Prevent lime scale without Chemicals

Conversion of Calcite to Aragonite by using the Vortex Process Technology®

The emergence of lime scaling

Hard water contains a lot of calcium in the form of relatively soluble calcium hydrogen carbonate $Ca(HCO_3)_2$, therefore in water calcium carbonate Ca^{2+} and bicarbonate $HCO3^-$ ions are present. When water is heated carbon dioxide $CO_2(g)$ evolves and raise the solid calcium carbonate $CaCO_3(s)$:

$$Ca^{2+}(aq) + 2(HCO^-_3)(aq) \rightleftarrows CaCO_3(S) + CO_2(aq) + H_2O(l) \rightarrow CaCO_3(s) + CO_2(g) + H_2O(l)$$

Formula 1

The resulting calcium carbonate $CaCO_3$ (Calcite polymorph) is heat-insulating and is therefore bad for the heat transfer in a heating element. The above reaction is actually a compilation of two equilibrium reactions.

Reaction 1: the carbonate-bicarbonate equilibrium

HCO_3^- ions react with itself (HCO_3^- is amphoteric) according to the following chemical equilibrium:

$$HCO_3^- + HCO_3^- \rightleftarrows H_2CO_3 + CO_3^{2-}$$ Formule 2

The formed H_2CO_3 is unstable and breaks down into CO_2 carbon dioxide and H_2O water. By heating the water, the solubility of carbon dioxide in the water decreases and disappears from the water. The above chemical equilibrium CO_2 disappears, and ensures that new CO_2 is formed: the chemical equilibrium shifts to the right (according to the principle of Le Chatelier). Because by replenishing CO_2 there is also CO_3^{2-} formed, which does not disappear from the reaction, the concentration of CO_3^{2-} ions is increased.

Reaction 2: The solubility equilibrium of calcium carbonate

The presence of Ca^{2+} ions will react with the now largely present, of CO_3^{2-} ions to calcium carbonate (lime scale):

$$Ca^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow CaCO_{3(s)}$$ Formule 3

Since calcium carbonate is insoluble in water, this equilibrium moves strongly to the right.

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Aragonite crystallization in the Vortex


Figure 1 uncontrolled cavitation

In the Limeteq Converter™ the Vortex Process Technology ® (figure$_4$) creates a powerful and stable vortex. This essentially is a **controlled cavitation**. In figure$_1$ is an uncontrolled cavitation can be seen, created by the pressure difference of a ship's propeller. In the Limeteq Converter™ the Vortex removes unbound gasses from the water by a vacuum in the middle of the vortex. This is a controlled cavitation. All unbound gasses, including carbon dioxide CO_2 gasses, are withdrawn by the sub pressure of the vortex. The relatively soluble calcium hydrogen carbonate $Ca(HCO_3)(aq)$ will be converted by this process in Calcium Carbonate $CaCO_3(s)$, see formula$_1$.

There is one important difference, the build-up of the $CaCO_3$ crystal!

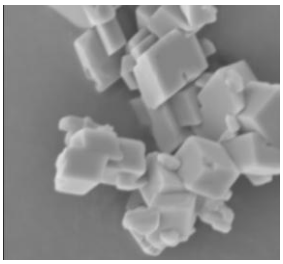
figure 2 Calciet

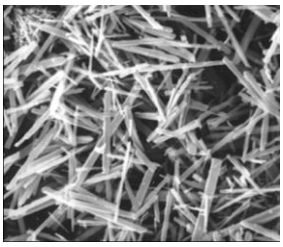
Figure 3 Aragoniet

Calcium carbonate $CaCO_3$ formed in the Limeteq Converter™ by the Vortex Process Technology® (figure$_4$) crystallizes differently. The **Aragonite crystal** (figure$_3$) is formed instead of the **Calcite crystal** (figure$_2$). During the formation of calcium carbonate, by the removal of CO_2 gas bubbles, the **forces of the vortex prevent** that the Calcite crystal is formed. Instead, the polymorph Aragonite is formed. Aragonite cultures that are created in the Vortex ensure that more Aragonite crystals form when calcium carbonate $CaCO_3$ is formed in a later process. The length of the Vortex, and thus the cavitation tunnel, determines the amount of unbounded gasses that are extracted. When more carbon dioxide CO_2 gas bubbles by the vortex are extracted more of the calcium carbonate polymorph Aragonite is formed.

Properties of Aragonite

The polymorphic Aragonite has a main characteristic that it **does not scale**. Calcium Carbonate $CaCO_3$ formed in the vortex remains dissolved in water and will not catch on to heat sources or other surfaces. **Treatment with salts or chemicals is no longer needed**. Furthermore, Aragonite is slightly harder than Calcite and usually grows in needle-shaped crystals (aciculair), while Calcite has a leaf-shaped habit. The more harder Aragonite can even wear down older Calcite lime scales and remove them.

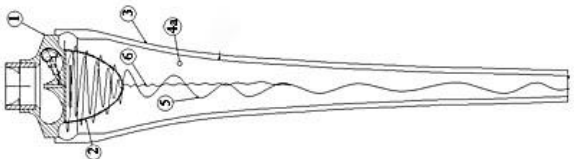
Figure 4 Vortex Process Technology ®

Vlottum, (2006), Ketelsteen, Wikipedia.org, 24/10/2010 http://nl.wikipedia.org/wiki/Ketelsteen

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