This is VCUUM

The Vacuum Cup – Explained

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The most visually recognized component of any vacuum material handling system is the vacuum cup, as this is one of the most crucial parts in a vacuum lifting system. Although every component is important in the successful implementation of a vacuum lifting system, if the vacuum cups chosen are wrong, it becomes apparent very quickly when the machine fails to handle the load being picked up.

There are many manufacturers of vacuum cups, so numerous in fact, it is sometimes overwhelming to the novice in being able to select the correct type of cup, the material, what manufacturer is best and so on. This article of This is Vacuum is intended to simplify the selection process and in turn remove the myths and inaccuracies put forward by manufacturers and marketing campaigns.

TYPES OF VACUUM CUPS

There are two basic types of vacuum cup, flat and bellows, which are shown in Fig 1. There are many variants on these two designs, but they are all intended to accomplish the same goal. The reason one is chosen over the other is based purely on what the cup is handling and how it is being transferred once the part is gripped by the vacuum cup.

FLAT CUPS

Flat vacuum cups offer excellent stability in high-speed part transfer, particularly in a horizontal movement or through a vertical/shear plane transition or where the part turns through 90 degrees. As the vacuum cup collapses when vacuum is created, the part being lifted "locates" against the base of the vacuum cup (fitting), which is a fixed datum point. This location point offers incredible sturdiness, especially when handling heavy loads, thin pieces such as steel plate, fragile items such as wafers and recently molded plastic product, where the part may deform unless the part is properly located across the base of the vacuum cup. Fig 2 shows the characteristics of a typical flat vacuum cup where the height compensation/compression is very limited compared with a bellows cup.

Fig 3 shows the difference between a typical datum surface of a flat and bellows cup. These pictures were taken from the underside of a piece of glass. The flat cup offers location across the complete diameter, whereas the bellows cup is only locating on the outside sealing lip. Therefore, the flat cup offers much greater stability and of course spreads the load across the diameter of the cup, minimizing distortion of the part being handled.

BELLOWS CUPS

There are four good reasons for using bellows cups in an application. The first is that the machine user does not have to be as accurate in the vertical approach when picking up product, such as in a destacking application for sheets of paper or steel. The bellows cup, depending on the design, is able to collapse onto the product before the vacuum is applied, whereas a flat cup needs to be positioned accurately to ensure the lip of the cup accurately seals against the load. Of course a flat cup could use a sprung level compensator, but this is an extra component (Fig 4) and of course further cost.

The second reason for using a bellows cup is for angle compliance where the product being handled is not square to the lip of the vacuum cup, as shown in Fig 5. Again, a flat cup is not able to offer this angle compliance unless utilizing an articulated joint as shown in Fig 4.

The third reason for using a bellows cup is for sheet separation. When destacking thin sheets with flat cups, there is a risk of multiple sheets being picked up due to the natural vacuum effect created when the machine moves in a perfectly perpendicular plane to the stack. The bellows cup offers a peel effect when the vacuum is applied because the bellows cup collapses, offering a small amount of lift, independent of the machine movement. This collapsing difference, compared to a flat cup, is shown in Fig 2.

Fig 4.

The fourth clear advantage of bellows cups over flat cups is when the product being handled is circular, convex or even concave. Fig 6 demonstrates this. The bellows cup is able to deform around the circumference of the part being lifted, whereas a flat cup is unable to deform to the profile.

Although it would appear the bellows style cup has many more advantages than a flat cup, the following should be considered. Flat cups are less expensive, they offer superior stability (which in turns enables them to work at higher speed), the volume inside a flat cup is less (and therefore it takes a shorter time to create a vacuum) and there is less "movement' on a flat cup when it is put under vacuum, so the cups tend to last longer because there are less potential fracture or stress points.

Fig 1.

Fig 3.

Fig 6.

Fig 2.

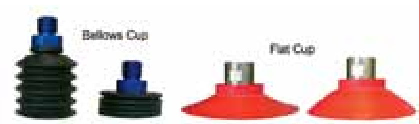

Fig 5.

Fig 7.

VACUUM CUP FITTINGS

Vacuum cups are assembled onto the metal fitting (which attach to the machine) using three different methods. The easiest is simply a push-on type, where there is an interference fit between the cup's internal neck onto the male barb of the fitting. This is an economical choice because when the cup needs replacing, the user simply replaces just the rubber cup. This can be done very quickly. The second method is by bonding the fitting to the cup using an adhesive. This method offers greater rigidity than the push-on type, but of course when the cup wears, the complete cup and fitting have to be replaced. The final method is by vulcanization of the fitting with the rubber cup. This is by far the most secure and offers superior bonding of the two materials. Normally vulcanized fittings utilize a steel fitting, which is much easier to vulcanize than aluminum, which is used purely for production cost. This steel vulcanization offers excellent life and reliability and is usually used on cups that need a very long cycle life or on large cups where the load being lifted is extremely heavy. Fig 7 shows these three types.

VACUUM CUP LIFTING CAPACITIES

The amount of weight a vacuum cup can lift is dependent on only two things: the vacuum cup sealing area and the pressure differential inside the cup (vacuum level). Vacuum is the reduction of atmospheric pressure, 14.7psi(a) or 29.92"Hg, in a known volume (a cup sealed against a load to be lifted). Therefore, if the user has a 4-inch diameter vacuum cup and a vacuum level of 15"Hg (7.35psi pressure differential), the calculation is as follows.

Vacuum Cup Area - πr^2, which is 3.142 x (2x2) = 12.568in^2. Pressure Differential is 7.35psi (pounds per square inch). Therefore, we have a pressure of 7.35 pounds multiplied by 12.568 square inches = 92.375lbs lifting capacity.

If the pressure differential is 11.76psi (24"Hg), the lifting capacity will be 147.8lbs. The difference in differential pressure versus the lifting capacity is, of course, linear.

The volume of the cup and the shape, style or height makes absolutely no difference. Only the area of the vacuum cup sealing lip multiplied by the pressure differential determines the lifting capacity.

VACUUM CUP MATERIALS

There are many vacuum cup materials available from many different manufacturers. However, the choice of compound is normally determined by one or more of the following characteristics: vacuum cup hardness, heat resistance, and chemical resistance.

Vacuum Cup Hardness - The durometer or hardness of a vacuum cup is chosen based on its ability to deform to the profile of the product being handled. Products such as cardboard, corrugated paper, textured surfaces and so on require a softer durometer to enable the cup to seal properly. A durometer (Shore Hardness) of 40 is normally considered to be a soft compound. Compounds such as natural or silicone rubber generally have such a hardness value. A common misconception is that the softer the compound, the poorer the wear resistance. This is not accurate. A Nitrile (NBR) rubber, which has a 60-durometer hardness, has a lower wear resistance than natural rubber, which is a 40 durometer. Silicone, however, which has the same shore hardness as natural rubber, has very poor wear resistance.

The softness or hardness of the compound does NOT determine the wear resistance. The user rarely requests a hard compound. The material selection based on other criteria, such as chemical or heat resistance, offers a hardness, which is characteristic to the compound, not the application.

Heat Resistance - Industry generally relies on silicone compounds for heat-resistant applications, such as injection molded part transfer, glass handling and so on. Although silicone rubber offers a temperature resistance of some 400ºF, it does not withstand wear resistance as explained above. Also, silicone should NEVER be used on surfaces that have yet to be painted or surface treated, or on decorative materials as the silicone compound "etches" into the surface being handled. This prevents adhesion of the paint and affects certain surface treatments. This is particularly relevant in hot metal stamping, glass and decorative stone handling, such as marble or quartz manufacturing. An alternative to silicone in a high-heat application could be Viton®, which offers an even higher temperature of some 700ºF but offers a hardness of approximately 60 durometer compared with the silicone compound, which is 40.

Chemical Resistance - Silicone is the most popular choice when handling products, which have a corrosive element on the surface. In comparison, natural rubber, although having an extremely good wear resistance in cardboard, paper, concrete or stone handling, has an extremely poor chemical resistance, which includes surfaces with an oil content such as steel and particularly steel stamping. Nitrile rubber is the first choice when handling surfaces with an oil film as this compound is less expensive than silicone and has a higher wear resistance also.

Most vacuum cup manufacturers offer cup compound comparison tables that illustrate the compatibility and hardness of the materials offered by that specific manufacturer. There are many other materials, too numerous to list, which offer specific user advantages, such as conductive silicone which is used in handling sensitive micro chips where the static electricity is absorbed by the cup, modified Nitrile compounds which resist the chlorine content found in metal stamping oils which is extremely corrosive, and particular non marking compounds for use in glass production applications.

The user's application determines the type of vacuum cup and the compound that should be used. As a good guide, choose a flat cup in Nitrile rubber. This is the most economical combination. Once the application is understood, this choice may change, but a flat Nitrile cup is a good starting point.

For more information, contact Daniel Pascoe, General Manager of Vacuforce Inc at www.vacuforce.com. Vuototecnica USA is a brand of Vacuforce Inc.