Applying Point of Use & Centralized Vacuum Venturi Systems

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The following is an opinion article written by Dane Spivak of Davasol Incorporated, an industrial brand management firm with many clients, one of which is Vacuforce LLC. The numbers provided in the examples are arbitrary and do not represent real-life data. Contact Dane via email at dspivak@davasol.com.

VACUUM VENTURIS ARE compressed air-driven vacuum pumps. Unlike common electrically powered industrial pumps, venturis consume compressed air to generate suction flow. This results in vacuum pressure, which is lower than atmospheric. This technology is a popular choice among vacuum pick-and-place, gripping, and hold-down applications across industries. The following article will focus on venturi technology and how it is best implemented based on project parameters.

HOW IT WORKS

A venturi produces a vacuum by compressed air flowing through a nozzle demonstrated in Figure 1. The decreasing diameter of the nozzle increases the air velocity across the cavity. This creates a low-pressure pocket that "sucks" in surrounding atmospheric air from the vacuum inlet. A venturi must have at least 3 ports to function including the compressed air source, vacuum port, and exhaust port as shown in Figure 1. Some units may have more ports for additional accessories though it must include the aforementioned 3 ports. Venturis are often underestimated in performance compared to a motor-driven pump such as a rotary vane model. Despite this, they can do the same task and reach similar vacuum levels (pressures) despite being a fraction of the physical size.

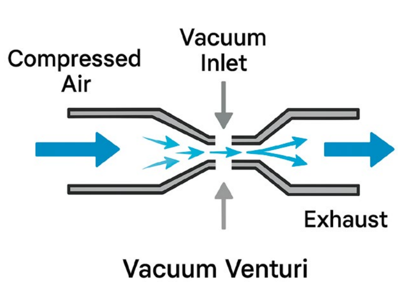

Figure 1 – *Venturi effect visualized*

POINT-OF-USE VENTURIS

Since venturis can be small, compact, and lightweight, point-of-use units where the venturi is installed close or directly at the application are commonplace. Figure 2 shows a venturi close-coupled to a vacuum suction cup. This offers the user maximized vacuum performance and a completely independent system from other venturis or vacuum pumps.

Figure 2 – *Venturi close-coupled to a vacuum cup*

These assemblies typically lack proper filtration. This may clog the venturi with debris, oil, water, or any other unwanted substance. Over time, this can reduce vacuum flow and/or level. Users can go without filtration for clean environments, though this is still less than ideal. However, dirtier applications can create problems quickly and filters are highly recommended. Figure 3 shows an external vacuum filter suitable for venturi protection, and an in-cup vacuum filter disk. For the external filter, dirty air enters the unit indicated by the grey arrow, traps the particulate with the visible white element, and clean air is exhausted indicated by the blue arrow. Filter disks are inserted into the suction cup bellows. They can be useful, but they clog quicker than a proper external filter unit and lack clear visibility. For that reason, using an external clear-bowled vacuum-rated filter is best practice.

Figure 3 – *External and in-cup vacuum filters*

ONE, TWO, AND THREE-STAGED UNITS

Figure 1 illustrates the basics of how a simple venturi system works. However, there are also more complex and effective ways to increase vacuum flow and reduce compressed air consumption. This is achieved by adding additional venturi stages to continue using the air after its first stage instead of exhausting it. See Figure 4 for more details on stage performances. In this example, the 3-staged venturi provides 4 times the amount of vacuum flow as the single-staged while using the same amount of compressed air. It also offers the same maximum vacuum level.

Number of Stages	Compressed Air Use	Vacuum Flow	Vacuum Level
One Stage	4CFM @ 60psi	3SCFM	27"Hg max
Two Stage		8SCFM	
Three Stage		12SCFM	

Figure 4 – *Venturi vacuum flow by stages*

Single-staged units are smaller and easier to manufacture, reducing the overall cost of the unit itself. This is attractive to machine builders and even end users for smaller or infrequently-used applications. However, using a 2- or 3-staged unit can reclaim the upfront cost on a higher priced venturi by saving on energy long term. The even cost point for both considerations can vary greatly depending on the difference in air consumption, energy costs, and how often the venturi runs. However, multi-staged units offer long-term financial benefits in automated machinery assuming they will be in use for a few months or years. From a practical perspective, single-staged units can fit in tighter areas and react faster to generate a vacuum, but these benefits are rarely significant. In recent years, this has caused a shift away from single-staged venturis. Figure 5 shows an example of changes in air consumption based on the number of stages with equal vacuum flow and vacuum level.

Number of Stages	Compressed Air Use	Vacuum Flow	Vacuum Level
One Stage	3.5CFM @ 60psi		
Two Stage	1.5CFM @ 60psi	2.5SCFM	27"Hg max
Three Stage	1CFM @ 60psi		

Figure5 – *Venturi air use by stages*

CENTRALIZED VENTURIS

In vacuum gripping, a centralized venturi refers to a unit that applies vacuum to a network of cups connected by various channels through hoses, tubes, and/or manifolds. Refer to the schematic in Figure 6. The venturi provides a common vacuum generation source to control the performance of multiple vacuum application points, or in this case, multiple vacuum cups to grip one part. For centralized venturi applications, a larger 3-staged unit is preferred to save on compressed air and generate higher vacuum flows. Higher flows allow for a quicker time to reach the maximum vacuum level and may increase the maximum vacuum level depending on vacuum leakage.

Comparable vacuum performance can be accomplished just as easily by using multiple point-of-use systems from Figure 2, but it becomes too complicated to monitor and maintain multiple independent systems when it is unnecessary. For these relatively larger-scale applications, centralized units are often preferred for those seeking a simplified design, lowered costs, and reduced maintenance.

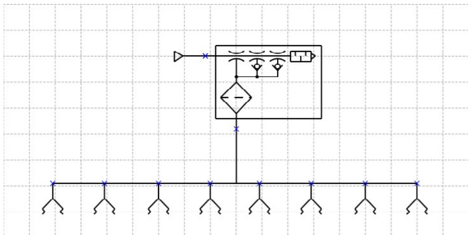

Figure 6 – *Schematic of 3-staged venturi powering an array of vacuum cups*

FINAL THOUGHTS

While many may argue compressed air is expensive, venturi technology continues to increase in efficiency. Selecting and sizing the right model for an application can offer tremendous benefits compared to a vacuum pump. This includes lower upfront costs, easier installation, and less maintenance. While vacuum pumps still have their place in the market, venturis are often a good choice for relatively smaller and localized applications for vacuum gripping.