Work going on these days in our group:

- Quench and temper of alloyed cast irons (carbon partition between martensite and retained austenite in the range of stasis of austenite decomposition)

- Austenite decomposition at HAZ during welding of pipeline steel (API X 80-100)

- Development and characterization of NICRALC, a family of Ni3Al IC-based Co free high temperature wear resistant alloy.

Proposal waiting for funding and student:

SUBSTITUTIONAL AND INTERSTITIAL ELEMENTS PARTITIONING DURING THE ISOTHERMAL DECOMPOSITION OF AUSTENITE IN 12% Cr BASE ALLOY STEEL

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History

- **Mannerskorsky (1964): γ decomposition in 0.31%C-13.5%Cr SS steel: eutectoid α + M23C6 first, with short range Cr, long range C partition, carbide free ferrite at the end of the transformation; results confirmed by Pinedo and Goldenstein in 1991 on a ASI410 SSteel**
- **P.R.Rios & Honeycombe (1992) : no long range C partition with high purity 0.2%C 10%Cr alloy, long range C partition with 0.056% Nb added**
- **Tsuchiyama, Ono and Takaki (1997): three 12% Cr SSteels, long range C partition with 0.15%C and 0.3%C, no long range C partition with 0.7%C alloy**

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Previous work: (Pinedo and Goldenstein, PTM 2005)

Material

Commercial AISI 410 wrought stainless steel, received as annealed rod, 35. mm diameter,

Chemical analysis (wt%):

Fe 0.1%C-12.0%Cr-0.95%Mn-0.39%Si-0.28%Ni-0.11%Mo-0.04%Cu-0.03%Al-0.029%P-0.021%S, 21ppm O and 130ppmN

Experimental Procedure

- Homogenization at 950°C - 48 hours followed by water quenching

- Samples re-austenitized at 950°C - 30 min and transfered to salt bath between 700 and 600°C, treatment interrupted by water quench

- Characterization by OM, after eletrolitic etching with chromic acid

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Experimental Procedure

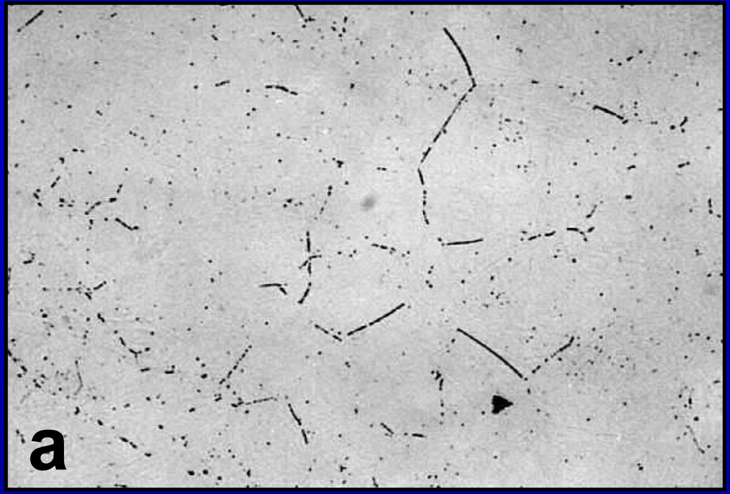
- Carbide extraction by selective dissolution of the matrix with Berzelius reactive, followed by X-Ray diffraction, EDAX microanalysis and mass balance of the extracted residue

- Dilatometrical study of the thermal arrest temperature during quenching (60K/s) after isothermal decomposition of austenite for different times at 700 °C, using a quenching dilatometer

Microstructure

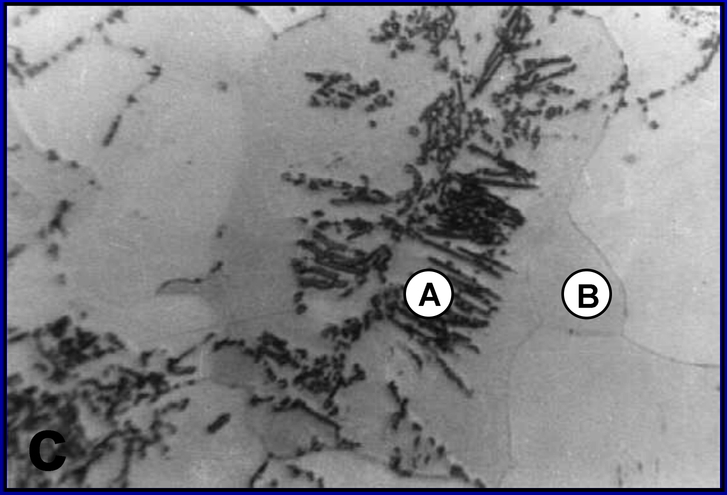
(a) Grain boundary precipitation of proeutectoid $M_{23}C_6$ carbide at 700°C, 700 s.

(b) Pearlite like eutectoid growth after 3,000 s at 675°C.



Microstructure

(c) Detail of the transformation product with the pearlite-like eutectoid and advancing ferrite, after 3,000 s at 700ºC .



(d) Interphase precipitation of carbides at the transformation front, after 6,000s at 675ºC.

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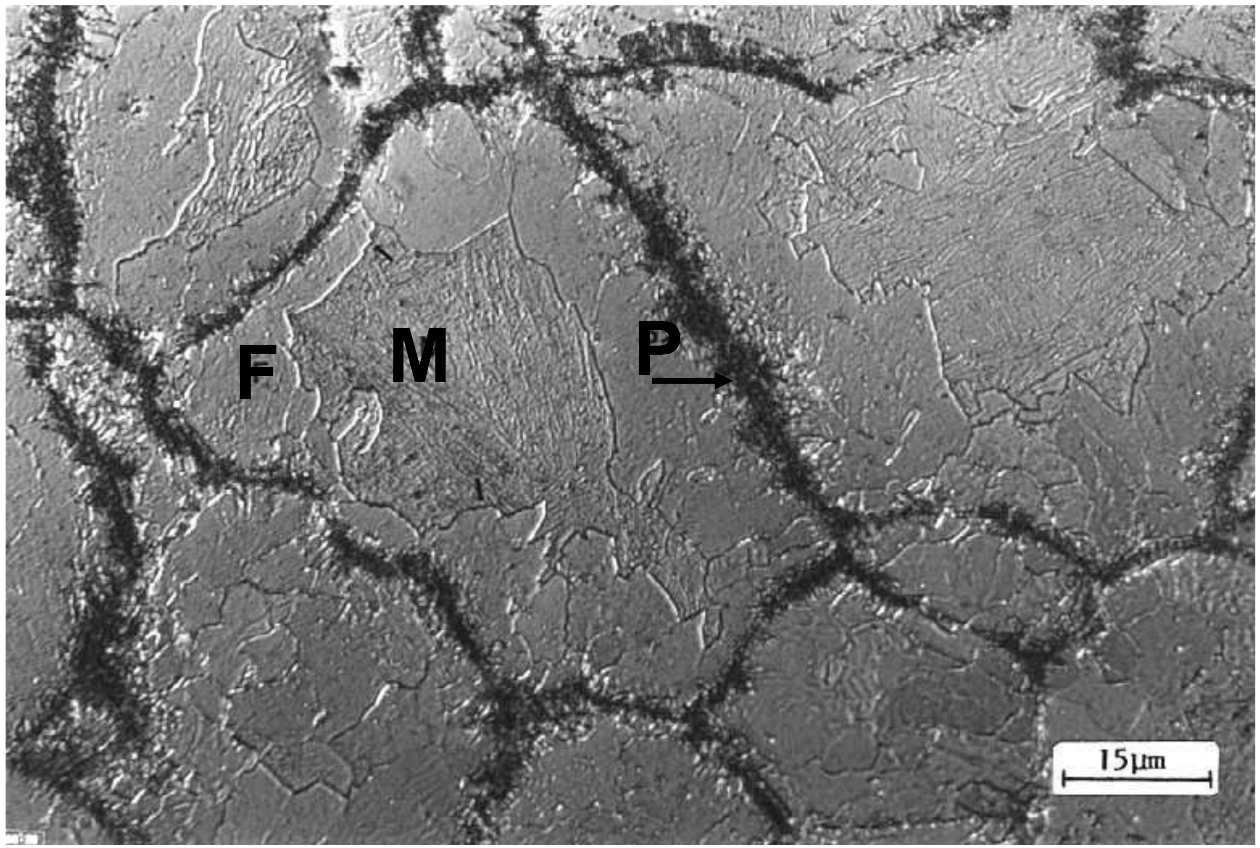
Microstructure

Pearlite-like eutectoid, ferrite, and martensite from the remaining austenite after 70,000 s at 600ºC .



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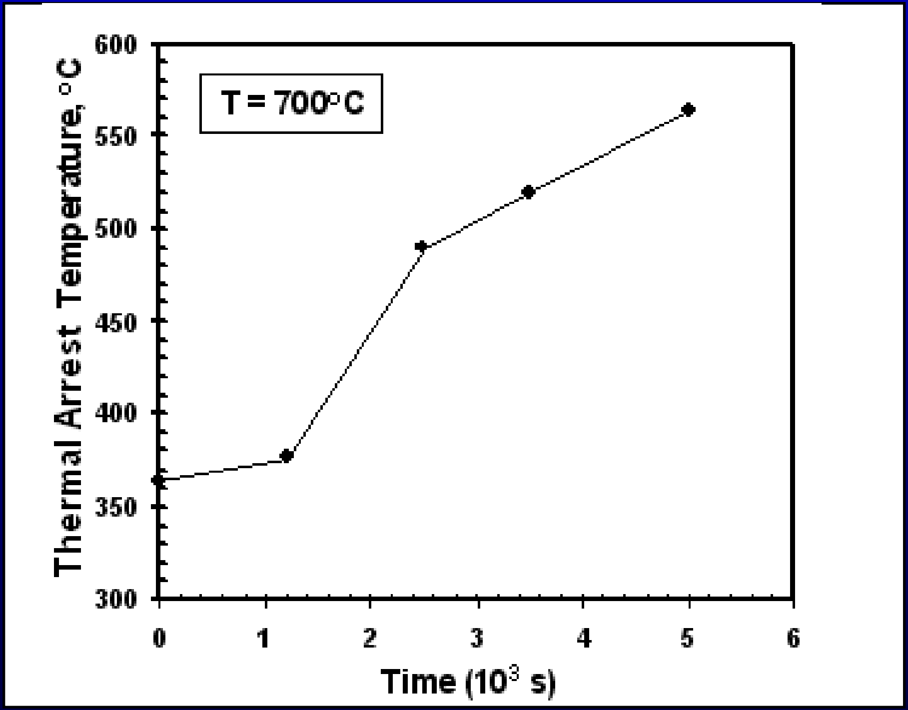
Dilatometric study

Thermal arrest temperature for the remaining austenite after isothermal transformation at 700°C for different times



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Discussion

Thermal arrest temperatures after 0 and 1200 s transformation at 700°C , 364 and 376°C, correspond aproximately to calculated Ms temperatures, using empirical equations

Thermal arrest temperatures after 2500, 3500 and 5000 s, 490, 520 and 564°C are within the range found by Gilbert and Owen and by Pascover and Radcliffe for high purity Fe-10%Cr(~530•C), transforming to a mixture of lath martensite and equiaxed (massive) ferrite

Those results show that after 2500s the C depletion fields ahead of the interface are already overlapping and after 5000 s there is no C left in the matrix

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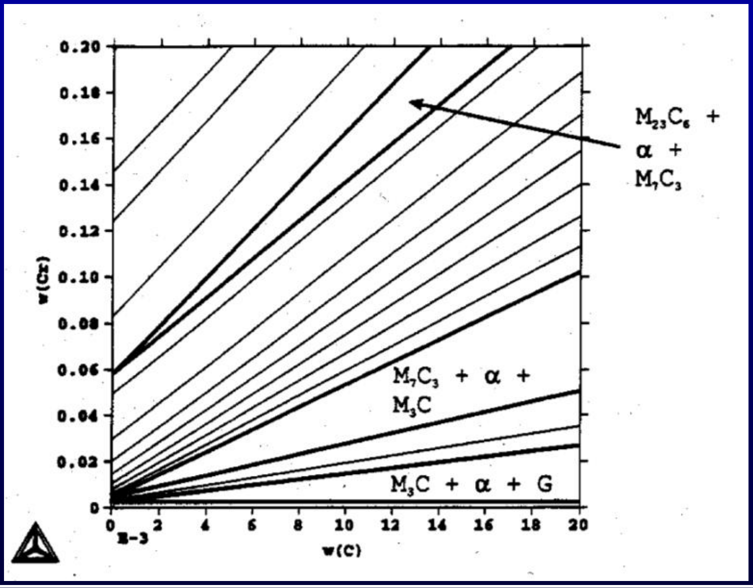
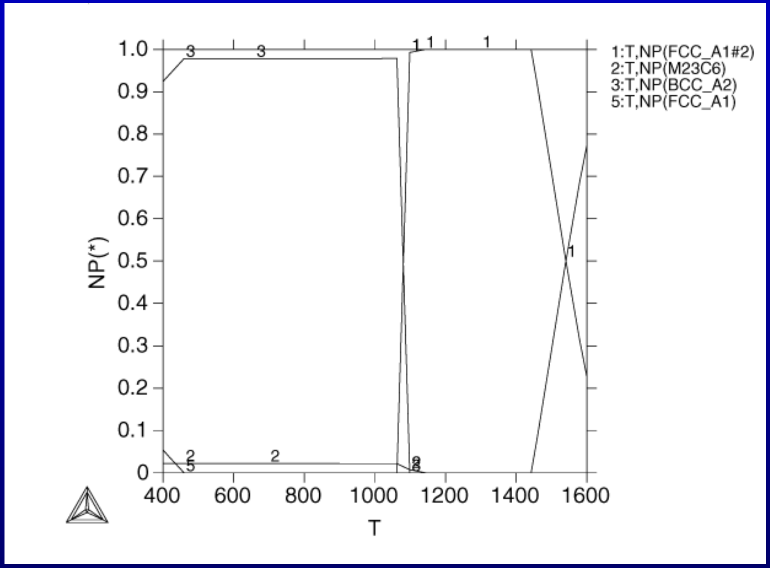
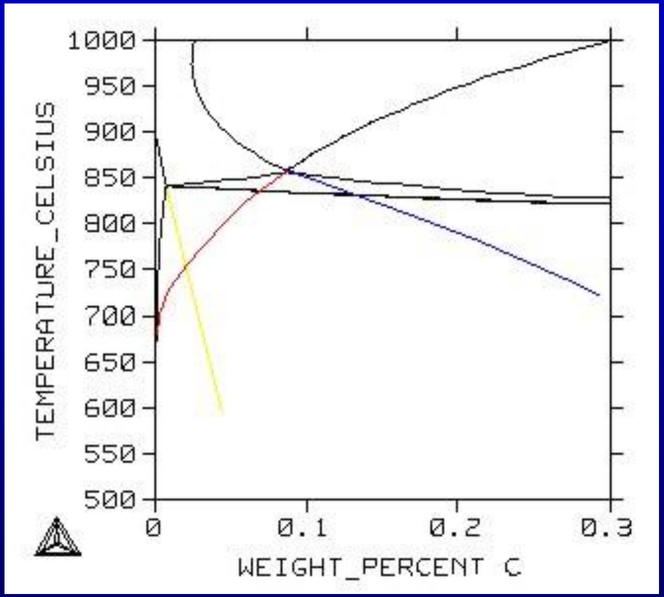
Discussion

- Tsuchiyama results, that 0.7%C - 12%Cr S.Steel transforms faster than .15 and .3%C, with no long range C partition, can be explained by the phase diagram: 0.7%C is within the $\alpha + M_7C_3 + M_{23}C_6$ field. It can transform to arborescent, spiky pearlite with metastable carbides, which later relax towards equilibrium carbide composition



Discussion



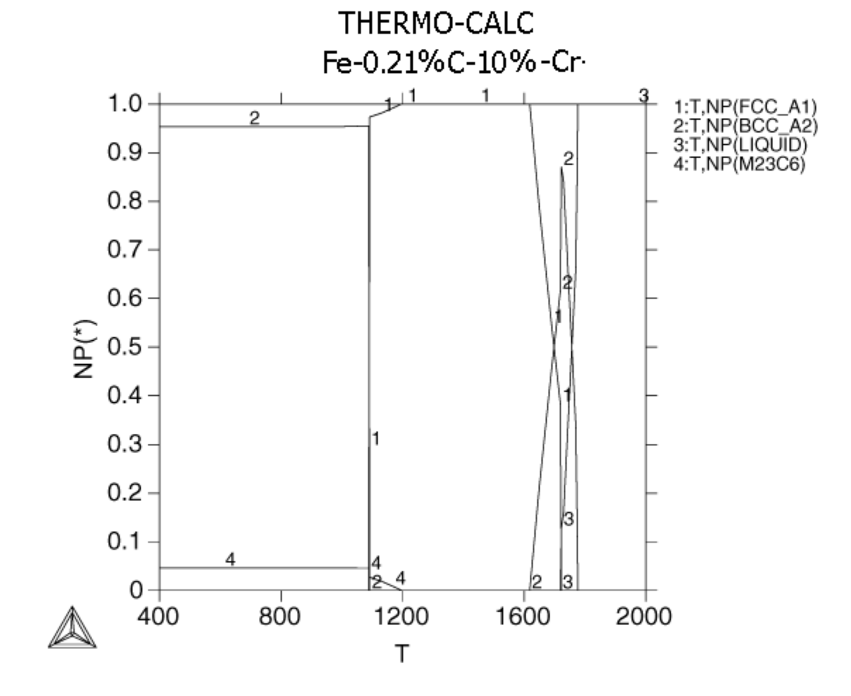


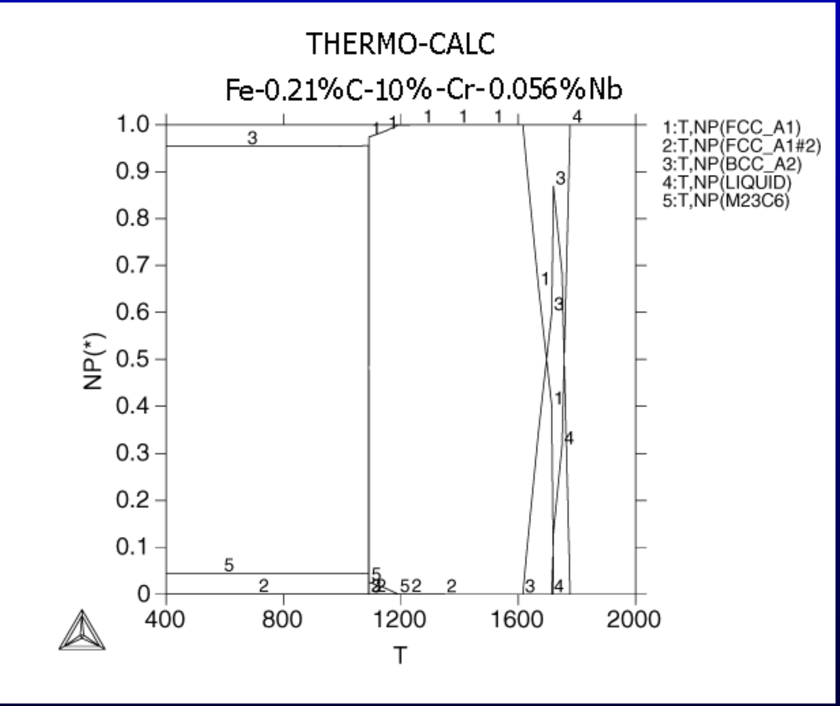
Phase map for the AISI 410 steel

12% Cr isopleth with extrapolation of γ/ γ + $M_{23}C_6$ and α/ α+ γ limits into lower temperatures

Discussion

- P.R. Rios results, that high purity 0.2%C - 10%Cr alloy does not present long range C partition, while the same alloy with 0.056%Nb transform much slower with long range C partition suggest that the slowing down of the austenite/eutectoid interface by the Nb plays a major role.
- Phase maps calculated with TC show the presence of Nb carbide





Summary

- The alloys where long range partition of C occurs are either commercial alloys or with impurity deliberately added.
- The “operating tie-line” during the eutectoid decomposition is not the equilibrium tieline, which passes through the bulk composition, but is determined by the C isoactivity line and by the need for equilibrium at the various interfaces (α/γ, $M_{23}C_6/\gamma$ and $M_{23}C_6/\alpha$).
- We propose that the “operating tieline” depends also on the interface kinetics, which is slowed down by solute drag on impurity containing alloys.

PROPOSAL

- Prepare a series of 12% (or 10%)Cr high purity Fe-Cr-C alloys, with enough carbon to cross the γ loop, and purposeful added impurities (Nb, Ti and Mo), one at a time.
- Study the kinetics of the austenite decomposition reaction and if there is long range partition of carbon or not.
- Try to model a kinetic based “operating tieline”, separating thermodynamic and kinetic effects and from this model extract information on interface movement

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