

mzr® - micro annular gear pumps

Pump technology between »Micro« and »Macro«



Highly precise dosage in the range of microliter and milliliter as well as smallest flow rates are the demands on pumps today in analytical instrumentation, process technology, medicine, biotechnology or industrial production. Offering a high process safety, micro annular gear pumps develop a new dimension of dosage and metering for numerous applications.

High-tech materials and precision mechanics employed in the manufacture of the micro annular gear pumps guarantee their excellent quality and unique features for low dosage volumes and flow ranges in such aspects as accuracy and pressurization, chemical compatibility and long service life.

Product range

The product range of micro annular gear pumps comprises four different lines of products showing different construction solutions, housing sizes and different performance. The pumps have flow rates ranging from 1 µl/h to 1.2 l/min or discrete dosage volumes starting at 0.25 µl. Dosage precision of better than 1% CV at low volumes is assured by precision DC drives. Due to the use of

extremely hard construction materials, it is possible to pump even non-lubricating liquids at a constant precision in a continuous operation.

Product lines

The *high performance pump series* is well suited for challenging dosage tasks requiring high precision in middle pressure range, high temperatures and for viscosity values ranging from 0.3 to 1,000,000 mPas. The pump is characterized by a double-sided bearing system and is driven by a powerful DC-servomotor with integrated control.

Considering a large choice of

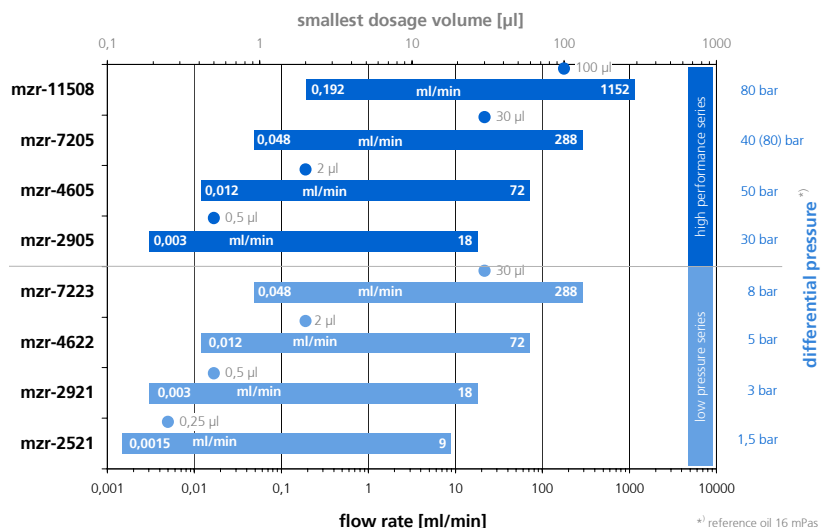
complementary modules such as the fluidic seal module, reducing gears, and an explosion-proof motor the pumps target both industrial production and demanding laboratory applications.

Depending on the pump size, standardized connectors 1/4" -28 UNF, 1/8" NPT or 3/8" NPT are offered.

The *low pressure pump series* targets precise dosage tasks at low pressures and for low viscosity values. The surprisingly small dimensions, low power consumption and simple integration in OEM applications of these pumps have been achieved by using DC mini motors. As to the compact construction, it is based on one-sided patented bearing system. The liquid supply can be connected either with slip fittings or a manifold assembly.

Due to their attractive price-performance relationship, the low pressure pumps are suitable for integration in analytical devices.

The *modular pump series* is provided with ceramic precision-machined rotors offering optimal



tribological and chemical properties for use with aggressive liquids. As to the remaining components, a choice of different materials is provided to customize the pump depending on the nature of the delivered liquid. The rotors are available in ZrO₂ ceramics or in the proven tungsten carbide. Alloy C276, titanium and PEEK™ are the different options for the pump body. The pump meets with the needs of biotechnology, analytical instrumentation and micro reaction technology.

The *hermetic and chemically inert series* has been specifically conceived to fulfill the most challenging tasks in chemical processing, mini plant and microreaction technology. The functional elements of this pump series are made of partially stabilized zirconium oxide. This material, universally recognized for a high chemical resistance allows for use with oxidizing and reducing liquids, acids, bases and solvents at the same time showing excellent resistance to wear. SSiC has been used as shaft and bearing material and the body consists of alloy C22. Due to the use of a magnetic NdFeB coupling the pump is perfectly hermetic.

Applications

- Chemical processing
- Industrial and plant engineering
- Packaging
- Medical and pharmaceutical industry
- Mini plant technology
- Spray technology
- Dispensing of adhesives
- Ink and paint dosage
- Analytical instrumentation
- Fuel cells
- Biotechnology
- In vitro diagnostics
- Microreaction technology
- Vacuum applications
- Silicone application
- Polyurethane filling
- Separating agents, parting compounds
- Micro hydraulics

To the application scope of mzp-pumps belong mechanical and chemical engineering, material processing, analytical technology, medical, environmental and biotechnology as well as other fields in which small amounts of liquids need to be metered precisely and fast.

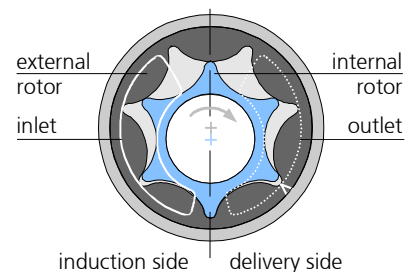
Operating principle of the micro annular gear pump

Micro annular gear pumps are *positive displacement pumps* provided with an externally toothed internal rotor and an annular, internally toothed external rotor turning around slightly eccentric axes. Both rotors are interlocked at any time with their *cycloidal indenting* and form during rotation a system of several sealed pumping chambers.

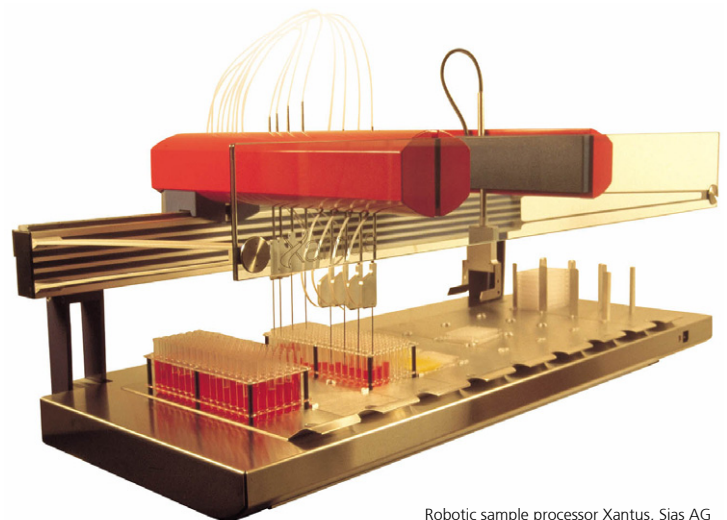
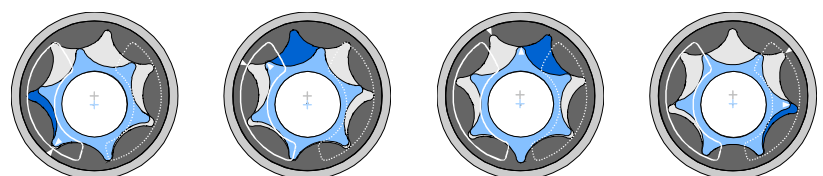
As the rotors turn around their offset axes, the pumping chambers increase on the induction side and simultaneously decrease on the delivery side of the pump. A homogeneous flow rate is generated between the kidney-like inlet and outlet. Operating without valves, the pumps are characterized by a *small clearance vol-*

ume and are therefore *self-priming*. The device works at low noise and assures a low shear stress operation.

The pump is directly connected to the motor shaft by means of a torsion-proof, flexible coupling. As to the sealing between the fluid-containing part of the pump and environment and drive, it is assured by a spring-loaded rotary lip seal.



If needed, the operating direction of the flow may be reversed.



Robotic sample processor Xantus, Sias AG



Small dimensions

Micro annular gear pumps open, owing to their small measurements, new ways in the field of fluid handling techniques. The compact design of the pump, drive and control and what follows small cubage, short tubing and low weight make them particularly suited for integration into devices. Pumps may therefore be applied in the direct process proximity such as among other in liquid handling robots and analytical instruments.

Precision and accuracy of dosage

The special feature of the micro annular gear pumps are their high precision rotors. They stand for a precise fulfillment of both delivery and dosage tasks as well as work under elevated pressures, which, depending on the rotor size and the displacement volume, may amount up to 80 bar an higher. HNP Mikrosysteme applies highly precise manufacturing and control methods to assure that the position and shape tolerances of the crucial pump components lie within the range of 2 µm. The types of machining employed are grinding and electro discharge machining, the latter being employed for the rotor set. The functional parts of the pump are made of *tungsten carbide* and *ceramics*, which enables to hold extremely

tight tolerances and assures both excellent resistance and high pumping efficiency.

The *dosage precision* of the pump at constant working conditions and for a given flow range or for given metering volumes in case of water solutions is better than 1% CV (Coefficient of variation) at low volumes. Higher precision or greater operating pressures may be obtained at higher viscosity values.

Materials and resistance

Depending on the pump series and type, the wetted components of the pumps consist of nickel-based tungsten carbide, ceramics Al₂O₃, ZrO₂, SiC, high-grade steel 316L, alloy C276, alloy C22, titanium, nickel-silver, PEEK™, graphite-reinforced PTFE, FPM, EPDM and FFPM.

The use of tungsten carbide, material showing an excellent resistance to both corrosion and wear and a high stability in longtime loads, assures high reliability of construction elements that are moved against each other.

Wetted parts

	High performance series	Low pressure series
rotors	tungsten carbide Ni-based	tungsten carbide Ni-based
shaft	tungsten carbide Ni-based	tungsten carbide Ni-based
bearing	tungsten carbide Ni-based, sapphire	tungsten carbide Ni-based, Al ₂ O ₃
case	stainless steel 316L (1.4404, 1.4435)	nickel-silver, 316L (1.4435), epoxy resin
static seals	FPM, EPDM, FFPM	FPM, EPDM, FFPM
shaft seal	PTFE, spring 316L	PTFE, spring 316L

PEEK™ is a registered trademark of Victrex plc

The use of the above mentioned materials stands for a *good media resistance* allowing the delivery of a large variety of lubricating and non-lubricating liquids such as deionized water, water solutions, solvents, methanol, oil, fats, adhesives, dyes and ink as well as high viscosity liquids. In the case of the modular series and the hermetic and chemically inert series also highly aggressive oxidizing and reducing liquids such as acids, bases and solvents may be handled.

Liquids that chemically react in contact with oxygen or water may be delivered by a high performance pump equipped with an optional fluidic seal module. The module enables to manipulate crystallizing liquids and other problematic media. Owing to this additional seal and a low NPSH_R value, the pump can deliver liquids showing high steam pressures and is adapted to vacuum applications.

Liquid compatibility

Low pressure / high performance series

acetone	+	mercury	+
acetonitrile (ACN)	+	methanol	+
acrylic enamel	-	mineral acids	-
adhesives	+	nitrocellulose lacquer	-
alcohol	+	oil	+
alkyd resin varnish	+	organic acid	o
blood	+	paraffin	+
cianoacrylate	-	pentosin	+
diesel	+	polishing slurry	+
dye	+	polyhydroxy alcohol	+
emulsion	+	polyurethane varnish	+
epoxy resin	+	radioactive iodid solution	+
fat	+	salt solution, 0.9 %	+
foto-lacquer	+	screw locking coating	+
fruit juice	+	silicone gel	+
gasoline	+	silicone oil	+
glucose-syrup	+	soap solution	+
glue	+	solvents	+
glue for cigarettes	-	stearin	+
heparin, EDTA	+	sugar solution	+
hydrochloric acid dilute	o	tetrahydrofurane (THF)	+
hydrochloric acid strong	-	titanium oxide susp.	+
hydrosilicon	o	UV-adhesives	+
ink	+	water deionized	+
isocyanate	+	watery solution	+

Legend: +...suitable o...conditionally suitable -...unsuitable
Note: Liquid determines pump configuration

For the modular as well as for the hermetic and chemically inert pump series the liquid compatibility goes far beyond the values stated in the chart above.

The *operating temperature range* of the pumps lies between -20° and $+60^{\circ}$ Celsius. By using supplementary measures, such as the heat-insulation module, the temperature range for the high performance pump series can be extended to up to 150° Celsius.

In the case of the high performance pumps the construction materials are uniform showing the same coefficient of thermal expansion. This enables to expand the liquid temperature range in order to deliver melts or liquid gases.

Service life, Maintenance

Compared to other metal or plastic made metering pumps, micro annular gear pumps have considerably longer service lives. They show only smallest changes in dosage precision over longer operating periods. Hard and wear-resistant materials enable to use the pumps even for liquids containing particles.

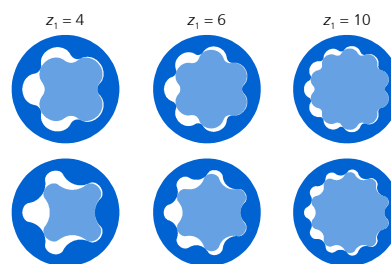
Due to the internal toothing, micro annular gear pumps show *excellent tribological properties* and a limited transmission loss. This is because the relative speed at the touching points of the rotors is reduced by the factor of the teeth number of the outer rotor.

The valve-free mzz-pumps offer *good maintainability* and a *long service life*. From the economic point of view this yields to longer maintenance intervals and lower costs for spare parts compared to other pump technologies.

Pulseless delivery

Due to the use the annular gear technology, the mzz-pumps show an outstandingly *low pulsation* and can therefore be used in applications demanding a *high flow rate constancy*.

The geometry of the gearing is decisive for the operating parameters of the pump. The number of teeth, the design and the dimensional tolerances considerably influence the achievable dosage precision, differential pressure, cubage and pulsation of the flow. HNP Mikrosysteme has developed its own *calculation* and *simulation models* which permit to determine an optimal, application-specific geometry of the gearing.



Dynamic features

Because of their low *mechanical inertia* micro annular gears have excellent dynamic features. They are suitable for fast dosing tasks within a *large flow rate range*, as the liquid is sucked in and discharged through large inlet and outlet in a slewing motion of 180° . At the same time the cavita-

tion effects in the induction area are being reduced.

Delivery of suspensions

The delivery of *liquids with solid content* is possible, however each individual application requires a throughout check. Positive experiences with ink, dye, suspension for polishing or with catalysts as well as liquids containing silicate have been carried out. A feasibility test should be done prior to such applications.

Low shear stress

The geometry and kinematics of the cycloid gears assure *low shear stress* during the delivery of sensitive liquids like biological cell solutions, blood etc. The observed damage rate of cells is as low as 2 %.

Drive technology

Offering economic dimensions and advanced control technique *DC drive* technology is the basis for a compact design of the mzz-pumps.

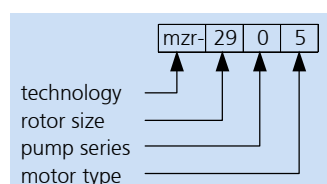
Due to the high function-related requirements exclusively *precision motors* are used. Depending on the dosage requirements, constant flow rates can be achieved with standard motors for continuous delivery. In the positional control mode the pumps can be applied for *precise metering* tasks. If special demands are submitted, HNP Mikrosysteme offers cus-



tomers-specific drive solutions such as stepper motors, AC-motors or DC-motors with higher power rates or *explosion-proof motors*.

The default resolution of the rotation with 16/32/100 increments per turn for the low pressure pump and 1,000 increments for the high pressure pump can be increased by using reduction gears.

By this measure the speed of rotation and consequently the flow rate can be decreased.



Nomenclature of the pumps

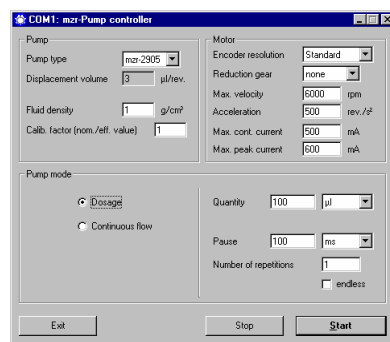
Control

The product program comprises an additional set of control modules carefully selected to complement the drive technology. Various OEM circuit board solutions and console drive modules are offered optionally for all product lines.

The control unit permits to operate the micro annular gear pump supported either by a built-in potentiometer or by an external analog interface (0–10 V or 4–20 mA). The execution of *PC* and *process computer-controlled* dispensing tasks is carried out via RS-232 interface. With the multiplexer circuit boards it is possible to *run simultaneously* up to 255 pumps with one single RS-232 interface. The pump may alternatively be operated with via a CAN-Bus interface.

Two programs provide support to the user as far as the operation of the pumps is concerned. The user-friendly control program »mzr pump control« can be applied for laboratory and test operation of the pumps. Two program modes

<continuous dosage> and <discrete dosage> enable to program and run the pumps and permit to adjust such motor parameters as the velocity profile, the maximal rotation speed and the current supply.



The execution of different dosing tasks is controlled by means of the PC-program »Motion Manager«, delivered with the device. It permits to specify the desired dosage amounts or flow rates and the timing via a graphical interface under MS Windows®. By using the ASCII command-language program and a RS-232 interface various parameters, data and programs can be transferred and stored in the EEPROM. A library of *sample programs* supports the user in fulfilling individual dosing tasks.

Supplementary modules for high performance series

A system of different supplementary modules has been conceived to increase the application spectrum of the universal high performance micro annular gear pumps.

For the delivery of liquids sensitive to air or water and for vacuum applications the *fluidic seal module*, a fluid chamber installed behind the pump shaft, can be provided. The sealing liquid prevents the delivered liquid from contact with the outer environment.

With the use of the heat insulation module hot liquids of up to 150° Celsius may be delivered.

This module made out of a synthetic material PEEK™ includes a thermally isolated coupling assembly between the pump and the motor in order to prevent the overheating of the latter. For applications in medicine and in food processing a hot steam resistant, sterilizable version (SIP) of the pump head is available.

To stabilize the temperature of the pumped liquid, a *heating module* actively increases the temperature of the pump head.

Different drives and *reduction gears* can be chosen for the high performance pump with regard to the output, speed and position control. Also an explosion-proof motor according to ATEX is optionally available for this type of pump.

For the dispensing of particle-free adhesives, screw-fixing varnish, lubricating and sealing liquids as well as for other highly viscous liquids a *dosage module* including a standard supply cartridge with a Luer-Lock fitting is provided. The cartridge is easy to replace and the system can be flushed by means of a three-way cock.

Patents and Trademarks

Micro annular gear pumps (and housings) are protected by assigned patents: DE 198 43 161C2, EP 1115979 B1, US 6,520,757 B1, EP 852674 B1, US 6,179,596 B1, EP 1354135. Patents pending: DE 101 46 793, US 10,466,792, DE 10 2004 052 866. In the US, Europe and Japan additional patents are pending. mzr® is a registered German trademark of HNP Mikrosysteme GmbH.

System design

As each new metering and dispensing application is submitted to specific conditions, we advise our customer to discuss every new project with one of our application engineers both during the

system design and the initial operation. We are open to extending the spectrum of our products by developing new customized solutions. These may include the adjustment of specific drives and flanges, development of gears or even new pump types.

HNP Mikrosysteme offers complete solutions for customized applications - turn-key dosage systems. You may count on our professional assistance as far as the engineering in micro fluidics and control techniques for the integration of the pumping systems are concerned.

Especially in micro fluidics an overall tuning of all components from the tank to the dosing nozzle is necessary.

Accessories

HNP Mikrosysteme provide fluid supply accessories such as *fittings, filters, hoses, tubes* and *valves* needed to operate the micro annular gear pumps. Filters are offered in many different sizes and designs. Considering the large range of accessories, a retrofit or an extension of the existing mzp-pumping systems is possible at any time.

Customer service

The satisfaction of our customers with the mzp-pumps is our most important concern.

For requests regarding the first operation of the pumps or drive systems, as well as the required accessories you may count on our support at any time.

We put all our efforts to optimize the range and performance of our products. As a young firm, we are eagerly looking forward to your ideas and encouragement.

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