Basic design criteria for agitators in alumina production

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Abstract

The cascade of agglomerators, precipitation growth tanks, and other mixed process vessels in a Bayer alumina refinery need a uniform suspension to assure a reliable and efficient process. Basic design rules for agitators for these process steps will be given with respect to solids concentration, solids size distribution and tank geometry. These design rules have been collected, evaluated and summarized from different alumina production installations worldwide. Two principle modes of design end up either with low investment cost or low operational cost. Both possibilities will be compared with their advantages and disadvantages. Local flow velocities, scaling behavior and natural overflow without air support will be examined.

Keywords: Alumina; Bayer; mixing; agitator; precipitation; agglomeration; suspension.

1. Mixing

Mixing is one of the main process tasks in the production of alumina. In the Red Area as well as on the White Area there are many different mixing tasks to be solved. Depending on size of the plant, there are sometimes 100 mixers installed. Mixing has a strong influence on alumina quality and production costs and is involved in the following process steps.

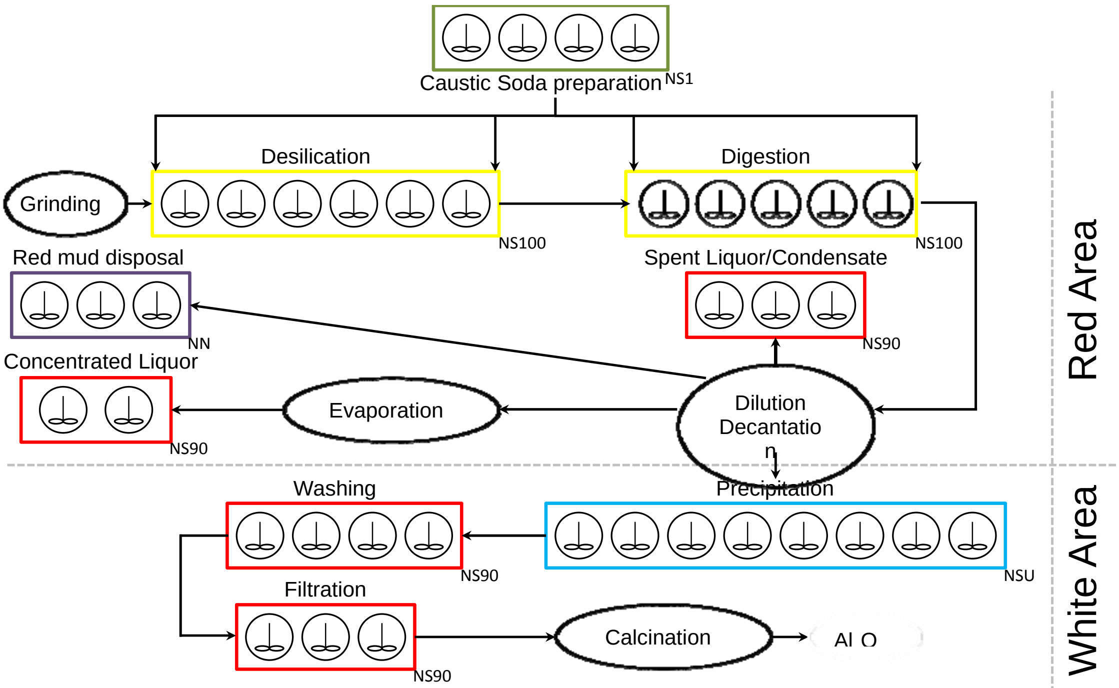
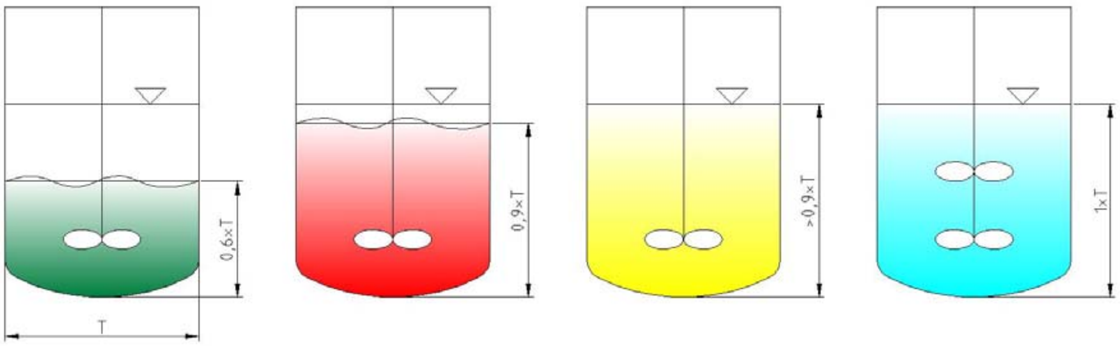


Figure 1. Mixing tasks in an alumina plant.

Fig 1 provides an overview of the mixing tasks which are involved. It is obvious that the majority deal with suspension. Red mud disposal (NN) is an exceptional case of non-Newtonian mixing for fluidization, but not dealt with in this paper.

Uniform suspension, called here "NSU", is a special case of high quality suspension, required to manage the natural overflow of the precipitator cascade and for wall scaling reduction or suppression. In most of these cases the mixing task is suspension. The mixing qualities in alumina refineries are defined as follows:



N=NS1	N=NS90	N=NS100	N=NSU
Preparation	Liquor, washing, filtration	Desilication, digestion	Precipitation
Complete	90 % height	Homogenous	Uniform

Figure 2. Basic cases for suspension quality.

N shaft speed (rpm)
NSj required shaft speed (rpm)

- Principally, the quality of suspension is distinguished by three different basic types; Complete suspension is the simplest task where a single particle is not allowed to settle longer than 1 second at the vessel bottom. This case means further that the cloud of particles can be lifted up to 60 % of the filling level. The speed which is necessary to lift particles in this manner can be calculated as a function of the settling velocity of the particles which will be given in detail later on.
- 90 % height suspension means that the particles or the cloud of particles is lifted up to 90 % of the filling level.
- In a homogenous suspension the particles are distributed in 100% of the liquid, up to the liquid surface.
- Further, there is a suspension type which is even better than homogenous – this is the so called "uniform suspension" (NSU) which is applicable in the precipitators. The uniform suspension is evaluated in its quality in detail in the following section.

Quality here means the solids distribution over vessel height, and is defined by statistical variance (Sigma).

The statistical variance of the solids distribution means suspension quality is defined by a statistical measurable standard.

$$\sigma = \sqrt{\frac{1}{n}\sum_{1}^{n}\left(\frac{Cv}{Cvav}-1\right)^2} \qquad (1)$$

Cv local concentration
Cvav average concentration
n numbers of measuring locations

flow velocity at the wall is 0.5 m/s, however a comparable installation with slightly bigger impellers has a 20 % higher flow velocity at the wall though a 20 % lower tip speed. The lower investment cost with the smaller impellers has to be paid for by higher operational costs which are growing disproportionately with inflation.

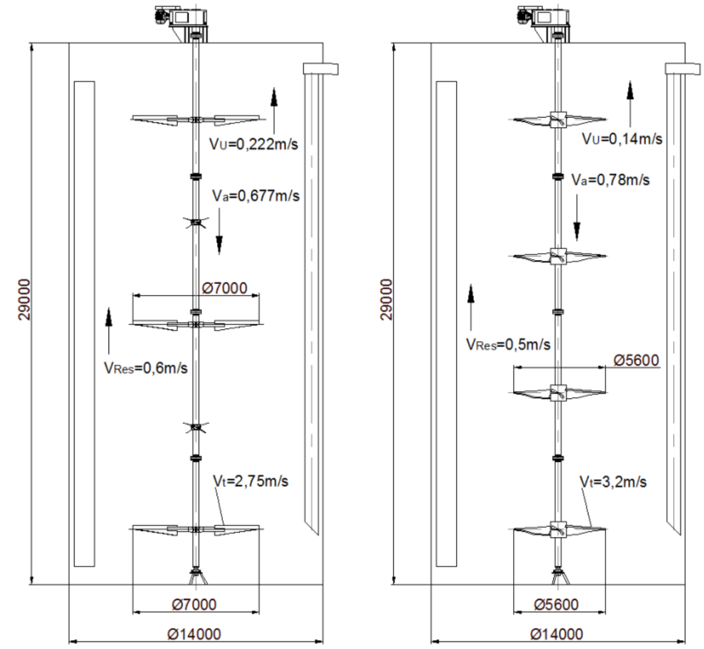


Figure 15. Design comparison for precipitators.

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