THE DEAL WITH DILUTION

Why do we dilute thickener feed?
The short answer... to improve flocculation.

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Flocculants are used in gravity thickeners to improve the natural settling properties of solid particles present in the thickener feed slurry. Put simply, flocculants are long chain polymers which could be imagined as a ‘glue’ that binds particles in the thickener feed to form larger aggregates which settle more readily than individual particles.

The process of adding flocculant to the thickener feed and the subsequent formation of these aggregates is referred to as flocculation. In some cases, in order to improve flocculation efficiency it can be necessary for the slurry to be diluted to a lower concentration.

The highs and lows of slurry concentrations

In cases where thickener feed dilution is required, the slurry feed to the thickener is commonly diluted in the thickener feed system. This improves both the mixing and contact of the solid particles with the flocculant in the thickener feed as contact and adsorption of those particles is essential for flocculation to occur.

As a general rule, thickener feed slurries containing solids with a finer particle size will flocculate more efficiently at lower slurry concentrations, while coarser feeds can tend to flocculate well at higher concentrations. This is due to finer particles having a higher surface area per unit mass than the coarser particles (assuming the same specific gravity). Thus for efficient use of flocculant, it is generally necessary to disperse finer particles in a more dilute solution to ensure the flocculant is able to better contact the surfaces of those particles.

Also of interest is that in some applications it can be necessary to increase the concentration of highly dilute feeds as additional solids will improve flocculation where otherwise the particles would be too highly dispersed for the particles to make contact with the flocculant and form aggregates.

The distinction between ‘fine’ or ‘coarse’ particles can be relative; consideration of other factors, such as surface chemistry and appropriate flocculant selection, will come into play in determining the optimal dilution for a given thickener feed type. Prior to installing a new thickener or upgrading an existing thickener, a series of tests should be carried out on indicative thickener feed samples for the particular application. During testwork one of the parameters measured is the optimal feed concentration for flocculation of the particular material. This information, along with a number of other variables measured, is then utilized during the design of the thickener.

Thickener feed dilution systems

In most cases, where feed is presented at a higher concentration than optimal, liquor from the surface of the thickener is used to dilute the feed slurry in the thickener feed system. This supernatant dilution liquor is usually introduced to the thickener feed, in or just prior to the feedwell, to dilute the slurry prior to the addition of flocculant. Diluting thickener feed using supernatant water from the surface of the thickener is highly efficient as feed can be presented to the thickener at higher concen-
trations and therefore lower volumetric slurry feed rates compared to diluting feed to an optimal concentration prior to the thickener. Thus pumping and pipeline capacity requirements can be minimized, reducing capital and operating costs.

**Directional Autodil™**

Directional Autodil™ is an advancement of Outotec’s Autodil feed dilution system which was introduced during the 1980s. It was the first automatic system to utilize supernatant liquor within the thickener to dilute thickener feed for improved flocculation.

Autodil™ harnesses the natural head difference across the feedwell wall. This is based on the principle that a hydraulic head differential exists between the overflow liquor outside the feedwell (generally having a specific gravity at or close to 1.0) and the slurry inside the feedwell (having a higher specific gravity due to the presence of solids in the feed pulp). Therefore, in this system, gravity drives the dilution flow into the feedwell as the slurry level inside is lower than the liquor outside of the feedwell.

By installing directional port(s) in the feedwell wall at an appropriate level, Directional Autodil™ allows supernatant liquor flow into the feedwell in the same direction as the incoming feed and hence promotes more effective mixing within the feedwell.

A further advantage of Directional Autodil™ over other fixed geometry feed dilution systems is that by utilizing the hydraulic head differential, the degree of dilution is naturally varied according to fluctuations in the density of the feed. Hence, this system is able to buffer feed density variations, producing optimum flocculating conditions over a range of feed conditions.

**Turbodil™ forced system**

In certain circumstances it may not be possible to achieve the dilution requirements for a particular application using the Directional Autodil™ system. This may be due to gravity alone being unable to provide sufficient driving head; or additional flexibility may be required due to process variations. Therefore it may be necessary to provide the required dilution flow by mechanical means. This includes applications where:

- the process requires further dilution of already low feed concentrations, or
- where high volumes of feed dilution flow are required to bring the incoming feed to the required density, or
- where large variations in feed conditions are anticipated, or
- where a low slurry specific gravity differential exists between the feed slurry and the overflow liquor due to the particles in the slurry having a low specific gravity.

Outotec’s Turbodil™ forced feed dilution system utilizes a low head radial flow impeller mounted inside a casing which drives the dilution flow into the thickener feed system. The casing also acts as a shroud at the bottom of the unit to ensure that solids are not drawn up from the settled bed inside the thickener.

This system can be set to deliver a fixed dilution flow. In cases where variability of the dilution flow is required due to highly variable feed conditions, a Variable Speed Drive (VSD) can be utilized to control the flow delivered by the Turbodil™ unit(s).
Installations
The Autodil™, Directional Autodil™ and Turbodil™ feed dilution systems have contributed to process objectives being achieved and operating costs minimized in over 1000 thickener installations and upgrades globally.

In one copper CCD circuit, as part of an upgrade of the thickener feed system, a Turbodil was installed to dilute incoming thickener feed to approx. 4% solids (w/w). As a result of this upgrade, optimized mixing and flocculant usage contributed to an increase in underflow density from approximately 40-45% solids (w/w) to ~55% solids (w/w). Overflow clarity was also improved. This equated to a significant improvement in the wash efficiency for the overall CCD circuit.

Another case involved a coal tailings application in South Africa where a Turbodil™ was retrofitted to the thickener feed system to accommodate a more demanding duty than the original design. The new duty required a solids throughput increase of approximately 9%. Following the feed system upgrade, including optimization of feed dilution, underflow density was increased by almost 7% while overflow clarity was also improved at this more onerous operating duty.

Benefits of thickener feed dilution
With a thorough understanding of the feed and dilution requirements, a thickener can deliver efficient usage of flocculant. Process performance can be optimized through correct flocculation, allowing better water recovery and clarity as well as improved underflow densities. This can have dramatic impacts in water usage, management of tailings and optimizing recoveries for operation.

Internal feed dilution systems utilising supernatant liquor from the surface of a thickener are a relatively simple solution when diluting thickener feeds. They provide significant capital and operational cost savings compared to diluting the thickener feed externally.

Thickener feed dilution is an important facet of good thickener feed system design. It can have a significant impact as to whether a thickener achieves its process performance targets, as well as the overall cost of operation.