DAAAM BALTIC-ESTONIA

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6th International DAAAM Baltic Conference
"INDUSTRIAL ENGINEERING"
24-26 April 2008, Tallinn, Estonia

First of all I would like to express my deep gratitude to prof. Tauno Otto who has invited me to be present on DAAAM – BALTIC Conference as well as to take a part in key-note lecture. Also I wish to greet all of members of his team.

In addition I would like to greet all of participants on this conference and wish to all of them a good success.

Because I am a member of different committees of DAAAM, including DAAAM Estonia , for a long time, I am taking an opportunities to say some words about conference of this type as well as some words about the Faculty where I am coming from and some words about our involving in scientific achievement.

This lecture has been prepared according to various DAAAM publications, web material of University of Rijeka and Faculty of Engineering in Rijeka.

DAAAM- Danube Adria Association for Automation and Metrology was founded in November 1990. at Vienna Symposium in order to mark the 175 anniversary of the Technical University of Vienna. The idea and initiative of establishing of DAAAM originates from Prof. Branko Katalinic, Ph.D., prof. of Vienna University, who was born in Croatia.

The purpose of DAAAM is to provide the opportunity for carrying out, presentation and discussion of new ideas, achievement and impact in science and technology. All of mentioned relates closely scientists and engineers of the Danubian-Adriatic region as well as experts of all other countries. During so many years DAAAM conferences have persisted in different countries.

Main aims of DAAAM are:

- To organize annual DAAAM International Symposium

-To organize long-term projects (Interuniversity Doctoral Studies)

-Exchange of people, scientific and other information, etc.

-DAAAM conferences provide the publishing of the most recent research results from all technical fields and disciplines which are of interest of DAAAM International.

All topics from the fields of advanced manufacturing, automation and networking are included in the Symposium. Focus is on all aspects of design, manufacturing and exploiting of all kind of technical products. All of mentioned topics can be found on DAAAM web site www.daaam.com.

CROATIA - RIJEKA

Left: Position of the town Rijeka

Up: Main city gate of the Rijeka town

Map of the Rijeka Region

Rijeka

University of Rijeka

MEMBERS OF THE UNIVERSITY OF RIJEKA

Academy of Applied Arts

Faculty of Economy

Faculty of Hotel Management

Faculty of Philosophy

Faculty of Civil Engineering

Faculty of Medicine

Faculty of Maritime

Faculty of Law

Faculty of Engineering

Faculty for Teaching

Faculty of Engineering

Rijeka

FACULTY OF ENGINEERING RIJEKA

The relocation of the Imperial – Royal Naval Academy from Trieste to Rijeka in 1854 marks the beginning of systematic education of engineering personnel in the Rijeka region. It enabled the establishment of the full time four – year study with courses in the fields of iron ship construction and steam engines for the needs of the Austrian navy, and it lasted until the end of 1.st World War.

FACULTY OF ENGINEERING RIJEKA

The foundation and the beginning of activity of the Faculty of Mechanical Engineering in 1960 can be regarded as the continuation of systematic education and scientific research work for the requirements of the industry of Rijeka and wider region, particularly for mechanical engineering and naval architecture. At the beginning, only the education of graduate engineers of Mechanical Engineering was offered. Since 1969/70 the graduate engineers of Naval Architecture were also educated and the faculty was renamed into Mechanical – Naval Architecture Faculty. In the year 1973 the faculty changed its name into Technical Faculty. During the academic year 1971/72 the faculty started its civil engineering program, but in the year 1976 the Civil Engineering Faculty was founded. It separated from the Technical Faculty and became an independent establishment.

FACULTY OF ENGINEERING RIJEKA

In the academic year 1965/66 the Faculty organised the education for earning higher vocational degree. This study of Mechanical Engineering and Naval Architecture was held not only in Rijeka but also for some generations of students in Labin and Pula. In 1987 the study of Electrical Engineering was established to satisfy the needs for specialists of higher vocational degree in the field of electrical engineering. In 1971/72 the post graduate scientific study was inaugurated to enable graduate engineers of Mechanical Engineering and Naval Architecture to widen their acquired knowledge and scientific permanent education.

FACULTY OF ENGINEERING RIJEKA

In 1999/2000 the education of graduate engineers in Electrical Engineering commenced.

At the vocational undergraduate study the mechanical engineers, naval engineers and electrical engineers are educated. The Faculty also has the university undergraduate program to educate graduate engineers of Mechanical Engineering, graduate engineers of Naval Architecture, graduate engineers of Electrical Engineering, while after post graduate studies of Mechanical Engineering or Naval Architecture students earn Master` s and Doctor` degrees in the field of engineering sciences.

FACULTY OF ENGINEERING RIJEKA

Until the beginning of November, 2005, 2429 students earned titles of graduate engineers in Mechanical Engineering, Naval Architecture and Electrical Engineering, 1307 students earned titles of engineers in Mechanical Engineering, Naval Architecture and Electrical Engineering, as well as 86 Masters of Science and 64 Doctors of Science in the field of engineering sciences.

FACULTY OF ENGINEERING RIJEKA

Educational, scientific research work and various forms of collaboration with economy are cherished within departments:

DEPARTMENT OF AUTOMATION, ELECTRONICS AND COMPUTING

DEPARTMENT OF NAVAL ARCHITECTURE AND OCEAN ENGINEERING

DEPARTMENT OF ELECTRIC POWER SYSTEMS

DEPARTMENT OF INDUSTRIAL ENGINEERING AND MANAGEMENT

DEPARTMENT OF MATHEMATICS, PHYSICS, FOREIGN LANGUAGES AND KINESIOLOGY

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

DEPARTMENT OF FLUID MECHANICS AND COMPUTATIONAL ENGINEERING

DEPARTMENT OF ENGINEERING MECHANICS

DEPARTMENT OF THERMODYNAMICS AND ENERGY ENGINEERING

DEPARTMENT OF ENGINEERING MECHANICS

DEPARTMENT OF ENGINEERING MECHANICS

Members:

Prof. D. Sc. Josip Brnić, Head of Department

Prof. D. Sc. Goran Turkalj

Assoc. Prof. D. Sc. Roberto Žigulić

Assoc. Prof. D. Sc. Marko Čanađija

Assist. Prof. D. Sc. Sanjin Braut

Assist. Prof. D. Sc. Domagoj Lanc

Jun. Researchers: M. Sc. Ante Skoblar,Marino Brčić, Igor Pešić, Goranka Štimac, Goran Vukelić, Sanjin Kršćanski

DEPARTMENT OF ENGINEERING MECHANICS

The Department of Engineering Mechanics was founded at the same time as the Faculty, in 1960. The scientific, teaching and professional activity of the Department has developed through time and today is based on non-linear numerical, especially finite-element and experimental analysis of constructions and engines, in the fields of elastomechanics and plastomechanics, viscoplasticity, stability, thermomechanics, dynamics and vibrations, durability and reliability, optimization in design and production, plastic metal forming, kinematics and dynamics of the robot and acoustics. The newest softwares such as Patran/Nastran, Dytran, Fatigue, Ideas, as well as personally created softwares offer a great possibility in numerical modelling and in response analysis of the structures and machines in various service performances. The members of the Department have published a great number of scientific works in prestigious international and national journals, presented papers at international and national conferences and published over 20 books and textbooks among which some abroad.

DEPARTMENT OF ENGINEERING MECHANICS

The complete teaching activity of the Department employs their own published textbooks. A great number of members of the Department have earned the academic title of Doctor of Science and Master of Science, and have taken an active part in all forms of scientific-teaching activity at postgraduate doctoral study, at university and vocational studies of Mechanical Engineering, Naval Architecture and Electrical Engineering. The Department has consistently worked on scientific research projects financed by the Ministry of Science, Education and Sport of the Republic of Croatia. It maintains intensive cooperation with related Departments of the Faculties in Vienna, Brno, Prague, Budapest, Kaiserslautern, Darmstadt, Zlin, Trnava, Cluj-Napoca, Ljubljana, Maribor, Zagreb, Split, Slavonski Brod and Mostar. The activities of the Department are directed also towards a collaboration with the economy, in the field of experimental testing and numerical analysis of structures and machines.

EQUIPMENT OF THE DEPARTMENT OF ENGINEERING MECHANICS

1. High temperature extensometer
2. High temp. furnace (900 ^{o}C)
3. Ttemperature control
4. Tensile test
5. Extensometer
6. Hydraulic power unit
7. 3pt bending
8. Compression test
9. Electronics
10. Software Test Expert
11. Low temperature chamber

Testing system Zwick Z400E – 400 kN

EQUIPMENT OF THE DEPARTMENT OF ENGINEERING MECHANICS

Charpy

HBM DMCplus

EQUIPMENT OF THE DEPARTMENT OF ENGINEERING MECHANICS

FIELDS OF INTEREST OF THE DEPARTMENT OF ENGINEERING MECHANICS

-Elastoplasticity

-Viscoplasticity

-Creep analysis

-Finite element analysis

-Thermomechanics

-Stability

-Rotor dynamics

-Vibration and noise control

-Experimental research

-General strength of materials

ACHIEVEMENTS OF THE DEPARTMENT OF ENGINEERING MECHANICS

Recent books:

1. Brnic, J.; Turkalj, G.: Strength of Materials II, (in Croatian), Zigo, Rijeka, 2006.
2. Brnic, J.: Statics, (in Croatian), University of Rijeka, Faculty of Engineering, Rijeka, 2004.
3. Brnic, J.; Turkalj, G.: Strength of Materials I, (in Croatian), University of Rijeka, Faculty of Engineering, Rijeka, 2004.
4. Brnic, J.: Elastoplasticity and Elastoviscoplasticity, PAMM-Centre, Budapest, 1998.
5. Brnic, J.: Elastomechanics and Plastomechanics, (in Croatian), Skolska knjiga, Zagreb, 1996.
6. Brnic, J.: Mechanics and Structural Elements, (in Croatian), Skolska knjiga, Zagreb,1993.
7. Brnic, J.: Strength of Materials, (in Croatian), Skolska knjiga, Zagreb,1991.

ACHIEVEMENTS OF THE DEPARTMENT OF ENGINEERING MECHANICS

Journals in which the staff has published articles:

1. Journal of Materials Science and Technology
2. Computers & Structures
3. International Journal of Plasticity
4. Acta Metallurgica Sinica
5. International Journal of Structural Stability and Dynamics
6. Proceedings of the Estonian Academy of Sciences: Engineering
7. Strojarstvo
8. Mashinostroene
9. Transactions of FAMENA
10. Bulletins for Applied & Computer Mathematics (BAM), PAMM-Centre,
11. Scientific Bulletin of the Politehnica University of Timisoara, Transactions on Mathematics & Physics
12. Engineering Mechanics (Journal for theoretical and applied mechanics)
13. Elektrotechnik und Informationstechnik

FEW DETAILS FROM CREEP RESEARCH AND STRUCTURAL ANALYSIS

Behavior of AISI 316L steel subjected to uniaxial state of stress at elevated temperatures

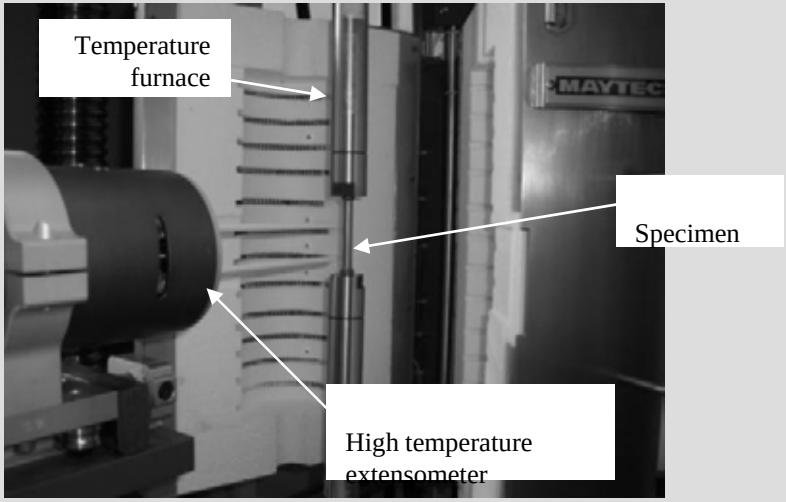
Abstract

This paper presents experimental investigation of AISI 316L steel regarding to the material properties and short uniaxial creep tests at elevated temperatures. These short-time creep tests were carried out for different but constant stresses. The obtained data of ultimate tensile strength, yield strength, creep curves and curves representing effects of elevated temperatures on mechanical properties are presented. For a selected rheological model, material parameters were obtained. As a justification, such rheological model is implemented in finite element procedure for a uniaxially stressed specimen at selected environmental conditions.

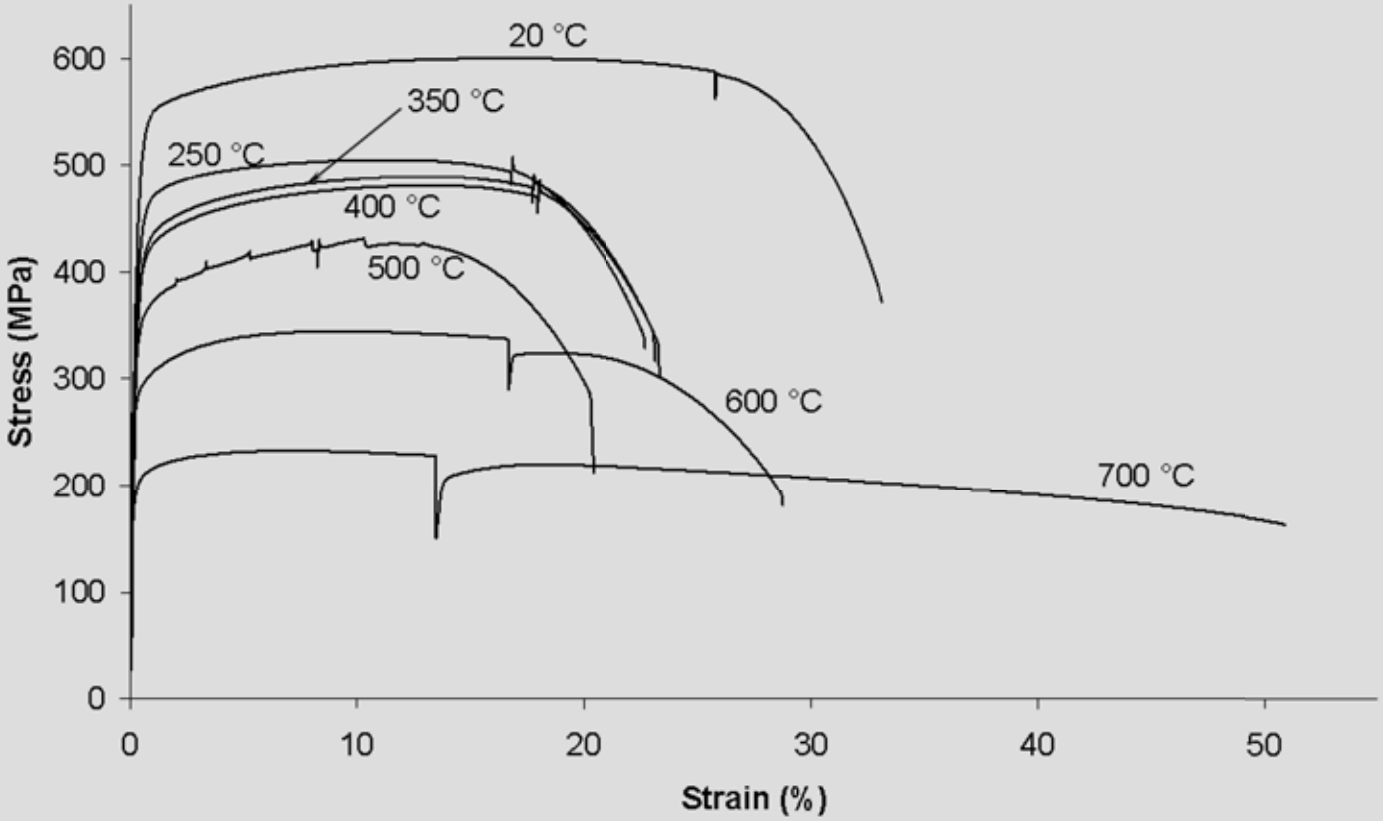
MATERIAL:

The material under consideration was AISI 316L with the following composition Wt(%): Fe(69.173), C(0.0265), Cr(17.91), Ni (8.23), Mn(1.51), Mo(1.85), Si(0.29), S(0.029), P(0.021), Cu(0.334), Co(0.23).

TESTING SYSTEM:

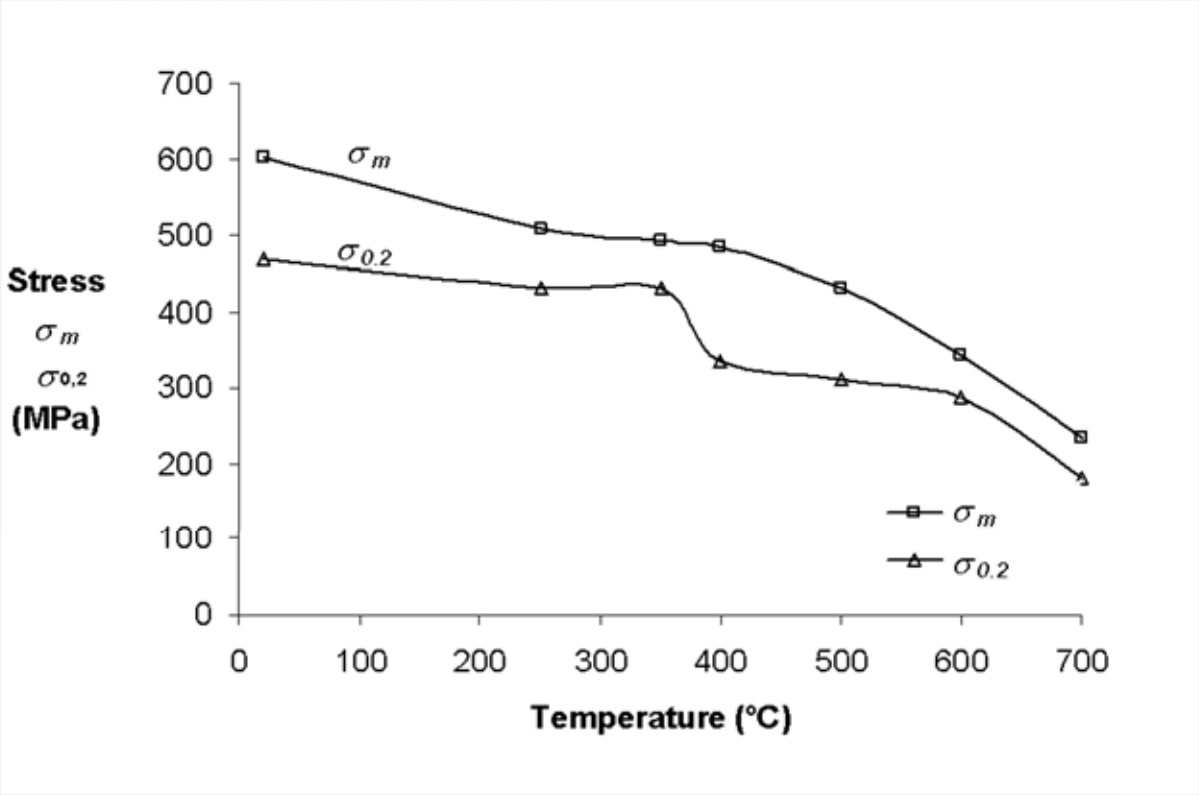


TENSILE TESTS:

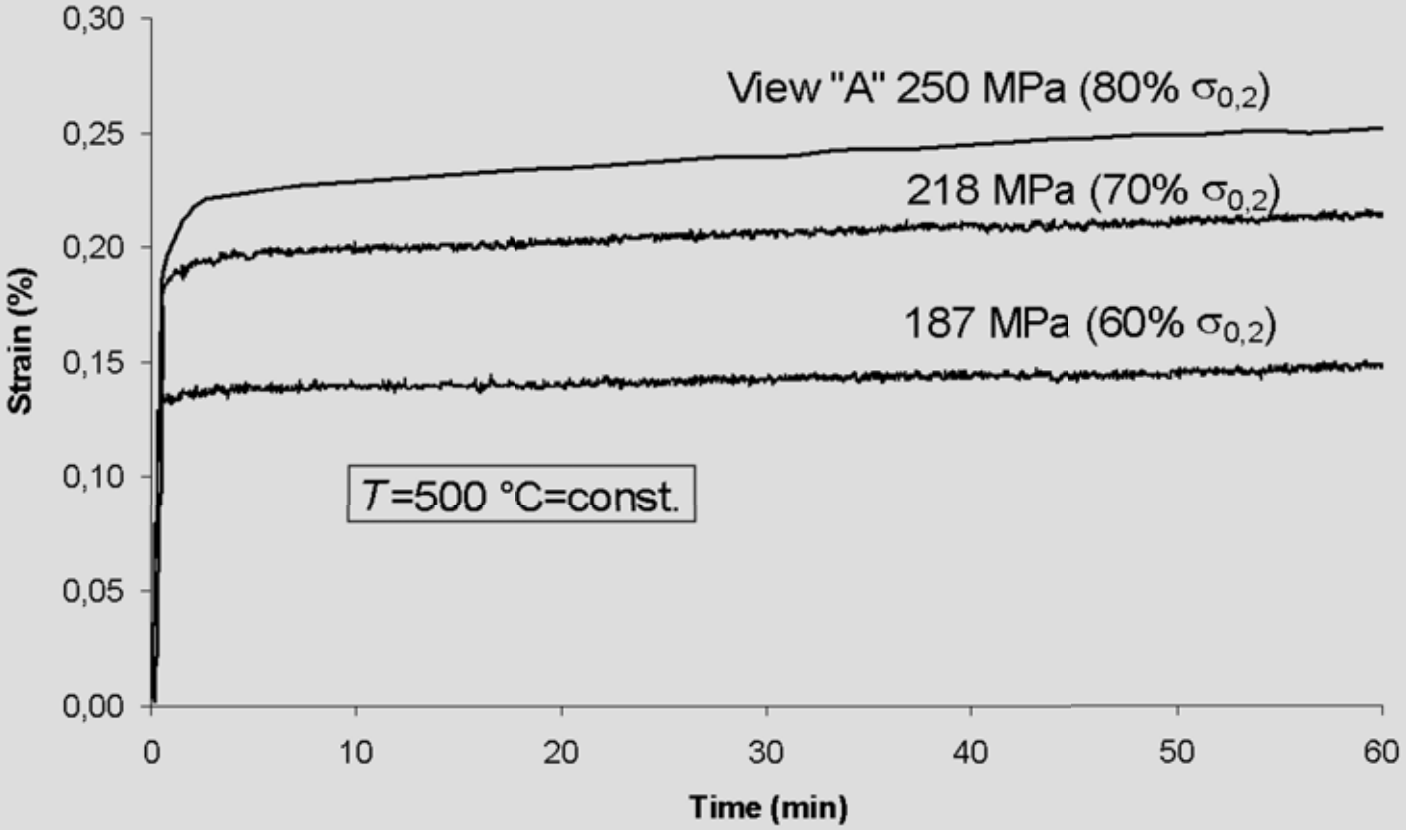


TENSILE TESTS:

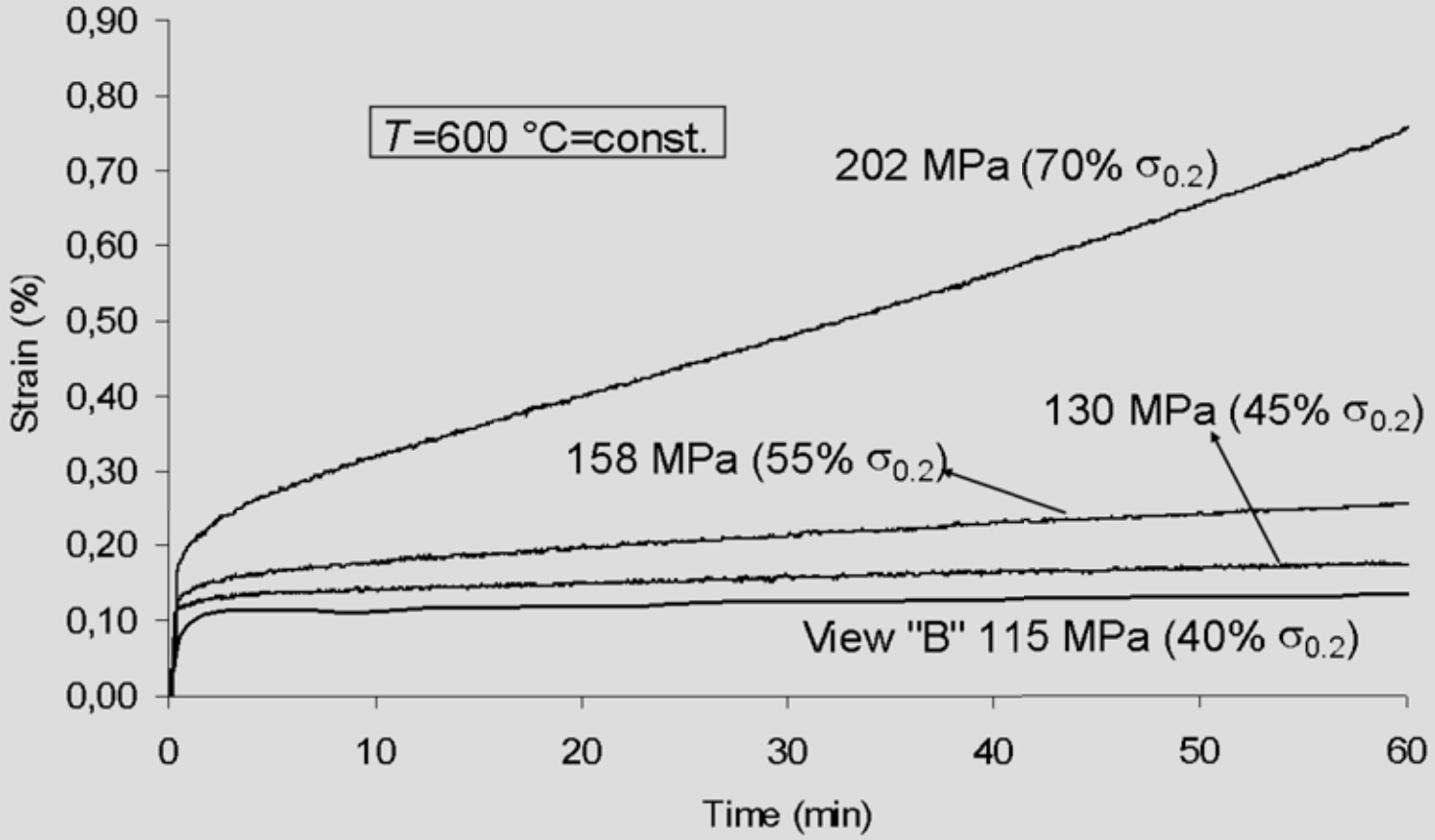
Ultimate tensile strength and Yield point strength vs. temperautre



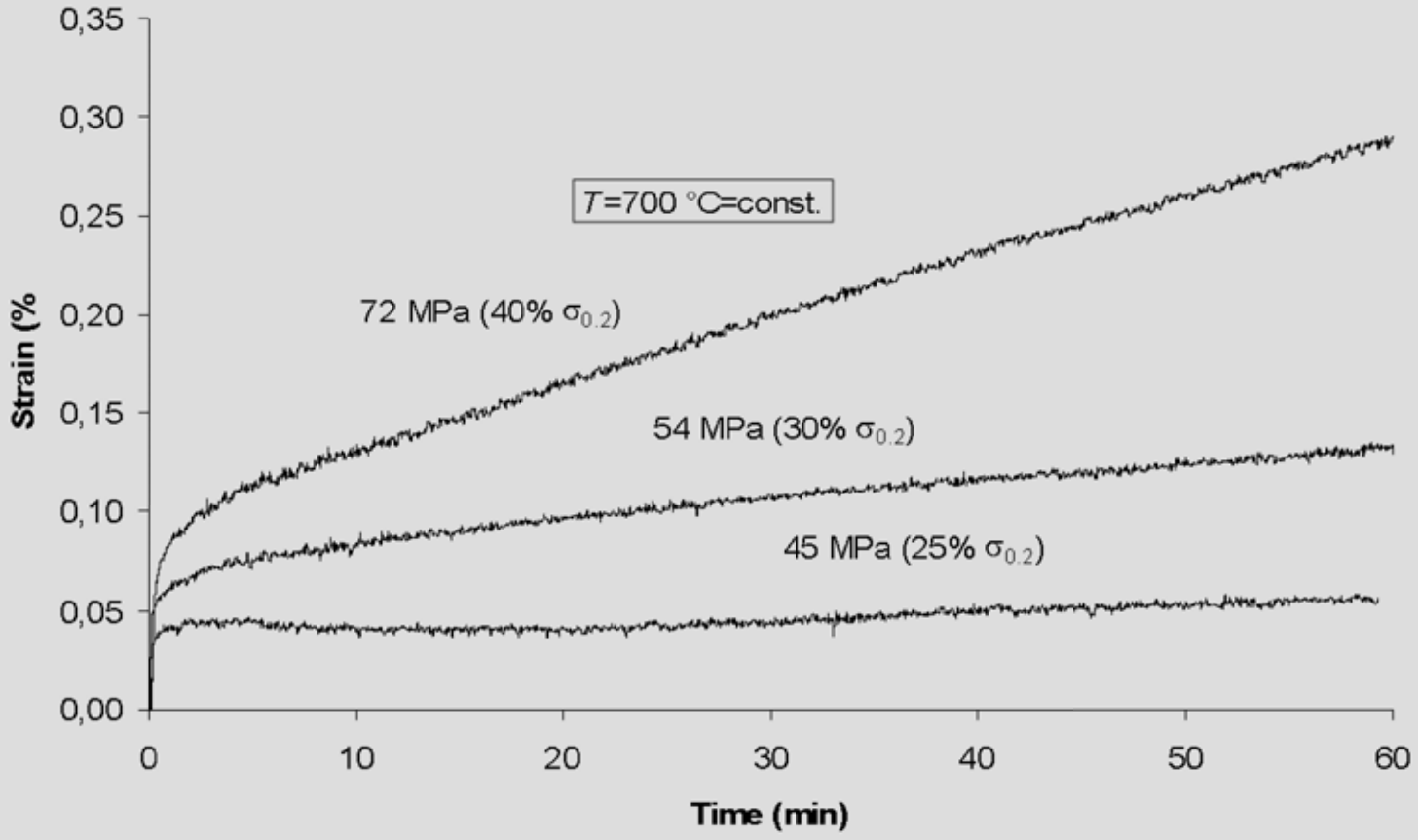
CREEP TESTS:


0,30
0,25
0,20
0,15
0,10
0,05
0,00
Strain (%)
0
10
20
30
40
50
60
Time (min)
View "A" 250 MPa (80% σ0,2)
218 MPa (70% σ0,2)
187 MPa (60% σ0,2)
T=500 °C=const.

CREEP TESTS:


T=600 °C=const.
202 MPa (70% σ0.2)
158 MPa (55% σ0.2)
130 MPa (45% σ0.2)
View "B" 115 MPa (40% σ0.2)
Strain (%)
Time (min)
0,00
0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
0,90
0
10
20
30
40
50
60

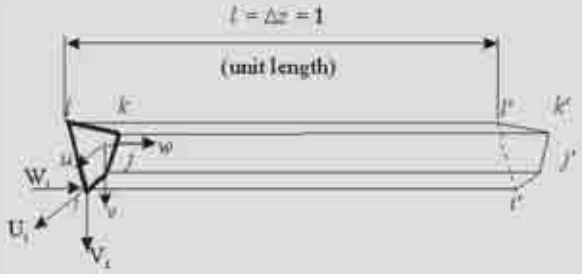
CREEP TESTS:

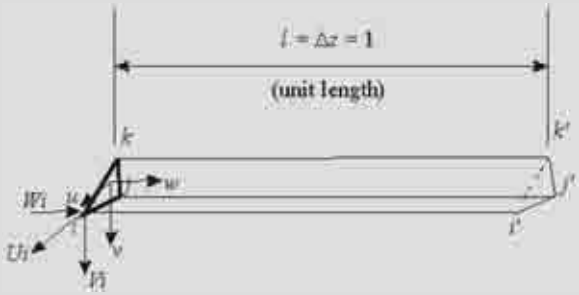

0,35
0,30
0,25
0,20
0,15
0,10
0,05
0,00
Strain (%
T=700 °C=const.
72 MPa (40% σ0.2)
54 MPa (30% σ0.2)
45 MPa (25% σ0.2)
0
10
20
30
40
50
60
Time (min)

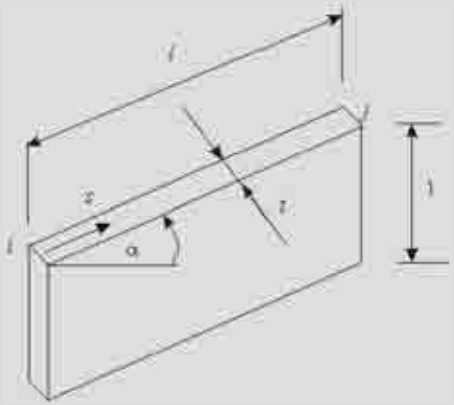
NUMERICAL STRUCTURAL ANALYSIS

Shear stress analysis - St. Venant's torsion and bending with shear

FINITE ELEMENTS:







FINITE ELEMENTS:

$$\left.\begin{aligned} u &= u(y,z) = -yz\theta \\ v &= v(x,z) = xz\theta \\ w &= w(x,y) = \theta\psi(x,y) \end{aligned}\right\} \qquad \theta = \frac{d\varphi}{dz} = const$$

$$\tau_{zx} = G\left(\frac{\partial\ w}{\partial\ x} - \theta\ \ y\right), \quad \tau_{zy} = G\left(\frac{\partial\ w}{\partial\ y} + \theta\ \ x\right)$$

$$w(x,y) = \mathbf{p}(x,y)\alpha$$

$$\boldsymbol{W} = \mathbf{p}^{b}\alpha$$

FINITE ELEMENTS:

General

$$w(x,y) = \mathbf{p}(x,y)\left[\mathbf{p}(x,y)^b\right]^{-1}\boldsymbol{W} = \mathbf{N}\boldsymbol{W}$$

St. Venant's torsion problem

$$\Pi = \iint \frac{1}{2} G\left[\left(\frac{\partial w}{\partial x} - \theta y\right)^2 + \left(\frac{\partial w}{\partial y} + \theta x\right)^2\right] dx\,dy - M_t\,\theta$$

$$\delta\Pi_{(w,\theta)} = \left(G\theta I_t - M_t\right)\delta\theta + \iint\left[\frac{\partial w}{\partial x}\frac{\partial \delta w}{\partial x} + \frac{\partial w}{\partial y}\frac{\partial \delta w}{\partial y} + \theta x\frac{\partial \delta w}{\partial y} - \theta y\frac{\partial \delta w}{\partial x}\right] dx\,dy = 0$$

$$\mathbf{K}_e = G\left(\mathbf{p}^b\right)^{-T}\iint\left(\mathbf{p}_x^T\mathbf{p}_x + \mathbf{p}_y^T\mathbf{p}_y\right)\left(\mathbf{p}^b\right)^{-1} dx\,dy$$

$$\boldsymbol{F}_e = -G\left(\mathbf{p}^b\right)^{-T}\iint\left(\mathbf{p}_y^T x + \mathbf{p}_x^T y\right) dx dy$$

FINITE ELEMENTS:

Bending with shear:

Stiffness matrix is the same

Load vectors:

$$\boldsymbol{F}_x^e = \left(\mathbf{p}^b\right)^{-T} \frac{Q_y}{I_x} \iint y\,\mathbf{p}\,dx\,dy \qquad \boldsymbol{F}_y^e = \left(\mathbf{p}^b\right)^{-T} \frac{Q_x}{I_y} \iint x\,\mathbf{p}\,dx\,dy$$

$$\boldsymbol{F}_x^e = \frac{F_y}{24 I_x} \begin{Bmatrix} A_1(3y_1 + y_i) + A_2(3y_2 + y_i) + A_4(3y_4 + y_i) \\ A_1(3y_1 + y_j) + A_3(3y_3 + y_j) + A_4(3y_4 + y_j) \\ A_1(3y_1 + y_k) + A_2(3y_2 + y_k) + A_3(3y_3 + y_k) \\ A_2(3y_2 + y_\ell) + A_3(3y_3 + y_\ell) + A_4(3y_4 + y_\ell) \end{Bmatrix}$$

$$\boldsymbol{F}_y^e = \frac{F_x}{24 I_y} \begin{Bmatrix} A_1(3x_1 + x_i) + A_2(3x_2 + x_i) + A_4(3x_4 + x_i) \\ A_1(3x_1 + x_j) + A_3(3x_3 + x_j) + A_4(3x_4 + x_j) \\ A_1(3x_1 + x_k) + A_2(3x_2 + x_k) + A_3(3x_3 + x_k) \\ A_2(3x_2 + x_\ell) + A_3(3x_3 + x_\ell) + A_4(3x_4 + x_\ell) \end{Bmatrix}$$

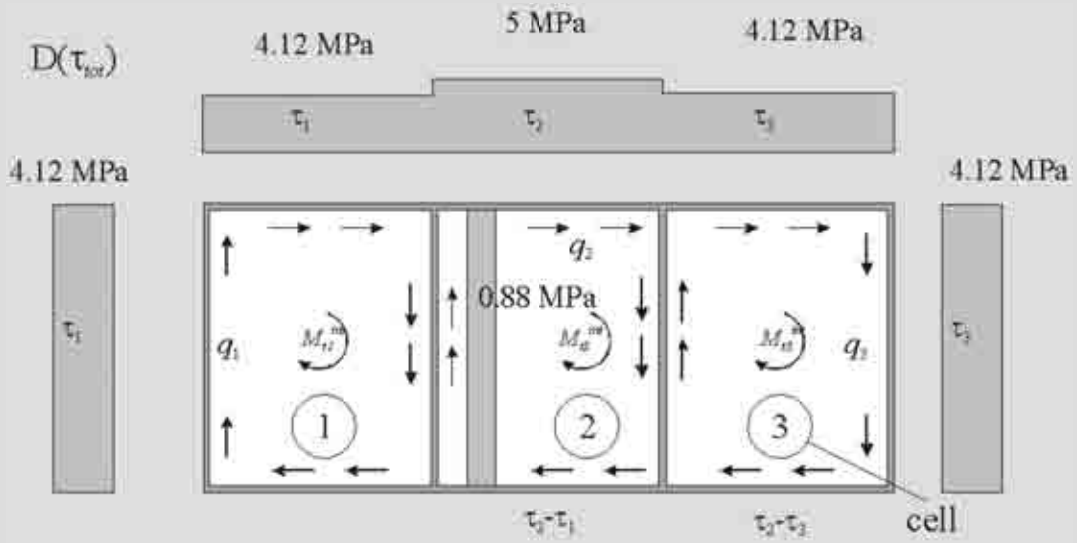
FINITE ELEMENTS:

General quadrilateral finite element

$$\mathbf{K}_e = G\left(\mathbf{p}^b\right)^{-.T}\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & A_e & 0 & S_x \\ 0 & 0 & A_e & S_y \\ 0 & S_x & S_y & I_x + I_y \end{bmatrix}\left(\mathbf{p}^b\right)^{-1} \qquad \boldsymbol{F}_e = -G\left(\mathbf{p}^b\right)^{-T}\begin{bmatrix} 0 \\ -S_x \\ S_y \\ I_y - I_x \end{bmatrix}$$

FINITE ELEMENTS:

Example *Mt*=1500 Nm



FINITE ELEMENTS:

Example *F*=50 kN *F*=50 kN