DICTRA® phase transformation study in AISI 442 used in steel mills heat exchangers

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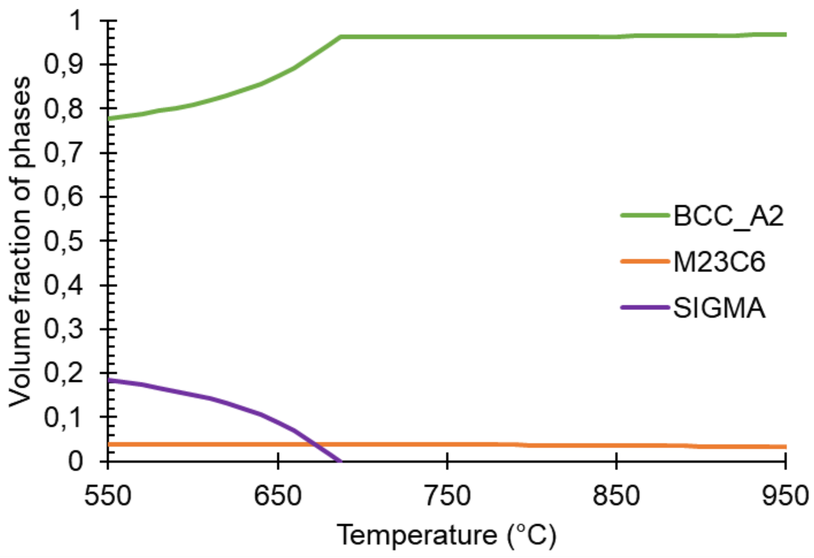
Is it possible to the predict the precipitation of phases in a material that will be used for many years without testing?

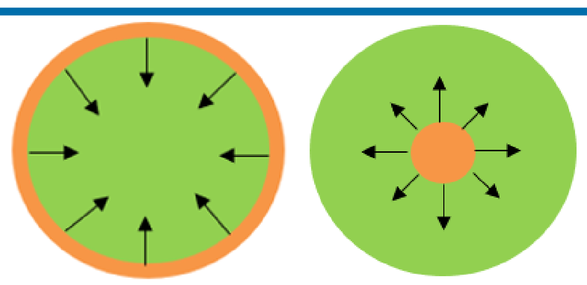
Stainless steels are used in steel mill heat exchangers, aiming reduction in energetic costs and fuel consumption.
Prediction formation of the sigma phase and $M_{23}C_6$ carbides using DICTRA® for AISI 442 (550°C - 950°C) was proposed, analyzing the formation of deleterious phases that could cause unexpected mechanical behaviors and reduction of oxidizing resistance and embrittlement.
Equilibrium simulations were done using Thermo-Calc® (TCFE9 database) and DICTRA® (MOBFE4 database) was used to diffusive simulations.

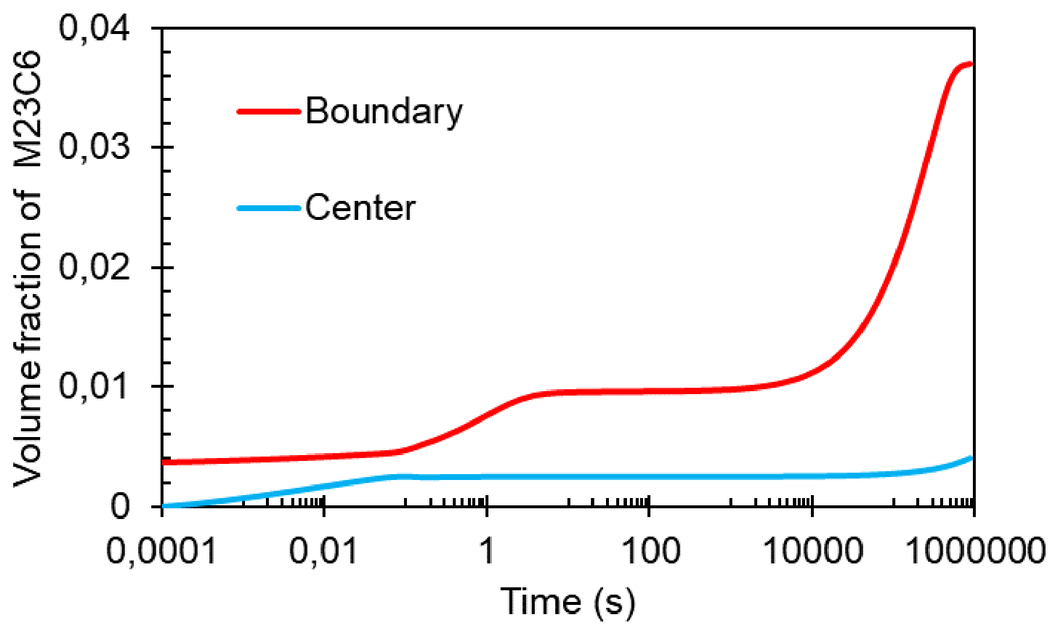
Heat exchanger after 12 years operation

Thermo-Calc® simulation (550°C – 950°C)

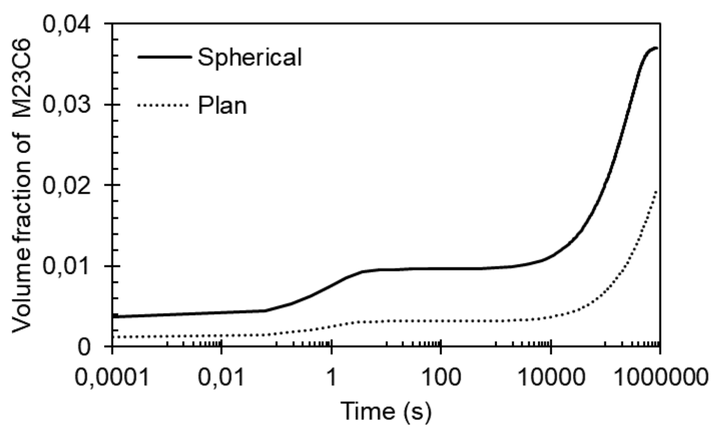


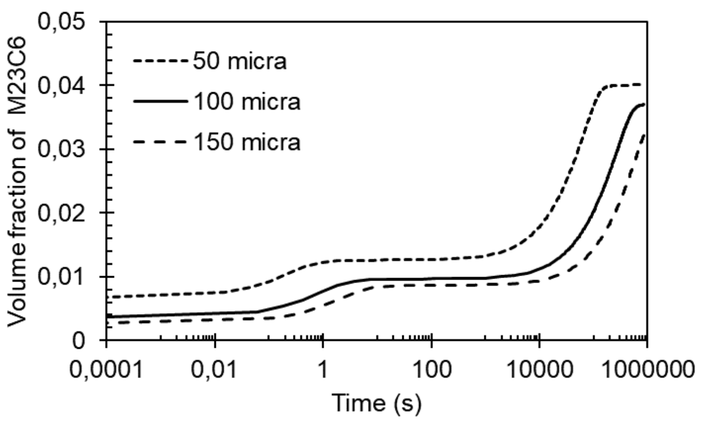
Carbide precipitation in the cell boundary has fast kinetics when compared to the center

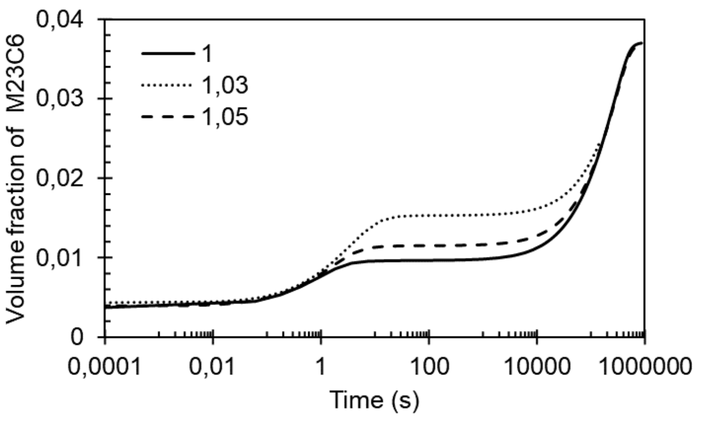


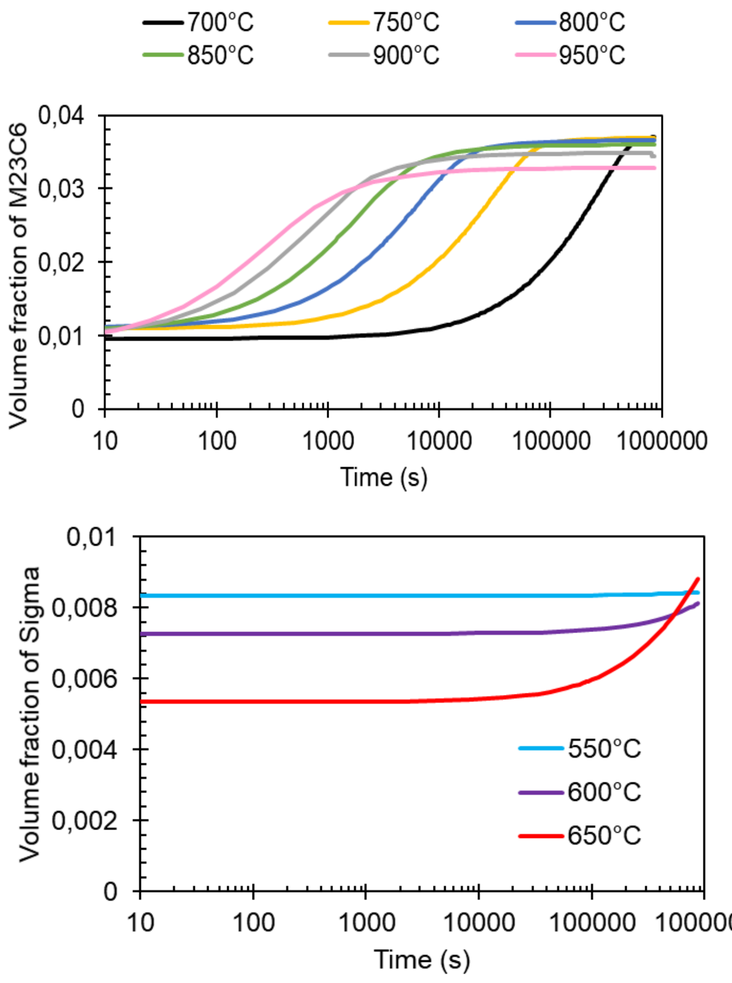


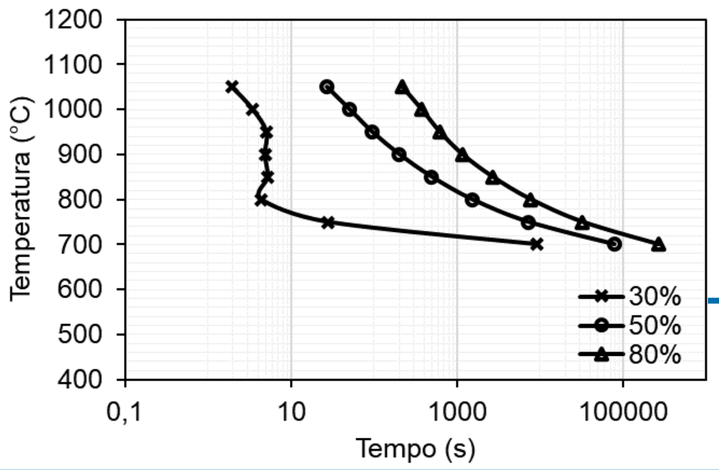
Changing the geometry and size of the simulation cell and the position of the points in the cell cause different kinetic behaviors. DICTRA® shows high sensibility to these parameters, requiring calibration.

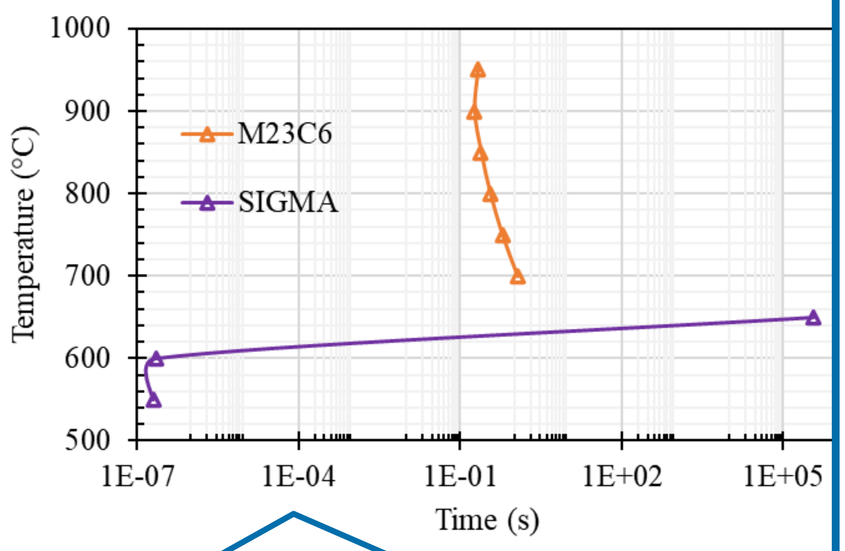












TTP diagram of beginning of precipitation ($M_{23}C_6$ and sigma phase)

Sigma phase presented higher kinetic for temperatures below 600 C. For higher temperatures, carbides have fast kinetic.

TTP diagram of $M_{23}C_6$