

# **The Rate of Creep Deformation**

**By**

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## **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.

Yi Shen

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

Albert Einstein (1879-1955)

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## **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.

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## 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
$\Delta L$	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



$\alpha$	Stress exponent
$\beta$	Constant for transient creep
$\dot{\varepsilon}$	Creep strain rate
$\dot{\varepsilon}_{ss}$	Steady-state strain rate
$\dot{\varepsilon}_{\min}$	Minimum strain rate
$\varepsilon$	Creep strain
$\varepsilon_0$	Creep strain
$\varepsilon_t$	Creep strain at the transition from primary to secondary stage
$\varepsilon_r$	Creep strain to rupture
$\sigma$	Creep stress
$\theta$	Theta-parameter or empirical constant