Among our many reports on advanced fabricating technology, we have given little attention to...suction cups. This oversight will now be corrected, and for good reason: There are big chunks of cycle time involved.
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In dollars and cents, material handling is a very big deal in most aspects of metalworking, including fabricating. Getting work in and out of machines can take a sizeable percentage of cycle time and, as laser cutting and other processes become faster, loading and unloading loom as a growing relative cost.

And so it pays to take a close look at what’s being done to improve operations we may take for granted. It turns out that it’s not really so mundane; to optimize cost effectiveness requires a lot of engineering. We asked a specialist in the business, FIPA Inc., to bring us up to date. The following is the reply from FIPA’s head of their sheet-metal handling business unit, Stephan Eifler:

Virtual all sheet metal processing applications follow a standard sequence of tasks: vacuum suction cups pick up a metal sheet, swiftly move it to the target position, and deposit it in place. During this process, the vacuum cups must securely hold the metal sheet, resisting the forces generated, particularly the high shear forces experienced during the dynamic handling of metal sheets.
Thus, system designers require vacuum cups with an exceptional holding force, enabling them to handle even heavy metal sheets safely. The internal structure of these sheet metal vacuum cups can vary considerably depending on their manufacturer, but requires optimized contact surfaces and an internal cup design that effectively absorbs lateral forces.

In a highly dynamic gripper system, the vacuum must be generated rapidly once the cup is set in place. To ensure exact positioning of sheet metal parts, particularly during short cycle times, the vacuum cups should have superior elastic recovery, ensuring that cup deformations caused by forces exerted during handling are immediately corrected when the sheet metal sections are deposited.

Vacuum Suction Cups for Automotive Manufacturing

Work-handling companies are facing new requirement. The use of high-tensile steel in automotive manufacturing has driven the requirement for sheet metal handling equipment designed for hot working temperatures. The sheet metal blanks must be taken out of the thermoforming machine via vacuum cups capable of withstanding temperatures exceeding 200°C (392°F) for a short time.

Most metal sheets used in the automotive sector are also coated with highly aggressive self-drying.

‘The internal structure of these sheet metal vacuum cups can vary considerably depending on their manufacturer.’

Stephan Eifler, FIPA
oils designed to dry very quickly. Accordingly, vacuum cups that come into contact with these coated metal sheets must be oil-resistant. Nitrile rubber (NBR), a robust material with excellent resistance to oil, is ideal for vacuum cup handling systems used in automotive manufacturing. NBR material is also free of paint-wetting impairment substances (PWIS) and silicone, which allows the metal sheets to be coated or painted at a later stage.

Further, vacuum cups design for use in the vicinity of welding applications must be constructed of ozone-resistant materials, such as HNBR (hydrogenated acrylonitrile butadiene rubber), FKM (fluorinated rubber), and EPDM (ethylene propylene diene monomer).

Vacuum Suction Cups for White Goods Manufacturing
In the white goods or appliance sector, dry metal sheets are normally used. A low-marking bellows vacuum cup made of specialized wear-resistant polyurethane with two different degrees of material hardresses is the preferred design for these applications. The upper body of the bellows is made from polyurethane with a hardness of 60° Shore A, making it extremely stable, with superior resetting force and the ability to withstand high lateral forces without buckling. The sealing lip of the vacuum cup that contacts the sheet metal surface has a hardness of 30° Shore A, and is both supple and durable. Thanks to this soft and flexible sealing lip, the vacuum cup generates high holding force, even on slightly curved surfaces.

Configuring A Vacuum System for Sheet Metal Handling
When designing a vacuum system for sheet metal handling, the objective is to generate an optimum vacuum seal on the metal sheet. The vacuum pressure must be sufficient to ensure that the cups hold the metal sheet securely; however, excessive pressure can cause deformation of thin metal sheets due to deep-drawing effects. This is a crucial aspect to...
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Flexible sealing lip for a high retention force on curved metal sheets

Anti-slip supports for absorbing lateral forces and preventing deformation

Like a car tire, advanced cups have a structure that prevents deformation and absorbs lateral forces.

monitor, particularly when thin metal sheets are deployed in automotive manufacturing. Optimally designed vacuum cups have cleats to help counter these deep-drawing effects.

Vacuum cups designed to suit an array of different applications are widely available on the market, and can be divided into three general categories: flat, bellows, and oval designs. We use a comprehensive questionnaire in which customers can record all of the key application parameters they need to share with a automation solutions provider, who can then use the information to compile suitable components for the system design, including the vacuum generation process. >
Bellows vacuum cups facilitate the handling of sensitive materials and workpieces with uneven surfaces, since they can easily compensate for any variation in material height and angle.

Flat Vacuum Cups – Stable and Precisely Positioned

Flat vacuum cups stand out for the exceptionally stable suction they provide. When depositing items, they also enable precision positioning accuracy. Additional cleats in the suction cup increase the lateral stability, prevent more flexible products from being drawn in, and avoid suction cup slippage at high accelerations, all of which can be important when handling thin metal sheets.

Bellows Vacuum Cups Equalize Differences in Height and Angles

Bellows vacuum cups facilitate the handling of sensitive materials and workpieces with uneven surfaces, since they can easily compensate for any variation in material height and angle. At the time of vacuum activation, the workpiece is hoisted to the lifting height of the vacuum cup.

All providers make bellows vacuum cups in designs that feature a varying number of bellows. The more bellows a vacuum cup has, the greater the scope of lifting movement possible. However, increasing the number of bellows comes with the tradeoff of a decline in stability. With this in mind, experts recommend limiting the use of bellows vacuum cups to vertical-only handling operations.

For applications in which it is not feasible to use a bellows vacuum cup to balance out differences in lifting or height, suspensions can also be used. A range of designs and nipples are available on the market, and an experienced supplier can also offer customized fittings specific to the application requirements.

Oval Vacuum Cups for the Reliable Handling of Elongated Goods

Oval vacuum cups are the preferred choice when it comes to handling elongated or cylindrical metal workpieces, like blocks, profiles, tubes, or bolts. They can be used to
grip curved workpieces and products with bars and, compared to round vacuum cups, generate far higher suction force with the same width.

**Magnetic Grippers and Sprue Grippers as Vacuum Cup Options**

Vacuum cups aren’t the only load suspension devices suitable for handling metal sheets. Magnetic grippers can be used to hold metal sheets made of ferromagnetic material, and are the preferred choice when holding metal sheets with punch-outs and special forms that lack the available surface area to accommodate vacuum grippers. These grippers also allow users to select between electrically and pneumatically controlled designs.

Electrically controlled magnetic grippers do not require tubing, and are ideal for handling extremely thin ferromagnetic sheet metal parts or alloyed workpieces. As with magnetic grippers, these electrically controlled devices are able to secure the workpiece by leveraging the force action of a built-in permanent magnet. When depositing items, however, a brief electrical impulse flows through the gripper coil, which counteracts the magnetic force field of the permanent magnet, and allows the workpiece to be deposited swiftly and safely in place. This feature also helps accelerate cycle times and boosts process security.

The operation of pneumatically controlled magnetic grippers centers on a double-acting cylinder with a permanent internal magnet that either attracts or repels the workpiece. These actions generate the holding force needed to move the workpiece, as well as allow it to be deposited in place.

Both electrically and pneumatically controlled construction types deliver process reliability, though. As long as a permanent magnet is used, the workpiece will remain secured by the gripper, even in the event of a power outage or a loss of compressed air.

An additional alternative to vacuum cups are grippers with jaws fully coated in HNBR elastomer materials, as these can accommodate even delicate workpieces, such as stainless steel sink units, with a delicate grip.

**Heavy Metal Sheets Effortlessly Moved by Hand**

Vacuum-based lifting systems make the manual handling of large metal sheets, semi-finished, and finished products, as well as cardboard packaging, far easier. Employment of this technology has also enhanced efficiency in the sheet and metalworking industries, especially with regard to the loading and unloading of materials on CNC laser machining centers, punching machines, and other sheet metal processing machines.

An additional alternative to vacuum cups are grippers with jaws fully coated in HNBR elastomer materials, as these can accommodate even delicate workpieces, such as stainless steel sink units, with a delicate grip.
Vacuum tube lifters effectively ease the load for employees, enhance workplace ergonomics, and boost overall sheet metal forming efficiency. Further, when employed as part of a complete, customized lifting solution that also includes material handling components such as vacuum, gripper, and crane technologies, vacuum tube lifters can reliably handle structured, smooth, oily, dry, non-magnetic, and hot metal sheets in a process-reliable manner, while simultaneously eliminating the risk of bulges, scratches, and leftover residues that could potentially be harmful to paint.

A reliable vacuum must be generated to ensure that vacuum cups work properly. Conventional solutions typically come in the form of vacuum pumps, side channel blowers, or ejectors. Since metal sheets are usually made of dense materials, sheet metal handling using vacuum technology generally employs rotary vane vacuum pumps or ejectors.

Rotary vane vacuum pumps are the preferred choice for generating a high-end vacuum and a large volume flow at the same time. With a high final vacuum of approximately -999.5mbar (-14.5psi), and a volume flow of between 2m³/h and 300m³/h, they are primarily used to supply a vacuum in central vacuum facilities or for handling dense workpieces.

Ejectors enable a vacuum to be generated directly at the item being handled, creating a high final vacuum of around -900mbar (-13.1psi) with a low (~10 l/min) to medium (~800 l/min) volume flow, and are installed directly in the compressed air line or on the vacuum cup. Compared to rotary vane vacuum pumps, they deliver significantly shorter cycle times, and have the added advantage of virtually maintenance-free construction and operation.