to break and enter the solution, thus causing secondary nucleation (acting as seeds). A special case occurs at very high supersaturation, where there is very fast dendritic/needle-like growth from the surface of crystals, and pieces of crystalline material can be easily broken off by fluid flow or mechanical action.

The effect of mixing on secondary nucleation has been reported in several studies.[11,66] An analogy of relation mixing and nucleation rate with reaction Damköhler number has been proposed for visualization of the effect of mixing severity.[12,67] The seed (fragment) generation is a proportion of the collision energy and frequency of collision in the size range of crystal length. Three different types of collision can result in attrition:

- Crystal–crystal impact: a function of both the local micromixing environment and the overall macromixing circulation.
- Crystal–impeller: a function of the impeller speed, the shape of the blade, and the construction material.
- Crystal–wall impact: a function of eddy turbulence, particle velocity and shape, and crystallizer design.

The critical mixing factors have been identified as impeller type and speed and their influence on local turbulence and overall circulation. Particle damage is a function of the shear produced by the agitator, which is nominally proportional to the agitator tip velocity. The attrition and fragmentation can be formed by contact of the crystals with a pump impeller (circulation line), the stirrer blade (traditional pitch blade impeller), or due to impact of the slurry on vessel walls (radial *vs.* vertical circulation in the liquid phase). Fluidized bed crystallizers have been used as an alternative approach to provide high mass transfer and mixing will minimize particle–particle and particle–wall attrition.[68]

Key effects in mechanically induced attrition and breakage in stirred tanks can be listed as:

- Supersaturation
- Crystal concentration or mass (magma density)
- Crystal mechanical properties
- Individual crystal size (or mass), aspect ratio, which also has an anisotropic aspect based on slice energy in the lattice and preponderance and nature of defects agitation/flow
- turnover time (s)
- impeller rotation rate (s^{-1})
- impeller tip velocity (ms^{-1})
- power input or energy dissipation rate (local *vs.* overall intensity of mixing W/L)
- impeller geometry (marine propellers or profiled blades *vs.* pitched flat blades with sharp edges) and mechanical properties (soft surface coating)