Vacuum Systems for Cans

Daniel Hilfiker, CEO at Pneumofore, describes various vacuum system solutions and technological trends

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Exquisite engineering is typical for two piece can production. The speed and the quality are constantly improved, we observe how tests for latest technologies in various steps of production are being executed by large can companies in several plants. The experience and understanding of engineers are impressive when it comes to minimal adjustments of many production phases to optimize the productivity.

Here we look at a secondary issue, vacuum is part of the facilities, yet crucial for speed and precision. Today, visiting two piece can factories worldwide, we observe following situations regarding **vacuum system design**:

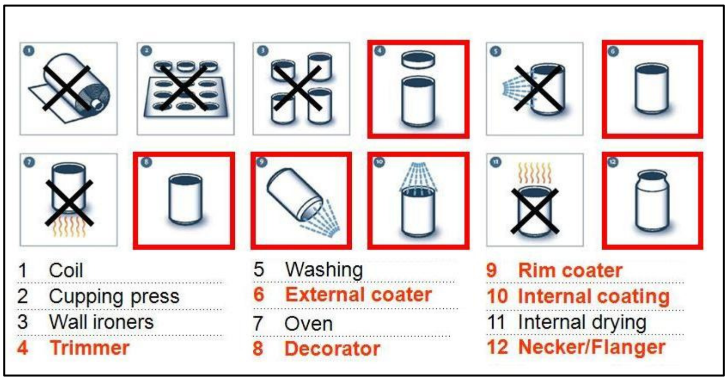
1. **centralized** vacuum system, 2. **Spread out** vacuum pumps and 3. **combination** of 1. and 2.

A **new factory** built today usually considers solution 1. Yet, it is not rare to find state-of-the-art factories, which failed to dimension the vacuum system correctly, independently from the chosen vacuum technology. Pumps must be added to satisfy the vacuum requirements in various spots, this is achieved either with more pumps in the central vacuum pumps room or with new, little, almost portable pumps installed exactly where required. The initially scheduled solution 1. turns into solution 3. within few months only after production start.

The commissioning phase, the start-up and the **first few years of operation** by the new can line are managed carefully. But when the senior engineers leave and production is meant to be smooth and linear, with a high output, when all single manufacturing processes are trimmed to the top, other issues arise, like insufficient vacuum level or low vacuum capacity due to seasonal climatic changes or vacuum system efficiency losses.

Particular for the vacuum application in cans is the continuous production, 24/7 with low need for personnel, compared to other industrial sectors. The evacuated air is quite clean, there are no problematic contaminants which could damage the vacuum pumps. Furthermore the vacuum capacity is kept constant, it is not a cyclic evacuation process, which has different design criteria.

Vacuum is next to electrical power, cooling water and compressed air. Out of these four, **vacuum is the most tricky** one, difficult to engineer, hard to budget on the long term. Still, it is kept on the same level like the others, where an electrical power supply is easier to quantify and calculate, eventually adapt. To generate compressed air and vacuum, machines are installed nearby the production line, to avoid capacity and pressure losses. The constant round-the-clock operation requires reliable equipment, production cannot be interrupted just to service a vacuum pump or a compressor.



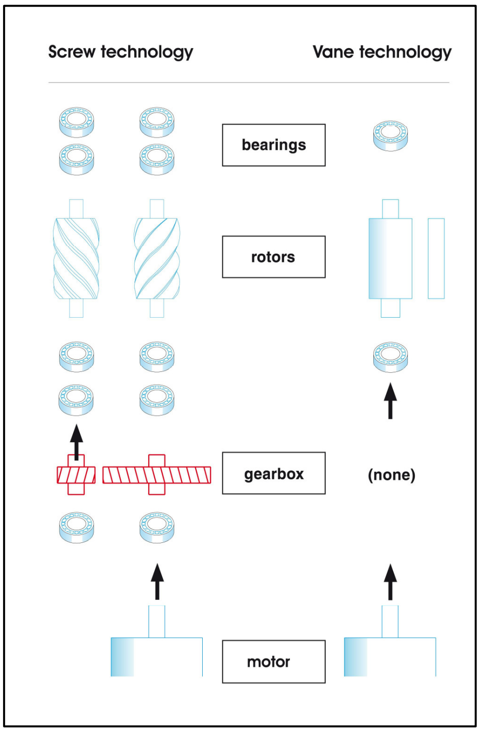
Picture n. 1 - Vacuum use in can production, courtesy of Rexam

Some production technicians faced situations with insufficient vacuum and the almost tragic consequences. Learning out of this experience, stand-by units are kept ready, not to jeopardize the production again. Only few, usually very skilled engineers assist the erection and operation of many can factories on different continents, experience which offers them the possibility to compare seriously many vacuum system layout solutions and long term performance of various vacuum technologies. These are the **experts who seek reliability, durability and efficiency** for all facilities, including vacuum, as there are enough potential worries on the production line itself. Vacuum shall be available and adaptable like the electrical power supply, just another energetic form.

After this basic description of production circumstances and of vacuum system design, we look now at the possible **vacuum technologies**. First is to be considered, that a vacuum pump alone is of little use if the piping design is not properly calculated and dimensioned, with sufficient safety margin. Vacuum is not the opposite of compressed air, system design requires special competence, it cannot be simplified to a number referring to the installed nominal power or theoretical capacity of the machines. The average size of a vacuum installation for a modern can line involves about 250 kW of nominal power. The power consumption cost is easily calculated, difficult are the long term ordinary maintenance, repair, overhauling costs, which all together add up to the **total Life Cycle Cost** over 5 or more years. This is the real expense for vacuum, this is the first engineering criteria for specialized vacuum pumps.

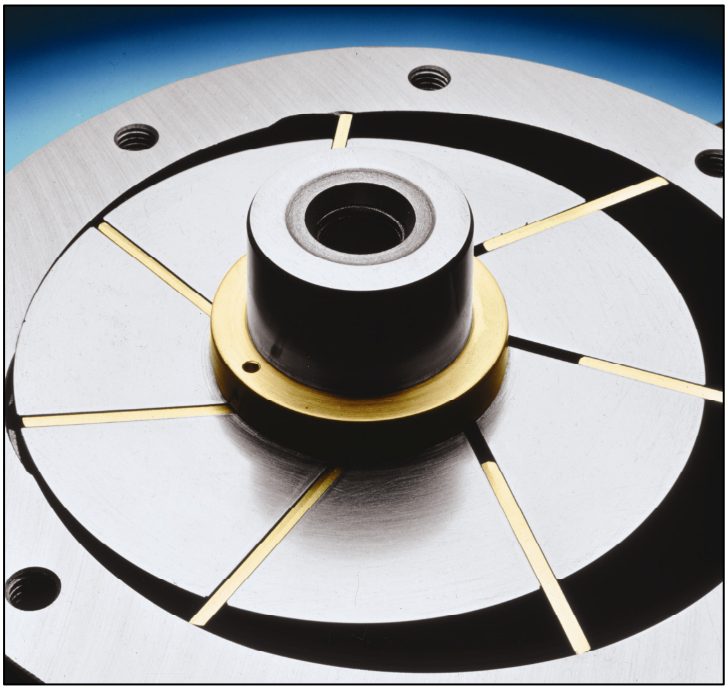
Basically we can separate **piston, vane, screw and liquid ring technology**. Only vane and screw can be air cooled, piston pumps are multi-stage with intercooling and liquid ring pumps strongly depend on the water. Industrial vacuum engineers know which technology causes how much trouble, thus costs. While the reliable and durable multi-stage piston pumps are disappearing due to their dimensions and complex repair, the other three are interesting to be compared. It is important to say that different manufacturers have different design criteria, so that you can find low to high quality products. However, hardly any screw pump producer started as vacuum machines factory, the vast majority of screw pumps are derivate from screw compressors.

Screw machines are offered at attractive low prices, but their performance decreases in the long run. The two screws of the air end do not have active sealing between the compression chambers and require **frequent maintenance** as well as the screw air end overhauling after about 25.000 hours of operation. The presence of an oil pump on all screw vacuum pumps shows how the internal suction potential of the pump is not used for a simple and reliable lubrication and cooling. The **initial savings** on the price tag disappear soon due to the mistaken approach of a vacuum pump being (compressor)$^{-1}$. High rotation speed up to 6.000 rpm, gear box as transmission and six bearings in the screw air end are standard. Screw machines also base on few decades of experience only and it is not uncommon to find desperate long term screw pump users.



Picture n. 2 - Comparison of screw structure vs. vane

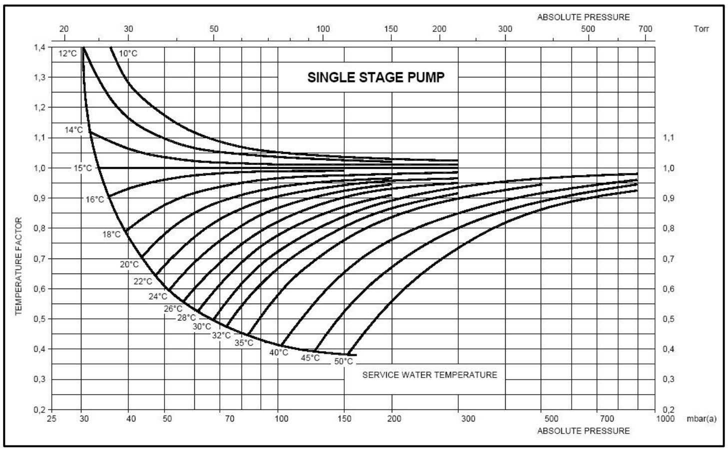
Vane pumps can be as small as few kW, but the ones here considered are of large capacity with a flow of several thousands m^3/h. Active sealing with non-consumable vanes made of metal guarantee efficiency in time. Like the piston machines, curious how they even increase their capacity, as the parts in contact (vanes and housing) adapt to each other and improve their sealing feature in time. This fortunate evidence is opposite to the above mentioned screw pumps. Vane pumps are also found as numerous small on-spot machines, but only in case of miscalculation or considerable vacuum requirement variation in certain production steps. Our focus goes towards industrial rotary vane vacuum pumps which have **direct coupling**, only two, oversized roller bearings, low running temperatures due to low rotation speed, with the option of air cooling also in hot climates. **Latest results** in rotary vane technology offer the variable speed option which allows to keep the vacuum level constant at certain set point, with optimized power consumption. Obviously, we talk here of vane pumps with no consumables, where only the lubricant, the oil separation and oil filter as well as air intake cartridge are replaced. This service operation shall be executed as rarely as possible, once or twice per year only. The negative side of state-of-the-art vane pumps is their higher selling price compared to rotary screw technology.



Picture n. 3 - Rotary vane section

Liquid ring pumps run trouble free for decades. Peace of mind is certain as long as the eye does not see the electrical power bill. The sealing is achieved with a water ring, which causes friction and high power consumption. Important is that a liquid ring pump alone does not work, it demands a cooling water circuit with water pumps and cooling towers, water integration and preparation. Being the **cooling water temperature** crucial for the liquid ring pump performance, particularly in tropical countries, the water cooling is enhanced with chillers. All the initial purchasing costs add up, including water piping and also the operational costs are considerable, as all devices of the vacuum system contribute heavily. The total cost of operation is such, that the average Return on Investment, following their replacement with modern pumps, is often less than 18 months.

Recently I met an Energy Manager of a major can production group who had made the detailed analysis of the different machines in various plants: ''We cannot discriminate any technology but numbers regarding costs for maintenance, power consumption and repair, as overhauling, speak clear. The correct choice of vacuum technology is insufficient, various brands offer different solutions. The key is the **competence of the supplier**, especially concerning vacuum system design, as piping dimensioning is an integral part of the offer for some experienced manufacturers only. The perspective here adopted is ten years, anything lower isn't aligned to the can factory lifespan''.



Picture n. 4 - Efficiency factor of liquid ring pumps vs. water temperature

Description of the Author / Company

Daniel Hilfiker represents the third generation of Swiss engineers managing Pneumofore, the world's oldest rotary pumps and compressor factory, celebrating soon 90 years. He is personally engaged in R&D due to his commitment to lowest environmental impact which corresponds to minimal operational costs. Daniel participates to the Asia CanTech Conference on regular basis, he appreciates the high mechanical engineering skills of the participants. Nevertheless, his vacuum theory and products are also applied in aerospace, medicine, drying processes, petrochemical and more. Pneumofore does not run the purchasing price races, sales are achieved with Return on Investment calculations when replacing vacuum pumps and air compressors of other technologies and brands. Particular for Pneumofore is the world's largest single-stage and air-cooled rotary vane pump named UV50, with important options like variable speed drive or extra cooling for hot climates up to 50° C. These pumps are found worldwide and famous for their extraordinary and absolute lowest Life Cycle Cost.