

A Course on Metallurgy based on Calphad Tools

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ABSTRACT

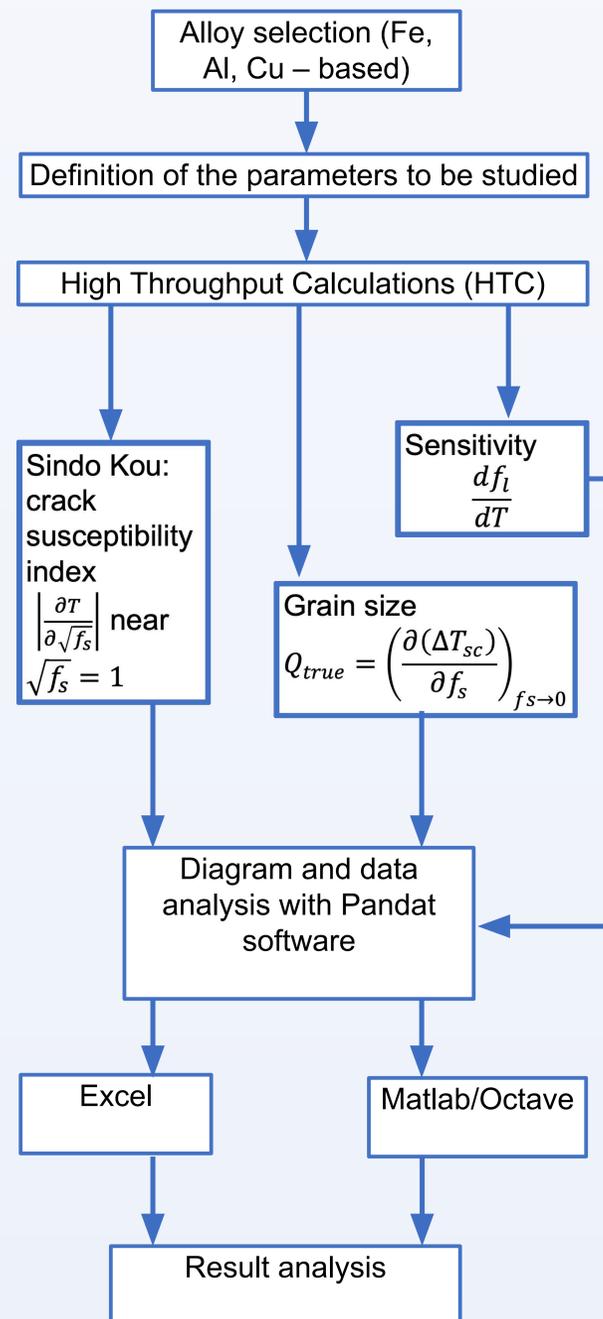
In the framework of traditional courses on traditional metallurgy for mechanical engineers, some modelling examples based on elementary Calphad tools have been introduced. This year, we have been dealing with different activities including the modelling of solidification cracking using the Sindo Kou approach, the modelling of semi-solid processes using the approach introduced by Kapranos, and the modelling of the compositional effects of grain size using the approach proposed by Schmidt-Fetzer and High Throughput Calculations (HTC). For all of the calculations, open simplified thermodynamic databases and the free version of Pandat (which allows the analysis of up to three components) have been used; results will be presented for Fe-based alloys, Al-based, and Cu-based alloys.

Main objectives

Our main goal is to evaluate the potential uses of a wide variety of alloys which require the use of efficient methods in order to find the values of certain criteria by analyzing the solidification simulation of these alloys and correctly acquiring a reliable set of results in order to make a scientific decision regarding the various uses for these alloys.

In order to define which alloys could be suitable for a certain manufacturing process, we need to study a large quantity of these alloys with different fractions of the additional materials present and see how the modification of the quantities of the aforementioned materials alters the behavior of the alloy itself. The obtained results can then be evaluated in order to find out which alloy might be suitable for a certain process, so it could later be studied using more experimental and practical methods.

Analysis Method

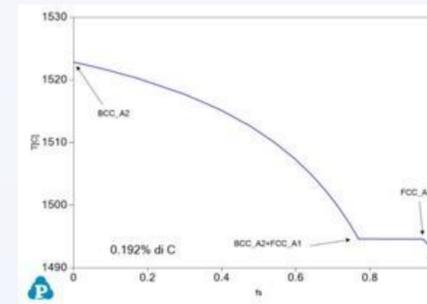


LEGEND:

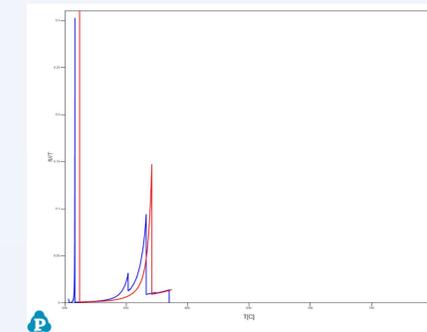
T: temperature
 f_s : solid fraction
 f_l : liquid fraction
 Q_{true} : constitutional undercooling
 ΔT_{sc} : true growth restriction factor

Results

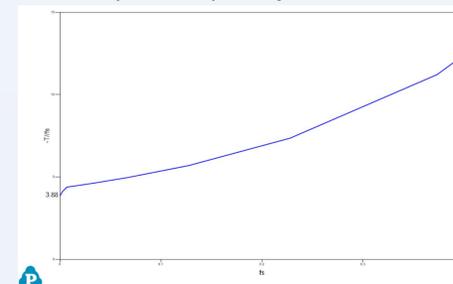
We represent a solidification diagram of an Fe-C alloy with a variation of w% of carbon with Sindo Kou parameter:



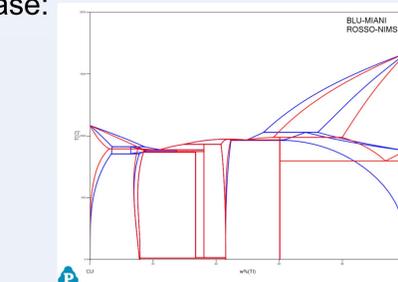
In the picture we represent the sensitivity for an Al-Si-Cu alloy (red line) and for an Al-Si-Cu and other elements alloy (blue line):



Now we represent the trend of the grain size of a Cu-P(w%0.2) alloy:

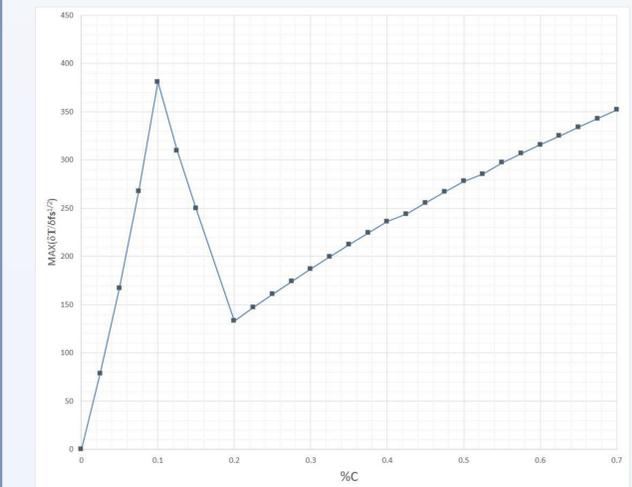


Finally, we reported a binary diagram of a Cu-Ti alloy, comparing the data of a commercial database and an empirical database:



Conclusions

From the results we obtained, we were able to produce a series of diagrams that represent the behavior of the various criteria with regard to the variation of chemical composition of the alloys and evaluate the results of these variations.



References

- [1] Sindo Kou, A criterion for cracking during solidification
- [2] Zoqui, E.J. Alloys for semisolid processing
- [3] Artem Kozlov, R Schmid-Fetzer, Growth restriction factor in Al-Si-Mg-Cu alloys