Custom vacuum solutions for analytics

Integration of modern vacuum technology into advanced analysis systems
The demands placed on vacuum technology in the field of analytics are very complex. Aggressive cost targets must coincide with high performance requirements and tighter space constraints. Consequently, the use of intelligent differential pumping systems based on the SplitFlow™ concept is a logical choice.

To meet the requirements of analytical instrument and systems engineering in vacuum technology, it is essential to integrate them early in the design stage. This is the only way in which goals such as higher sensitivities, improved resolution and greater sample throughputs as well as significantly improved data management can be implemented alongside cost and space optimization in new analysis systems. In the process, special attention must be given to the vacuum system. Early professional consultation with vacuum experts is necessary to maximize the integration of vacuum technology into existing systems.

Market conditions and system requirements
The requirements for new systems are constantly increasing and call for corresponding adjustments to be made to adjacent modules. Typical applications such as LC-MS (liquid chromatography mass spectrometer) or GC-MS (gas chromatography mass spectrometer) may not make any especially critical demands on the vacuum system themselves. However, with ionization procedures such as chemical ionization (CI) and plasma ionization (ICP), or in the presence of critical gas components of analytes and reactants, demands on the vacuum technology can increase significantly. Major

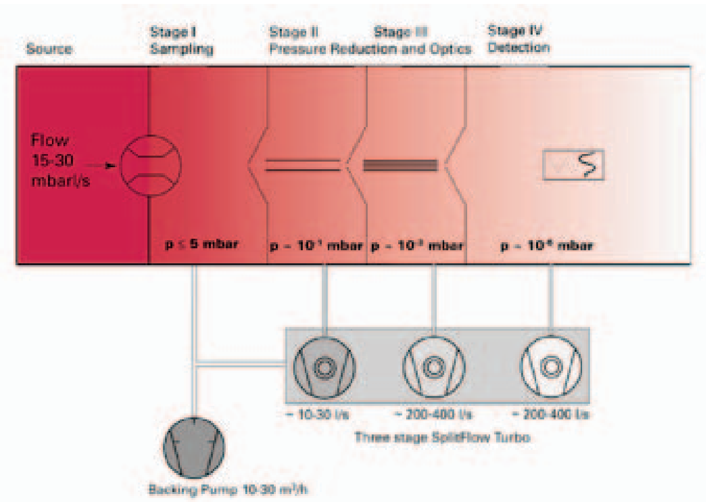

Figure 1: Innovative mass spectrometer system with a three-stage SplitFlow™ turbopump

Figure 2: Four different versions of Pfeiffer Vacuum SplitFlow™ turbopumps

application areas and growth markets for mass spectrometry are environmental technology and sectors of biomedicine, in particular protein and genetic research. Furthermore, this principle is used in the pharmaceutical industry as well as in applications for residual gas analysis.

Numerous new developments and new technologies are revolutionizing the market for mass spectrometers and increasing the choice and range of diverse functionalities. The drive for new developments is not only determined by the technological possibilities but also by new needs in certain healthcare and environmental engineering areas. However, even more technological possibilities are available, and the industry is happily taking these on as a challenge.

Driven by these new applications, the demands placed on the required vacuum systems are also growing, asking for higher throughput and improved resolutions. Cost-effective and compact solutions are in high demand.

Conventional technology

Traditionally, differentially pumped vacuum systems such as sample chambers, some multi-stage ion optics and the detector system of a mass spectrometer are evacuated with discrete high vacuum pumps. Turbopumps are primarily used for this purpose, while separate pumps are used for the respective pressure and gas throughput ranges.

At least two high vacuum pumps with a pumping speed of between 50 and 300 l/s are necessary. These are pre-evacuated by using a small mechanical backing pump, such as a rotary vane pump. An additional vacuum pump is also required for evacuating the source. Depending on the requirements, it must attain a gross pumping speed of at least 30 m^3/h or more. This solution requires a lot of space and the reliability of the overall system is reduced due to numerous individual components.

Innovative concepts

The SplitFlow™ principle developed by Pfeiffer Vacuum uses a modular approach to the basic process of designing turbo drag pumps, thus offering maximum flexibility for the system manufacturer. The concept developed combines precise adaptation of the geometry and the performance data within a single vacuum system. Particularly in view of the growing complexity and the trend towards benchtop devices, this principle precisely matches the requirements of the market and the customer's wishes. In addition to pure geometrical adaptation, it is necessary to achieve specified vacuum technology parameters. By integrating different pumping principles (for example, combining a turbopump and a Holweck pressure stage), the tolerable fore-vacuum pressure, for example, will be significantly increased and the compression performance will be enhanced by several degrees of magnitude. By cleverly arranging the rotor geometry, it is possible to produce up to three different pumping stages which are oriented in a way that they only partially influence each other. This arrangement allows up to two discrete high vacuum pumps and one mechanical backing pump to be replaced.

The diagram in Figure 2 describes the possibilities offered by such a concept. The design can even go so far as to realize complete integration into the vacuum chamber of the analyzer. This requires close cooperation between the system manufacturer and the vacuum supplier from the very beginning. Sound advice in the design phase is of essential importance here. The result is a significantly reduced footprint of about 50 percent for the vacuum system as well as significant cost savings of over 50 percent, too, depending on the system´s configuration. By eliminating discrete pumping units and using findings from the series production of standard pumps, a pump reliability of over 100,000 hours MTTF (mean time to failure) can be achieved today.

This high reliability is made possible by an optimized bearing technology, which positions the rapidly rotating rotor on either side with a maintenance-free magnetic bearing and a precision ball bearing, so that it is effectively damped.

The pump is complemented and completed by the corresponding integrated electronic drive unit as well as by the extensive range of accessories. Standardized interfaces are available for the computer-controlled integration of the turbopumps. Due to the special arrangement, these pumps only require one air cooling system, which means that additional water cooling and other installation costs can be dispensed with.

Implemented and available concepts
It has been possible to develop different concepts for vacuum in cooperation with various system manufacturers. The modular and flexible approach allows individual adaptation to customer requirements.

Application	Typical pumping speeds of different stages [l/s]	Typical differential N_2 compression ratios
Plasma monitors	60 - 5	$10^5 – 10^7$
Helium leak detectors	30 - 10 - 5	$10^3 – 10^6$
Electron microscopes	230 - 10	$10^3 – 10^7$
Mass spectrometers with different specifications	200 - 130	$10^3 – 10^6$
	280 - 240	$10^3 – 10^7$
	280 - 240 - 10	$10^3 – 10^5$
	400 - 400 - 30	$10^3 – 10^7$

Figure 3: Typical applications with custom turbo drag pumps based on the Pfeiffer Vacuum SplitFlow™ concept

Summary
Early integration of innovative SplitFlow™ turbopumps in the design of modern mass spectrometers has made it possible to realize significant cost and space advantages. In addition, overall system reliability is enhanced. Tailor-made solutions can be designed and implemented. As a result, close cooperation with the customer becomes increasingly important. It is only through this that co-creative vacuum solutions become possible.

Vacuum solutions from a single source

Pfeiffer Vacuum stands for innovative and custom vacuum solutions worldwide, technological perfection, competent advice and reliable service.

Complete range of products

From a single component to complex systems: We are the only supplier of vacuum technology that provides a complete product portfolio.

Competence in theory and practice

Benefit from our know-how and our portfolio of training opportunities! We support you with your plant layout and provide first-class on-site service worldwide.

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