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The Effect of Alloying Element on Pearlite Growth Rate by Neural Network within Bayesian Framework

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***Abstract*— Isothermal austenite-to-pearlite transformation can be done by using a neural network technique within a Bayesian framework. In this framework, the growth rate of pearlite can be represented as a function of Mn, Cr, Ni, Si and Mo alloying contents and temperature which have great important in pearlite growth rate. The growth rate of pearlite for different steels has been calculated by using MAP. There is a relative importance of the alloying elements on pearlite growth rate. Here, the growth rate can be represented as a function of variables such as Mn, Cr, Ni, Si and Mo alloying contents and temperature which are of great importance for the pearlite growth mechanisms.**

***Index Terms*— Pearlite,neural network,Bayesian framework.**

I. INTRODUCTION

The growth step in a phase transformation occurs when an embryo has exceeded the critical size, and becomes a stable nucleus. Nucleation will continue to occur simultaneously with growth of the new phase particles. Nucleation cannot occur in regions which have already transformed into the new phase. The growth process will stop in region where particles of the new phase meet, since the transformation will have reached completed [7].

Particle growth which occurs by long-range atomic diffusion, normally involves several steps—for example, diffusion through the parent phase, across a phase boundary, and then into the nucleus. Therefore, the growth rate is determined by the rate of diffusion, and its temperature dependence is the same as for the diffusion coefficient.

Several physical phenomena may be explained in terms of the transformation rate-versus-temperature. First, the size of the product phase particles will depend on transformation temperature. For example, for transformations that occur at high temperatures have low nucleation and high growth rates. Hence the resulting microstructure will consist of few and relatively large phase particles (e.g., coarse grains).Conversely, for transformations at lower temperatures, nucleation rates is high and growth rates low.

II. EXPERIMENT PROCEDURE

For the experiment we have used program MAP STEEL PEARLITE GROWTH which enable the user to estimate the growth rate of pearlite for any temperature as a function of chemical composition [2]. It makes use of a neural network program called **generate44**, which was developed by David MacKay [1].

Process variables and their Limits

The input variables are Manganese (wt.-%), Silicon (wt.-%), Chromium (wt.-%), Molybdenum (wt.-%), Nickel (wt.-%), Isothermal temperature (ºC).

Output Growth rate – Go [logarithm of growth rate (µm/s).

A complete description of the chemical composition and the isothermal transformation temperature is required to analyses the model which have gives an idea about Growth rate of pearlite in steels. The 6 input variables used for the growth rate analysis. Because of higher sensitivity of the model to small variations, the ***growth rate values*** are expressed in logarithm values

In this experiment Mn increases from 0.00 to 1.80%(wt%),Cr 0.00 to 2.28wt% , Si 0.00 to 1.99 wt% ,Mo 0.00 to 0.48 wt% ,Ni 0.00 to 3.00wt% and temperature decreases from 603.00 to 566.78 ºC based upon the maximum and minimum value of input variable of software..Input table (combination of various alloying elements) and corresponding output (pearlite growth rate) which are obtained from various combination of alloying element are given below.

In this research total six experiment carried out.

Experiment-1 in this experiment Mn wt% varying from 0.00 to 1.80.

Mn	Si	Cr	Mo	Ni	T
0.00	0.00	0.00	0.00	0.00	603.00
0.25	0.00	0.00	0.00	0.00	597.83
0.50	0.00	0.00	0.00	0.00	592.65
0.75	0.00	0.00	0.00	0.00	587.48
1.00	0.00	0.00	0.00	0.00	582.30
1.25	0.00	0.00	0.00	0.00	577.13
1.50	0.00	0.00	0.00	0.00	571.95
1.80	0.00	0.00	0.00	0.00	566.78

Experiment -2 in this experiment Si wt% varying from 0.00 to 1.99.

Mn	Si	Cr	Mo	Ni	T
0.00	0.00	0.00	0.00	0.00	603.00
0.00	0.25	0.00	0.00	0.00	597.83
0.00	0.50	0.00	0.00	0.00	592.65
0.00	0.75	0.00	0.00	0.00	587.48
0.00	1.00	0.00	0.00	0.00	582.30
0.00	1.40	0.00	0.00	0.00	577.13
0.00	1.75	0.00	0.00	0.00	571.95
0.00	1.99	0.00	0.00	0.00	566.78

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Experiment -3 in this experiment Cr wt% varying from 0.00 to 2.28.

Mn	Si	Cr	Mo	Ni	T
0.00	0.00	0.00	0.00	0.00	603.00
0.00	0.00	0.40	0.00	0.00	597.83
0.00	0.00	0.80	0.00	0.00	592.65
0.00	0.00	1..20	0.00	0.00	587.48
0.00	0.00	1.50	0.00	0.00	582.30
0.00	0.00	1.80	0.00	0.00	577.13
0.00	0.00	2.00	0.00	0.00	571.95
0.00	0.00	2.28	0.00	0.00	566.78

Experiment-4 in this experiment Mo wt% varying from 0.00 to 0.48 from increases value of Mo wt%,

Mn	Si	Cr	Mo	Ni	T
0.00	0.00	0.00	0.00	0.00	603.00
0.00	0.00	0.00	0.06	0.00	597.83
0.00	0.00	0.00	0.12	0.00	592.65
0.00	0.00	0.00	0.18	0.00	587.48
0.00	0.00	0.00	0.24	0.00	582.30
0.00	0.00	0.00	0.30	0.00	577.13
0.00	0.00	0.00	0.40	0.00	571.95
0.00	0.00	0.00	0.48	0.00	566.78

Experiment-5 in this experiment Ni wt% varying from 0.00 to 3.00.

Mn	Si	Cr	Mo	Ni	T
0.00	0.00	0.00	0.00	0.00	603.00
0.00	0.00	0.00	0.00	0.40	597.83
0.00	0.00	0.00	0.00	0.80	592.65
0.00	0.00	0.00	0.00	1.20	587.48
0.00	0.00	0.00	0.00	1.60	582.30
0.00	0.00	0.00	0.00	2.00	577.13
0.00	0.00	0.00	0.00	2.50	571.95
0.00	0.00	0.00	0.00	3.00	566.78

Experiment-6 In this experiment chemical composition of all alloying element changes such as Mn increases from 0.00 to 1.80%(wt%),Cr 0.00 to 2.28wt% , Si 0.00 to 1.99 wt% ,Mo 0.00 to 0.48 wt% ,Ni 0.00 to 3.00wt% and temperature decreases from 603.00 to 566.78 ºC

Mn	Si	Cr	Mo	Ni	T
0.00	0.00	0.00	0.00	0.00	603.00
0.25	0.25	0.40	0.06	0.40	597.83
0.50	0.50	0.80	0.12	0.80	592.65
0.75	0.75	1..20	0.18	1.20	587.48
1.00	1.00	1.50	0.24	1.60	582.30
1.25	1.40	1.80	0.30	2.00	577.13
1.50	1.75	2.00	0.40	2.50	571.95
1.80	1.99	2.28	0.48	3.00	566.78

III. RESULT &DISCUSSION-

The growth rate of pearlite usually decreases due to the solute dragging effect of the alloying elements segregated into austenite grain boundaries. If the alloying elements precipitate as carbides or nitrides in austenite, the precipitates also lower the grain growth rate by pinning the grain boundaries. alloying elements are added in the carbon steels, the grain growth rate generally decreases. In case of Mo addition, growth rate almost prevented because Mo segregated on grain boundaries more than any other alloying element [4].

In the first experiment Mn wt% varying from 0.00 to1.80.from increases value of Mn wt%, pearlitic growth rate decreases from 1.776106 to 0.376044 µm/s as shown in fig1

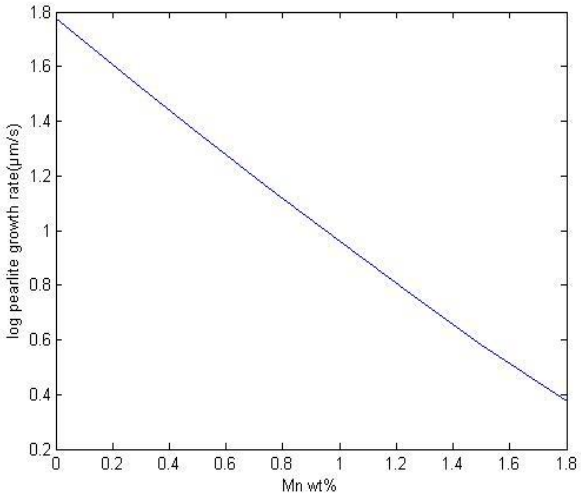

Fig-1 growth rate vs. Mn wt%

In the second experiment Si wt% varying from 0.00 to1.99.from increase value of Mn wt% ,pearlitic growth rate decreases from 1.776106 to 0.171549 (µm/s) as shown in fig 2[3].

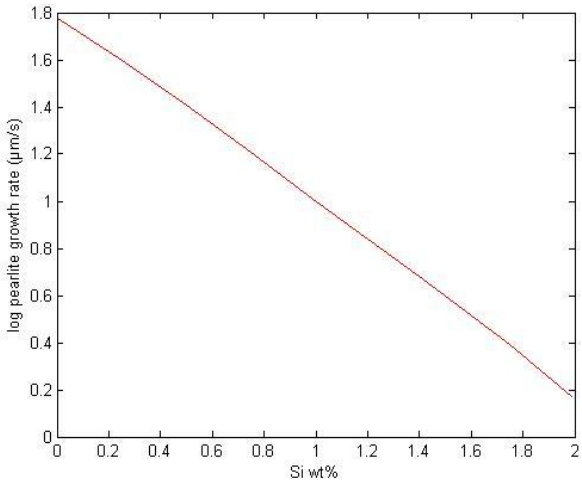

Fig- 2 Growth rate vs. Si wt%

In the third experiment Cr wt% varying from 0.00 to2.28 .From increase value of Cr wt% ,pearlitic growth rate decreases from 1.776106 to -0.852290 (µm/s). Here large variation in pearlite growth rate is achieve) as shown in fig 3.

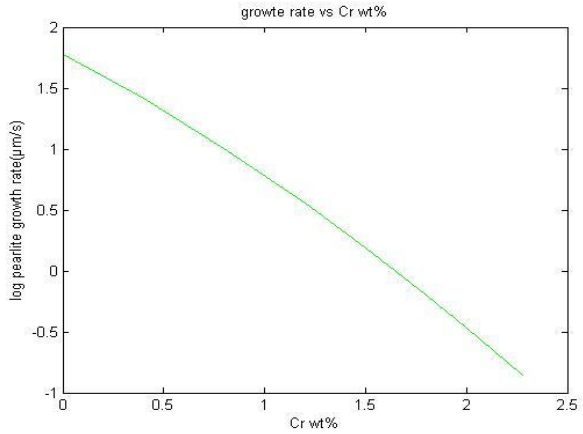

Fig -3 Growth rate vs. Cr wt%

In the forth experiment Mo wt% varying from 0.00 to0.48 from increases value of Mo wt%, perlitic growth rate decreases from 1.776106 to 1.706426 µm/s. After increasing value of Mo wt%, the growth rate almost prevented as shown in fig 4.

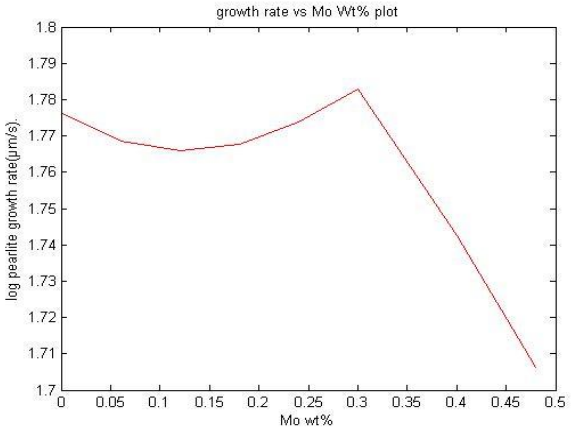

Fig 4-Growth rate vs. Mo wt%

In the fifth experiment Ni wt% varying from 0.00 to3.00, perlitic growth rate decreases from 1.776106 to 1.122679 µm/s as shown in fig 5.

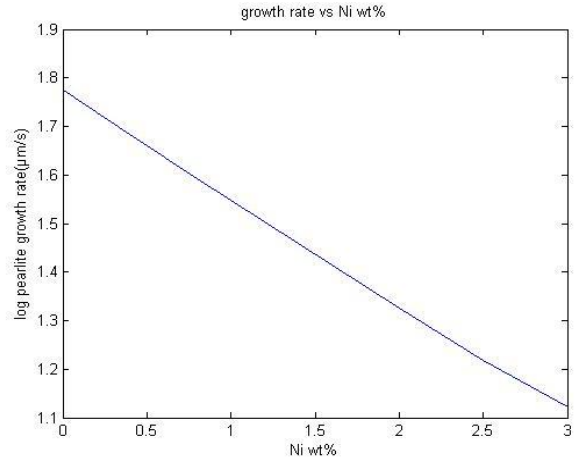

Fig -5 Growth rate vs. Ni wt%

In the sixth experiment chemical composition of all alloying element changes such as Mn increases from 0.00 to 1.80%(wt%), Cr 0.00 to 2.28wt%, Si 0.00 to 1.99 wt%, Mo 0.00 to 0.48 wt%, Ni 0.00 to 3.00wt% and temperature decreases from 603.00 to 566.78 ºC and pearlite growth rate varied from 1.776106 to -0.710945 µm/s as shown in fig 6.

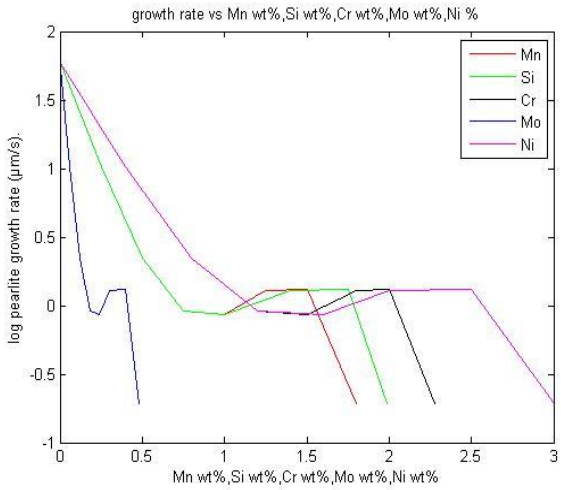

Fig 6-Growth rate vs. combination of all alloying elements.

IV. CONCLUSION-

- The addition of Mo is found more effective to prevent austenite grain growth than Cr and Ni[8] that is growth rate almost stop because in case of Mo there is very little variation in growth rate.
- Fe-C-Mn isotherms invariably occur under non steady state condition with an interlameller spacing that increase in time and a growth rate that decreases in time throughout all the reaction.
- From this research it can be calculated pearlite growth rate decreases with an increases chemical composition of alloying element during isothermal austenite to pearlite conversion[3].

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