Saving lifecycle costs through use of mineral cast pumps

Where processing conditions combine both abrasive and corrosive attack, for example in pigment and fertilizer production, specialized materials are required for the manufacture of handling equipment such as pumps. German company Düchting Pumpen Maschinenfabrik has devised a materials solution based on the use of mineral casting – where particles of some mineral (in this case the synthetic ultrahard silicon carbide) are dispersed in a polymer matrix in liquid form and cast. Here, Dr Carsten Düchting discusses the development, characteristics and use of the company's SICcast® material in pumps for handling such challenging media.

Most processes in the chemical pigment industry are characterized by a combination of corrosive and abrasive attack. Pumping chemically aggressive liquids with solid contents offers two challenges. Firstly, the pump material has to be chemically resistant against liquids like sulphuric acid or hydrogen chloride, which are used for digestion of the ore. As the strength of the acid is usually 80–95% even high alloyed stainless steels can barely resist. Secondly, hydraulic transportation of solids will obviously be accompanied by wear problems. The use of rubber-lined volute casings or plastic pumps helps to withstand chemical attack but offers only limited resistance against the problem of wear. Hard metal alloys provide good abrasion resistance but cannot be used in chemically aggressive applications. Hence, process engineers involved in pigment production report pump lifetimes not exceeding a few weeks.

Improving lifecycle costs

Based on practical experience, avoiding the use of metal in the construction of wetted parts can extend the lifetime of pumps significantly. For example, with clients involved in the production of both white and black pigments based on titanium dioxide (TiO_2), a minimum lifetime of six months has been achieved. This represents much higher lifetimes than other technologies with metal pump parts like impellers or wear plates. Today's procurement costs sometimes constitute roughly 10% of total lifetime costs, which shows the outstanding relevance of lifecycle costs. Playing a big role in the overall calculation, wear and maintenance handling have to be examined in more detail.

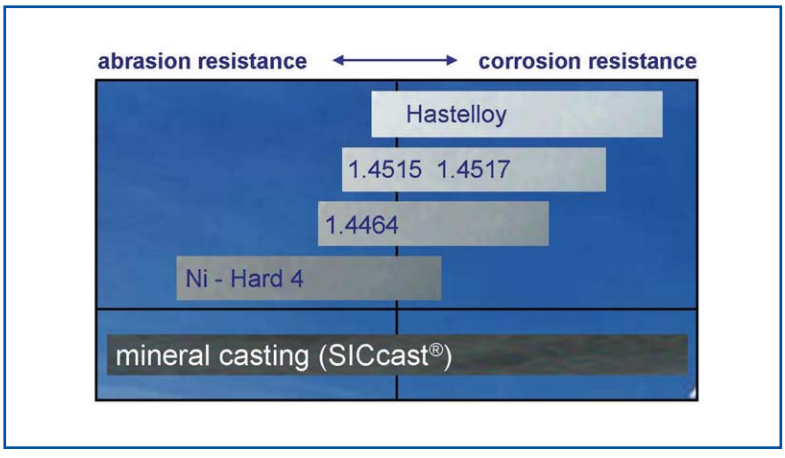

Figure 1. Comparison of the properties of high alloyed steels with Düchting's mineral cast material SICcast®.

Figure 1 depicts a comparison of various high alloyed steels and mineral casting concerning their corrosion and abrasion properties. Erosion–corrosion occurs if metal materials are destroyed by fast flow velocities in combination with chemically aggressive conditions. Metals only offer the opportunity to fully meet one or other of above-mentioned characteristics. Hastelloy has outstanding qualities towards corrosion but nearly no resistance against abrasion. This material can be used for acids but it is not suitable for fluids with solid content. Materials like stainless steel 1.4464 represent a weak compromise between both but do not show satisfactory results especially not in combination with acids and particles. Ni-Hard 4 is a very hard material that has a good wear resistance but cannot stand acids or corrosive liquids for a prolonged time due to a lack of chrome. Finally, mineral casting offers the whole range of wear and corrosion resistance, which predestines this material for transportation issues in the chemical pigment industry.

Figure 2 shows the result of field tests relating to the correlation of flow velocity and wear. Both materials shown – duplex stainless steel 1.4517

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and mineral casting – show a linear interrelationship between wear and the velocity of the flow. The main observation is the significant difference in the dimension of wear. Starting at the lower flow velocities, the alloyed steel suffers wear several times higher than mineral casting. This phenomenon occurs over the whole test range in very similar proportions.

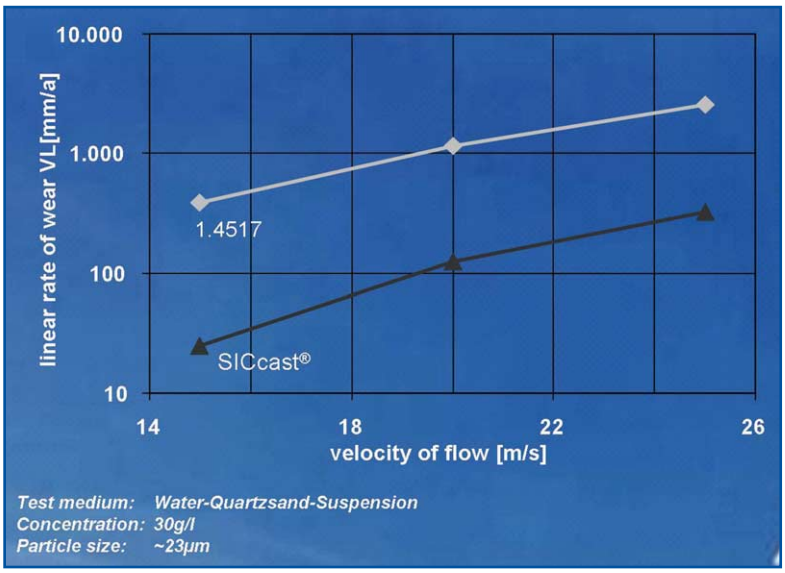

Figure 2. Comparison of wear.

Producing SICcast®

Going back to the early 1990s, Düchting Pumps started testing mineral castings by replacing single pump parts. After good results concerning wear and corrosion, Düchting founded a mineral casting company in 1994. This company, called SICcast®, started manufacturing pumps with all wetted parts made of mineral casting, including volute casings, wear plates and impellers. Over the subsequent years SICcast® achieved good results in several industries such as flue gas desulphurization, waste incineration plants, food industry, biochemistry, fertilizer plants, petroleum industries, glassworks, potassium mining and salt extraction, which are all well known for their corrosive and abrasive character.

Silicon carbide (SiC) is artificially produced with a value of 9.6 on the Vickers hardness scale, which is the second highest value after diamond. In the past, SiC was only of use for fashioning simple shapes and smaller parts. This restriction was due to the fact that sintering was the only possible production method. In order to produce more complex parts for pumps, like impellers, parts have to be cast. This requires a binder material, in which particles of SiC are dispersed. Several tests and experiments finally led to the use of an epoxy resin (EP) as the binder. The two materials are mixed in a ratio of approximately one part binder to four parts SiC. This process takes place under vacuum in order to get a bubble-free pour, which will be cast into highly precise moulds. Threads are realized by means of cast parts that are placed in the moulds in advance. After a hardening process in the oven, the parts are de-moulded and are returned straightaway to the oven in order to be tempered. After that step the parts are ready for machining. Due to the material's hardness, fittings are processed with diamond tools on the lathe. Thanks to the temperature-controlled casting process, which enables a secure and homogenous hardening process, parts of weight from 1 kg up to 8000 kg can be cast.

Düchting's process has been certified to ISO 9001 by Lloyd's Register. The essential quality features are the measurement of the glass melting point and the test of the tensile strength with a test piece from every charge. With the storage of these pieces the results are traceable for an extended period.

In Figure 3 the surface of the cast silicon carbide and epoxy resin material is shown magnified 50 times. By use of a certain particle size distribution curve, smaller and larger particles of silicon carbide (light) are achieved and surrounded by epoxy resin without any trapped air due to the technical vacuum in the mixing process. The binder appears dark after cauterizing the surface. Figure 3 also shows the chemical formula for the epoxy resin used in the SICcast® material.

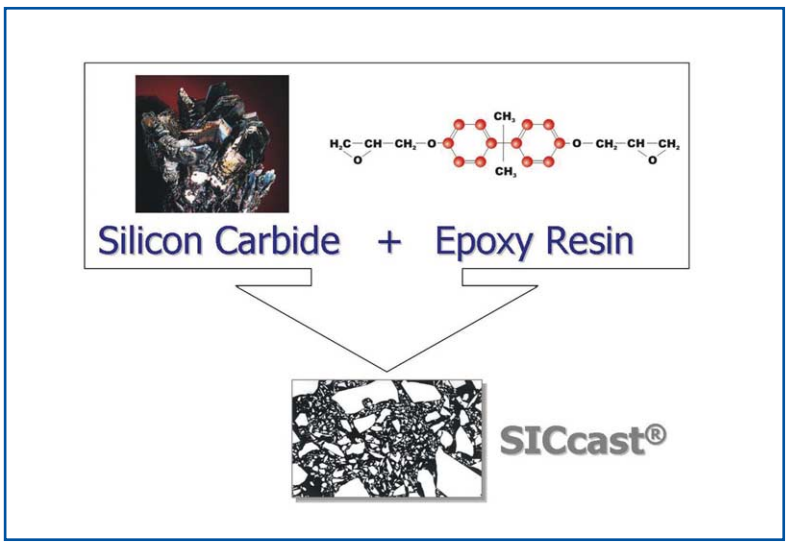

Figure 3. The components of SICcast®.

Pumps made from SICcast®

With the purpose of using the above-mentioned mineral cast material in the chemical industry, Düchting Pumps has designed the ROWA-MC Series, which is made entirely of SICcast® material (Figure 4).

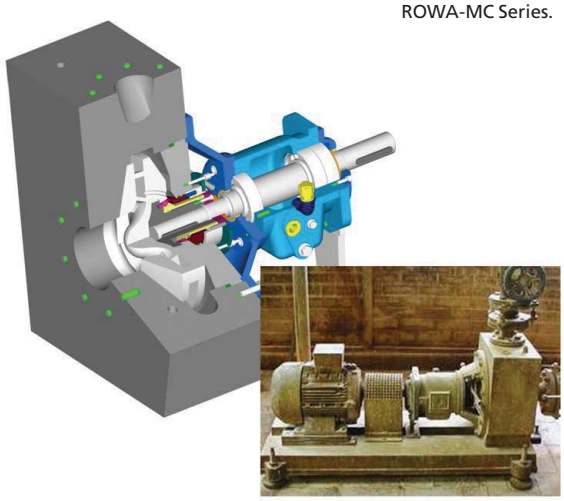

Figure 4. Düchting's ROWA-MC Series.

The ROWA-MC Series is a single-stage centrifugal pump with a closed impeller. In most wear-intensive applications, abrasion can be found between the impeller and the wear plate. With regards to the efficiency, the design of the bearing housing and the back-pull-out design (enabling the impeller and seal to be easily inspected or replaced without dismantling the pipes) allows a quick adjustment of the gap between the wear plate and the impeller – even during operation. This reduces the handling costs and the efficiency can be kept at a high level over the whole lifetime. A metal-free wet end can be achieved by installing single- or double-acting mechanical seals with SiC-only parts. Pumps in the ROWA-MC Series are offered with a radial discharge flange (DN 32 up to 150; ANSI 1.25 inch up to 6 inch), or tangential discharge flange (DN 200; ANSI 8 inch). The nominal pressure goes up to 10 bars with a rotary speed up to 3500 rpm.

According to the company's sales figures, the ROWA-MC Series is enjoying ever greater popularity, with more than 1500 pumps sold to date. ■

CONTACT
Dr Carsten Düchting
Düchting Pumpen Maschinenfabrik GmbH & Co KG
Wilhelm-Düchting-Straße 22
58453 Witten, Germany.
Tel: +49-2302-969-160
Fax: +49-2302-969-156
E-mail: c.duechting@duechting.com
www.duechting.com