The Rate of Creep Deformation

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A dissertation submitted for the degree of Master of Philosophy at the University of Cambridge

August 2003

Preface

This dissertation is submitted for the degree of Master of Philosophy in Modelling of Materials at the University of Cambridge. The research described herein was conducted under the supervision of Professor H. K. D. H. Bhadeshia and Dr T. Sourmail in the Department of Materials Science and Metallurgy, University of Cambridge, between May 2003 and August 2003.

This work is to the best of my knowledge original, except where acknowledgements and references are made to previous work. Neither this, nor any substantially similar dissertation has been or is being submitted for any other degrees, diploma or other qualification at any other university. This dissertation contains less than 15,000 words.

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August 2003

"If we knew what it was we were doing, it would not be called research, would it?"

Albert Einstein (1879-1955)

Acknowledgement

I would like to express my sincere gratitude to Professor H. K. D. H. Bhadeshia for his guidance, knowledge, encouragement and great enthusiasm. I am extremely grateful to Dr T. Sourmail for his constant support and friendship.

It is my pleasure to acknowledge all the members of Phase Transformation Group, past and present, for their assistance, friendship and for many enjoyable times, in particular Dr. Thomas Sourmail, Dr. Carlos Garcia Mateo, Pippa Swannell, Teruhisa Okumura, Mathew J. Peet, Kazukuni Hase and Yokota Tomuyuki. It was an enormous pleasure to work with them. Thanks also to my friends and to the people I met both in St. Edmund's College and other colleges during my time in Cambridge.

Finally, I take this opportunity to express my gratitude to my family and friends for their love and unfailing support, specially my parents Liping Wei and Derong Shen.

Abstract

Creep and creep fracture represent one of the major problems associated with the selection and use of engineering materials for high temperature applications. From the results of previous scientists and researchers, creep deformation is a function of stress, strain, temperature and time. Constants associated creep equations are usually obtained through various tensile tests at different strain rates and temperatures. Although there are a great number of fundamental theories describing the process of creep deformation in different regimes of stress, temperature and strain rate, the theories have not been applied with effect in practical materials of the type used in engineering since useful materials tend to be complex.

To find out the creep strain and its dependences and test the significant creep constitutive strain equations, 2.25Cr-1Mo steel has been selected for detailed study and predictions. It is a very well established alloy and experimental creep strain data has been collected from the published literature, and a neural network model was created with inputs determined by the power law formulations of the simple creep theory. The creep strain neural network model was used to make predictions against variation of composition, stress and temperature. The dependence of creep strain on stress, time, and temperature is discussed for steady state stage and variable uni-axial loading at different constant temperatures.

Contents

Nomenclature and Abbreviations

a_1	Empirical constant
A	Constant
B	Constant
b	Magnitude of the Burgers vector
C	Constant
C'	Constant
D_0	Constant
d	Grain size
E	Young's modulus
G	Shear modulus
k	Boltzmann constant
L_0	Original length of the testing sample
ΔL	Change of the sample length
m	Stress exponent
n	Stress or time exponent
Q	Activation energy for self-diffusion in iron
r	Constant
R	Gas constant
t	Time
T	Absolute temperature
T_m	Absolute melting temperature

α	Stress exponent
β	Constant for transient creep
$\dot{\varepsilon}$	Creep strain rate
$\dot{\varepsilon}_{ss}$	Steady-state strain rate
$\dot{\varepsilon}_{\min}$	Minimum strain rate
ε	Creep strain
ε_0	Creep strain
ε_t	Creep strain at the transition from primary to secondary stage
ε_r	Creep strain to rupture
σ	Creep stress
θ	Theta-parameter or empirical constant