Size Control in Pelletisation

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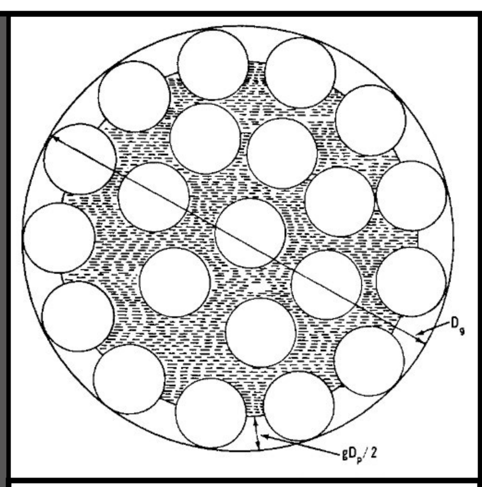
Size control in pelletisation, specifically of ferrous by products, is a very complex topic for such a minor a part of the processing of steel. Pelletisation is necessary as a method of converting fine ferrous wastes which cannot be sintered ordinarily. Pelletisation is also more efficient than simply sintering the material, but more difficult to prepare.

The pellets should be of a consistent size within a specific size range. The production rate of pellets in a drum is faster than a disk, but lacking a passive sorting mechanic the size distribution is harder to control. Using a holistic approach to the problem, a theory has been developed which has been simulated and compared against the literature

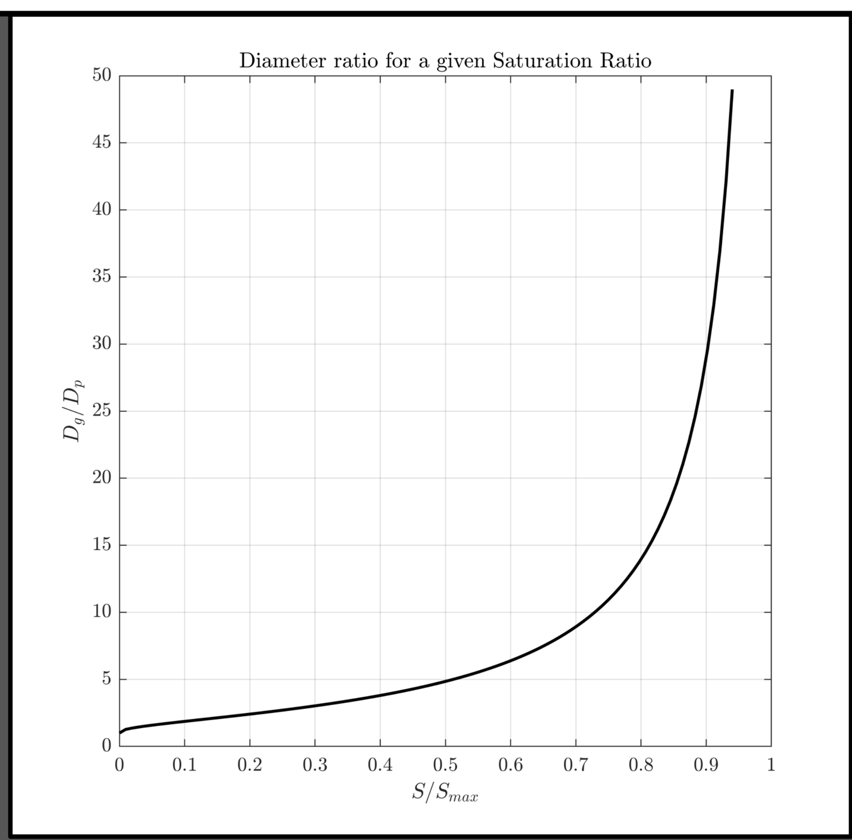
Limits

Saturation



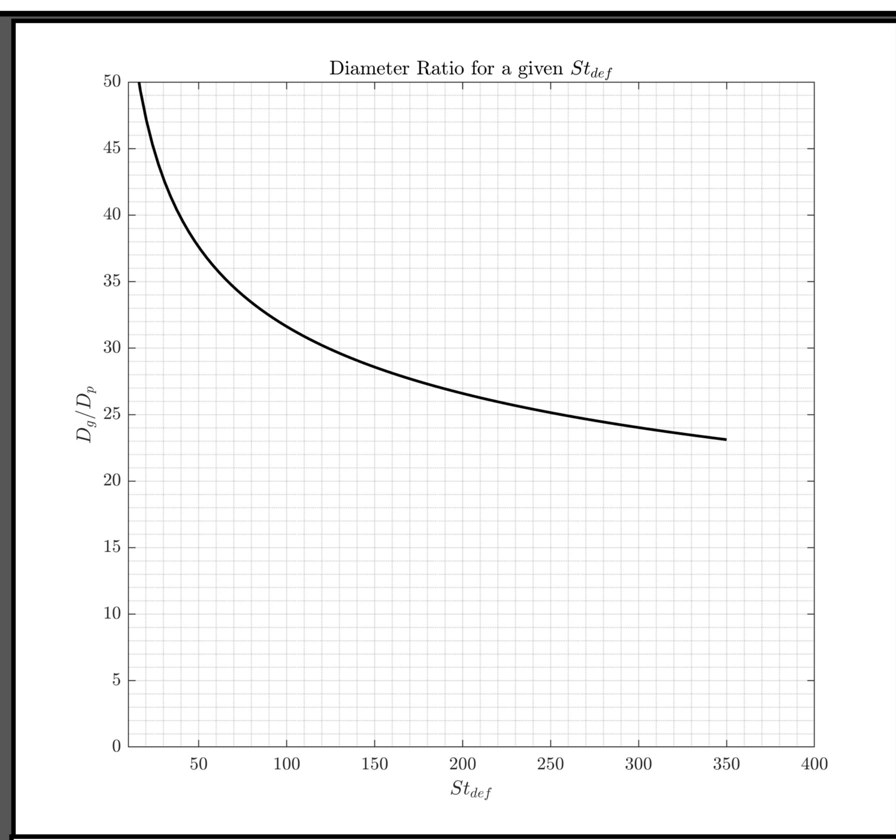
Butensky, M & Hyman, D Ind. Eng. Chem. Fundam. Vol 10. Is. 2 1971

$$\Delta_{sat} = \frac{gD_p}{\left(1-\left(\frac{S}{S_{max}}\right)^{\frac{1}{3}}\right)}$$



The liquid content is well established as increasing the diameter, but alone it does not describe the size. Instead, the saturation, which defines the pore volume filled, is an accurate predictor. This relationship is also hyperbolic, which means that controlling it can be difficult if the pellet size required involves large pellet to particle diameter ratios. The effect of binders on the quantity of liquid required is considered in the variables g and S_{max}.

Dynamics



$$\Delta_{merge} < C_m \frac{\lambda_{ch}}{K_H^{\frac{3}{4}} K_\alpha St_{def}^{\frac{1}{4}}} K_{\frac{t}{c}} \alpha_{wet}(\varepsilon_{rr}) \frac{(1+r)^{2K_\gamma - 2\frac{11}{12}}}{r^{K_\gamma - 3}(1+r^3)^{\frac{3}{4}}}$$

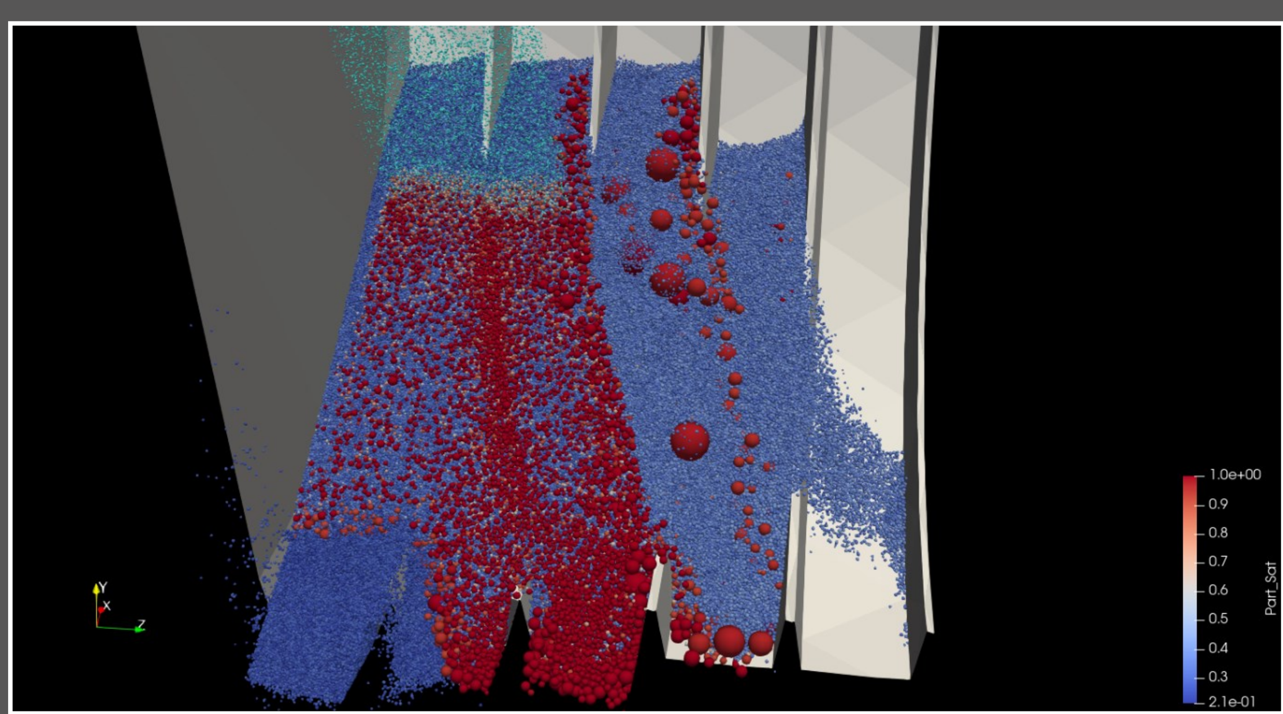
The dynamic behaviour comprises of the bonding behaviour (left) and the consolidation behaviour (below). It is described in terms of St_{def}, which describes the ratio of kinetic energy to energy of plastic deformation.

$$\epsilon = \epsilon_{min} + (\epsilon_0 - \epsilon_{min}) e^{-k_{\epsilon A} e^{\frac{-k_{\epsilon B}}{St_{def}} t}}$$

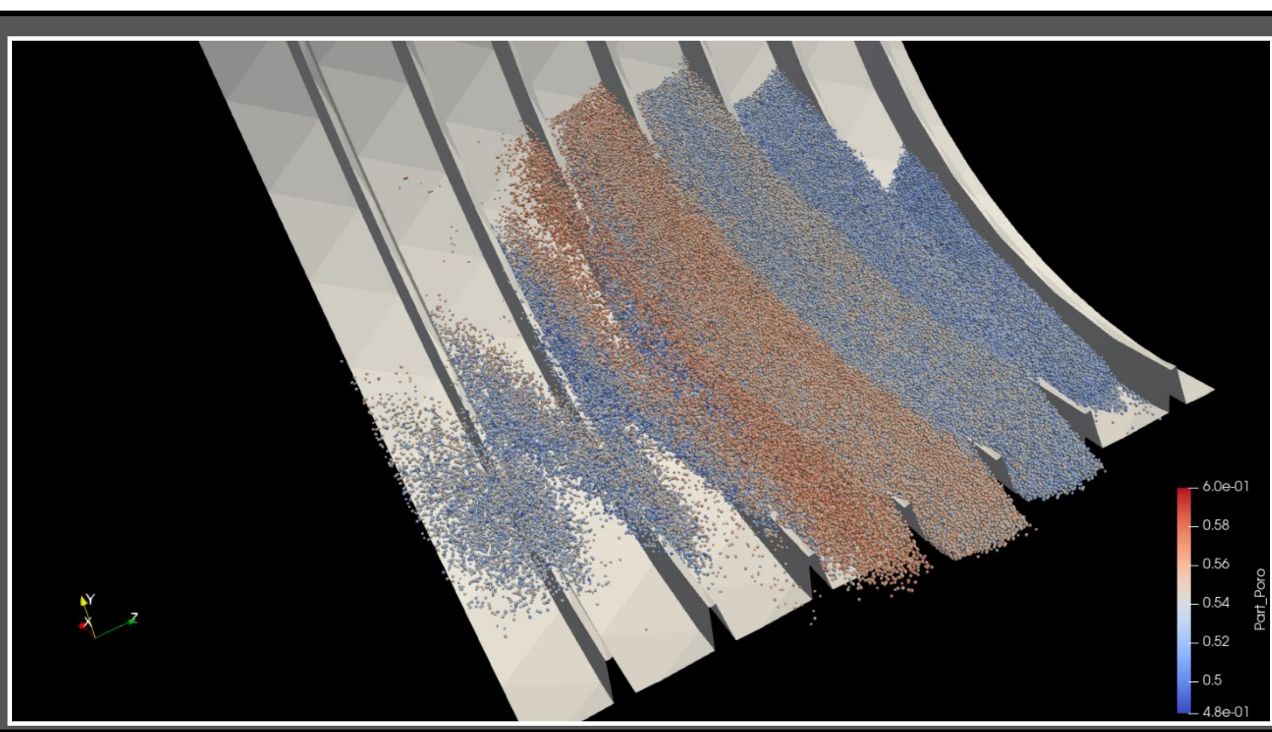
The consolidation behaviour refers to the porosity. The consolidation rate is an stretched exponential function related to the deformation number, but the minimum porosity can either be positively or negatively correlated to St_{def}, depending on whether dilation or compression dominates.

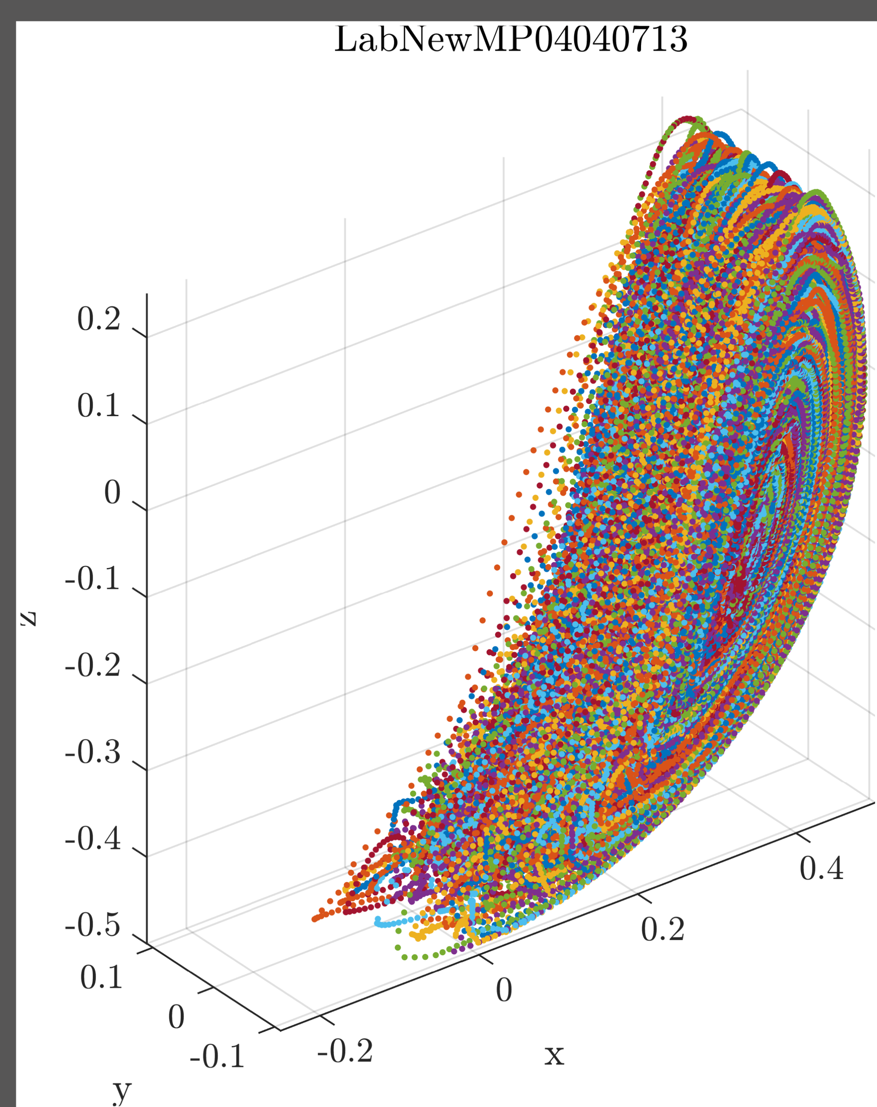
The bonding meanwhile depends on the strength of initial bonds formed relative to the general shearing, and is a function of the collision velocities of the system, the mean free paths, the strength of adhesion, and the size distribution of the pellets involved.

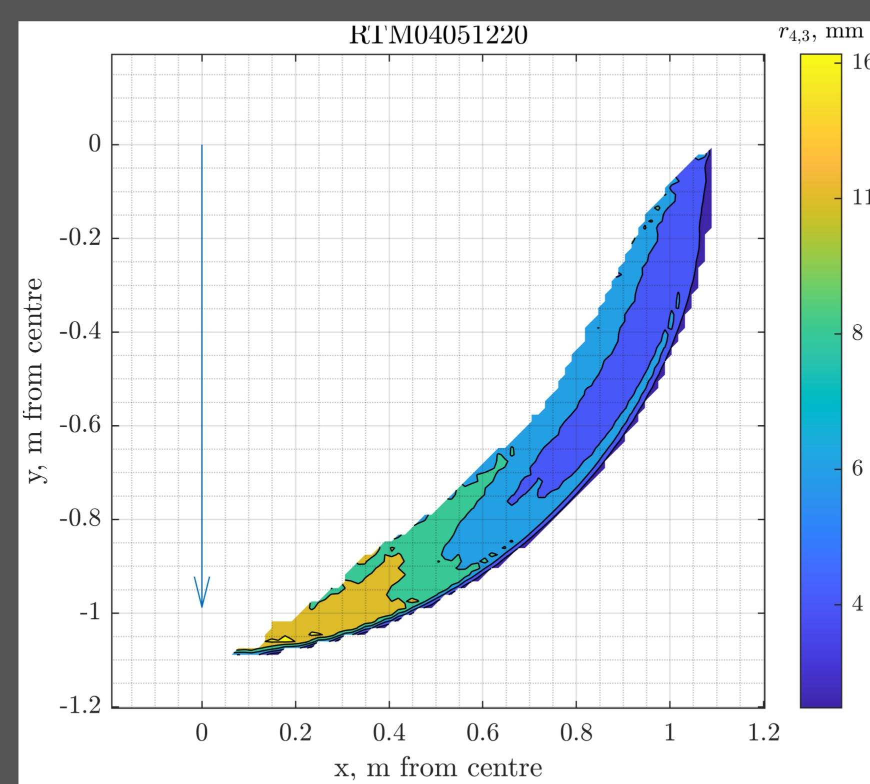
Variability



Sources of variation in the saturation comes from the fact that the spray must be applied on the surface of the particles. Some redistribution will occur through mixing of the feed, however even if the saturation is perfectly evenly distributed, the consolidation is dependent on the strength and rate of the collisions, and these are not equal throughout the pelletising drum

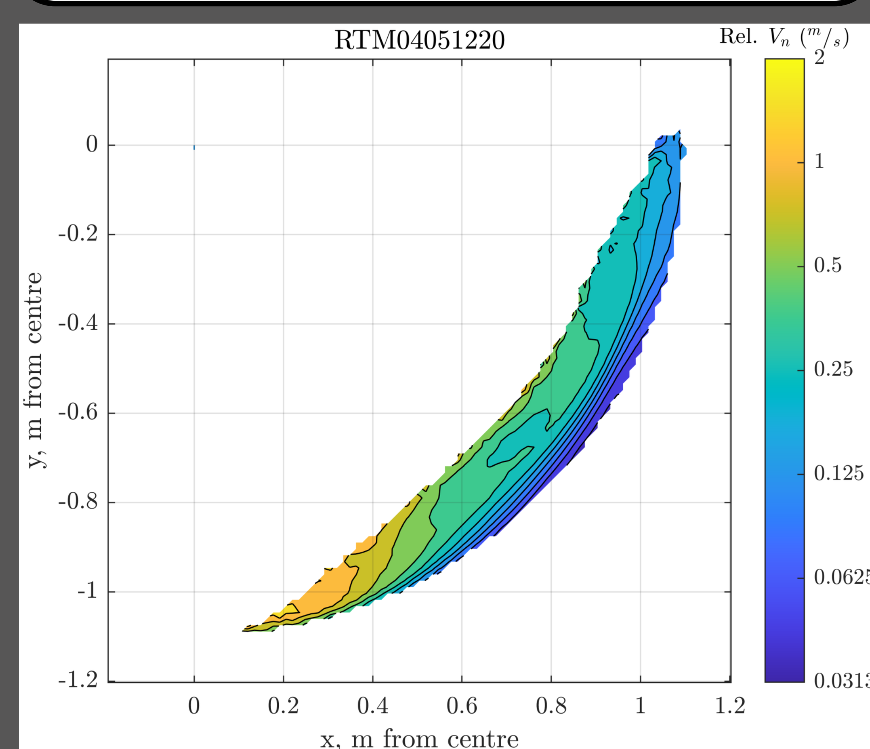






The segregation impedes the homogenisation and so contributes to the subsequent variance. The velocity of collisions shows that the fastest collisions occur right where the largest pellets can be found.

These plots show the pure kinetics, with no saturation effects. The above shows that little diffusion occurs, which would assist in mixing the drier pellets in the centre with the more moist pellets on the surface. The highest collision velocities are very confined, which is conducive to greater growth if saturation permits. And the segregation ensures that the largest pellets, which need less saturation, are the most likely to get directly sprayed.



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