Self-Cleaning Hydro Screens

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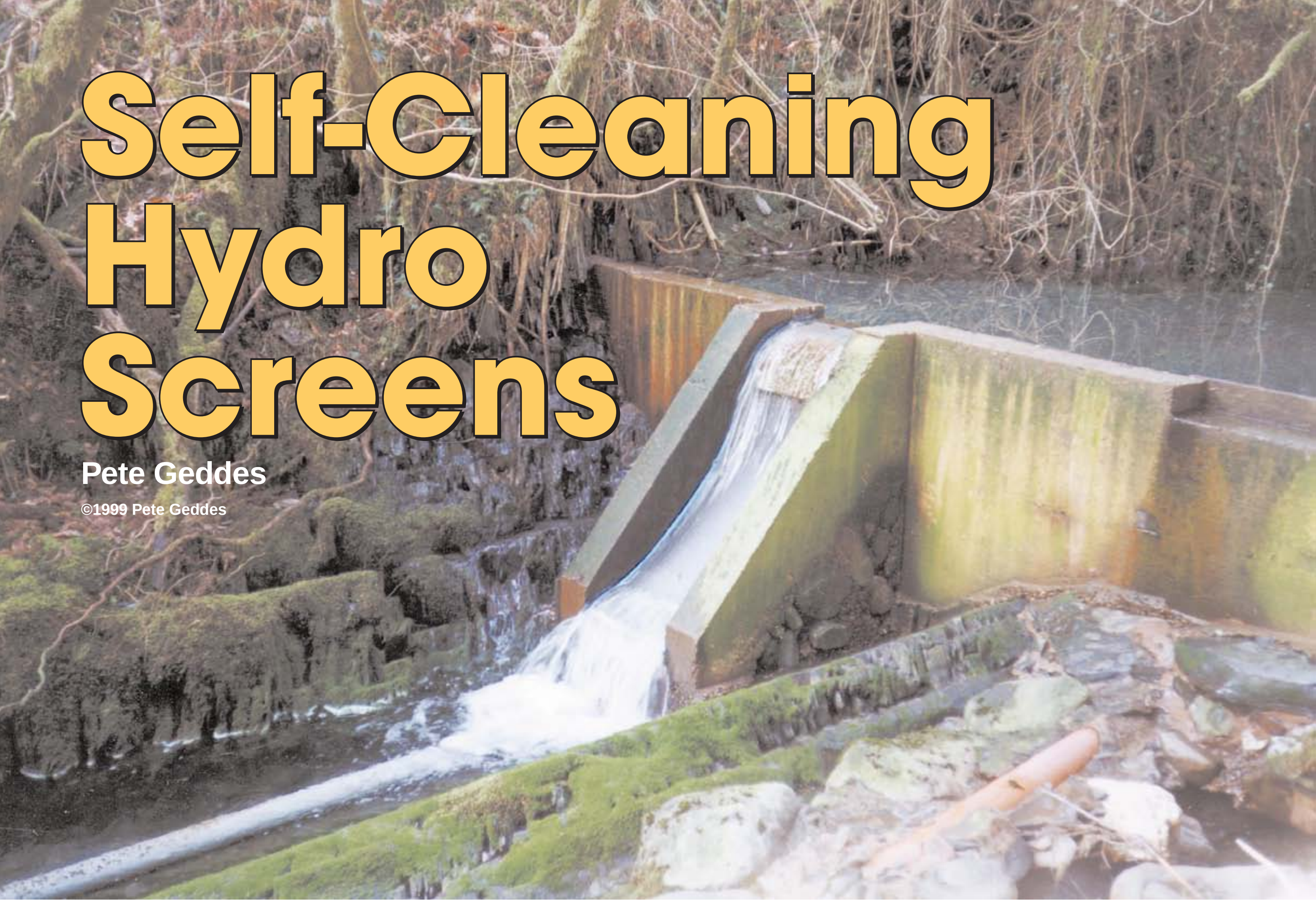


A Coanda effect screen on the intake at Nick Mills' site saves lots of long cold walks during the night to clean out debris.

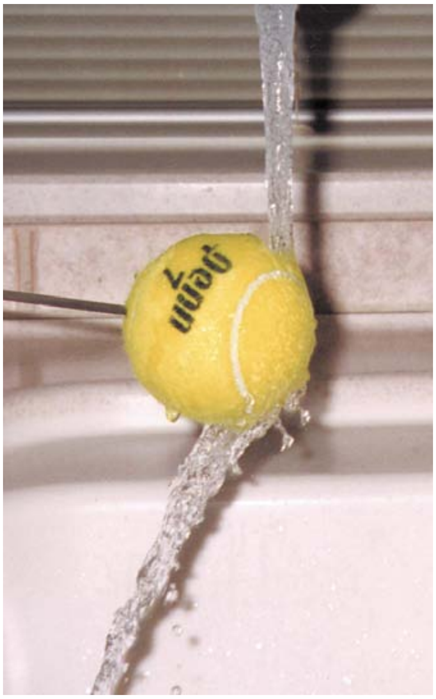
Run-of-river microhydro systems use stream water as it's available, with no significant water storage. Most of these systems use fixed trash racks for diverting marine life and debris at the intake point. Although the racks themselves are not expensive, their maintenance and periodic cleaning, whether manual or powered, can cause real problems in debris-laden streams.

Common problems include intermittent power output caused by blocked screens, pipes, or jets; turbine damage caused by continuous abrasion or sudden impact; or even burst pipes caused by sudden pressure rise (surge) as a result of a completely blocked jet.

The Aqua Shear screen can avoid many of these problems. This innovative intake screen was developed in the USA, and is proving popular internationally. The screen protects fish, removes debris and silt, and requires no manual cleaning, maintenance, or external power source.

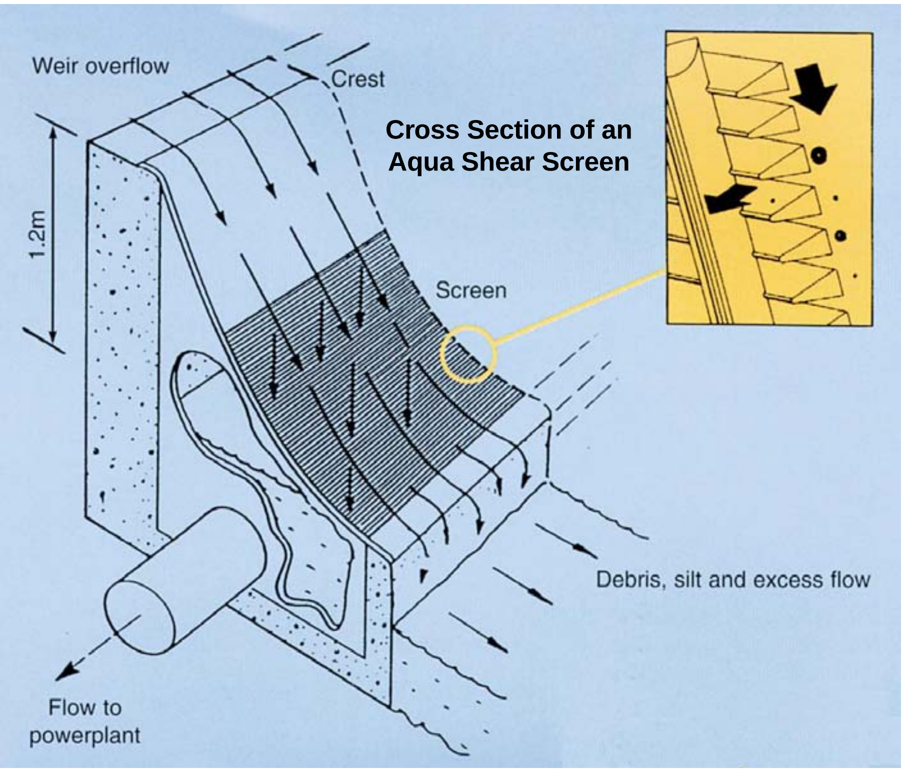
Coanda Effect

The Coanda effect is named after Henri-Marie Coanda, who first identified the effect in 1910. It describes the tendency of fluids to follow a surface. Stick your finger under a tap and notice how the water runs along the underside of it; this is an example of the Coanda effect. Today the effect is exploited in the design of jet engines and turbo-charged internal combustion engines.



The Coanda effect is demonstrated by the water adhering to the surface of the tennis ball.

This tendency of fluids to follow a surface is utilized in the Aqua Shear screen by the means of a row of horizontal "wedge wire" bars, arranged with a spacing of 1 mm or less, perpendicular to the flow. The bars are tilted up about five degrees relative to the slope of the screen and "shear" a part of the flow passing over the screen.



The flow is separated by this shearing action and the Coanda effect, which pulls the water down along the vertical surfaces of the bars. Clean water passes down through the screen, drawn in at the rate of 102 liters per second per square meter of screen (2.5 U.S. gps/ft^2). Water containing fish, sediment, and debris passes over the screen to rejoin the watercourse below the weir.

From Coal to Hydro

The screen was originally developed in 1955 as a simple apparatus for the wet screening of coal slurries. Some years later, it was found to be ideally suited as a maintenance-free screen for hydro systems with high silt loads or debris problems.

In the USA, the screens have been in use since the early 1980s, installed on fifteen systems of up to 11.9 MW capacity and up to 7 cubic metres per second (1,849 U.S. gps) flow. In Europe, the screen is manufactured under license by Dulas Ltd. in the UK, and is installed in eight systems ranging from 0.5 KW to 300 KW.

Fish and other forms of aquatic life are washed over the surface instead of being sucked through or onto the screen, as in a normal hydro installation. As a result, the Coanda screen has been well received by environmental and wildlife organizations, including the U.S. Fish and Wildlife Service.

The screen's performance has been proven under severe conditions of freezing and floods. The screens resist impact damage from tree limbs and boulders during floods, due to their steep angle away from the flow and the high degree of frame rigidity. For widths of more than 0.5 metres (1.6 ft), an integrated stainless steel supporting frame is welded to the screen to allow several sections to be bolted together side by side.

Screen Construction

The Aqua Shear screen is fabricated to high tolerances from stainless steel. In addition to its self-cleaning property, the screen has a desilting function. Ninety percent of 0.5 mm suspended silt particles and all 1 mm particles are screened out of the flow to the turbines, eliminating a desilting tank in many systems. Screen spacing is engineered for a certain size, which can be 0.2 to 1 mm, as chosen by the client.

The associated concrete construction is straightforward. The frame is simply bolted to horizontal and vertical concrete faces. There is a loss of about one metre (3 ft) of head from the weir top to the intake water level, which can be reduced as low as 0.64 metres (2 ft) for low head systems.

Another possibility currently being investigated is to mount a screen in a box attached to the diversion outlet. Water is piped to the box, where it is screened, with the debris and overflow returning to the stream. This alternative eliminates the need for a large and costly diversion structure, while still providing a relatively maintenance-free screened diversion.

Vulnerability

Compared to the heavy bars typical in conventional intakes, the fine wire of the Aqua Shear screens might seem to be vulnerable to rock damage. But the screen is angled steeply away from the direction of water flow, and has heavy framing and support rods. These design features protect the screens from boulders and tree limbs in almost all cases. To give one example, severe flooding on the Bear Creek 3 MW site in northern

The 4 KW system in Wales after several months without any cleaning, with no detrimental leaf build-up.

California in 1986 put the entire diversion under three metres (10 ft) of water, but the intake continued to perform normally.

Freezing
With a lateral intake, the conventional approach is to submerge the screen, use low conductivity materials or coatings, and encourage ice to form at the surface by keeping velocities low. These techniques seem unnecessary with Coanda screens used down to air temperatures of -20° C (-4° F), where there is evidence of good performance. A system on Blueford Creek in California, for example, has data for one week at -20° C with no reported problems. The diversion at Beaver City, Utah has operated successfully at air temperatures as low as -30° C (-22° F).

The Competition
Some small hydro screens have just a short length of large diameter pipe with holes or slits cut in it. These can be partially dammed around to keep them submerged. This type of screen has problems—vulnerability to rock damage and gradual blocking of the screen holes. Hole size is limited by the turbine jet nozzle size. The screen must not allow particles larger than the nozzle to pass through, or else the jet is liable to block. If this happens suddenly, the pipe may burst due to surge.

The Tyrolean style weir is a more expensive but partially self-cleaning intake. This screen is angled away from the flow like the Aqua Shear, so it is less susceptible to blockage and boulder damage. Its self-cleaning effects are limited, however, so it is still more vulnerable to blockage than the Aqua Shear. Complicated concrete construction can result in this intake design costing more than an Aqua Shear intake.

A last type of intake screen is the automatic screen cleaner, or "screener." In this type of system, a hydraulically operated brush or scraper periodically brushes the screen to remove debris. These are becoming more popular, despite being expensive and requiring power. Due to the relatively high power demand, these screen cleaners are not considered appropriate for small domestic systems.

In contrast to these common intake arangements, the Coanda effect screens work exceptionally well. Three examples of hydro sites utilizing the Aqua Shear intakes follow.

4 KW System: Holiday Cottage in Wales
A full monitoring programme was completed by Dulas Ltd. in 1996 at a 4 KW system in a wooded catchment (watershed) in the mid-Wales region. The goal was to verify capacity, self-cleaning, wear, reliability, and anything that might decrease the system's capacity over time, such as algae growth or freezing. The system supplies mains power to a nearby holiday cottage, with storage heaters and dehumidifiers connected as dump loads. The loads run continuously during the long spells when the cottage is empty.

During the eight month monitoring period, the Aqua Shear screen worked perfectly, with no cleaning necessary. Silt exclusion was excellent, with 97 percent of silt removed, above and below 0.5 mm size. The cottage no longer suffers from dampness or mustiness when the owners turn up for a weekend, and they get clean, quiet electricity for free. A self-cleaning screen is ideal for this kind of system where a dwelling is unoccupied for long periods.

1.75 KW System: Nant-y-Garren, Gwynedd, Wales
An old secondhand 1.75 KW Gilkes Turgo turbine and Newage generator supply Nick Mills' only electricity. The intake is remote to the house, being one mile (1.6 km) up the road, and down a steep 50 foot (15 m) gorge. The catchment area is steep and flashy (prone to flash floods), with lots of leaves every fall.

Over a period of five years, Nick tried a number of devices to reduce blockages. Watching the TV fade out and having to go out to clean the screen two or three times a week in the winter in the cold rain convinced him to do something serious. He decided it was a choice between noisy, expensive diesel power and sorting out his hydro intake.

A new intake structure with an Aqua Shear screen completely eliminated Nick's problems, and made the intake system 100 percent reliable. He has not had to visit the intake since installing the screen in 1996!

300 KW System: Swiss Alps

Entec, a Swiss renewable energy consultancy, recently completed an investigation on a 300 KW system in the high mountains of the Swiss Alps, monitoring a difficult intake. The new Aqua Shear screen replaced the original Tyrolean (drop type) intake. For thirteen months, the performance was monitored by various means including the use of an automatic camera, providing a still photograph every 24 hours.

After the new screen was fitted, the system did not shut down once due to a silted or clogged intake. Removal of debris and leaves was found to be excellent; the screen was 100 percent self-cleaning. It performed normally under freezing conditions down to -20° C (-4° F) air temperature. Freezing is prevented in very low flows by using stoplogs to direct the flow over the centre of the screen. Sand rejection was considered particularly good; 94 percent of particles greater than 0.5 mm were rejected. This investigation concluded that the screen was economically and ecologically sound for systems with sufficient head.

Maintenance-Free Intake

The Aqua Shear screen offers significant advantages in a wide range of small hydro applications as the trend to unattended systems increases. European prices start at UK£350 (about US$564), for a 7 liter per second (0.25 cf/s) capacity screen. They can be retrofitted to existing difficult sites, but are more economical when included in a new system.

The range of applications includes small hydro intakes, filtering water for agricultural irrigation, and pretreatment for municipal and industrial water supplies. Aqua Shear screens offer maintenance-free intake management. They reduce wear on turbines and completely eliminate potential blockage.

Access

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The Rises & Falls of Henri-Marie Coanda, Air & Space Magazine, Aug./Sept. 1989