

CVacuum CLAMPING

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Fig. 1

One of the most common uses of vacuum cups and related vacuum products is material hold down or clamping. Often misunderstood, this article attempts to explain the basic selection process of components and the way in which they are employed.

In vacuum lifting, the performance is based upon the lifting capacity of the vacuum cups at a specific vacuum level. However in vacuum clamping applications, it is the holding force that is the determining factor of machine design success. Holding force is normally measured in Newtons (N), which is the SI unit of force measurement. The metric system, of course, offers simple conversions, and to help visualize Newton force, you can convert kg holding force to Newtons by multiplying the kg figure by 9.8 or using a “rule of thumb” by 10. Therefore, if you hang a 200-kg weight off the bottom of a crane hook, the force being exerted is 1960N (200 x 9.8) or about 2000N if multiplied by 10.

The first question that needs to be asked of the vacuum user is what holding force they require when vacuum clamping. If the answer is 5000N, then visualize the part being “clamped” under vacuum, having a 500-kg weight laid upon it. It’s the same and no more complicated than that. Imagine that the user needs to clamp an aluminum billet on a CNC machining center while various holes are drilled into it. This machining process is straightforward enough that if the holes are of a small diameter and if the actual billet itself has significant mass, then only a small amount of additional clamping will be required. However, if the aluminum billet requires serious machining with pockets being milled out and the outside profile being machined to shape, then a more substantial hold down method will be required.

Many applications utilize the common toggle clamp, as shown in Fig. 1. However, the toggle clamp method is often a troublesome obstacle to the machinist if they have to negotiate around the clamps while machining an outside profile, taking clamps away while the cutter passes, etc. This is particularly irritating if there are many pieces to machine.

By utilizing vacuum pods, as shown in Fig. 2, the machine operator is able to mill the complete profile without interference. This is demonstrated in Fig. 3, which shows the same work piece before and after machining shape.

Toggle clamps give a very specific clamping force based on the leverage and distance between the pivot point and contact distance with the work piece. Toggle clamps also offer a very obvious clamping “feel” to the user, whereas with vacuum pods the clamping force is not as apparent. However a 6" diameter vacuum pod connected to a vacuum source such as compressed air venturi or electric pump can offer 1559N at 27"Hg of vacuum. Therefore, the five pods being used in the application shown in Fig. 3 offer 7794N of holding force. Significant, when you consider this is the same as placing a 1750-lb weight on top of



Fig. 2

the work piece. Of course if you need a higher clamping force, use either more vacuum pods or ones with a larger surface area.

However, this is a vertical holding force. Serious consideration should be made to the type of vacuum seal or cup being used to resist side loading during machining. Fig. 4 shows a vacuum pod seal. This seal has zero deflection when under vacuum unlike the typical vacuum cup shown in Fig. 5, which will twist and flex under load. The seal shown in Fig. 4 has a particular surface that has small cusps protruding from the surface. These “grip” points offer significant resistance against side loads experienced during a machining process. A flat, smooth surface will offer very low friction and therefore low resistance against side loading.

Sometimes a machine bed with “submerged” vacuum cups is an effective solution as shown in Fig. 6, which uses the vacuum cup type shown in Fig. 5. The actual location face is now the machine

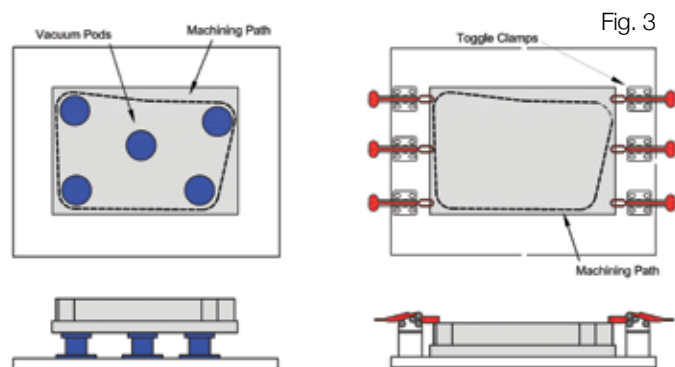


Fig. 3

table, and the part is located against a secure datum. With this method of vacuum clamping, the cup is simply pulling the work piece against the machine table face as the vacuum force compresses the vacuum cup. This is often used when machining larger work pieces such as steel sheet. Dimension X is the amount that the cup face protrudes above the machine table when there is no work piece in position. The vacuum cup should have a compression movement of more than this amount to allow location of the work piece against the machine table.

Vacuum generation is an important part of any vacuum system, but in vacuum clamping, often the wrong selection is made. Once the work piece is under vacuum and securely clamped in location, the vacuum source can be turned off to save energy. This, of course, is only practical if the vacuum seal is airtight and the part being held is not porous. In applications where the system is airtight, however, switching off the vacuum pump or venturi is a tremendous power saving and can be achieved by the correct selection of a vacuum switch and control valve technology.

Significant production improvements can be achieved by utilizing the correct vacuum components in a material clamping application. However as in most industrial applications, there are many different methods and indeed preferences used to dictate the end solution, but the final result is often one of component availability and supplier expertise.

This article is intended as a general guide and as with any industrial application involving machinery choice, independent professional advice should be sought to ensure correct selection and installation.



Fig. 4



Fig. 5

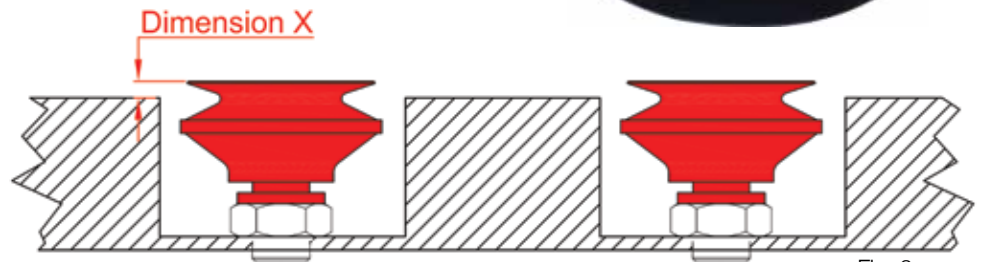


Fig. 6

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