The Perfect Equipment for Digital Water Meters – Porous Ceramics as a Key Factor

Sensus metering systems utilize Kläger's three-dimensional injection-moulded ceramics parts. High-end engineering delivers state-of-the-art flow metering.

Fig. 1
Porous ceramic plug

Introduction

All innovative solutions start with a challenge. In this case the challenge was detecting even the smallest amounts of our most valuable resource: clean drinking water. The overall worldwide water consumption is increasing with the growth of the world population. And unfortunately vital clean water is not evenly distributed around the globe. Some regions in the world hardly accommodate any water at all. Of all the water on Earth only 2,5 % are freshwater. And 70 % of the freshwater is bound as ice in the polar regions and therefore not available as drinking water.

It is a misconception that sustainable water management is an issue of the poor and arid regions on Earth. In the developed countries, some 20 % of the treated water is lost through leaks and other wasteful habits by private households and large factories. Therefore smart solutions for the water system, as developed by Sensus, a Cleantech company for utility infrastructure, are urgently needed. The latest generation water meter by Sensus, the iPERL, replaces conventional water measurement with a more communicative system: it continuously acquires data on consumption and operating mode, transmits the data and provides detailed and valuable information for utilities and consumers alike.

It's all about the (measurement) principle

During its predicted life span of 15 years, iPERL uses remanence magnetic field technology to measure within a constantly linear flow range. It features a measurement precision to within 1 l/h. This in turn allows for precise leakage detection at the consumer's installation.

Porous ceramic plugs – ideal protection for measurement electrodes

So far the measurement electrodes have been protected by graphite plugs injected into the water meter's plastic housing. A later solution utilized porous ceramic plugs manufactured using low-pressure injection moulding. These have had strength issues and high geometrical and size tolerances, thus impairing the safety and resulting in a high scrap rate.

The solution: small porous ceramics plugs, manufactured by high-pressure injection moulding

Kläger Spritzguss GmbH & Co. KG in close cooperation with Sensus and the Glas/Keramik GmbH (FGK) Research Institute for Inorganic Materials in Höhr-Grenzhausen/DE developed a base material for injection moulding tailored towards the demands placed by daily operation. Building on the FGK materials research, Kläger took over the complete materials-based engineering including tooling and machine. The porous ceramic parts are being injection-moulded, debound and sintered. The ceramic membranes are then inserted into the Fortron plastic component and moulded. Fortron is lightweight and strong. It can replace met-

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Fig. 2a
Injection moulding machine

Fig. 2b
CIM tool for porous plugs

als and other thermoplastics, and is ideal for applications with high demands on dimensional stability, thermal stability and strength over a wide temperature range. Furthermore, Fortron complies to all requirements of the US Food and Drug Administration (FDA) and the European Union (EU) for contact with food.

Tap water constantly flows through the shaped plastic channel of the iPERL water meter. The electrodes to the left and right of the channel measure the amount of water flowing through the channel. Ceramic plugs integrated into the system protect this sensitive measurement system against contamination, yet allow the signals to pass through.

Porosity as a key element

A precisely defined open porosity of the ceramic material is Sensus' main requirement on the protection of measurement electrodes. Kläger has been researching the material and the transfer to a manufacturable compound for mass production from 2011 to 2014. They achieved the key porosity by composition and special processing of a new compound material. Jens Graf, Marketing and Sales Manager at Kläger, explains: "The resulting material is a joint development and is a compound material containing coarsegrained aluminum-oxide and further materials. The resulting homogeneously treated material is responsible for the porosity – the formation of defined cavities in the material – which is key to the specific purpose." In the course of three years of research and implementation the ceramics plugs with the new compound underwent extensive durability tests. The components went into production in 2015. "This project is a prime example of material-based interdisciplinary engineering. Not only the know-how is a key factor, but the "know-why" plays a major part in the process as well", states Jens Graf. Not only did the appropriate material need to be determined for the application – tooling and the proper injection moulding technology had to be refined as well.

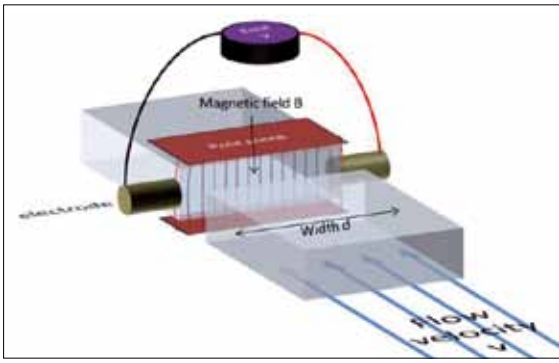

Fig. 3
Scheme iPERL

Fig. 4
Installed Sensus system

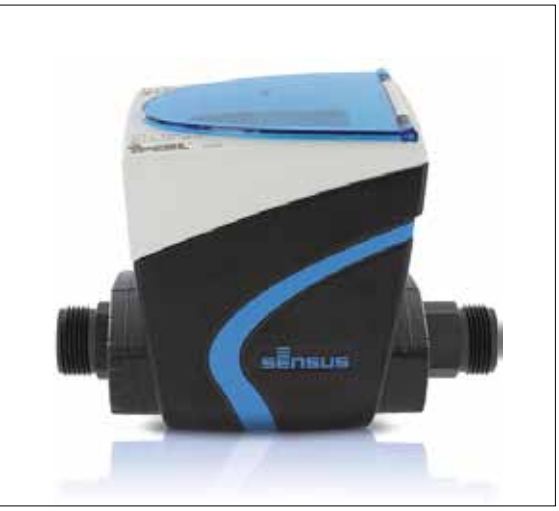

Fig. 5
Water-meter-default

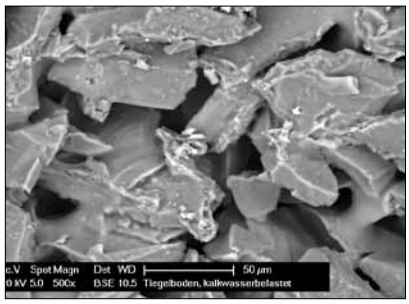

Fig. 6
SEM image of the porous ceramic microstructure

The inner structure is essential

The Kläger engineers regarded two specifications as particularly important: the plugs needed to have a pore size of 10 – 20 µm, an open porosity between 28 – 35 % and a defined surface chemistry in order to fulfil the functional requirements of the iPERL. Kläger achieved these with the newly developed material compound adapted to ceramics injection molding. Jens Graf elaborates: "It was essential for our clients that we achieve a process-stable component geometry and dimensional stability. The developed compound fulfils these requirements, since porosity in the compound is not achieved by sintering termination but by careful selection and composition of materials. The developed feedstock allows forming of three-dimensional geometries. After sintering the mechanical strength remains. In this case the membrane has a thickness of 3,5 mm against a total height of 8,6 mm. The inner and outer diameter of the ceramic plug is 3 mm each, whereas the inner diameter with all the measurement sensors only has a dimensional variance of ±0,02 mm. The components are required to have a compressive strength of 2200 N for subsequent moulding".

As with all ceramic components they are corrosion-resistant, chemically clean, resistant against temperature shock and – of particular importance for water metering – they are food-safe. Kläger places high demands on their internal quality control and their tests for processes and components to ensure a constantly high component quality.

Tailored to the new material

Materials engineering however was not the only challenge for Kläger. They also had to adapt the tooling technology and the injection moulding components to the new material. CIM processed powder generally has a grain size of <2 µm. Even such a fine-grained material is particularly abrasive. In the ceramic plugs the grain size exceeds this value by multitudes, pushing the abrasiveness and processability to technical limits. In order to ensure durability of the injection moulding systems and tools over a sustainable period of time, all components in contact with the compound are being manufactured from highly wear-resistant materials. That way the ceramic components can be manufactured in a process-stable, large-scale and economic manner.

Sustainable water management

The smart system solutions by Sensus show that even small improvements help us to handle water as a resource more efficiently. A growing number of water utilities agree to this attitude. And the German utility company ENTEGA AG now relies on iPERL by Sensus. The company fully exploited the benefits of the first 40 000 installed devices. 300 drinking water shaft meters were no longer required to be read manually. And appointments with thousands of consumers are no longer necessary thanks to optional remote reading. "We are now able to read 6000 metering devices per day instead of only 200", confirms Martin Grüger, Head of Drinking Water Metering at ENTEGA.

Whether for porous ceramic plugs or for hard grinding disks in fully automatic coffee machines, wear-resistant jets for high-pressure cleaners, spray systems or delicate components for electrosurgery – injection moulding of ceramic materials offers flexible geometry shaping and therefore advanced product performance, substantial cost benefits and the realization of until now impossible or impractical applications.

Ceramic and plastic injection moulding techniques are comparable in certain ways because their manufacturing processes show similarities. Ceramic components however need to be debound and sintered after injection moulding to obtain their final form and strength.

Kläger: leader in ceramic processes and plastic injection moulding

Injection moulding is Kläger's core business. Kläger have been perfecting injection moulding of plastics for almost 50 years and of ceramics for 20 years now and are therefore pioneers in plastic and ceramic injection moulding. The company maintains its own engineering and tool manufacturing division. Customers therefore have access to profound knowledge and competence in these areas and benefit from individual process support.

In plastic injection moulding alone Kläger currently processes 300 different materials in more than 2000 active products. A main focus area with Kläger showing a high level of materials and process competence is manufacturing of engineering-grade plastics and the substitution of metals with plastics. The company is also leading in the area of compound components made from plastics and ceramics.