Foam flotation: the pilot plant has the capacity to remove more than 95% of the oil from rolling-mill effluent.

Foam flotation

an efficient liquid-waste treatment

Brett Wright

A method originally developed to concentrate metallic ores in the minerals industry looks set for success in the treatment of industrial waste.

Known as foam flotation, the innovation basically uses air bubbles to remove unwanted contaminants in the waste-water discharged by potentially water-polluting industrial processes. A foam generated by the bubbles attaches to the contaminants, separating them from the water.

The use of flotation to separate ore particles from the surrounding gangue or dross is a long-established technique in minerals processing. A three-year joint research project between CSIRO and BHP has developed flotation into a versatile technology capable of handling a range of liquid wastes. The wastes may be from industries such as food processing, pulp- and paper-making, steel production, wool scouring, chemical manufacture, and textile dyeing.

Australian industry each year produces a torrent of waste-water — one estimate is 100 million cubic metres a year — much of it contaminated with oil, grease, detergent, salt or rotting vegetable and animal matter. The cost of treating this water before re-use in the plant or discharge to sewer, creek or farmland is rising sharply, in line with tighter environmental controls on industrial and commercial premises.

In 1990, BHP and CSIRO agreed to jointly investigate and test novel methods of ameliorating industrial effluents and spills by both biological and chemical means. Among three areas of research under the agreement was foam flotation, a CSIRO-patented process that had not then been studied beyond the laboratory.

Aim

Adapt foam flotation technology for treating a range of liquid wastes.

Benefits

Cheaper and more versatile than existing methods. More water can be recycled in plant.

Future

Installation of foam flotation plants at Western Port and Port Kembla. Partners sought for commercialisation of process in Australia and overseas.

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In a series of pilot-plant trials, a team led by Dr Julie Beeby at BHP Research in Newcastle and Dr David Dixon at CSIRO's Division of Chemicals and Polymers in Melbourne evaluated an experimental foam flotation unit used in the treatment of effluent from steel rolling mills.

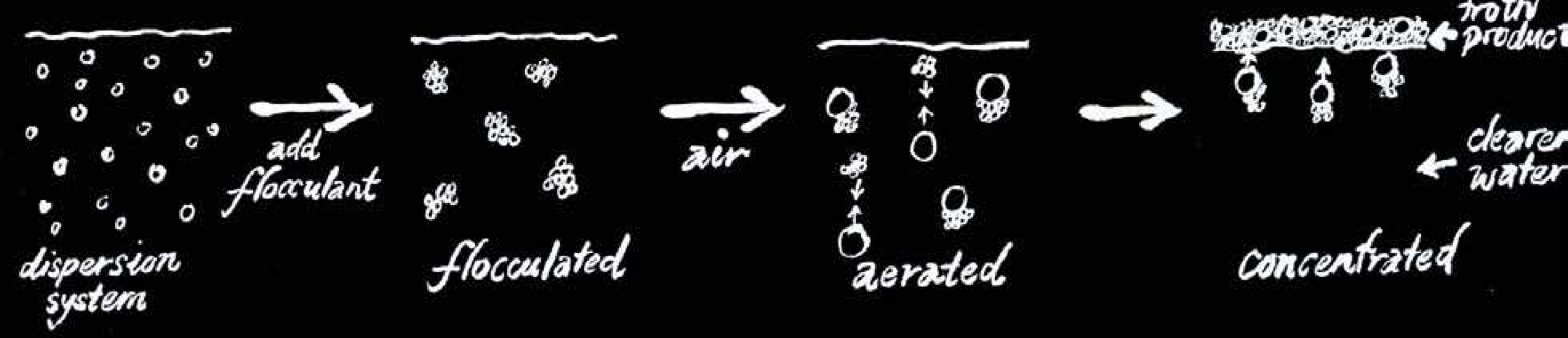
The effluent — an emulsion of water, oil and detergent — comes from the rolling of steel at two BHP mills. The mills are at Western Port in Victoria and Port Kembla in New South Wales. The Victorian mill produces about 250 000 litres of waste-water a day, requiring treatment before discharge. An existing treatment plant, built in the 1970s, uses heat and acid to 'crack' the emulsion and separate oil from water, but the acid plant is severely overloaded and costly to run.

At Port Kembla, the mill daily produces more than 600 000 litres of waste-water that needs treatment and, although the mill has an adequate treatment plant, there is an urgent need to improve the plant's ability to handle other effluents from steel production.

Foam flotation is based on the principle that many of the contaminants commonly found in industrial waste-water, such as oil and grease, can be made to coalesce and rise to the surface more readily than sink and settle at the bottom. This is because the organic compounds in oil repel water molecules and, whenever possible, tend to move quickly to the air-water interface.

Detergents, however, keep the oil droplets finely dispersed through the water and stop them from coalescing and floating to the surface. In treatment systems that depend on settlement, it may take many hours or days for the oil to separate from the

Foam treatment bubbles oil away



1. Oil is dispersed in fine droplets throughout the waste-water coming from the rolling mills. Such oil-water emulsions are often highly stable and do not quickly separate out with treatment.

2. Polyelectrolytes are added to the effluent, flocculating the emulsion. 'Bridges' are formed between the dispersed oil molecules, causing them to clump together.

3. Air is pumped into the water. The aggregated oil particles attach themselves to the air bubbles and rise to the surface.

4. The oil and air form a foam floating on the surface of the effluent which can be skimmed off for further treatment. The remaining liquid is much cleaner and suitable for discharge or re-use in the plant

water. But in foam flotation, the effect of the detergent is reversed by adding a chemical called a polyelectrolyte that forms an electrical bridge between the organic compounds in the oil and makes it easier for the emulsion to break down into separate water and oil phases.

BHP Western Port: the steel mill produces about 250 000 litres of waste-water a day.

The specific polyelectrolytes used in the CSIRO-BHP research are a commercial secret. Typically, however, they are polymers in the shape of long chains with electrically-charged side branches that attract the oil molecules. Each polyelectrolyte molecule can therefore cause many oil molecules to join up and form an aggregate or clump of oil droplets. The process is called flocculation.

Air is then pumped into the effluent through a tube that has a small rotating blade at its base. The blade 'slices' the air into finely dispersed bubbles about 1 mm in diameter. As these percolate through the water, the aggregated oil particles attach themselves to the bubbles and are rapidly carried to the surface where a froth or foam is formed. Once on the surface in a foam, the oil can be mechanically skimmed and removed, leaving a relatively clean body of water behind for discharge or re-use in the plant.

A major advantage that foam flotation has over other treatment systems is its ability to handle widely varying concentrations of contaminants without any substantial loss in treatment quality. The concentration of oil in rolling-mill effluent, for example, can vary from 100 parts per million (ppm) to as high as 10 000 ppm.

Although the principle behind foam flotation is surprisingly simple, much

Inside BHP's hot strip mill. Rolling of steel slab into long sheets occurs here and at the cold-rolling mill, where mineral oil and tallow are used as lubricants. The mills roll about 1.5 million tonnes of steel a year.

research effort has been devoted to determining the best combination of two key factors: the amount of polyelectrolyte added and the length of time spent aerating the effluent. In the trials, the researchers set themselves two main goals: the process had to remove at least 90% of the oil, and the volume of the removed oil-foam fraction had to be less than 15% of the incoming effluent. Achieving these goals is a balancing act: a high level of oil removal requires more flocculant and aeration, but at the expense of creating a greater volume of oil and foam.

Using a computerised technique known as statistical experimental design, the scientists devised a series of laboratory tests that would optimise the concentration of polyelectrolyte and the 'residence time' (the time the effluent spends in the treatment tank). These tests led to lengthy trials, using a pilot plant with 10-litre tanks capable of treating up to 6 litres of effluent a minute.

One such trial — with effluent containing between 350 and 3500 mg of oil per litre of water — removed more than 95% of the oil and grease. When the residence time was limited to 8 minutes, it was still possible to remove more than 92% of the oil, while maintaining the volume of the output below 15% of the input volume.

Dr Dixon, a senior principal research scientist at the CSIRO Division of Chemicals and Polymers, says the foam flotation system is faster, more robust, cheaper to build and cheaper to run than existing treatments.

'BHP has 100 years of flotation expertise, and we have a long history in effluent treatment, so the combination of research skills has been pretty good,' he says.

In recent months, the researchers have proved that foam flotation can treat effectively many different types of industrial effluent. With the highly polluting effluent from wool-scour mills, for example, the process removed more than 98% of the turbidity (a measure of the cloudiness of the effluent) and more than 95% of the wool grease.

Successful tests have also been conducted with effluents from dye houses, abattoirs, chicken and coffee-processing plants, print businesses and pulp and paper mills.

BHP Steel is considering the installation of two foam flotation plants, one at Western Port and the other at Port Kembla. CSIRO is seeking a business partner interested in the commercialisation of the process, both in Australia and overseas.

More about the topic

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Dixon DR & Ha TC (1992). Effluent treatment. Australian Patent No. 623787.

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