New stainless steels for casting, not only for centrifuges

Many centrifuge components are produced of so-called duplex steels. These are steels with a 2-phase texture in which the properties of stainless austenitic chromium-nickel steels are combined with those of stainless ferritic chromium-steels. Duplex steels thus have both high corrosion resistance and also high ductility and strength. The essential alloy elements of duplex steels are nickel and molybdenum besides chrome. The content of these three elements is summarised as a measure of the corrosion resistance into the so-called PRE number (%Cr + 3.3%Mo + 16%Ni). As Georg Wilhelm Overbeck explained, the prices of duplex steel are determined particularly by the prices for molybdenum and nickel, which, in the past, were not only high, but were also subject to large fluctuations.

The endeavour to produce cost-effective, yet firm and corrosion-resistant materials has led to the development of the so-called Lean Duplex and/or Ultra-Lean-Duplex grade. Already in May 2012, the casting material Centralloy® G21-02 (GX3CrMnNiN21-5-2, an Ultra-Lean-Duplex steel) was launched on the market. The material has good strengths similar to conventional austenitic Cr-Ni steels, which are used in pumps, centrifuges and related equipment, as well as very good resistance to intergranular corrosion.

Dr. Henrik Astemann presented Centralloy® G45Mo (G-NiCr35MoCuN), an austenitic cast steel, as the latest material development, which has not, like many other cast steels, been developed through modification of a comparable rolled and forged steel, but rather, the special requirements for processing form casting were taken into consideration in the development. In addition, certain requirements for mechanical strength and corrosion stability also had to be fulfilled, and, moreover, the material should be cheaper than existing nickel-based steels. G45 Mo contains 45 wt.% of nickel and 35 wt.% of chrome, and hence is planned for use in highly corrosive surroundings. Spin, shape and precision castings can be produced from G45 Mo. The steel was developed within the scope of a BMU research project for the realisation of geothermal power plants, which is being coordinated by the Georesearch centre in Potsdam. The potential to gain geothermal energy and to produce electric power from it, too, is harboured by territories with aquifers whose water temperature is in excess of 100°C. The Gross-Schönebeck research station lies in such an area. There, water horizons are being opened at about 4000 m depth. The hot liquid which is thereby extracted to the surface is a salt brine with an overall concentration of about 300 mg/l and a pH value of 5.3 - 5.8. With this medium, different materials that are known as being corrosion-resistant were and are being tested in a specially installed bypass pipe, among them also the new Centralloy® G45.
Mo in the form of pipes, flanges, etc. The probability of general corrosion or pitting corrosion is determined on-line with electrolytic methods. In parallel, additional laboratory measurements on corrosion resistance are carried out in the Federal Institute for Materials Testing (BAM). The results of both measures will lead in future to finding the most suitable materials and possibly operating parameters for such demanding applications.

**An important market: Sewage sludge treatment**

Sewage sludge dewatering is a standard application for decanters. Here, dewatering performance (throughput and achievable solid matter content) and energy consumption are generally in the focus of the users. How sewage sludge treatment is handled in Germany’s largest municipal sewage treatment plant in Hamburg, was described by Hendrik Schurig of Hamburg Wasser. The sewage treatment plant is designed for 2.7 million PE (population equivalents) and consists of two biological treatment stages. The whole system of sludge treatment is shown schematically in Fig. 1. In this sewage treatment plant, about 1.5 million m³ fouled sludge originate during the cleaning of about 150 million m³ of wastewater annually that is dewatered with 5 decanters and afterwards is dried and combusted on site. In addition, 8 decanters provide for the thickening of the surplus sludge since static thickening produces insufficient dewatering. Moreover, the sludge combustion accepts dry sludges from other plants. Altogether the energy requirements of the sewage treatment plant can be covered up to 75%, and the remaining 25% are provided by wind power. The biogas originating with the sludge digestion is processed and fed into the gas grid.

The low solid matter content of the dewatered sludge of 21% before the dryer is noteworthy here. Because of the combustion on site, there are no transport costs for the sludge, and therefore polymer consumption for dewatering was crucial for the treatment costs. A stronger dewatering would have led here to the increase of polymer consumption.

Sewage sludge dewatering with decanters down to only 21% TS is far below what these machines are able to perform and is also not economical, since for disposal one has to factor in about 40 to 80 euros per ton of dewatered sludge, dependent on location. Here, one calculates for the reduction of water content by 1%, with a reduction of the sludge volume to be treated and to be transported by 4 to 5%. This was also highlighted by Wolfgang Steiger of the company Flottweg, which was also the supplier for the Hamburg sewage treatment plant. His lecture was about the design of decanters for sludge dewatering, inter alia. The basic principle of the design is based on the calculation of the required clarification area according to the so-called Sigma principle. The equivalent clarification area \( \Sigma \) is the area for static dewatering multiplied by the acceleration factor (expressed as a multiple of gravitational acceleration \( g \)). In case of consideration of the centrifuge bowl as a cylinder, one can accordingly convert to the diameter and the length and/or the centrifugal acceleration - the same value \( \Sigma \) will then always mean the same dewatering performance. That is the theory, because decanter drums consist not only of a cylindrical part but have, according to make and construction form, different long and steep conical elements (see Fig. 2). How one includes the not cylindrical parts of the drum in the calculation of \( \Sigma \) is not established uniformly and, much to the regret of the lecturer, is solved by every manufacturer with another formula. Into the formulae, the length of the conical part and the diameter of the solids discharge are included with different factors. If one carries out the Scale-Up of the pilot up to industrial scale in each case with the same formula, one receives similar magnification factors. It becomes difficult for various manufacturers in preparing their tenders, because the different calculation methods mean that different enterprises offer machines of different sizes for the same dewatering performance, whereby distortions of competition can occur. With the same external dimensions, dewatering performance is increased.

**Highlights 2013**

There is only one thing we will not separate: your process and our customized solution. We adapt machines to needs, not needs to machines.

GEA Westfalia Separator Group GmbH
Werner-Habig-Straße 1, 59302 Oelde, Germany
Phone: +49 2522 77-0, Fax: +49 2522 77-2488
ws.info@gea.com, www.gea.com

GEA Mechanical Equipment
engineering for a better world
through a steeper cone (synonymous with a longer cylindrical zone) and through a deep pond (corresponding to a bigger process volume). The calculation of the equivalent clarification area does not include any specific design parameters of a machine like the screw design, the inlet geometry or the drive system. However, these play also an important role, inter alia, for the compaction pressure and hence the achievable dewatering.

In practice scaling-up is performed according to the required maximum capacity. For applications on wastewater and sewage sludge, Flottweg offers its standardised decanter series C4E. It was pointed out that maximum dewatering does not always mean the most efficient operating mode, but rather one must consider the relationship between water content of the solid matter and the throughput capacity. The dryness of the solid matter drops approximately linearly with increasing throughput.

For further use of the sewage sludge as fuel, this is dried. In the Hamburg sewage treatment plant, this happens in disc dryers, which are heated with steam generated during the sludge combustion. Also here there are now alternative drying systems on the market, like solar drying alone or in combination with waste heat recovery. Dr. Steffen Ritterbusch, Thermo-System GmbH, reported about such methods. The drying happens in climate-controlled halls of glass or PE sheeting, which resemble greenhouses and, when required, are also equipped with a waste air treatment facility. According to sludge volume, the process is carried out intermittently (loading and unloading with a wheel loader), semi-continuously (automatic loading, unloading with a wheel loader) or continuously (automatic filling and emptying). In the meantime, a large number of plants exist worldwide. The biggest solar sludge drying plant, with a capacity of 140,000 t/a, is currently in construction in Dubai. The fact that solar sludge drying can be operated not only in southern countries is shown by the example of Oldenburg, Lower Saxony. Here, the sludge of a 400 - PE sewage treatment plant (corresponding to 40,000 t/a sludge) is dried by utilisation of solar heat and waste heat. The use of waste heat reduces the space requirements of the plant to about 20% of that for pure solar drying, for which one calculates about 1 m² surface area for 1 t of sludge. The supply of the waste heat is done either via the supply of warm air or via underfloor heating. A component especially worth mentioning for small and medium-sized sludge drying plants is the Electric Mole™, an automatically controlled appliance, made completely from stainless steel, for turning and aerating the sludge during drying.

Other construction type: Vertical decanter

As a known manufacturer of decanters and separators, the Plerialisi Group has significantly expanded its product portfolio in recent times. On one hand, the company’s own centrifuge programme is complemented by horizontal screen screw centrifuges. On the other hand, through cooperation with Kyffhäuser Maschinenfabrik Arten GmbH (KMA) and the Japanese enterprise TOMOE Engineering Co. Ltd., other machine models are available. KMA is a manufacturer of vertical disc centrifuges and TOMOE is regarded as a world leader in large decanters for the process industry and wastewater treatment. Gert Bergjohann, Pieralisi Deutschland GmbH, presented the vertical decanter built by TOMOE (see Fig. 3) as a special machine model. This construction type was originally developed more than 50 years ago at Sharples in the USA and was for a long time the only form in which a decanter was feasibly gastight. Nowadays, vertical decanters are used for separation tasks that take place at high temperatures and under high pressure. These include coal liquefaction and applications in the presence of organic solvents, such as for example the recovery of catalysts. As is evident from Fig. 3, the spindle area and all technically sophisticated equipment, such as the gearing and the main bearing for the drum, are outside the
product chamber. Besides their suitability for temperatures up to 400 °C and pressures up to over 30 bar, the vertical construction form is fascinating because of the relatively small installation surface. In Asia, this machine model takes on an important role in the production of PET (Polyethylene terephthalate). The centrifugal acceleration in vertical decanters is normally 2000 - 3000 *g*. They are made with diameters of 150 to 900 mm and can process 100 kg/h up to 20 t/h of dry solids. In addition, there are special designs with 5000 - 10,000 *g* centrifugal acceleration that are not suitable, however, for high solids concentrations.

**Centrifuge drives**

Different drive systems are available to put the drum and screw of a centrifuge into rotation at different speeds. Nils Zieglegänsberger from Sumitomo (SHI) Cyclo Drive Germany GmbH presented the Cyclo drive whose operating principle had been invented in the 1920s and had been used first in 1949 in a centrifuge built by the manufacturer Siebtechnik. A Cyclo drive is an excentric drive whose outer profile describes a cycloidal curve path. It consists of the components: high speed shaft with excentric bearing, cycloid discs, ring gear housing with pins and rollers, as well as the slow speed shaft with pins and rollers. The single-stage cycloid drive here creates a transmission ratio of 1:87 (see Fig. 4). Higher transmission ratios are feasible in multistage construction methods, inter alia, in combination with a planetary gear in which mechanical transmission takes place via gear wheels in a toothed ring gear member. Different construction forms permit different operating modes of screw centrifuges, depending on whether the screw should turn more slowly or faster than the drum. With a two-stage gear unit with differential planetary gear stage, the setting of a variable relative rotational speed with pre-triggered and also with retarded screw is possible in the entire control range of the engine.

The alternative to the energy transfer to the screw of a decanter is a hydraulic driving mechanism whose advantages compared with a mechanical transmission had already been shown by Marco Metzger of the Swiss firm Viscotherm AG at the 3rd Separation Technology symposium /1/. The heart of this driving mechanism is a so-called radial piston machine whose rotor has a cam disc with cylindrical winding. The rotor consists of a cylinder block in whose boresholes pistons are pressurized alternately with the pressure medium and return medium via a distribution system. The radial forces are converted into tangential forces, through the incline of the cam disc over the piston parts as a joint, and generate therefore the necessary torque between rotor and stator. This year Metzger presented, inter alia, the most recently developed stepped piston with which an even higher torque can be generated at the same dimensions because more liquid is moved per stroke of each of these pistons.

**Screen screw centrifuges and hybrid forms**

Screen screw centrifuges are screen centrifuges with forced transport of solids /2/. They are used for dewatering coarse material like coal or minerals (grain size for coal about 0.25 to 2 mm). Bernard Feldkamp, Andritz Separation GmbH, showed details of the design of this type of centrifuge. The cone angle of the screw, the height and spacing of the filaments and their rotation speed determine the dwell time of the solid matter in the machine and with it the levels of achievable dehumidification. With the help of these parameters, the speed that the solids cake onto the basket, or the time-dependent position of the solid particles on the transport path until discharge, are calculated. The result is the curve of the saturation of the filter cake above the basket diameter, which is hyperbolic. This curve path helps in the design of a screen screw centrifuge for a separation process, but cannot be carried out for every substance system, which is why one ventures to dare a transmission.

The differential speed between the screen basket and screw results from the speed of the screen basket and the transmission of the gearbox. Here, Cyclo or planetary gear drives are interchangeable because of their similar external dimensions.

Sedimentation and filtration centrifuges in many special designs make up the product portfolio of Siebtechnik GmbH, and in most applications solid matter is the product. As Andre Adam elaborated, this mostly concerns crystalline particulate solids, which sediment rapidly. In his presentation Adam drew special attention to the machines in which sedimentation, as happens in a solid bowl centrifuge, and filtration in the centrifugal field, take place side by side or successively with a drum designed as a screen basket. The motivation for these combination machines lies, inter alia, in that a pure screen centrifuge, depending on the degree of separation and selectivity of the screen, generates particle losses and that one wants to lower the humidity of the dewatered solid matter and, nevertheless, one wants to get a clear centrate. In the Conthick combination centrifuge, the feed suspension enters first into a conical bowl portion and is then transported into the cylindrical screen member. This arrangement allows a smaller separation limit compared to a pure screen centrifuge (as the minimum, still separable particle diameter at which no clogging of the screen occurs). The Turboscreen model is a combination of decanter and screen centrifuge and the diameter of the screen member is increased abruptly relative to the decanter member. A higher centrifugal acceleration is thereby achieved in this area and a thinner filter cake is generated. In both combinations one obtains a clear centrate of the decanting part and a filtrate conditioned by the separation limit of the screen, in which particles might still be present. The TwinCone machine is a decanter with two separation stages of different diameters. The dewatering degree and the solids capacity can be increased by this arrangement. As was shown on the basis of tests results from comparisons of a standard decanter with Turboscreen and/ or Twin Cone, the improvement of the material separation through the combination machines is not equally high for every product, so that one must produce the justification of the higher investment costs for a combination machine in individual cases by tests.

---

**Literature:**


---

**Fig. 4: Structure of a Cyclo drive (images: SUMITOMO (SHI) Cyclo Drive Germany GmbH)**

**Fig. 5: Structure of a screen screw centrifuge (images: SUMITOMO (SHI) Cyclo Drive Germany GmbH)**

---