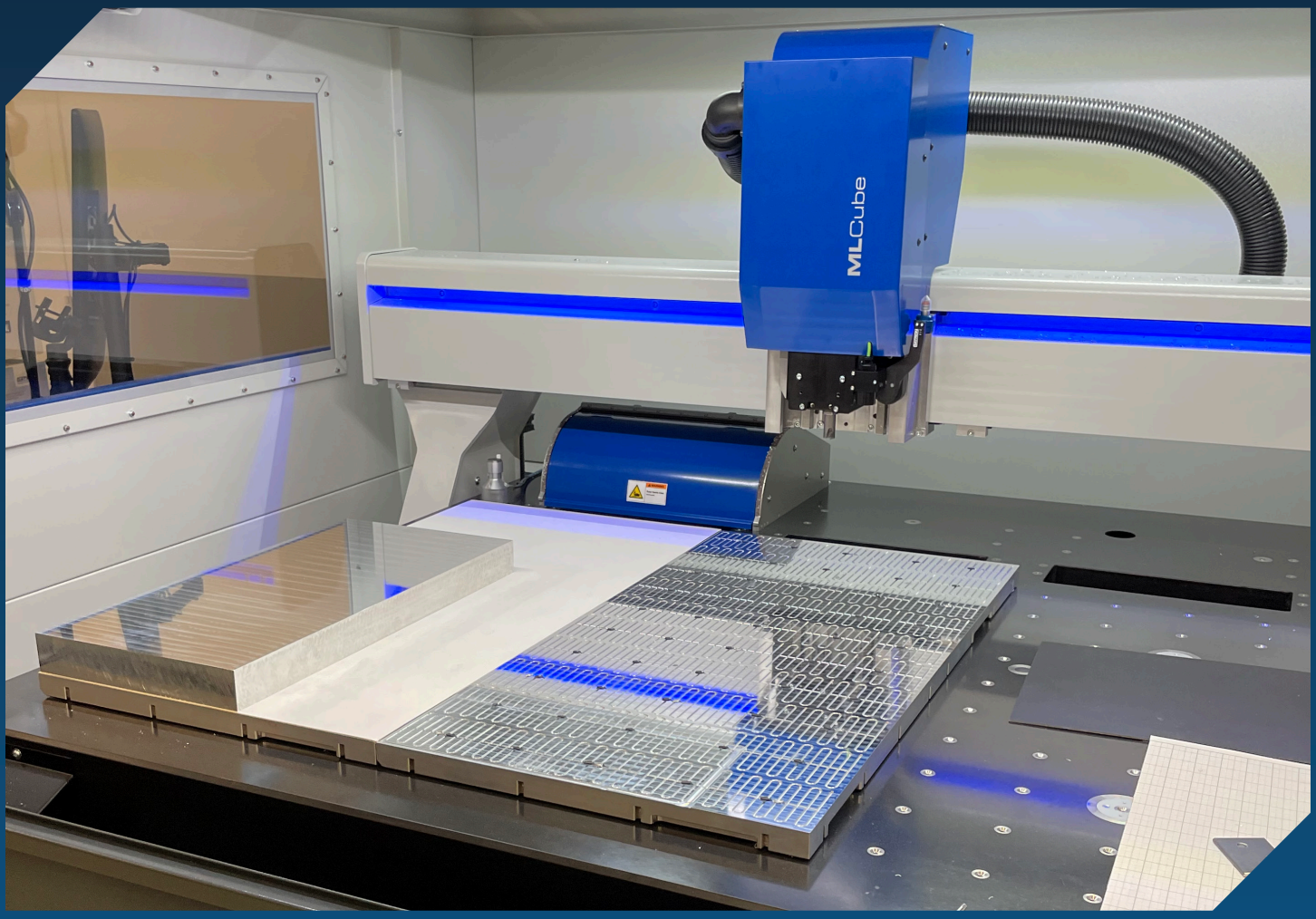
The Impact of Vacuum Table Technology on CNC Machining

White Paper



DATRON

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Vacuum Tables Can Revolutionize Your Production Capabilities

If you are leery about vacuum tables or have had a bad experience with using them, you need to read this article. Often bad experiences can be attributed to not using the right table for the right application or sometimes, vacuum tables are not the right fit for your parts. But if they are, you can make a significant improvement in throughput and profitability.

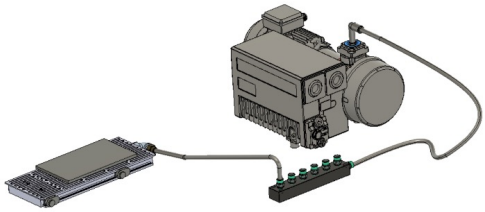
What is a Vacuum Table?

A vacuum table for a CNC (Computer Numeric Control) is a flat table or holding fixture that has a vacuum source attached allowing it to draw vacuum through holes in the table surface. With vacuum suction or in technical terms the atmospheric pressure pushing downwards, the table (sometimes called a chuck) can hold flat material sheet firmly in place while machining. Using a vacuum table can reduce set-up times, improve the quality of parts, optimize material usage, part tolerances, and reduce cycle times (the time to machine each part).

Vacuum tables are not appropriate for all types of machining applications. Generally, they are well-suited for machining flat and smooth materials. Therefore, trying to machine an aluminum extrusion that does not have a large surface area or a cast metal part that might have a rough surface finish would not be appropriate for vacuum table designs. Metal, composite, or wood sheet material machining are more typical applications. Vacuum tables are particularly effective for thin materials when traditional work holding options simply will not work.

Vacuum tables might be a good alternative to resolve a process you are struggling with today to secure your parts. For example, if you are using double-side adhesive tape to hold down thin materials, this could be eliminated. The time-consuming approach of pre-drilling sheet material and using mechanical fasteners to screw down the material to a custom subplate would not be necessary anymore. Machining parts out of sheet material and having to leave tabs or bridges, so parts don't fly off or become loose during the machining process in most cases would not be necessary. With the right application and the right vacuum table, you can potentially double or triple your throughput with substantially less part rejection.

There are basically five types of vacuum table designs, each having their advantages and disadvantages. Each design has its strengths for various applications, CNC machine types, cost, and flexibility. Choosing the right vacuum table for your machining center and type of work is imperative. Not using the right table could have a negative impact on your production capabilities and quality of parts. This could result in you having to choose another type of work holding to machine your parts, scrapping all your time, efforts, and investment. The following are five of the more common vacuum table designs.



Types of Vacuum Tables

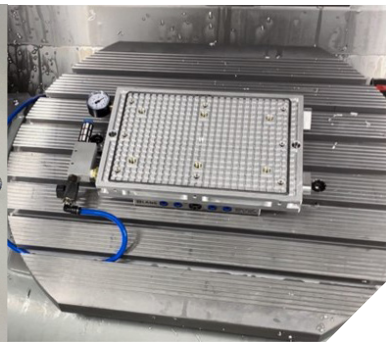
The Grid and Gasket Design

One of the earliest known designs of the vacuum table is called the grid and gasket design. The configuration consists of a thick base or table often made from aluminum or phenolic which are both stable to moisture. In the base is a grid of slots machined into the top. Within the matrix of slots or the little islands, is a series of ports that feed through the table and are connected to a main hose that further connects to an industrial vacuum pump.

Typically, an industrial pump is used, not a shop vac because they are designed to run continuously in production environments and generally have more suction pressure. If you tried to use a shop vac, you would likely burn out the motor in a few hours trying to draw air through such a small tube or flexible hose. If there are multiple tables, often a manifold or distributor with on/off valves are used.

Next, you place a soft, compressible, foam type neoprene gasket into the grooves and create a closed-loop shape (often a rectangle) that is slightly smaller than the size of material you are securing. Therefore, when you place your sheet material on the table, the gasket path is within the size of your sheet material. Then quite simply when you apply the vacuum, air is drawn through the open ports within the gasketed area, and your sheet material sucks down firmly to the table. Most of these types of designs allow you to close or plug the unused vacuum ports.
The advantages of this style vacuum table is you can secure various size sheets of material simply by chossing a different size polygon shape. The cost is relatively inxepensive for this style of table and you have the option to build it yourself because of the relativly simple design. You can also use flood coolant because there is no risk of the coolant getting into the sealed vacuum system. Keep in mind the operating costs of a venturri type system is gernerally more expensive over a small pump. The disadvantages of this style of vacuum table is you can not cut through your sheet material. If you do, you will break the vacuum and cut into your table. Therefore you are limited to pocket machining with no through holes or openings. Additionally, the set-up times can be moderately lengthly resetting a new gasket for each sheet size. This type of vacuum table design is ideal for engraving sheet material because there are no through holes in this application.

Because of the sealed vacuum design you can use a small, low-powered vacuum pump or even a venturri type system that runs off of your shop compressed air system.

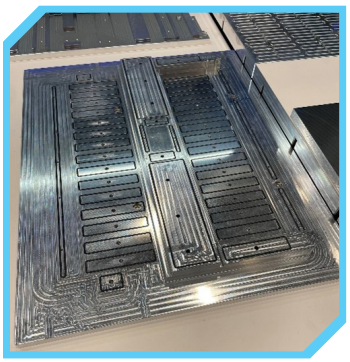


Types of Vacuum Tables

The Custom Gasket Design

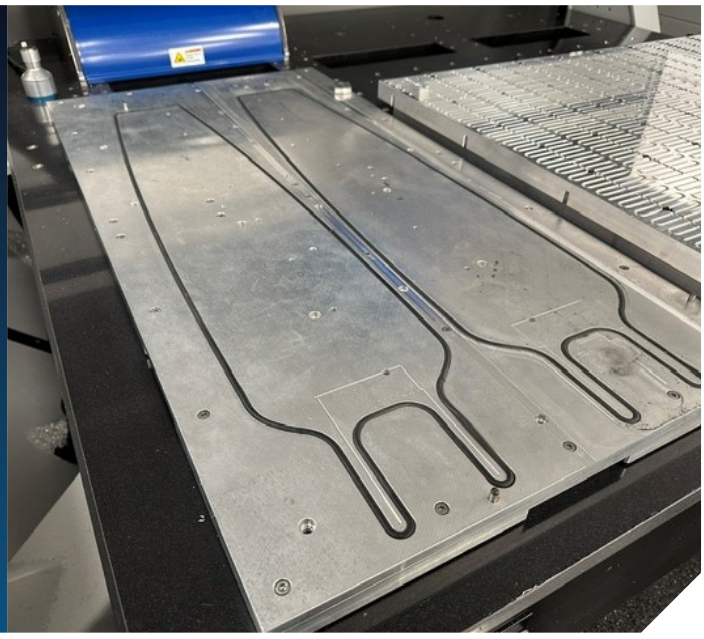
Similar to the grid and gasket design, is the custom gasket design version. Instead of having a grid of open slots to insert a gasket polygon, you would have a dedicated path or shape to hold down your work piece. Typically, this would be used for a high-volume dedicated production run because it would take time to manufacture the custom fixture.

The gasket in this case would be secured into the groove with an adhesive, like silicone, to keep the gasket in place over the many hours of production the set-up would encounter. Keep in mind if you are building a custom gasket fixture yourself, only use a small amount of silicone to secure the gasket because you might need to replace the gasket from time to time, depending on the production volume.



The advantages and disadvantages are nearly the same as the grid and gasket design. A couple of additional advantages with the custom gasket is you can secure an irregular, free-from shape and it no longer needs to be rectangular. Also, you can use this fixture style to machine the outside perimeter shape and even build in a cutting path channel in the fixture, so you do not cut the table. One obvious disadvantage, this is a dedicated table design and cannot be used for any other type of production run. Generally, you would only use this for a specific dedicated design for a high-production volume type of scenario.

An example of an application is the manufacturing of an aluminum longboard (skateboard) as pictured (right). Because the shape is always the same, you can simply place a rectangular sheet of material down on the custom vacuum table and cut the irregular shape out afterwards. Any designs or engravings on the surface can change. In this design, there are some through holes at each end of the longboard that can be avoided with the gasket profile allowing the machining program to mill the openings and drill the holes. This vacuum table design also accommodates two boards, the top and a bottom design of the longboard.



Types of Vacuum Tables

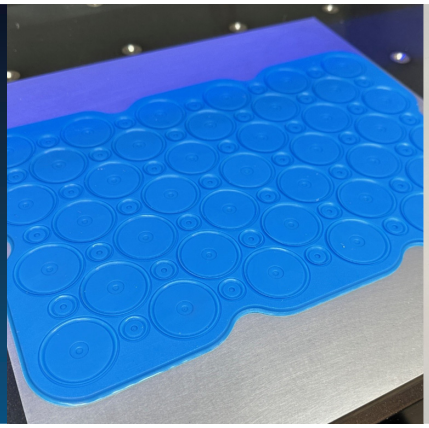
The Vac Mat Design

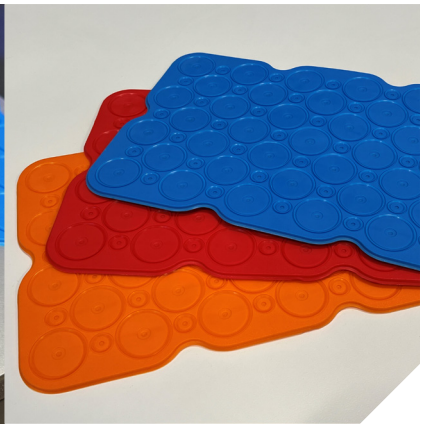
One of the big disadvantages of the gasket and grid design is you cannot mill or drill any holes through the material because you will compromise the vacuum. There is a vacuum table design that uses a molded flexible plastic mat instead of a rubber gasket that alleviates that issue.

The specially designed mat has an array of molded circular suction cups with a small pin sized hole fed to each suction cup. So simply, you place your mat on the vacuum table and ports in the table would line up with the ports in the mat. The mat is also rubber-like and tends to help grip the sheet material. If you have an oversized vacuum pump, it will be able to keep up with a small amount of vacuum loss through the holes because of the very small hole in each suction cup. These rectangular mats can be placed side by side for larger sheet material.

In addition to the ability to drill or mill through holes, another advantage is you can profile cut your piece out, cutting into the disposable mat below. Typically, you would be able to use the mat over again machining the same shape but if you were to do a different job, you might have to start with a fresh mat. Some disadvantages of this system are it can get expensive to replace the mat frequently. The mats are quite small so you may need several to do a job. If you are machining thorough holes and using flood coolant, you may need a separator to capture coolant before the liquid enters your vacuum pump. Any water or oil can seriously damage your vacuum pump. You also will need a larger size vacuum pump, for extra vacuum capacity, if you are machining through your material and into the mat, exposing open ports.

Due to the nature of the design of many circular suction cups, if you were to drill or mill through the material, you would only lose vacuum in that one small suction area. The remaining suction cups would continue to hold your material.





Types of Vacuum Tables

Permeable Fiberboard Design

There is a very interesting vacuum design technology that is used mostly for large part machining from sheet material commonly found on router table machines. These vacuum tables only work with a large surface area, are quite effective, and have a lot of advantages.

They are commonly found in cutting wood for the furniture industry or machining plastics for the sign industry. They do not work well for cutting metals because the coolant required to cut metal would compromise the system. You simply lay your material on the large permeable fiberboard that has a vacuum drawn over the entire surface that is fed from underneath. There are no gaskets to configure or expensive mats to replace, you simply run many jobs before having to replace the sacrificial board or vacuum table surface. The fiber board is basically a particle board material and is inexpensive to replace over running multiple jobs. The setup is quick, taking only a few minutes to go from job to job.

The downside of the design is you are restricted to machining only large parts, and you cannot use coolant. Additionally, you might need to machine the surface of the fiberboard material after a production run to remove tooling marks, so the vacuum is consistent over the surface for the next job. This takes time and eventually, the fiber board will need replacing. For the furniture and signage industries and applications, this is a good solution.

The vacuum drawn is not very strong and would not be enough to hold small parts but for the furniture and sign industries, these parts are quite large and have sufficient surface area for the process to work. The interesting part of the design is you can machine right through your sheet material into the sacrificial fiberboard below with little concern of losing vacuum.

Types of Vacuum Tables

The DATRON Vacuum Table System

The best way to describe the DATRON Vacuum Table system is, it is like the permeable fiber board system but at a smaller and more precise scale. You can machine small flat parts right through the material without significant surface area required on the parts.

The ingenuity and effectiveness of the DATRON system lies with the specially designed table, the thinner and more permeable card stock instead of fiberboard and the robust vacuum pump. This combination allows you to hold small flat parts, that are completely machined through the sheet material including through holes, without them lifting or letting go during the machining process.

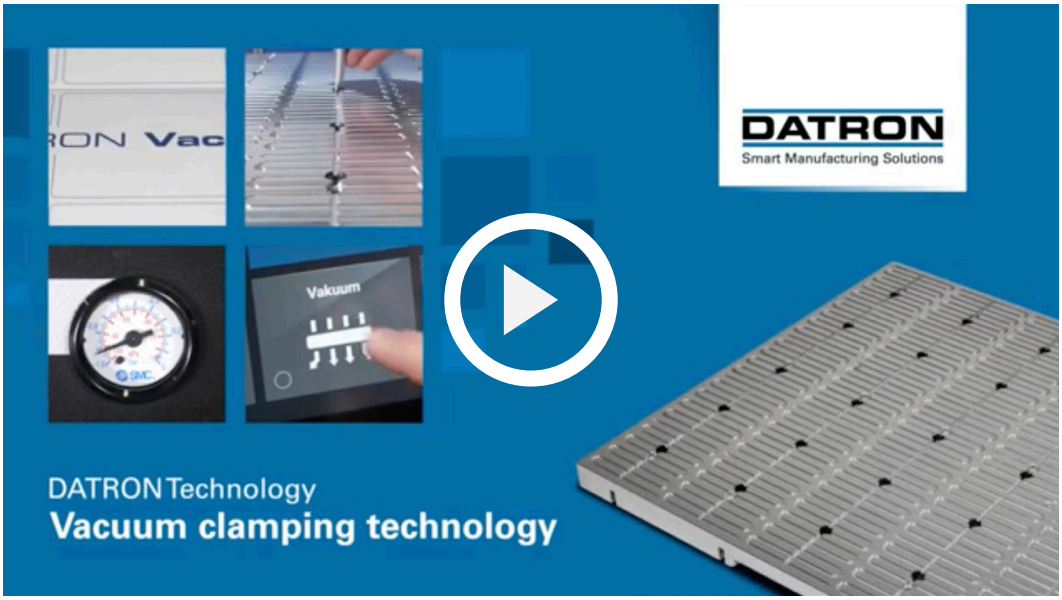
These vacuum table systems are often found in applications requiring machining of small parts from sheet material such as aluminum and plastic. Common applications include: small electromechanical parts, thermal management parts such as heats sinks or cold plates, wave guides, test fixtures, satellite, aerospace and electronic enclosure, nameplates, control panels, buttons, engraved plates, counter plates, micro fluidics, fuel cells, signage, brackets, fixture plates and general sheet metal fabrication or blanks. The main advantage of the DATRON system is the ability to secure a large flat sheet of material and machine multiple to hundreds of nested parts, completely cut out, in one cycle run. The setup is extremely fast, often less than a minute, and is the same setup process from varied production runs. No screws, tabs, tapes, rubber gaskets or expensive mats are required. The disadvantages include the cost of the oversized vacuum pump, the permeable sheet material is considered a consumable and requires replacement, and you cannot use traditional flood coolant systems. The efficiency and production time improvements however cover the cost of the initial investment very quickly and subsequent consumables. In some cases, the time savings of a few weeks of production can cover the investment.

The DATRON Vacuum Table System (continued)

Since a permeable cardboard material is used, any liquid would be absorbed through cut areas of the sheet material and eventually through to your vacuum pump. Any oil-based flood coolant entering the vacuum pump could damage the pump. Also, the permeable material would swell creating tolerance issues in your parts. Alternatively, the DATRON CNC machines are equipped with a high-pressure Ethanol based micro jet system that has the coolant evaporating before impacting the permeable cardboard material. It also has no impact on the vacuum pump system; therefore, you can machine non-ferrous materials like aluminum and brass right through, very efficiently without any concern of harming your system or impacting the permeable cardboard.

Another distinct advantage of using a DATRON machining system with the vacuum tables is the effectiveness of the high-speed spindles. Having a high frequency spindle (40k – 60k RPM) allows you to machine parts with very low cutting forces. This means you can cut very small parts with little surface area because only a small amount of vacuum is needed to secure the part. Machining centers with slower spindle speeds (less than 10k rpm) can still be used with the vacuum system but generally requires larger size parts, with more surface area, for the part to remain in place while machining because of the increased forces from the cutting tool.

See the DATRON Vacuum Table system in action:



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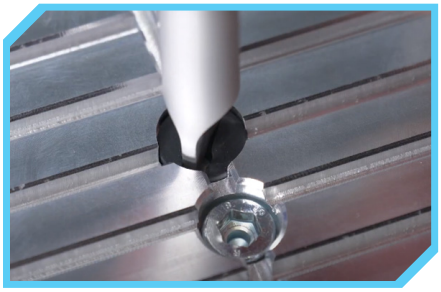
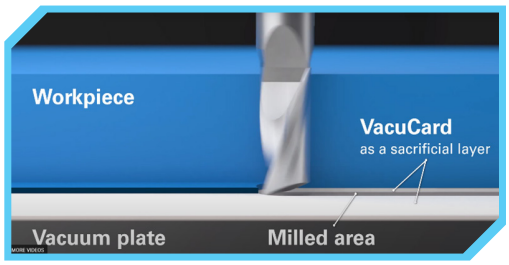
How the DATRON Vacuum Table Works



The **DATRON Vacuum Table** consists of a fabricated aluminum plate or table, sacrificial permeable cardboard called VacuCard and a vacuum pump.
The aluminum table has a series of serpentine channels that each have a tiny feeder hole that can be opened or shut by turning a plastic plug. The large industrial vacuum pump connects to the table with an industrial hose that draws the vacuum through the feeder hole within serpentine channels. The permeable material lays on the surface of the aluminum table and spreads the vacuum evenly over the surface of the cardboard like material from the serpentine channels. Now when you place the flat material on the cardboard substrate, the material is sucked down very securely. You can now machine your parts out individually, like a cookie cutter, about .020" deep into the substrate material which is about .040" thick, avoiding cutting into the vacuum table. Like the vac mat design, because the vacuum feeder hole is so small, even if you cut through your sheet material, the loss of vacuum will be minimal, and the oversized vacuum pump will make up for the loss. For the next production run, simply remove the cardboard substrate and replace it with a fresh sheet.
Note, if you do not have any cut throughs, you can typically use the permeable substrate multiple times. At the end of your production run, you simply turn off your vacuum pump and harvest your parts. You can change the size and design of your parts from job to job and not have any additional work or setup time. You can also run various size sheets because you can shut off zones that are open by turning the plastic plugs.

The **DATRON Vacuum Tables** come in various sizes. They are all modular and can be mounted side by side on the machining table to make one large vacuum table. The DATRON machining systems have tables roughly 30" x 40" and 40" x 60" so you can build a vacuum system to cover the entire machining envelope. The more vacuum tables you need however, will require scaling up the size of your vacuum pump. The permeable cardboard comes in a range of sizes to accommodate the various vacuum table configurations.

Depending on the application, sometimes a little extra hold is required, especially small parts, smaller than the size of a coin. DATRON developed a unique permeable cardboard that has a light adhesive layer on the surface, like a Post-it Note®. The adhesive layer is also permeable and does not leave any residue on your parts. This cardboard is called VacuCard++ and is more expensive compared to the regular card stock but can be highly effective on those difficult or small parts.



These parts were machined on a DATRON vacuum table system using the Vacucard ++

Conclusions

Not every machining application is conducive to using vacuum tables but for machining parts from sheet material, they are often the best solution. The size of parts, part materials and size of the production runs will often dictate which type of vacuum table should be used.

If you need to machine small parts out of non-ferrous sheet material, the **DATRON Vacuum Table** system is an excellent choice and could revolutionize your production process.

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