Dredging drives innovation

Francois Couturier of SNF reports on the chemical industry's efforts to develop solutions to the challenges presented by dredging processes

Traditionally, the drivers of chemical innovation have been the municipal water treatment, paper and mining industries. Nowadays, though, emerging markets such as oil and gas and dredging are bringing new challenges for water treatment engineers.

What challenges? How about increasing polymer versatility in those dredging projects showing sediment composition variations? What about treating contaminated sediments, or providing polymer protection against high salt levels in oil applications?

Here's a quick round-up on some of the work being done by researchers to address these questions.

Flocculants for geotextile tubes

Used widely in dredging projects where time and space are an issue, geotextile tubes can be a cost-effective solution, achieving high solids- and high pollutant-concentrations, but at higher cost and needing land-consuming settling ponds.

Sediments are directly pumped into the tubes which retain most of the solids thanks to flocculation. Filtration is initially made through the geotextile membrane, then combined with cake filtration after it has formed on the inner side of the tube.

Any polymer used here has to be shear-resistant, because the strong mixing during tube loading may destroy its long chain structure. However, the polymer expert knows this and, during jar testing (the initial laboratory or field test for polymer selection), selects a polymer that is resistant enough.

The other challenge in this application is for water to retain its ability to exit the tubes even as the pressure drop increases with cake thickness. Special polymers, such as branched emulsions, have recently been developed to keep the channels open for water.

Branched polymers have lower viscosity than linear polymers and so improve water release by reducing the filtrate viscosity. In the past, some projects have suffered either from poor flocculation (leading to membrane pores' closure by non-flocculated fine particles) or from the cake's poor ability to let water flow.

In both these cases, the pressure drop increases until the project has to be stopped. An initial partnership between the dredging contractor, geotextile tube supplier and polymer supplier can be the key to avoiding such embarrassing situations and making the project successful for all parties.

Discharging from geotextile tubes

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Polymer slicing unit

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Amphoteric polymers

Most dredging projects have a high variation in both solid rate and sediment composition. Installing a holding tank for sediment homogenisation at the start of the treatment process is one way to deal with these variations. Variations still occur, however, depending on the dredge pump's flow rate and the holding tank size.

As polymers have good flexibility, they can cope with these variations up to a point. During jar testing, a polymer expert will first work on a composite sample made from equal fractions of each sediment sample, then check a selected flocculant's results against each sample.

If there is a high variation in organic/mineral ratio, that may lead to the selected flocculant being inefficient for some of the samples. This may create subsequent problems at the job site, such as lower cake solids or high turbidity in released water.

So, new amphoteric polymers – capable of reacting chemically as either an acid or a base – have recently been designed to solve this. These contain both cationic and anionic charges all over their chain's length, making flocculation happen whatever the sediment composition.

These highly versatile polymers need accurate jar testing, since they display different chain lengths and non-ionic, cationic and anionic ratios. Selecting one flocculant per sediment type cannot be done at industrial scale, as only one storage area and one preparation unit are possible.

So, for example, Solindus' giant lab in Belgium, which aims to explore treatment and valorisation solutions for 6M m^3 of southern Belgian riverbed sediment, is using an amphoteric polymer precisely because of its high sediment variability.

Fast polymer preparation

Fast dissolution equipment for polymers in powder form was initially designed for the oil industry, where dissolution time and maturation space are issues. In traditional polymer applications – municipal water treatment or mining industries – typical dosages are below 100kg/h of active polymer. However, in dredging and the oil and gas industry, the dosage frequently exceeds that and may reach up to 600kg/h.

Existing polymer preparation units can't cope with such high dosages. The polymer needs to be first dissolved in a 5-10g to l solution that needs hours of maturation before injection into the water being treated.

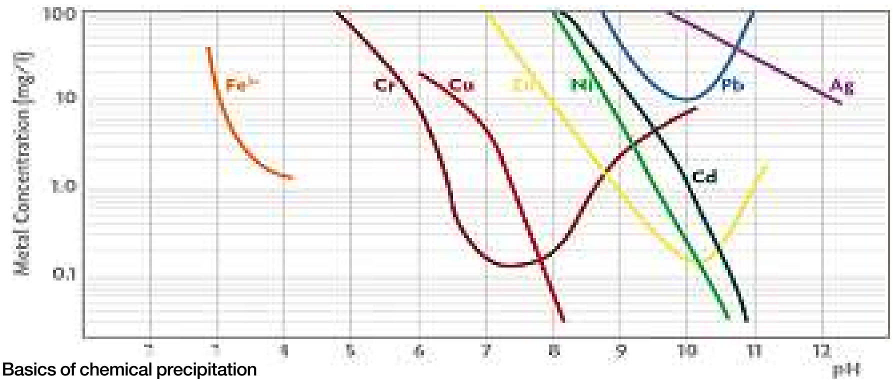
The size of the maturation tanks depends on dosage, water temperature and polymer type, and it becomes an issue in applications where a high dosage is required. Most previous attempts to reduce equipment size led to the formation of gel particles, altering the polymer dosage and its efficiency.

Specific equipment recently designed to solve this problem includes a (patented) polymer slicing unit, which reduces dissolution time from several hours to less than 30 minutes. It pre-wets the polymer and needs a minimal rate to operate correctly, typically 100kg/h.

The key point of combining both mechanical and chemical effects is to avoid damaging the polymer structure, prove the molecular weight hasn't changed, and ensure the polymer's initial efficiency is retained for the final treatment. Using the polymer slicing unit reduces downstream equipment by a factor of 2-3, bringing cost and space benefits.

Heavy metal catchers

Heavy metals are frequently present in riverbeds or lake sediments, a heritage of past industrial activity. Their acute toxicity at very low doses and their tendency to accumulate in living organisms explains the growing need for remediation in effluents as well as the increasingly strict regulations worldwide.



Basics of chemical precipitation

Despite sediment treatment, the released water may contain residual heavy metals coming either from desorption from the substrate, or from fine particle resuspension during treatment process. Available treatments to reach required target levels include chemical precipitation, ion exchange, adsorption, electrolysis and filtration.

Chemical precipitation is the cheapest option and a longtime standard. Basically, a chelating agent (anionic) that bonds with the metal in the dissociated form (cationic) is added to the water and forms an insoluble compound that precipitates and exits the water phase. This doesn't always work where a heavy metal has created a soluble complex from upstream chlorine or ammonia. If the complex is destroyed, it can subsequently release its heavy metals.

Clean water returns to the environment

Recently a new generation of polymeric chelating agents has been designed with optimised chain length distribution to give them a complex-breaking ability without lowering their chelating and flocculating properties. Some strong small molecules available on the market already have this complex breaking ability, but their toxicity makes them unsuitable for dredged sediment treatment.

Complex-breaking, metal-chelating and flocculating properties combined in an all-in-one product are a unique achievement never before achieved by chemists. After treatment, heavy metal residual levels in water are close to parts-per-billion levels, which is enough to meet any existing local legislation.

Enhanced sediment dewatering

A combination of ferric chloride and lime is widely used by sediment treatment plants as a chemical conditioning mixture before dewatering with centrifuge or filter press. Ferric chloride brings micro-flocculation properties, whereas lime increases the final cake dryness and its storage ability.

Typical dosages range from 3-10% for ferric chloride and 10-40% for lime (in weight percent per dry matter of sediment sludge) but this increases the post-treatment cake volume overall, along with the disposal cost of contaminated sediments. A further drawback of ferric chloride is its high corrosivity, which requires specific pumps and special handling.

Recently organic chemists have designed some alternatives to partially or totally replace ferric chloride. These bring several benefits: lower dosage (usually 5-10x less), higher filtration results, greater handling safety and suppression of corrosion problems. These are available as a powder which can be mixed with the lime for an all-in-one slurry preparation, or as a liquid for blending with the hydrated lime. Specific lime can be selected to enhance the combined properties.

Finally…

Chemists are continuing to research and design solutions for many industrial sectors – the dredging industry is one of many that is both spurring on their efforts and benefiting from them. DPC

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