Vacuum - The Universal Conveying Force
Suction and transportation of powders, liquids and gases

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With the introduction of the ATEX guidelines in Europe facility managers now have to seriously consider their in-plant powder and bulk material transport. While the legislation requirement as such may not exist in the USA, none the less the need to consider such aspects of safety surely does. Past health & safety regulations should have given enough evidence for the need of a dust-free powder transfer methodology. To meet such guidelines, Vacuum Conveyors have established themselves as the most suitable due to the "closed system" function, providing easy & safe feeding of plants, processes and containers. In the simplest of terms under vacuum if leaks do occur it is always inwards! This obvious advantage is but one associated with vacuum transfer since the negative pressure advantage can be put to additional effective uses.

Powder Conveying with Vacuum

Multijector® Venturi Vacuum Conveyors have the advantage over alternative pump technologies, in that they are able to transport the material with a substantially higher negative pressure (fig. 1)

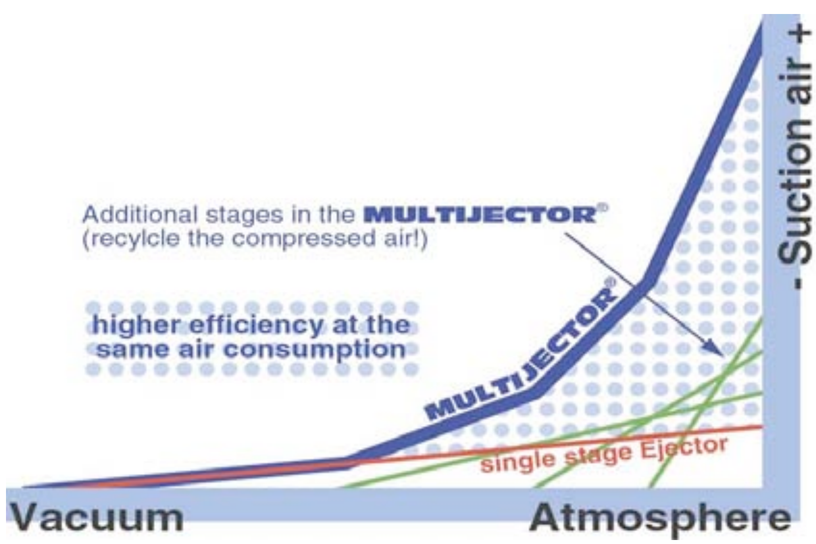

Fig 1 Graph showing the increased efficiency and vacuum potential of Multijector Pumps

Thus, a far larger application field is available. While basic suction conveyors can suffer suction line blockages when moving difficult and poor flowing bulk materials, this is not the case with Multijector® Vacuum Conveyors. The high negative pressure differential of up to 960 mbar is easily able to draw agglomerates and plugs through the conveying pipeline. Additionally, the low available pressure differential of conventional suction conveyors permits only Dilute (Lean) Phase Conveying which, owing to the high velocities involved, leads to strong mechanical stresses on the material to be conveyed and/or to extensive abrasive wear on the conveying line itself. Furthermore high velocities lead to the segregation of particles according to size. Many clients are unaware that Multijector systems can convey effectively at low velocities in Dense (plug flow) conditions.

With the Multijector® Vacuum Conveyor, the high vacuum level required for Dense-or-Plug Flow is available and this ensures gentle and separation-free material transport.

Efficient Vacuum Production

Both high negative pressures and large suction air-flow rates are available from multiple-stage, gas-jet-driven Multijector® Vacuum Pumps. These powerful ejectors are characterized by maintenance and wear-free operation, cyclic running (energy saving, since energy is only consumed when the suction part of the cycle is occurring, as opposed to continuously running electric pumps), compact and extremely simple installation. Power requirements are minimal because the supplied driving gas (usually compressed air) is used up to four times (in four stages) in the Multijector® Vacuum Pumps. The generated suction airflow created in one stage of the pump is recycled in the following stage to create an even larger total flow. (fig. 2)

The Multijector® Vacuum Pump contains no ignition sources (no electrical parts, no heat generation, no mechanical friction and spark impact, no electrostatic loadings) and therefore does not fall under that area of the new ATEX guidelines for explosion risk thereby illustrating the suitability for Explosion proof applications. The specific advantages of the Multijector® Vacuum Pumps can be utilized in many other processing areas.

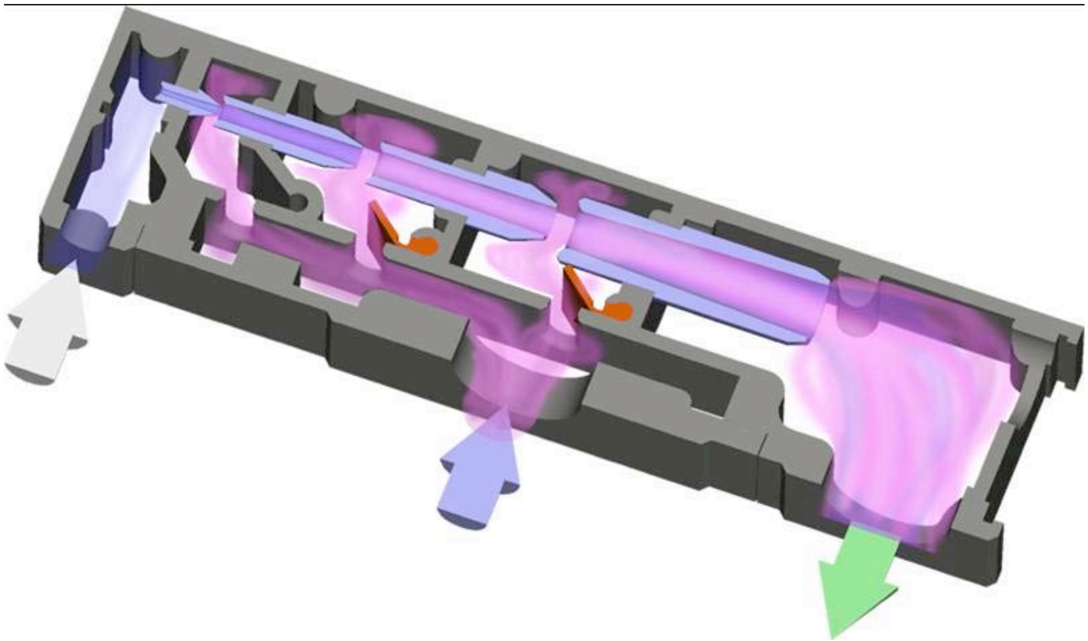

Fig 2 – Multijector Vacuum Pump – Sequential use of nozzles leads to high levels of vacuum down to -900 mbar

From Conveying to Powder-Locking

With the conveying of powders and granulates, the use of the vacuum goes further than the material transport itself. When loading chemical reactors, stirring vessels or cookers, the typical gravimetrical discharging of a Vacuum Conveyor under atmospheric conditions could be a disadvantage. In particular, problems can be found when solvents are present in the process-vessel. Vapors can escape into the conveyor. In this case, to minimize potential explosive conditions and or environmental concerns, the receiver of the Vacuum Conveying System is extended to form a powder-lock function thus: Towards the end of the suction cycle, a valve at the suction port (inlet) of the receiver is closed. The Multijector® Vacuum Pump continues to run and the powder inside of the Conveyor is thus exposed to vacuum. The amount of oxygen in this chamber, and in the already conveyed powder, is correspondingly considerable reduced. The powerful ejectors can achieve final negative pressures of up to 40 mbar absolute. Since the typical non-critical residual-oxygen-concentration is reached at 300 mbar absolute the mixture is inherently safe. After completion of this pre-evacuation cycle, the multi-stage ejector is switched off and the internal pressure balance is obtained by the use of a reverse jet air shock, which also cleans the filters. Commonly, the compressed air is replaced with nitrogen. In addition, a nitrogen-purging valve opens before the discharging valve opens and the powder is thus moved under a slightly positive pressure into the reactor or stirring vessel. If extremely small residual-oxygen-concentrations in the powder are desired, the pre-evacuation and the subsequent pressure balance at atmospheric level are successively accomplished in a series of steps. Here high dilution of residual O_2 concentration is obtained because the pressure balance takes place in each single step with nitrogen.

This principle is expandable, so the Vacuum Conveyor can be designed to provide a positive pressure powder-lock if required. In this case, special pressure-resistant receiver vessels and valves are used to build the Vacuum Conveyor (fig. 3).

Fig 3 – Examples of an Inert Gas Based Conveyor (Left) and a Powder Lock System (Right)

Alternatively, the conveying procedure and powder locking functions can take place separately. This is particularly interesting for applications in which the Vacuum Conveyor is mobile (e.g. for the loading of multiple vessels) or if it is not known whether powder-locking is necessary. Because of the modular design of the entire Vacuum Conveying System, the powder-lock can be added at any time (fig. 3).

The powder transfer system becomes increasingly secure if the actual material conveying procedure takes place, not by means of normal ambient air, but under an inert gas environment. This can be necessary from an explosion-technical view or when oxidation-sensitive powders are to be conveyed. In this instance additional special injection nozzles in the suction location are utilized. The material to be conveyed can be introduced into the conveying cycle with a hopper (charging funnel), suction wands (manual operation) or with the Automatic-Bin-Discharging-System. If a precise dosage of the bulk-solids into the process is required, the Vacuum-, Weighing and Dosing System (VAWIDOS) is selected.

Liquids and Steams

Users trust multiple-stage ejectors not only for powder transfer, but also for the suction and transfer of liquids. Such systems are similar in design to powder conveyors, the vacuum pump being connected to a receiver/separator on the suction side. When handling inflammable liquids such as oil, benzene or solvents, non-electric Multijectors® have safety advantages compared to conventional mechanical and electrical vacuum sources.

If aggressive steams or vapors, which typically react adversely with conventional pumps, are to be removed, then a multi-stage ejector is the best choice since these pumps are available in stainless steel (various grades, AISI 316 l, etc.). These special RVA-Multijectors were developed for specific applications, e.g. in order to remove gas bubbles from a viscous liquid using the strength of the applied vacuum. Here the space above the liquid level is evacuated with a powerful stainless steel ejector achieving vacuum levels down to 40 mbar absolute. As a consequence, gas bubbles are drawn out of the liquid and removed by the pump.

The importance of a flexible material choice becomes clear in the following example: In a chemical-pharmaceutical company, it was current good manufacturing practice to CIP (Cleaning in Place) the entire piping system attached to the vacuum pump, with a hot caustic soda solution. In this example our client used mechanical roots-vacuum-pumps, which were briefly switched on in order to draw the cleaning liquid through the piping. However, the roots type pump needed to be switched off in time to ensure rinsing of the piping system while avoiding contact of the pump with the aggressive caustic soda solution. This failed to work reliably, and the mechanical pumps experienced frequent damage. As a solution, they were replaced with Multijector® jet-pumps made of stainless steel and CIP ready. These can be intensively rinsed with caustic soda solution and since ejectors can be mounted in any desired position, they are installed vertically to allow easy drainage of the rinsing fluid.

Contrary to the suction of powders and other particles, steams and aerosols cannot be separated completely before the vacuum pump. This leads to conventional mechanical pumps experiencing repeated problems because the gas or liquid phase, which is to be drawn off, appears later in either the circulated oil of the rotary vane pump or in the operating-liquid of the water ring pump. These contaminated operational-liquids must then be recycled at considerable expense. Dry running Multijectors® eliminate this expense and can easily be made of an appropriate chemical-stable material.

For more information on any of the applications described, to arrange a test, or to discuss a specific need, contact

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