KYOCERA

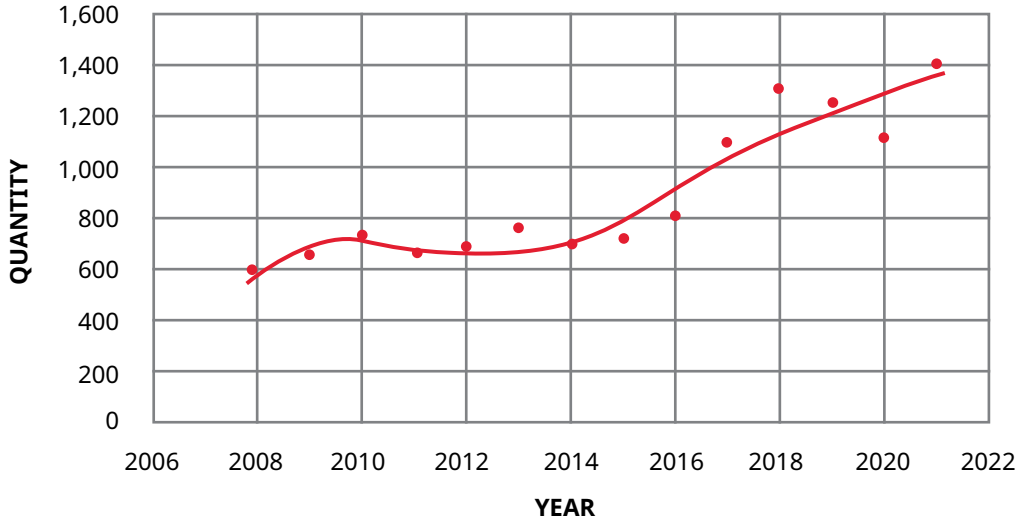
CONTAINMENT SHELLS FOR THE PUMP INDUSTRY

High-performance ceramics

WELL-ESTABLISHED ON THE MARKET

The current development of state-of-the-art sealing systems applied in the pump industry focuses on magnetic couplers more and more. Here, containment shells made of oxide ceramics form the central element. That is because of the unique magnetic, corrosive and mechanical properties ceramic materials offer to realise such applications. In close cooperation with our customers we develop tailor-made solutions meeting their very specific requirements.

Development of unit sales ceramic containment shells



Containment shells protect pumps, environment and employees

TECHNICAL CERAMICS FROM KYOCERA

Magnetically coupled centrifugal pumps require non-magnetic components highly resistant to mechanical forces and corrosion. High-performance ceramics hold suitable material properties to meet such exceptional combination of requirements.

Magnetic couplers ensure hermetic sealing of the pump against the drive. Minimum maintenance requirements allow for leakage-free operation. This prevents any environmental impact caused by spilt pumping media from the outset.

Source: Klaus Union

Meeting highest pumping standards

Compared to conventional materials, containment shells made of high-performance ceramics hold the following benefits:

- **Zirconia is not electrically conductive** - eliminating the creation of performance-impairing eddy currents and reducing electrical drive power by 10 to 15%. In addition, eddy current losses generate up to 20 kW of heat, hich can pose a safety risk depending on the process and the pumped media. For substances close to boiling point or explosive materials, additional heat input should be avoided. This can minimise hazards from any boiling distortions or deflagrations that may occur.

- **Zirconia is corrosion-resistant** - allowing for universal application to virtually all acids and bases.

- **Zirconia offers high mechanical stability** – depending on the size of the inner diameter, test pressure conditions up to PN 63 bar can be achieved at temperatures from -200 °C to 450 °C and more.
  A relatively small elastic modulus ensures a certain elastic deformation capacity.

To keep the magnetic split as little as possible the wall thickness in the cylindrical section of the containment shell ranges between 1.5 and 3 mm, only – again depending on the inner diameter.

Thanks to the above-mentioned properties, containment shells made from advanced ceramics for magnetically coupled pumps stand for the ideal choice for any application in the chemical industry. The design of the containment shell is adapted to the individual pump type specified by our customers.

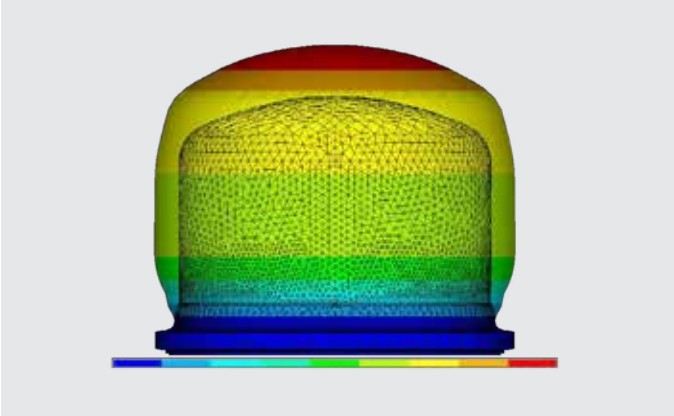
The optimal design of the transitions to the dished end and to the flange base allows for a smaller wall thickness of the containment shell and thus a more cost-effective dimensioning of the magnets used.

ZIRCONIA FZM AND FZM+

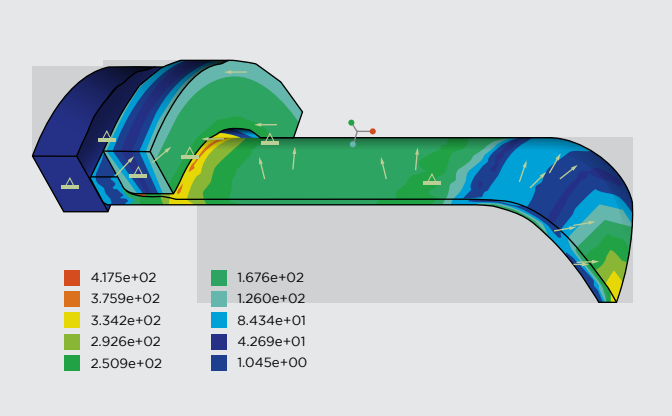
FZM has proven itself as an ideal ceramic material characterised by high fracture toughness as well as wear and corrosion resistance. Low thermal conductivity, excellent thermal shock resistance and superb thermal expansion properties comparable to cast iron round off the unique features of the material.

With the further development of FZM+, the application range of our materials can be extended even further.

The white zirconia is characterised by improved flexural strength and high fracture toughness. This allows test pressures of up to 95 bar (pressure rating PN 63) for a temperature range from -200 °C to over 450 °C.
This makes the material suitable for use in cryogenic applications as well as for external pressure applications in cans with gas as the medium.



Global deformation (50-fold stilted presentation)
Pressure: inner pressure 36 bar, inner temperature 250 °C



FE evaluation assembly

Material properties		Unit	FZM	FZM+
Main components		-	ZrO_2, MgO	ZrO_2, MgO
Purity		wt-%	> 99.7	> 99.9
Density		g/cm^3	≥ 5.7	≥ 5.75
Open porosity		Vol. %	0	0
Average crystal size		µm	50	25
Hardness	HV1		1,220	1,200
Compressive strength		MPa	2,000	2,000
Bending strength σ_m	DIN EN 843-1	MPa	500	650
Young's modulus	static	GPa	185	215
Weibull's modulus		-	> 15	> 20
Poisson ratio		-	0.3	0.32
Fracture toughness K_{Ic}	SEVNB	$MPa*m^{0.5}$	6.3	8.7
Max. operating temperature		°C	900	900
Specific heat	20 °C	J/(kg*K)	400	490
Thermal conductivity	20 °C 500 °C 900 °C	W/(m*K)	3 2.3 2	3.75 - -
Thermal expansion coefficient	20 - 100 °C 20 - 500 °C 20 - 900 °C	10^{-6}/K	9.3 10.4 10.6	9.3 10.3 -
Specific electrical resistance	20 °C 900 °C	Ω•cm	10^{10} 84	10^{10} -
Typical colour		-	yellow	white

The data indicated on this table are in line with the introductory German Industrial Standard DIN 60672-2 and relate to test specimens from which they were obtained. They are not unconditionally applicable to other forms of the same material. The data must be regarded as indicative only. All data refer to a temperature of 20 °C, unless otherwise specified. The material is extremely resistant to corrosion. We should be pleased to send you brochures about the corrosion resistance of oxide ceramics.

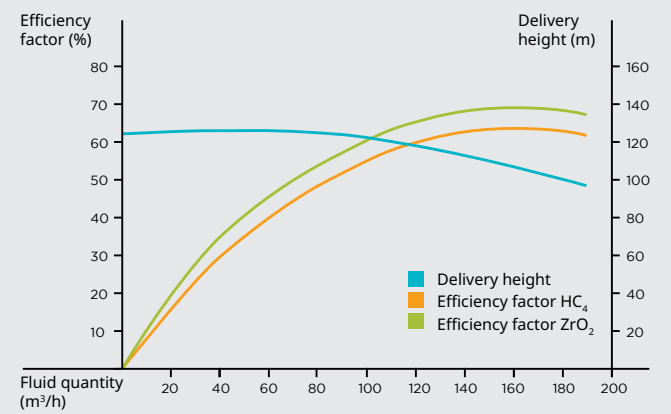
ENERGY EFFICIENCY

Electric drives in industry and commerce consume almost two-fifths of all electricity in Germany. In these two sectors, their share of electricity consumption is even around 80%. The Federal Environment Agency, for example, calculates that the use of energy-efficient pumps alone could save around 5 bn kWh of electricity[1]. The latest climate balance published by the Federal Environment Agency states that this would correspond to around 401 kt of CO_2 in 2019. Assuming an electricity price of 15 ct/kWh, the industries concerned could also reduce their energy costs by around EUR 750 m.

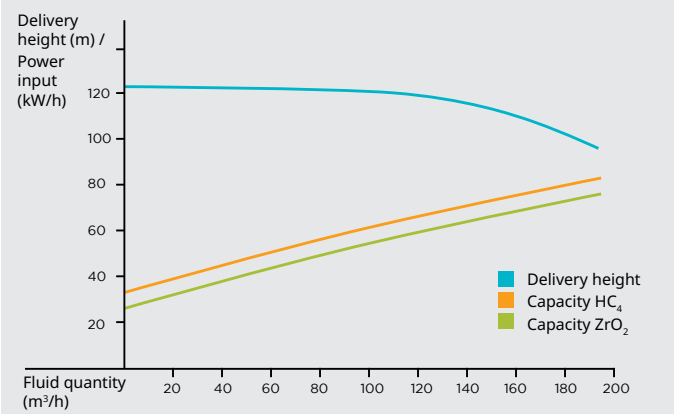
Against this background, magnetic drive pumps with metallic containment shells are increasingly coming into focus. The power loss generated in these systems has a negative effect on the efficiency of the pumps and causes a high proportion of the energy costs incurred.

Unlike metallic containment shells, ceramic containment shells are not capable of being magnetized. Eddy currents that reduce performance are prevented and energy efficiency is significantly improved It is therefore possible to reduce the drive power of a pump by up to 15%.

[1] Source: https://www.umweltbundesamt.de/themen/klima-energie/energiesparen/energiesparen-in-industriegewerbe#energieeinsparpotenziale



Comparison of efficiency ceramics / steel;
Source: Klaus Union



Comparison of power input ceramics / steel;
Source: Klaus Union

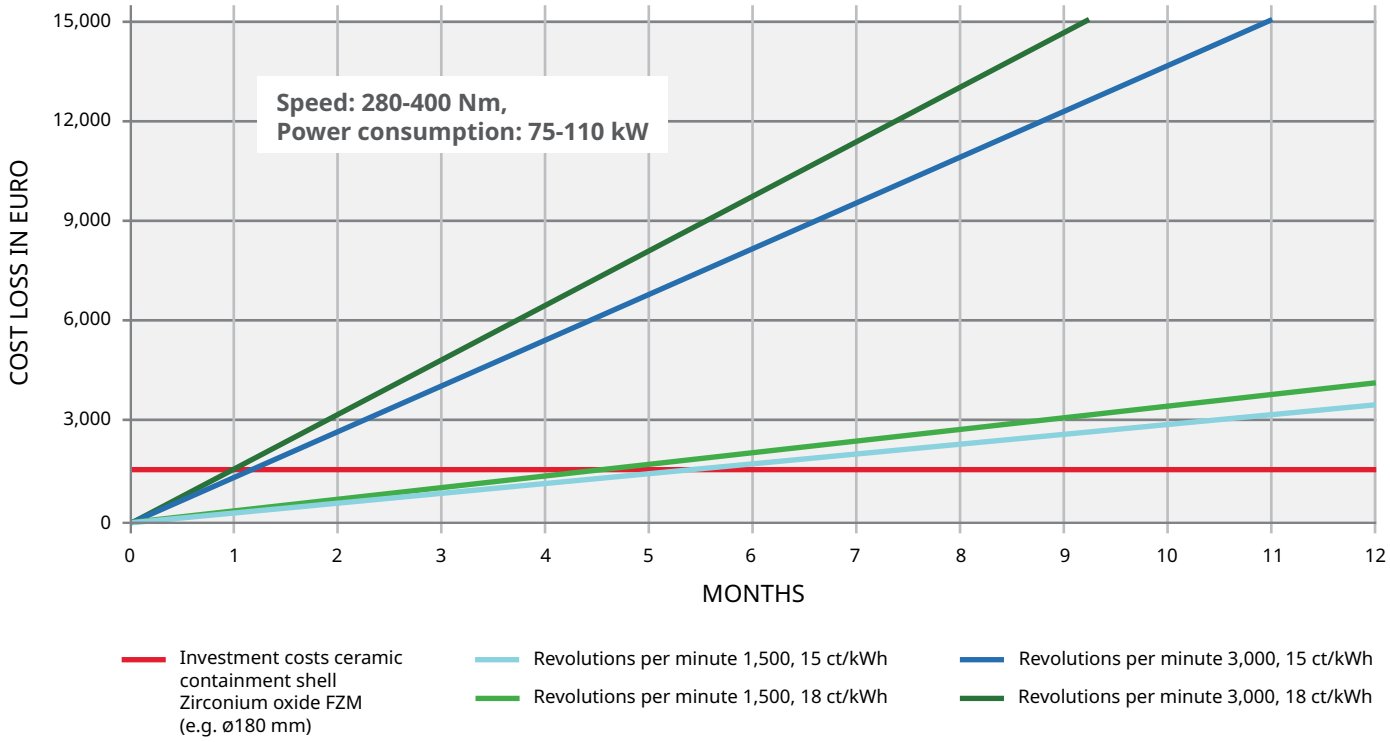
Investment in the future

Magnetic coupling with metal containment shell

Revolutions per minute [rpm]	1,500	3,000
Power loss [kWh]	20,000	100,000
Cost loss at 12 ct/kWh [Euro]	2,600	13,000
Cost loss at 15 ct/kWh [Euro]	3,300	16,000
Cost loss at 18 ct/kWh [Euro]	4,000	20,000
Cost loss at 3 ct/kWh [Euro]	650	3,300
CO_2 reduction [kg]	13,400	68,000

Assumptions: 8,000 operation hours per year, speed with 280-400 Nm, power consumption with 75-110 kW

Costs due to eddy current loss with metallic containment shells

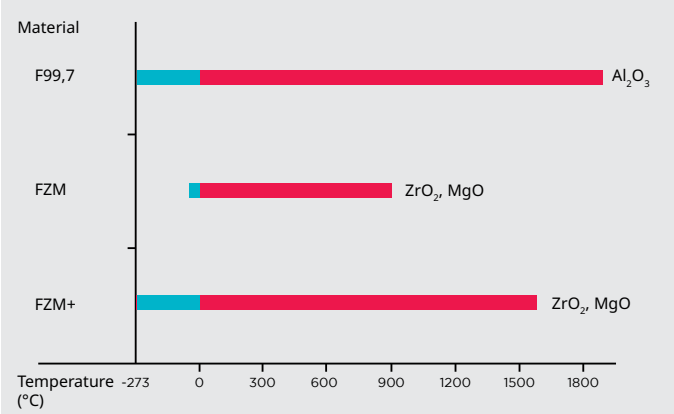


CONCEIVED FOR AGGRESSIVE PUMPING MEDIA

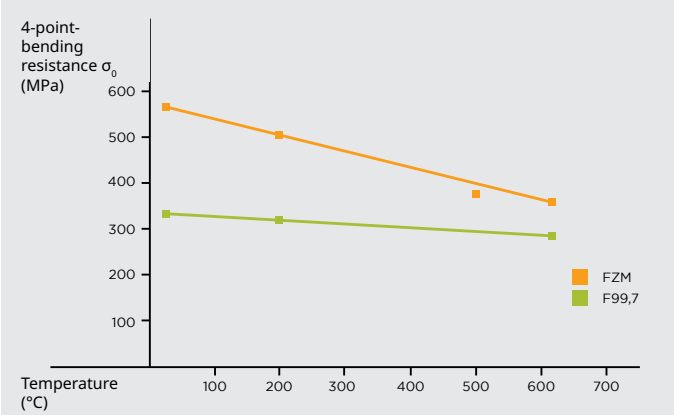
Containment shell made of zirconia are used for pumping widely varying and – in particular – very aggressive media.

These can be, e.g. heat transfer oils that are pumped up to temperatures of 350 °C or heavy oils that are pumped up to 160 °C.
Other chemicals such as methanol, acrylamide, propane, ethylene oxide, nitric acid, phenol, etc. are pumped at temperatures between -30 °C and 250 °C.

To protect the ceramic material against the extremely aggressive hydrofluoric acid (HF) the inner surface of the containment shell may be coated with a chemically resistant and pore-free lining.



Operating temperature of oxide ceramic materials applied in oxidizing atmosphere



Bending resistance in relation to temperature

Excellent materials containing corrosion

CORROSION RESISTANCE LIST

Agent	Chemical formula	Concentration (%)	Temperature (°C)	F99.7	FZM / FZM+
Methanol	CH_3OH	all	Rt	A	A
Phenol	C_6H_5OH	pure	Rt	A	A
Nitric acid	HNO_3	7	Rt	A	A
Hydrochloric acid	HCI	0.5	Rt	A	A
Sulfuric acid	H_2SO_4	2	Rt	A	A

Excerpt. Full list available on our website.

A resistant
Rt room temperature

EXPLOSION PROOFNESS

Directive 94/9/EC on equipment and protective systems intended for use in potentially explosive atmospheres (ATEX) does not provide for any limitation for integrating ceramic containment shells into any Group II Category 2 equipment for application in Zone 1.

Diversion of electrostatic charges through coating

In collaboration with the National Metrology Institute of Germany (Physikalisch-Technische Bundesanstalt) in Braunschweig extensive measurements were conducted to determine the antistatic discharge capability as per IEC 60093 and IEC 60167.
Eventually, it was established that only an additional external coating could considerably underrun the limits for surface resistivity and discharge resistance (RA < 106 Ω).

Hence, a modified ceramic containment shell can be operated in contact with all inflammable media and in any explosive atmosphere.

COATING EXAMPLE

Properties	Unit	Specific value
Coating thickness	µm	approx. 3
Service temperature	°C	< 450
Micro hardness	HV 0.05	2,300 ± 400
Density	g/cm^{-3}	5.2
Thermal conductivity	Wm^{-1}K^{-1}	30
Electrical resistance	µΩ*cm	25
Colour	-	gold

ABOUT KYOCERA

The global Kyocera corporation - a strong partner.

Headquarters:	Kyoto, Japan
Foundation:	1959
Employees:	over 80,000 worldwide
European headquarters:	Esslingen, Germany
European production sites:	Mannheim, Germany Selb, Germany (further subsidiaries in Europe)

KYOCERA = KYOTO CERAMICS

KYOCERA – it all began with ceramics

KYOCERA Fineceramics Europe GmbH is a subsidiary of KYOCERA Europe GmbH, which has been successful in Europe for over 50 years. The Kyocera Group is one of the world's leading providers of high-performance ceramic components for the technology industry, offering over 200 different ceramic materials, as well as state-of-the-art technologies and services tailored to the specific needs of each market.

KYOCERA Fineceramics Europe GmbH has grown steadily in recent years – and is now a leading European supplier of customised solutions made of technical ceramics. Working in partnership, we develop and manufacture products that offer our customers added value in their respective markets and secure their technological lead in the long term. We are committed to this every day.

Throughout Europe, we are represented by two production and development sites in Mannheim and Selb, as well as six sales offices – in Mannheim, Selb, Esslingen, Neuss, Rungis (France) and Frimley (United Kingdom).

Our hearts beat completely for ceramics. Our team provides comprehensive advice on the selection of ceramic materials, product design and project execution – from the development stage to prototyping.
We supply system components for high-tech applications in numerous industries. Our products are characterised by high quality, precision and durability.

Our business partners benefit from the fact that we think and work across divisions within the Kyocera Group. Because innovations and real milestones can only be achieved together – across industries and national borders.

This is what we believe.

About the KYOCERA Group

KYOCERA Europe GmbH is a company of the KYOCERA Corporation headquartered in Kyoto/ Japan, a world leader in semiconductor, industrial and automotive components as well as electronic components, printing and multifunction systems, and communications technology. The technology group is one of the world's most experienced manufacturers of smart energy systems, with more than 45 years of industry expertise. The Kyocera Group comprises of around 300 subsidiaries.

Kyocera aims to create a better future for the world, using the power of technology to solve issues we face as a global society. This ambition is rooted in our Kyocera Management Rationale: to contribute to the advancement of society and humankind.

We will continue to work together with people around the world to solve issues critical to society leveraging all of the technologies and management capabilities we have accumulated during our 60-plus year history.

The company also takes an active interest in cultural affairs. The Kyoto Prize, a prominent international award, is presented each year by the Inamori Foundation established by Kyocera founder Dr Kazuo Inamori to individuals worldwide who have contributed significantly to the scientific, cultural, and spiritual betterment of humankind.

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