The Comb Separator: Design improvements following real-world experience

"Comb Separator" : améliorations de conception suite à des expériences concrètes

Donald Ian Phillips*, Michael Simon**

*Water Solutions (Aust) Pty Ltd. → watsolptyltd@bigpond.com
**WATSOL Water Solutions GmbH → simon.m@watsol.de

RÉSUMÉ

Le « comb separator » est un dispositif de séparation, installé principalement dans les chambres des déversoirs d'orage, fonctionnant de manière continue pour séparer les eaux des solides. Ce séparateur en peigne piège les matières solides et les ramène après l'événement au réseau en direction de la station d'épuration. Les séparateurs en peigne ont été installés depuis plusieurs années en Allemagne et en Australie. Au cours de cette période, ces dispositifs sous observation permanente ont été modifiés dans le but d'améliorer leur fiabilité et de réduire leur entretien. La communication décrit la fonctionnalité du séparateur en peigne avant l'identification des problèmes opérationnels qui ont émergé sur cette période. Nous discutons ensuite des améliorations simples mais efficaces qui ont mises en œuvre.

ABSTRACT

The comb separator is a screening device primarily for installation on CSO chambers. It screens out the visible solids from spills and later returns them to the sewer for onwards conveyance to the WWTP. Comb separators have now been installed for several years in both Germany and Australia. During this time they have been monitored leading to design modifications aimed at reducing maintenance needs whilst improving reliability. The paper describes the workings of the comb separator before identifying the operational problems that have arisen over this period. It then discusses the simple yet effective design modifications either carried out or proposed for future comb separators.

KEYWORDS

Comb separator, CSO chambers, practical applications, spills

1 INTRODUCTION

The comb separator is a device that screens the visible solids from combined sewer overflows (CSO's) and later returns the screened solids to the sewer flow for onward conveyance to the treatment plant.

Papers presented at Novatech 2010, (Phillips, Simon) and Novatech 2013, (Phillips, Simon) reported on progress in the development of the comb separator from laboratory studies to full-scale tests using raw sewage. These latter tests were conducted at United Utilities Plc North Warrington waste-water treatment plant (WWTP).

Following this work it was subjected to the independently conducted SRV tests, (ThompsonRPM) that showed that the comb separator was the most effective static screen device available, even surpassing most of the mechanical screening devices. The results were presented at Novatech 2013 and are available in those proceedings.

Since then comb separators have been installed in both Germany and Australia and their performance monitored over several years to identify and address several problems that arose.

2 PROBLEMS ARISING IN PRACTICE

The main problem was blinding of the combs due to far greater spills than the design spill specified by water authorities. While the combs were cleaned as part of normal maintenance it was felt that as "prevention is better than cure", design modifications were necessary.

A more serious problem was distortion of the comb bars caused by the impact of heavy solids against them. Such distortions promoted comb blinding requiring more frequent maintenance needs. While stainless steel bars are relatively stiff, long combs can be bent by heavy impacts and so, by shortening them, this problem can be reduced.

Full comb blinding can lead to raised water levels in the CSO chamber and, where the sewer grade is flat, flow can back up into premises.

These three problems are closely related and can be addressed by design changes.

Another problem was the snagging of flexible solids in the retention screen both during the early and late phases of the spill event. Again, while these can be readily hosed off, simple design modifications can significantly obviate the problem.

The purpose of this extended abstract is to describe how these faults, that became apparent when the comb separator was subjected to real-world sewer overflows, were corrected.

3 OPERATION OF COMB SEPARATOR

Before doing so it is helpful to understand how the comb separator functions with the aid of the figure below.

As is shown, the spill over the sharp-crested weir occurs as a free nappe and passes through the comb arrays where the visible solids are screened from the nappe and fall into the holding chamber while the screened nappe impacts on the cover plate before discharging to the receiving water.

The combs are arranged to overlap each other so that solids passing through a forward comb are intercepted by the following comb. The spacing of the bars in the forward combs are greater than those in the following combs with the last comb having the closest bar spacing set at that of the smallest solid to be intercepted, often 5mm.

When the spill ceases and the sewer flow returns to the dry weather flow, the ball closing off the valve falls to allow the screenings to pass through to the CSO chamber for onwards conveyance to the WWTP.

The figure below shows the improvements made to address the problems identified above.

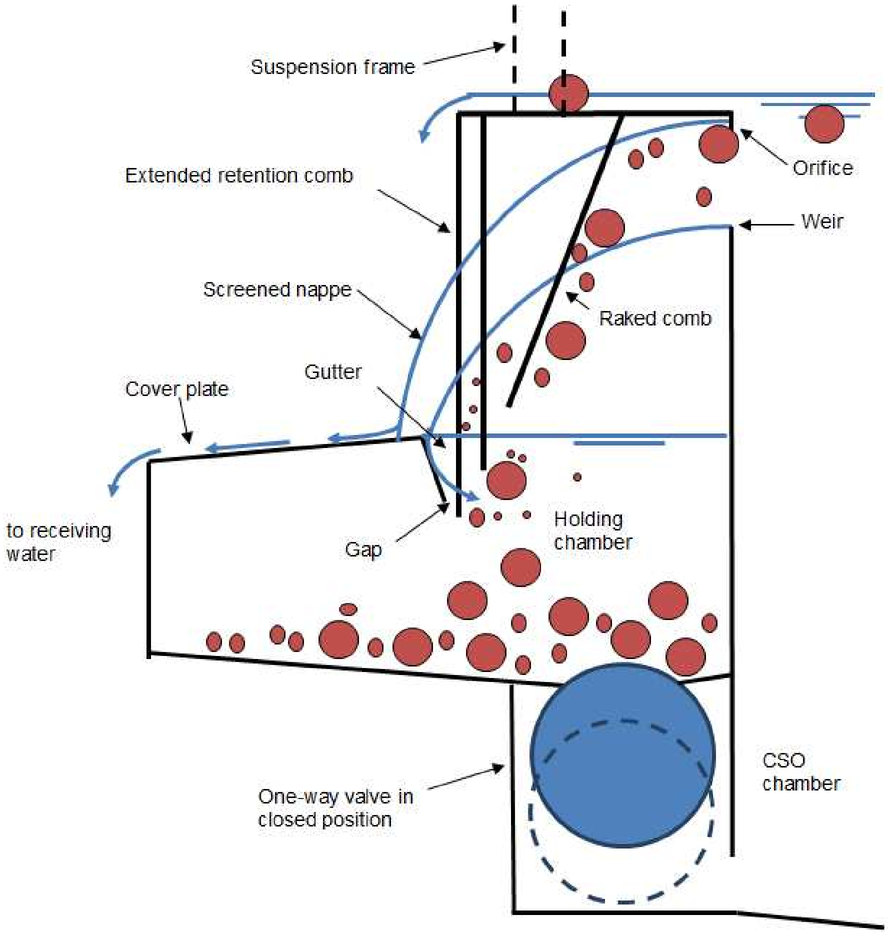

Figure of cross-section of comb separator illustrating design modifications

4 DESIGN MODIFICATIONS

The first of these is the bypass provision wherein spills in excess of the design spill are bypassed above the comb assembly. During the United Utilities tests, spill depths on the weir of up to 300mm and rates of 310L/m/s were tested and the trajectories of the corresponding nappes measured.

The diagram shows a cross-section of the comb separator through the central valve chamber. Between the hanger and the combs is a flat plate that extends forwards to the weir where it bends down to form a sharp-edged orifice in combination with the weir.

Consequently spills in excess of the design spill will be throttled by the orifice and forced to bypass over the plate to discharge without treatment. As the plate extends the length of the combs, the orifice head will be small and so not materially increase the orifice flow or trajectory.

Three improvements follow this modification. The first of these is that by limiting the spill, blinding of the combs is eliminated. The second is that the bypass plate above the weir can be lowered so as to prevent significant back-up in the sewer during bypass. The third is that the length of the comb bars can be reduced to confer additional stiffness.

To intercept heavy solids that might otherwise impact adversely on the combs, the front comb is raked backwards so as to reduce the magnitude of such impacts and to deflect the solids down to the holding chamber.

The figure shows the modified retention screen designed to prevent snagging of screened solids. This snagging was caused when the nappe fell directly into the holding chamber rather than passing through the combs and impacting on the cover plate.

The falling nappe can re-suspend screened solids in the holding chamber that may then drift with the spill flow to become trapped in the retention screen. When the valve opens these solids can remain caught in the screen and, with successive spill events, build up and in the worst case scenario, block the screen.

As the re-suspended solids snag the retention screen at the level of the cover plate, the modification was to turn down the leading edge of the plate to form a gutter and to extend the comb bars to below the bottom of the gutter while leaving a gap between them.

Consequently, when solids are intercepted by the retention screen, they are suspended in neutral equilibrium in the gutter. When the valve opens and the water level in the holding chamber rapidly falls, the solids can easily slip down the bars and pass through the valve as was seen in the testing program.

5 CONCLUSIONS

- Comb separators monitored since 2012 have been subject to severe spills requiring design modifications.
- The monitoring revealed that comb blinding occurred when spill flows exceeded the design value and impacted on the combs at angles greater than the self-cleansing angle.
- It also showed bending of the comb bars occurred when impacted by heavy solids and snagging of solids on the retention screen.
- Blinding can be prevented by limiting the spill treated to the design value.
- This is achieved by creating an orifice plate over the weir and bypassing the excess spill.
- Distortion of the bars by high spills and heavy solids can be reduced by raking the forward comb backwards.
- Snagging on the retention comb is addressed by a gutter and extension of the comb below the gutter.
- The modifications should achieve the objectives of a low-maintenance, reliable comb separator.

6 LIST OF REFERENCES

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