6 Referências Bibliográficas

1 SPEER, J.; MATLOCK, D. K.; DE COOMAN, B. C.; SCHROTH, J. G. **Carbon partitioning into austenite after martensite transformation**. Acta Materialia, v.51, n. 9, p. 2611-2622, 23 May 2003.

2 COLORADO SCHOOL OF MINES, US. John G. Speer; David K. Matlock; Matthew Gallagher. **Method for producing steel with retained austenite**. Int Cl C21D 9/00. WO 2004/022794 A1. 04 set. 2002, 18 mar 2004.

3 MARTINS, A.R.F. A. **Têmpera e participação em aços de alta resistência contendo Ni : modelagem cinética, microestrutura e propriedades mecânicas**. Rio de Janeiro, 2007. Tese (Doutorado em Metalurgia) - Pontifícia Universidade Católica do Rio de Janeiro.

4 AMERICAN IRON AND STEEL INSTITUTE. **The Steel Industry Technology Roadmap for Automotive**. Disponível em: www.autosteel.org. Acesso em: fevereiro 2008

5 FEDERICI, C.; MAGGI, S.; RIGONNI, S. **The Use of Advanced High Strength Steel Sheet in the Automotive Industry**. Disponível em: http://www.msm.cam.ac.uk/phase-trans/2005/LINK/11.pdf. Acesso em: fevereiro 2008.

6 AMERICAN IRON AND STEEL INSTITUTE. Disponível em: http://www.autosteel.org/Content/NavigationMenu2/Automotive/UltralightPrograms/default.htm. Acesso em: fevereiro 2008.

7 WAGONER, R. H. **Advanced High Strength Steel Workshop Report**. 2006

8 FERRER, M.H. **Estudo das transformações de fase de aços TRIP ao Si-Mn microligados com Nb**. São Paulo, 2003. Tese (Doutorado) - Universidade de São Paulo.

9 BHADESHIA, H.K.D.H.; HONEYCOMBE, R.W.K. **Steels: Microstructure and Properties** 3ed. Oxford: Butterworth-Heinemann, 2006. 360p.

10 CHATTERJEE, S. **Transformations in TRIP-assisted Steels: Microstructure and Properties**. Cambridge, 2006. Tese (Doutorado). University of Cambridge.

11 JACQUES, P.J. **Transformation-induced plasticity for high strength formable steels**. Current Opinion in Solid State and Materials Science, v. 8, n. 3-4, p. 259-265, jun./ago. 2004

12 BHADESHIA, H.K.D.H. **TRIP-Assisted Steels?** ISIJ International, v. 42, n. 9, p. 1056-1060, 2002.

13 VAN SLYCKEN, J.; VERLEYSEN, P.; DEGRIECK, J.; BOUQUEREL, J.; DE COOMAN, B.C. **Dynamic response of aluminium containing TRIP steel and its constituent phases.** Materials Science and Engineering: A, v.460-461, p.516-524, 15 Jul. 2007

14 LANI, F.; FURNÉMONT, Q.; VAN ROMPAEY, T.; DELANNAY, F.; JACQUES, P.J.; PARDOEN, T. **Multiscale mechanics of TRIP-assisted multiphase steels: II. Micromechanical modeling**. Acta Materialia, v. 55, n.11, p.3695-3705, June 2007

15 JACQUES, P.J.; FURNÉMONT, Q.; LANI, F.; PARDOEN, T.; DELANNAY, F. **Multiscale mechanics of TRIP-assisted multiphase steels: I. Characterization and mechanical testing**. Acta Materialia, v.55, n.11, p.3681-3693, June 2007.

16 SHERIF, M.Y. **Characterization and Development of Nanostructured, Ultrahigh Strength and Ductile Bainitic Steels**. Cambridge, 2006. Tese (Doutorado) - University of Cambridge

17 PORTER, D. A.; EASTERLING, K. E. **Phase transformations in metals and alloys** 2 ed. London: Chapman & Hall, 1992. 514p.

18 VERHOEVEN, J. D. **Fundamentals of physical metallurgy**. New York: Wiley, c1975. 567p.

19 DE COOMAN, B.C. **Structure–properties relationship in TRIP steels containing carbide-free bainite**. Current Opinion in Solid State and Materials Science, v.8, n.3-4, p. 285-303, Jun./Aug. 2004.

20 BHADESHIA, H. K. D. H.; EDMONDS, D. V. **The Bainite Transformation in a Silicon Steel**. Metallurgical Transactions A, v.10A, p.895-907, 1979.

21 JACQUES, P.; GIRAULT, E.; CATLIN, T.; GEERLOFS, N.; KOP, T.; VAN DER ZWAAG, S.; DELANNAY, F. **Bainite transformation of low carbon Mn–Si TRIP-assisted multiphase steels: influence of silicon content on cementite precipitation and austenite retention.** Materials Science and Engineering A, v. 273-275, p.475-479, 15 Dec. 1999.

22 GALLAGHER, M.F., SPEER, J.G., MATLOCK, D.K.; FONSTEIN, N.M. Microstructure Development in TRIP-Sheet Steel containing Si, Al, and P. In:

Mechanical Working and Steel Processing Conference, 44, 2002, Warrendale, PA. **Proceedings**… London: Iron and steel Society, 2002. p.153-172.

23 EDMONDS, D.V.; HE, K.; RIZZO, F.C.; CLARKE, A.; MATLOCK , D.K.; SPEER, J.H. **Microstructural Features of a New Martensitic Steel Heat Treatment: Quenching and Partitioning**. Super-High Strength Steel, Italia, 2005.

24 SPEER, J.H.; EDMONDS, D.V.; RIZZO, F.C.; MATLOCK, D.K. **Partitioning of carbon from supersaturated plates of ferrite, with application to steel processing and fundamentals of the bainite transformation**. Current Opinion in Solid State and Materials Science, v.8, n.3-4, p.219-237; Jun./Aug.2004.

25 EDMONDS, D.V.; HE, K.; RIZZO, F.C.; DE COOMAN, B.C.; MATLOCK, D.K.; SPEER, J.H. **Quenching and partitioning martensite — A novel steel heat treatment.** Materials Science and Engineering: A, v.38-440, P.25-34, 25 Nov. 2006.

26 CLARKE, A.J. ; SPEER, J.G. ; MILLER, M.K.; HACKENBERG, R.E.; EDMONDS, D.V. ; MATLOCK, D.K.; RIZZO, F.C.; CLARKE K.D.; DE MOOR, E. **Carbon partitioning to austenite from martensite or bainite during the quench and partition (Q&P) process: A critical assessment**. Acta Materialia, v.56, n.1, p.16-22, Jan.2008.

27 HILLERT, M.; ÅGREN, J. **On the definitions of paraequilibrium and orthoequilibrium.** Scripta Materialia, v.50, n.5, p. 697-699, Mar.2004.

28 SPEER, J.G.; MATLOCK, D.K.; DE COOMAN, B.C.; SCHROTH, J.G. **Comments on "On the definitions of paraequilibrium and orthoequilibrium" by M. Hillert and J. Ågren, Scripta Materialia, v.50, p.697–9, 2004.** Scripta Materialia, v.52, n.1, p.83-85, Jan.2005.

29 HILLERT, M.; ÅGREN, J. **Reply to comments on "On the definition of paraequilibrium and orthoequilibrium"**. Scripta Materialia, v.52, n.1, p.87-88, Jan.2005.

30 KOISTINEN, P.P. ; MARBURGER, R.E. **A General Equation Prescribing the Extent of The Austenite-Martensite Transformation In Pure Iron-Carbon Alloys And Carbon Steel**. Acta Metallurgica, v.7, p.59-60, 1959.

31 ANDREWS, K.W. **Empirical Formula for the Calculation of some Transformation temperatures.** Journal of Iron and Steel Institute, p.721-727, 1965.

32 SCHUH, C.A. **Nanoindentation Studies of Materials**. Materials Today. v.9, n.5, Mai.2006.

33 DOENER, M. F.; NIX, W. D. **A method for interpreting the data from depth-sensing indentation instruments**. Material Research, v.1, n.4, p.601-609, Aug.1986.

34 OLIVER, W. C.; PHARR, G. M.. **An improved technique for determining hardness and elastic modulus using load and displacement sensing indentation**. v.7, n.4, p.1564-1583, Jun.1992.

35 NANOINDENTAÇÃO. Disponível em: http://www.sorocaba.unesp.br/gpm/indentacao.htm. Acesso em: Abril 2008.

36 ZHANG, LIANG; GUO, DONG CHENG. **A General Etchant for Revealing Prior-Austenite Grain Boundaries in Steels**. Materials Characterization, p.299 – 305, 1993.

37 FISCHER-CRIPPS, A.C; EBRARY, INC. **Nanoindentation**. New York: Springer, c2002. 197 p.

38 FISCHER-CRIPPS, A.C. Critical **review of analysis and interpretation of nanoindentation test data.** Surface and Coatings Technology, v.200, n.14-15, p.4153-4165, 10 Apr. 2006.

39 DELINCÉ, M.; JACQUES, P. J.; PARDOEN, T. **Separation of size-dependent strengthening contributions in fine-grained Dual Phase steels by nanoindentation**. Acta Materialia, v.54, n.12, p. 3395-3404, Jul.2006.

40 FURNÉMONT, Q.; KEMPF, M.; JACQUES, P. J.; GÖKEN, M.; DELANNA, F. **On the measurement of the nanohardness of the constitutive phases of TRIP-assisted multiphase steels.** Materials Science and Engineering A, v.328, n.1-2, p.26-32, Mai.2002.

41 GARCÍA-JUNCEDA, A.; CAPDEVILA, C.; CABALLERO, F.G.; GARCÍA DE ANDRÉS, C. **Dependence of martensite start temperature on fine austenite grain size.** Scripta Materialia, v.58, n.2, p.134-137, Jan.2008.

42 BHADESHIA, H. K. D. H. **Interpretation of the Microstructure of Steels**. Disponível em: http://www.msm.cam.ac.uk/phase-trans/2008/Steel_Microstructure/SM.html. Acesso em: Abril de 2008.

7 Anexo I – Macro ThermoCalc

```
@@ Diagrama de fases da liga Q2
go d
sw ssol
@@ Selecao das especies e fases
d-sp fe c cr mo mn ni si
rej p*
restore p liquid cementite bcc fcc
get

go pol

@@ Condicoes iniciais
s-c t=1500 p=1e5 n=1
 s-c w(c)=.0022 w(cr)=.0072 w(mo)=.0049 w(mn)=.0242 w(ni)=.0139
w(si)=.0249
l-c
c-e
l-e
SCREEN
VWCS

s-a-v 1 w(c) 0 .05 .00125
s-a-v 2 t 400 2500 52.5

add

map

post

@@ Grafico
s-d-a y t
s-d-a x w-p c
s-l-c-o E
s-title Q2 Fe C Cr Mo Mn Ni Si
s-s-st y n 400 2000
s-s-st x n 0 5
s-s-st y n 900 1200
s-s-st x n 0 0.6
@@ Adicionando o ponto (0.22, 1040) ao grafico
add .22 1040 N
```

```
. (0.22, 1040)
.25

@@ Adicionando o ponto (0.22, 1040) ao grafico
add .4 1040 N
. (0.4, 1040)
.25

plot
SCREEN

set-interactive
```

8 Anexo II – Macro Dictra

```
@@ Liga Q2
go da
sw ssol

def-sp Fe C Cr Mn Ni Si
rej ph*
rest ph bcc fcc
get

append
mob2
def-sys Fe C Cr Mn Ni Si
rej ph*
restore ph fcc bcc
get

@@Condições Iniciais
go d-m
set-cond glob T 0 1040; * N

enter-region
Austenita

enter-grid
AUSTENITA
10e-6
LINEAR
50


enter-phase
ACTIVE
AUSTENITA
MATRIX
fcc

enter-phase
Inactive
AUSTENITA
No
```

bcc
fe
1E-05
CLOSED_SYSTEM

enter-comp
AUSTENITA
FCC_A1

fe
w-p
C
LINEAR
.22
.22
CR
LINEAR
.72
.72
Mn
LINEAR
1.42
1.42
NI
LINEAR
1.39
1.39
SI
LINEAR
2.49
2.49

set-sim-time
1e6
YES
100000000
1E-07
1E-07

s-s-c
0
1
2
NO
ACTIVITIES
YES
YES
1
2
NO

```
YES

@@Simulação
sim
```



```
Post
@@Grafico
s-d-a x dist global
s-d-a y w-p c

s-p-c time 0 10 10800 1e6

set_title  Q2

plot
SCREEN

@?

set-interactive
```