Grow grains in light metals

S. Jäger[1]

[1]Light Metals Technologies Ranshofen, Austrian Institute of Technology, Ranshofen, Austria, stephan.jaeger@ait.ac.at, +43 664 81 57 950

When water freezes and becomes ice or snow, small crystals form. These crystals vary greatly in size depending on several environmental conditions and criteria. One of them is the cooling rate - the change of temperature over time - which is the reason for different types of snow one may notice while skiing or tobogganing.

Metals behave similar during solidification. Comparable to ice crystals, small grains start to grow initiated at single nuclei during the phase change from the liquid state to the solid state. Basically, higher cooling rates result in smaller grains, due to an increased number of nuclei starting to grow.

Why is the size of the grains important?

Grain size strongly influences the properties of metallic components. The strength and the ductility of metals can be increased at the same time by getting a homogeneous distribution of small grains. It is well known in theory, but the application of this knowledge remains a big challenge to be realised in the manufacturing of light metals at industry relevant scale. Since the industrial scale (production) and the physical scale of the microstructure strongly differ (few meters vs. several nanometers), the influence from large to small scale must be investigated. Nowadays it is still not possible to implement the prediction of microstructure behavior of metals into the industrial process.

Due to limited resources and performance, the employment of the Lattice Boltzmann Method (LBM) – recently developed for high performance computing – in combination with a highly efficient Cellular Automaton (CA) method promise to overcome this obstacle. The combination of LBM and CA can simulate the cooling of large scale applications and the growth of grains on small scales as well as their interdependency. This supports future interpretation and process optimization based on fundamental knowledge and impact assessment instead of the common try-and-error approach that is very cost intensive. The potential impact is not restricted to improved material properties after casting. The gained information about grain size and distribution also serves as a basis for further processing steps, and corresponding simulations, like heat treatment and forming. Furthermore, an improved process management may drastically reduce the rejection rate in metal material processing while simultaneously enhancing the quality of semi-finished cast products.

Finally, the decreased rejection rate results in less energy usage and reduced greenhouse gas emissions during production. In addition, higher quality and higher performance materials provide the opportunity for lightweight design and for the decrease of vehicle weight, which in turn enable the further reduction of greenhouse gas emissions.