Tutorial class n°1 : Excel-VBA Training session

1.1 Phase transition : ferrite-austenite

1.1.1 Introduction

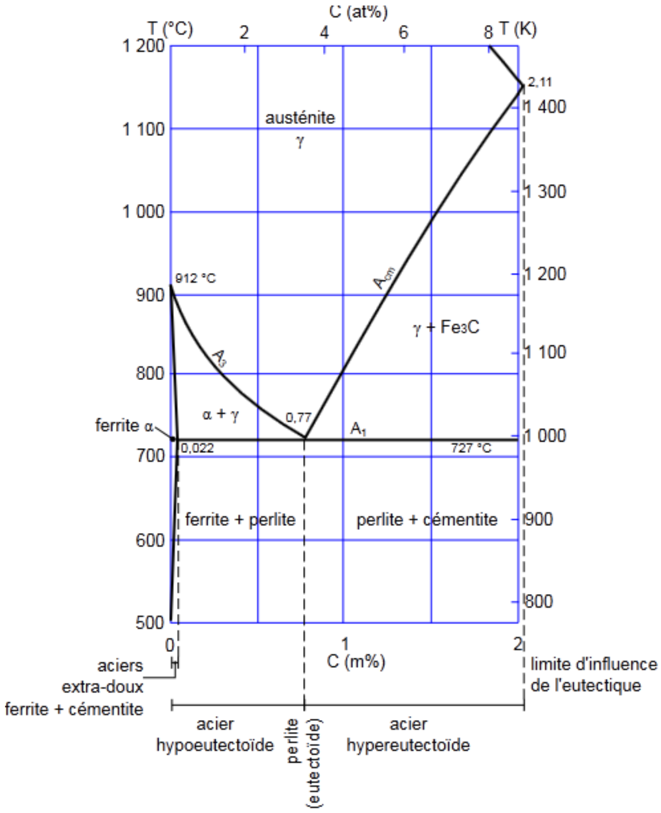

Fig. 1.1: Phase Diagram of Steel (Fe-C)

The objective of this study is to characterize the thermal phase transition properties of an industrial steel. This steel is constituted by Iron (Fe), majority element, by carbon (C) in small proportion, lower than 1% for our sample, but too with other elements which are kept secret by the industrialist. The binary phase diagram Iron-carbon, cf. figure 1.1, describes the evolution in temperature and phase of the steel. For an increase in temperature of 500^oC in more of 1000^oC we start with ferrite, iron in phase α, to go to austenite, iron in phase γ, by crossing a inter-critical domain consisted of a mixture iron α and γ.

The industrialist transmits with its sample of steel the temperatures of transition (limits of the inter-critical domain $\alpha + \gamma$) for a heating of $300^oC/h$: $T_c^\alpha = 745^oC$. The aim is to verify experimentally by means of Gleeble, a machine of dilation, available on the INSA, cf. figure 1.2, if the temperature is exact.

The manipulation with Gleeble consists to follow the evolution of the sample dilation according to the temperature. Indeed, the phase α is cubic centered and the phase γ is cubic centered faces, their parameters of mesh are different. We shall thus observe an important change of volume during the

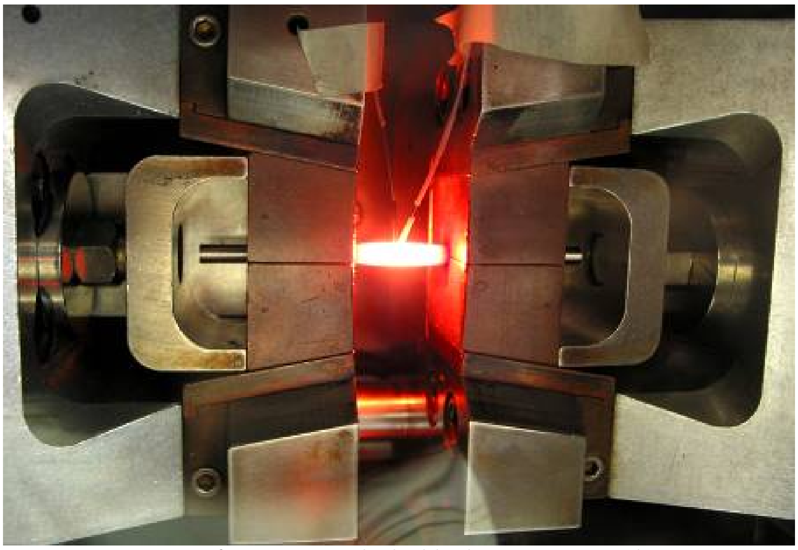

Fig. 1.2: Picture of Experimental Gleeble dispositiv : sampling in center

appearance of the austenitic phase then during the disappearance of the ferritic phase (for the rise in temperature and conversely during the descent).

The experiment realized is the following one. It begins with a sample of steel at room temperature $\approx 18^oC$. Next the temperature is increased in the austenitic domain, $\approx 850^oC$, with a chosen velocity. Then the sample is maintained in this hanging temperature for 5 minutes. The experimental data of the dilation according to the temperature are given in the available Excel file "$DilatationGleeble$" under Moodle.

1.1.2 Composition and temperature phase transition of an industrial steel

Thanks to data in the available Excel file "$DilatationGleeble$" can we easily find the temperatures of transition to compare them with those supplied by the manufacturer, and do we find the same for a heating and a cooling?

Q.1 - Open under Excel the file DilatationGleeble.xlsx and plot the dilatation in function of the temperature.

Q.2 - Find the transition temperature and the dilatation coefficient in all phases. The dilatation coefficient is given by:

$$\alpha = \frac{1}{L_0} \cdot \frac{\partial L}{\partial T} \tag{1.1}$$

where L_0 is the sample size: $L_0 = 6cm$.

1.2 Bode Diagram of a 2nd order filter

1.2.1 Introduction

A second order filter H(s) has a general expression given by :

$$H(w) = \frac{H_0}{1 - (\frac{w}{w_c})^2 + j\frac{w}{w_c \cdot Q}}, \tag{1.2}$$

where Q is the quality factor, H_0 is the static gain (may be negative) and $f_c = w_c/2\pi$ being the cut frequency and j the complex number. We can define respectively the gain and the phase filter as:

$$|H(f)| = \frac{H_0}{\sqrt{\left(1 - \frac{f^2}{f_c^2}\right)^2 + \left(\frac{f}{f_c \cdot Q}\right)^2}}, \tag{1.3}$$

and

$$\phi(f) = -\frac{180}{\pi} \cdot arctan(\frac{\frac{f}{f_c \cdot Q}}{1 - \frac{f^2}{f_c^2}}) - 90 \cdot (1 - sign(H_0)) - 90 \cdot (1 + sign(f - f_c)). \tag{1.4}$$

An audio signal is made of different signals with different frequencies. For a high quality audio restitution, phase shifts between a signal and its harmonics must be the same. Such a conditions corresponds to a constant group time T_g with :

$$T_g = -\frac{1}{2\pi} \cdot \frac{\partial \phi}{\partial f}. \tag{1.5}$$

1.2.2 Basic maths operation, relative and absolute to cells

Q.1 - In the file called "$SecondOrderFilters.xls$", we will complete all columns to draw the phase, the gain and the group time of the parametered second order filter:

- Complete column D in order to obtain frequencies between f_1 (B1) and f_2 (B2) with N points (B3). One may think to use a recursive relation like $f_{i+1} = f_i \cdot 10^{\frac{log_{10}(f_2/f_1)}{N}}$ and extend the formula until line number 1002 for N=1000.
- Define the gain of the filter in column E thanks to equation 1.3.
- Define the phase of the filter in column F thanks to equation 1.4, with sign() is a function that returns 1 for positive values and -1 else. This function will be replaced using the SI (; ;) function in Excel. The numerical value of π is obtained using the PI() function and the arctangente function is given by ATAN().
- Define the group time and the variation of the group time respectively in columns G and H thanks to equation 1.5.

From now, we will complete columns I and J to draw the asymptotic bode diagram.

- in column I, use the following formula:

$$|H(f)| = |H_0| \; for \; f < f_c \; and \; |H_0| \cdot f_c^2/f^2 \; else$$

- in column J, define ϕ as being $-90 \cdot (1 - sign(H_0)) - 90 \cdot (1 + sign(f - f_c))$

Q.2 - Using the graphical icons in the *Excel's* interface, change the appearance of the document by modifying the format of the cells : background color, borders, font color, number format, auto-adjust column, ...

1.2.3 Drawing 2D curves : dynamical bode diagrams

Q.3 - On a single graph draw both the asymptotic and exact gain as a function of the frequency. On a second one, represent the filter phase and its asymptote. For the gain use logarithm scale for x and y-axis, only in x-axis for the phase.

Q.4 - Plot in the same new graph the group time T_g and its variation vs the frequency. The x-axis will be in logarithm scale and add a right axis for the variation of the group time.

Q.5 - From now, graphs can be dynamically changed. Create three Scrollbars, on the current Excel sheet, linked respectively to the value of f_c, Q, and H_0 in order to find values for which we obtain the flatest curve in the bandwidth, with no exceed compare to the asymptotic model. Don't forget to define the min, max and step value for each Scrollbar. A click on a Scrollbar must imply the instantaneous modification of graphs.

Q.6 - Which value of Q minimizes the T_g variations are minimized in the bandwidth (check different value of Q and f_c) ?

1.3 Grain size distribution : ferrite-austenite

1.3.1 Introduction

Metals, except in a few instances, are crystalline in nature and, except for single crystals, they contain internal boundaries known as grain boundaries, cf. figure 1.3. The size, the orientation, the phase and the number of the grains depends on the thermal and/or the mechanical treatment undergone by the metal sample. It is well known that most mechanical properties of metal depend on the size distribution of the grains.

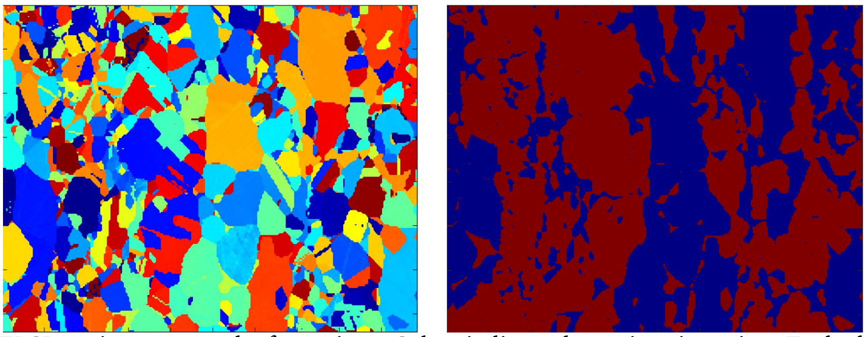

Fig. 1.3: To the right, EBSD grains cartography for an iron. Colors indicate the grain orientation. To the left, the phase of every grain, in red the ferrite, in blue the austenite.

THE EBSD (Electron Back Scattered Diffraction) is an experimental technique allowing to create crystallographic orientation pictures of a crystalline material surface. The sample to be studied is positioned in an scanning electron microscope, and illuminated by an electron beam. The electron beam interacts with the surface and electrons are diffused in all the directions around the impact point of the beam. Electrons diffracted by the crystal are detected by a phosphorescent screen. We obtain a diffraction snapshot which allows to distinguish the grains of the crystal, cf. figure 1.3.

1.3.2 Log-Normal distribution

Q.1 - Open under Excel the file "$TailleGrain.dat$" obtained after an EBSD on an iron sample. Attention on the format of reading! Change the appearance of the document by modifying the format of the cells : background color, borders, font color, number format, ...

In this file we find six columns with each line gives the surface and its equivalent radius of all ferrite and with or without twinning austenite grains detected by EBSD. In a first approximation, the radius of the grains is approximated as a circle, which is not in accordance with by example the EBSD cartography in figure 1.3.

Q.2 - Fill in the cells giving the total surface of ferrite, austenite with twining and ferrite + austenite.

The aim is to plot the grain distribution of grains of the ferrite and twinning austenite only, in function of their size. You must then count the number of grains with a typical size. As mentioned in the data file, a pixel of the EBSD cartography corresponds to $0.45\mu m^2$. We define the class 1 pixel as the number of grains with surface size between 0 and $0.45\mu m^2$, the class 2 with surface size between 0.45 and $0.9\mu m^2$, the class 3 between 0.9 and $1.35\mu m^2$, ..., and class n between $(n-1)*0.45$ and $n*0.45\mu m^2$.

Q.3 - After finding the max surface of the grains and its corresponding class number, create two columns in a new sheet with the class numbers and the associated surfaces in μm^2 respectively.

Q.4 - In the same sheet, in three other columns calculate for the ferrite the number of grains in every class, its percentage in number and per square meter respectively. You can use the Excel function NB.SI.ENS();

Q.5 - In a graph, plot the grain size distribution of ferrite and austenite.

Q.6 - The grain size distribution can be fit by a Log-Normal law defined by :

$$f(c) = \frac{f_0}{c\sigma\sqrt{2\pi}} e^{-\dfrac{(ln(c)-\mu)^2}{2\sigma^2}}, \tag{1.6}$$

where c the class surface, f_0 the magnitude, μ the mean and σ the standard deviation of the distribution.

In an other column, define the Log-Normal law for ferrite, with for the moment $f_0 = 0,5$, $\mu = 2$ and $\sigma = 1$. Careful, in cases empty classes. With the solver of Excel try to find the parameters f_0, μ and σ fitting best the experimental results.

1.4 Conductivity of silica aerogel

Traditional solutions for insulation (glass wool, polymer foams, etc.) become prohibitive in view of the new energy efficiency regulations for building renovation. Silica aerogels super insulators offer a very high performance alternative both in the building sector and for industry and transport. These materials are composed of a very light silica structure, containing more than 95 percent of air entrapped in nanometer-sized pores. It is this particular structure that gives them the lowest thermal conductivity known to date. But it is also this structure that explains the poor mechanical properties of composite products based on silica aerogels. Silica aerogels have a very low mechanical strength which greatly limits their potential (difficulty of implementation, dust formation). Study thermal properties of silica aerogel in function of their compositions and structures is a challenge.

In order to calculate the thermal conductivity of a simulated silica aerogel (Molecular Dynamics simulations), we applied, to the simulation box, a temperature gradient: we heat on one side and cool on the other. The slope of the temperature profile induced in the box is proportional to the thermal conductivity.

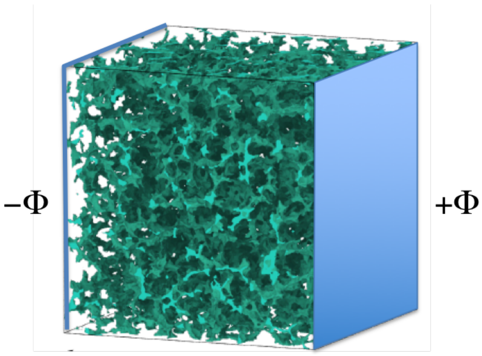

Fig. 1.4: To the left, a silica aerogel layer. To the left, Molecular Dynamics simulation box.

Q.1 - Open under Excel the file $"SIO230fluximp-4.profile"$. In this file, we find the evolution of the temperature profile versus time. We have two columns: the first is the position of a slice along the box and the second the temperature. The problem is that the data is written one after the other, and so it is impossible to use as is. Create a VBA procedure (macro) to overcome this difficulty.

1.5 Command file

The aim of this tutorial work is to use the Active Controls available on Excel.

On the "Commandes" Excel file available on Moodle we can find different columns listing the type of goods and their suppliers, quantities, packages, delivery dates and remarks.

Q.1 - Create for every column a combo in order to select one item and avoid scan the entire sheet with the mouse.

Q.2 - Create un Panel of radio buttons which should enable the choice of the delivery date : 5 days, 10 days or 1 month. This choice must be write in the right cell.

Q.3 - Create a button which validates the command and write it on a new line on the second sheet of the Excel file.

Q.4 - From this second sheet create a button linked to an Userform which calculate the command percentage achieved by a goods, a supplier, a quantity, a version. This Userform will be composed of a panel of radio buttons to select if the percentage is realized on the goods, the supplier, the quantity or the version. When the users will select a goods, a supplier, ... a list box will have to list all choice of goods, suppliers, ..., and finally a selection of this choice on the list will give the percentage in a text box.