European Structural Integrity Society

ESIS Newsletter #62, July, 2018

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EDITORIAL BY THE ESIS PRESIDENT

This will be my last editorial as I will be stepping down as President after two, four year terms. It has been wonderful working for ESIS this last eight years. Our Technical Committees (TCs) are strong. There are five new ones and three have been reinvigorated. The National Committees (NCs) in many countries are very active with their own local activities.

Aleksandar Sedmak is preparing ECF22 for us which will take place in Belgrade, Serbia from August 26 until August 31, 2018. We are looking forward to that event. http://www.ecf22.rs/

As usual there will be several medals and awards presented at the conference. These include the Griffith and Wöhler medals, the Award of Merit and the ESIS-Elsevier Young Scientist Awards. The Awards Committee is working on the decisions for the first three. The Young Scientist Awards are dedicated to the best contributions at ECFs, as selected by the Awards Committee. The award will include a certificate and 1000 € for first place and 500 € for second place. It should be clear, that the award will only be given if there is a deserving individual. We thank Elsevier for their support. Finally, there is support available for deserving scientists who require financial help to attend ECF22. Approximately 20 individuals will be receiving this support.

I remind you that ESIS has four affiliated Elsevier journals including: Engineering Failure Analysis, Engineering Fracture Mechanics, International Journal of Fatigue and Theoretical and Applied Fracture Mechanics. We encourage you to publish your articles in these journals. A list of special issues is within the pages of this Newsletter.

ESIS is requested to support many conferences, most of which are part of TC or NC activities. In order to coordinate the dates so as to avoid conflicts, the ExCo has suggested to TC and NC Chairs to coordinate their meetings with Aleksandar Sedmak.

Our blogger, Per Ståhle, has reviewed many papers from Engineering Fracture Mechanics. We have an agreement with Elsevier which allows open access of these papers for six months. Hence, everyone can have access to them and join in the discussion on the blog. We welcome your comments which may be posted on the blog: http://imechanica.org/node/9794

The issues of Procedia Structural Integrity that have been published in 2018 include:

- Volume 8, Pages 1-628 (2018) AIAS2017 – 46th Conference on Stress Analysis and Mechanical Engineering Design, 6-9 September 2017, Pisa, Italy https://www.sciencedirect.com/journal/procedia-structural-integrity/vol/8/suppl/C

- Volume 9, Pages 1-328 (2018) IGF Workshop "Fracture and Structural Integrity" https://www.sciencedirect.com/journal/procedia-structural-integrity/vol/9/suppl/C

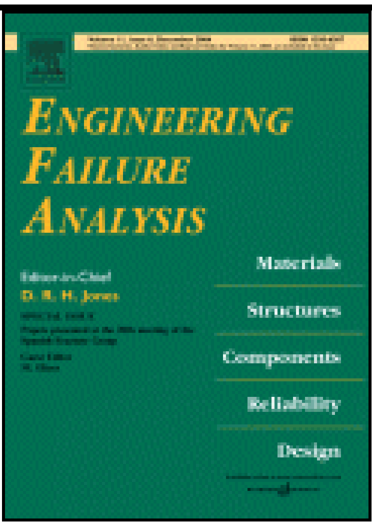
Four more issues are expected by the end of 2018. These are open access publications. The link to the journal is: https://www.journals.elsevier.com/procedia-structural-integrity. In order to encourage TCs and NCs to take advantage of this option, ESIS will support part of the publication costs. I would like to encourage you to join ESIS for 30€. Go to our web site www.structuralintegrity.eu and sign up. There are various ways to join ESIS. Join a National Committee. Have your university join for a group of faculty members through a National Committee or directly to ESIS; similarly for a group at a company. Or join as an individual. This can be done easily through PayPal. In 2016, ESIS had 473 members from 22 countries.

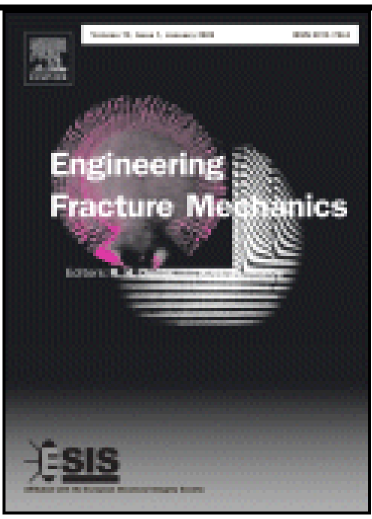
Finally, I would like to thank all of the TC Chairs and NC Chairs for all of their hard work for ESIS. I would also like to thank the ExCo for being such an excellent, positive and supportive group. They have all made my job easy. ESIS is the benefactor of everyone's effort.

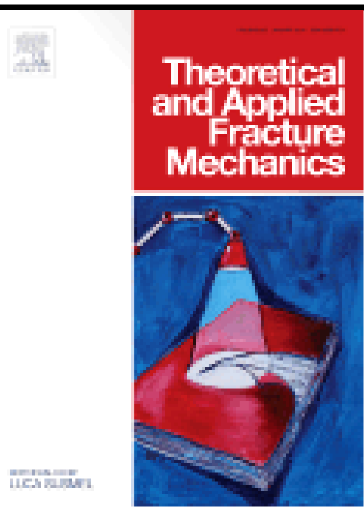
I wish you all the best of health, fruitful research and future collaborations.

Leslie Banks-Sills

4 Elsevier journals are affiliated with ESIS







Special Issues 2017-18

Journal	Title	Source	Editor	Status
Eng Fract Mech	Multiaxial Fracture 2016	11th International Conference on Multiaxial Fatigue and Fracture (ICMFF11)	M.Endo, C.Navarro, M.Vormwald, A. Carpinteri	EFM 174, April 2017
Int J Fatigue	Multiaxial fatigue 2016: Experiments and modeling	11th International Conference on Multiaxial Fatigue and Fracture (ICMFF11)	A.Carpinteri, A.Fatemi, Th.Palin-Luc, S.Vantadori	IJF 100, part 2, July 2017
Int J Fatigue	Special Issue on the 21st European Conference on Fracture	ECF21	F. Iacoviello, D. Firrao, Th.Palin-Luc, M.Zimmermann	IJF 102, September 2017
Theor and Appl Fract Mech	Mixed Mode Fracture: Recent Developments	ECF21	F. Berto, M. Ayatollahi, L. Marsavina	TAFM 91, October 2017
Int J Fatigue	Special Issue on the 21st European Conference on Fracture	ECF21	F. Iacoviello, D. Firrao, Th.Palin-Luc, M.Zimmermann	IJF 103, October 2017
Eng Fract Mech	Modern Imaging Techniques in Fracture and Damage Analyses	ECF21	A. Spagnoli, Y. Hong, G. Risitano, L. Susmel, Ph.Withers, V. Di Cocco	EFM 183, October 2017
Int J Fatigue	Special Issue on the 21st European Conference on Fracture	ECF21	F. Iacoviello, D. Firrao, Th.Palin-Luc, M.Zimmermann	IJF 104, November 2017
Int J Fatigue	Special Issue on the 21st European Conference on Fracture	ECF21	F. Iacoviello, D. Firrao, Th.Palin-Luc, M.Zimmermann	IJF 105, December 2017
Eng Failure Anal	21st European Conference on Fracture	ECF21	L.Susmel, A.Carpinteri, D.G.Hattingh, Z.Bozic, D. Angelova	EFA 82, December 2017
Theor and Appl Fract Mech	21st European Conference on Fracture in Catania (Italy) in 2016	ECF21	F. Iacoviello, G. Ferro, C. Ruggeri, V. Shlyannikov	TAFM 92, December 2017
Int J Fatigue	Special section on International Conference on Structural Integrity and Durability 2017, Fatigue of Materials and Structures at all Scales	ICSID 2017	Ž. Božic, L. Banks-Sills, M. Vormwald, D.M. Frangopol	IJF 112-113, July, August 2018
Int J Fatigue	Special Section on International Conference on Structural Integrity 2017	ICSI2017	P. Moreira, P. Tavares	IJF 113, August 2018

National Committees

Greece

The Greek Society of Experimental Mechanics of Materials (GSEMM) organized the "***1st International Conference of the Greek Society of Experimental Mechanics of Materials***" from May 10 to May 12, 2018, under the aegis of ESIS (http://www.gsemm.gr/en/).

More than 100 articles were submitted for consideration, out of which 78 were accepted by the scientific committee for presentation on the basis of their scientific soundness and the relevance of their content to Experimental Mechanics of Materials.

Three plenary lectures were delivered during the conference by:

- Professor **Leslie Banks-Sills**:

President of European Structural Integrity Society-ESIS, Tel Aviv University, Israel: "Woven Multi-Directional Composite: Mode I Fatigue Delamination Propagation",

- Professor **Francesco Iacoviello**:

President of Gruppo Italiano Frattura, Università di Cassino e del Lazio Meridionale, Italy: "Fatigue Crack Propagation in Ductile Cast Irons" and

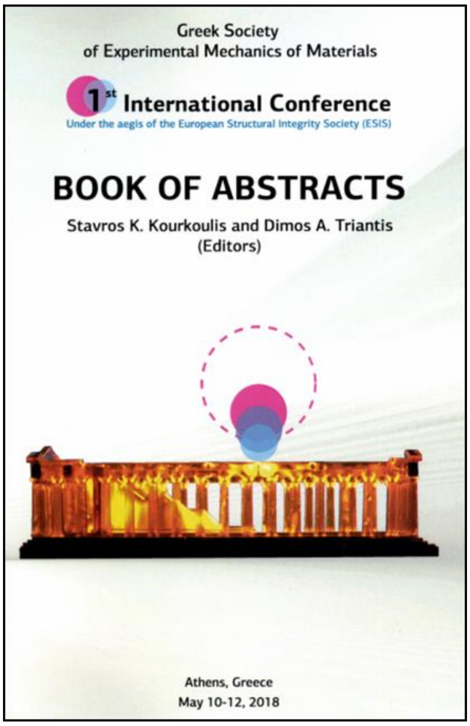
- Professor **Giovanni Barla**:

Editor-in-Chief of Rock Mechanics and Rock Engineering, Politecnico di Torino, Italy: "Advanced Laboratory Testing of Weak Rocks with Attention Paid to the Time Dependent Behaviour and Constitutive Modelling, with an Eye on Engineering Applications".

The president of GSEMM Professor Stavros K. Kourkoulis offers to the president of ESIS Professor Leslie Banks-Sills a copy of an ancient Greek sculpture after her plenary Lecture that opened the Conference

The treasurer of GSEMM Professor D. Triantis offers the "Young Scientist Award" to Mechanical Engineer Dr George Seretis, during the closing ceremony of the Conference

The extended two-pages abstracts of all the papers presented in the conference were published in a special volume according to the order of presentation in the Conference's program. The PDF format of the book is downloadable from the site of the conference (http://www.gsemm.gr/conference/). The full texts, after the review process, will appear in a special issue of "Procedia Structural Integrity". Thematically selected papers will be proposed, after the Conference, for publication in a special issue of "Fracture and Structural Integrity".



The cover page of the bounded volume with the extended abstracts of the papers presented during the 1st conference organized by GSEMM

During the conference the first General Assembly of the society took place and the first Board of Directors was elected. According to the results of the elections the board is formed as follows:

- Professor **Stavros K. Kourkoulis**, National Technical University of Athens, President,
- Professor **Dimitrios Karalekas**, University of Piraeus, Vice President,
- Dr **Ermioni D. Pasiou**, Acropolis Restoration Service, Ministry of Culture and Sports, Secretary General,
- Professor **Dimos Triantis**, University of West Attica, Treasurer,
- Assistant Professor **Nikos Alexopoulos**, University of the Aegean, Member,
- Professor **Dimitrios Manolakos**, National Technical University of Athens, Member,
- Professor **Ilias Stavrakas**, University of West Attica, Member.

For next year, the Society is working towards the organization of a summer school devoted to the education of young scientists in the application of two novel experimental techniques, i.e., that of "Acoustic Emissions" and that of "Pressure Stimulated Currents".

The next conference of the Society is planned for spring 2020.

Stavros K. Kourkoulis

Poland

The members of the Polish Group of Fracture Mechanics were the organizers of two conferences in the first half of 2018. On 22-25th May the XXVII Symposia of Fatigue and Fracture Mechanics was held in Bydgoszcz under the auspices of the Committee of Machine Construction of the Polish Academy of Sciences (PAN). The initiator of these biennial conferences devoted to fatigue strength and fracture of materials and structures was, many years ago, Prof. Stanisław Kocańda, the member of the PAN. Usually, the conferences gather research from the academic and research centres in Poland. This scientific event was once again entrusted to the University of Science and Technology in Bydgoszcz. The chairman of the Organizing Committee was Prof. Janusz Sempruch and the Scientific Committee was led by Prof. Józef Szala. At the XXVII symposia 55 people participated, who presented 36 plenary lectures and 11 posters. In the session devoted to fatigue problems the issues of new materials testing and structural components, as well as riveted and welded joints were undertaken. In the session of fracture mechanics modelling of materials stress state and models of material fracture were discussed. The special guest of the XXVII Symposia was Prof. Ali Fatemi from the University of Memphis, USA. He gave a lecture on "Multiaxial Fatigue of Additive Manufactured Metals". The problems of fatigue crack development under multi-axial loads, as well as the fatigue of materials produced by using additive technologies, especially by means of selective laser sintering were discussed.

Presented papers after review will be issued by AIP Conference Proceedings.

During the Symposia, new testing methods and new stands were presented. This scientific meeting was marked by the presence of industry representatives who reported their research in the oral session and in an open session of Construction Section. Especially, the presence of representatives of the PESA S.A. factory, the largest Polish manufacturer of nearly all types of railway vehicles was marked. The participants of the Symposia had the opportunity to familiarize themselves with the electric train production process during the visit to the PESA S.A. factory.

The second scientific event in 2018 was the 14th International Conference of Mechatronic Systems and Materials (MSM 2018) on 4th – 6th June 2018 in Zakopane – the capital of the Tatra mountain held by the Department of Mechanics and Fundamentals of Machine Design of Opole University of Technology in Poland under the auspicious of the Polish Society of Theoretical and Applied Mechanics as well as the Committee of Machine Construction of the Polish Academy of Sciences (PAN). The honorary patronages held the Rector of Opole University of Technology Professor Marek Tukiendorf and Professor Janusz Kowal, the chairman of the Committee of Machine Construction of the PAN. The MSM conferences are annual scientific events organized alternately in cooperation with four academic centers: Białystok Technical University and Opole Technical University from Poland as well as Kaunas University of Technology and Vilnius Gediminas Technical University from Lithuania. The MSM 2018 conference was for the fourth time organized by the Opole University of Technology. The main conference organizer was supported by the companies: the Science and Technology Park, EthosEnergy, Explomet, Ferrpol Matuszewscy Brothers, Schaltbau Rawag, Lenso and Nanores. The representatives of the mentioned above companies gave lectures and conducted the workshop (Lenso), as well.

The chairman of the conference, as well as the leader of the scientific committee was Professor Tadeusz Łagoda.

The subject of the conference included four main blocks: mechatronic systems, trends in the development of working machines, materials and the development of education in the field of mechatronics, as well.

I. In the scope of mechatronic systems the following problems were considered :

• Robotics: industrial robots, micro robots, mobile robots,

• Teleoperations, teleoperations of semiautonomous systems,

• Sensors and actuators in mechatronics,

• Control in mechatronic systems,

• Vibration and deformation analysis,

• Optimization and optimal design,

• Integrated diagnostics,

• Tribology in mechatronic systems,

• Analysis and signal processing,

• Measurement techniques,

• Analysis and prevention of damage in systems.

II. Trends in the design of working machines.

III. The scope of materials (properties, modeling, production) included:

• Methods and techniques for testing materials

• Intelligent and multifunctional materials

• Biomaterials

• Functional composites

• Piezoelectric materials

• Nanomaterials.

IV. In the scope of mechatronics in education there were the questions:

• New trends in mechatronics and characterization of materials and their impact on teaching

• Teaching materials and laboratory stands.

The conference was attended by 131 people, including 19 participants from abroad, namely: Czech Republic, Slovakia, Russia, Lithuania, Latvia, Estonia, Romania, Turkey, Germany and Israel.

36 papers were delivered as part of plenary sessions, as well as thematic sessions. 67 posters were presented at the poster sessions. The selected works, after positive reviews delivered by the members of the Conference Scientific Committee, will be published in open access in the AIP Conference Proceedings indexed, among others, in the Web of Science database.

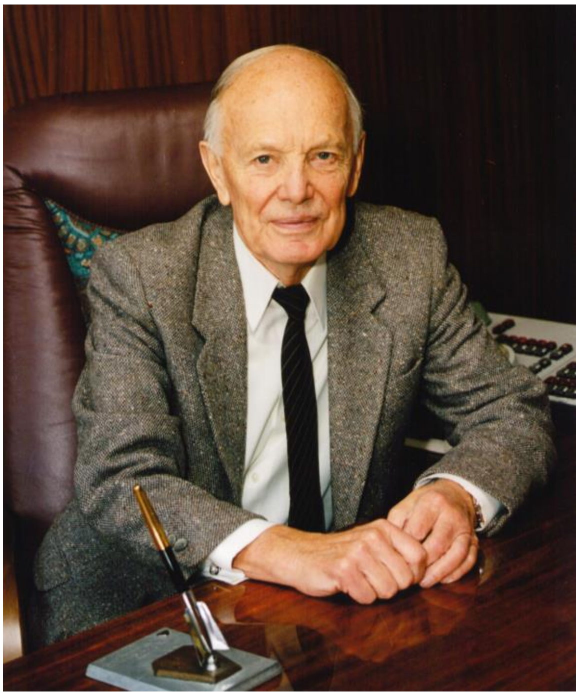
The most interesting presentations of young scientists, who very much joined the ranks of the speakers were awarded with diplomas and prizes funded by the Organizers.

Dorota Kocańda

Ukraine

Cooperation of the Academy of Sciences of Ukraine with ESIS (to the 100th anniversary of the Academy foundation)

The Academy of Sciences of Ukraine celebrates this year a centenary of the Academy foundation. During this period the Academy was headed by: V. Vernadskyi (1918–1921), M.Vasylenko (1921–1922), O. Levytskyi (1922), V. Lipskyi (1922–1928), D. Zabolotnyi (1928–1929), O. Bohomolets (1930–1946) and O.Palladin (1946–1962). Since 1962 B. Paton is the President of the Academy. During different times the Ukrainian Academy of Sciences was named differently. Since 1994 it has been named "the National Academy of Sciences of Ukraine" (NASU).



NASU President B. Paton

This anniversary is an important date in the development of science in Ukraine. Over the past years, scientists of NASU have achieved significant results in the field of fundamental and applied research, including the problems ensuring the integrity of structures.

The institutes are the main structural branches of NASU. Karpenko Physico-Mechanical Institute (Karpenko Institute) located in Lviv is the most powerful in Western Ukraine and is the basic organization of the Ukrainian Society on Fracture Mechanics headed by Prof. V. Panasyuk. This Society is the base for the Ukrainian National Group of ESIS. It should be noted that the Lviv scientific school of mechanics originates from the works of Prof. M.-T. Huber, the worldwide scientist in the field of elastic-plastic bodies strength. In the post-war time Lviv School of mechanics was headed by Prof. H. Savin, the known scientist on problems of stress concentration in structural elements with holes and notches.

Later the crack theory became the basis for the further development of Lviv School of mechanics. The problems of working environments (surface active, corrosive and hydrogenated) influence on deformed metal (formulated in Karpenko Institute by Prof. G. Karpenko and other scientists) were developed in studies of crack propagation phenomenon under the influence of aggressive environmets. Scientific results were published mainly in the Journal "Physico-Chemical Mechanics of Materials" and since 1965 are available in English in "Soviet Materials Science" and "Materials Science" journals.

Possibilities of scientific contacts and cooperation of Ukrainian scientists with world scientific societies were broadened with the disintegration of the Soviet Union. Scientists of Ukraine in the field of structural integrity also used it. The 8th International Conference on Fracture (ICF8) was held in Kyiv in 1993. The conference organizers from Ukraine were Karpenko Institute and Paton Electric Welding Institute. Such a high level conference was held for the first time in the countries of Eastern Europe and became a recognition of the authority of Ukrainian scientists, NASU and, namely, Karpenko Institute as the scientific center in this field of problems.

In 1992 Ukraine became an ESIS member and about 25 researchers are ESIS members from Ukraine. The National Group cooperates with ESIS, its members regularly take part in the organization of separate symposia within the framework of the ECF.

Collaboration is realised, mainly, through two Technical Committees: TC10 "Environmentally Assisted Cracking" (co-chairmans until 2010 Dr. W. Dietzel and Dr.G. Gabetta, later Prof. J. Toribio) and TC13 "Education and Training" (co-chairmans until 2012 Prof. H. P. Rossmanith and Prof. L. Toth, since 2015 Prof. P. Yasniy and Prof. L. Marshavina). Activity of these TC was repeatedly noted by ESIS: Dr. W. Dietzel was given the Award of Merit (2014) for his outstanding contributions to stress corrosion cracking, and his service to ESIS by establishing TC10 on Environmentally Assisted Cracking; Prof. J. Toribio was elected the ESIS fellowship (2014) for his outstanding contributions to the art, science, teaching or practice of fracture mechanics and his service to the Society; Prof. L. Töth was given the Award of Merit (2016) for his important and longstanding contributions in the development and application of fracture mechanics methods to the study of microstructural testing methods, material selection, testing and technology and engineering design methods, as well as his service to ESIS.

Porto Marghera (Venice), 2004, chairpersons of TC10 during the TC10 Workshop. From left to right: H. Nykyforchyn, G. Gabetta and W. Dietzel

In 1995 within the framewok of TC10 a Sub-committee on "Hydrogen Degradation" was formed (Head Prof. O. Andreykiv, since 2002 Prof. H. Nykyforchyn, both from Karpenko Institute) focusing its work on

- investigations on materials degradation under long term loading affected by temperature changes and by hydrogen/hydrogen sulphide containing media (gas and petroleum refining plants, offshore structures etc.);
- investigations on hydrogen degradation in metal welded joints under long term loading;
- methods for diagnosing hydrogen degradation in structural elements and for degradation prevention.

The Ukrainian National Group together with TC10 in 1999 organized the TC10 Workshop in Truskavets near Lviv. It enabled researchers from Ukraine to acquaint nearer with the ESIS activity, and first of all, with the problems of material fracture under simultaneous action of mechanical loadings and aggressive environments. Repeatedly the special issues of the Journal "Physico-Chemical Mechanics of Materials" were devoted to the lectures delivered during the TC10 Meetings.

Wroclaw, 2002, meeting on the Summer Schools activity. From left to right: W. Kasprzak, K. Miller, V. Panasyuk, L. Töth

The Ukrainian Society on Fracture Mechanics together with Karpenko Institute and Wrocław University of Technology (Prof. W. Kasprzak) back in 1995 organized Polish-Ukrainian Summer Schools on Fracture Mechanics for young researches and engineers which were joint by German specialists (Prof. S. Sáhn, Dresden University of Technology). The Schools were held in Poland, Ukraine and Germany. In 2002 during ECF14 (Cracow, Poland) the organizers of these Schools raised the question about the new status of Summer Schools as ESIS Schools in Eastern and Central Europe. ESIS President K. Miller supported this idea, his suggestion was approved during the ESIS Council Meeting but its realization was not succeeded at that time. And only with the renewal of TC13 activity in 2015 due to the initiative of Ukrainian National Group these Schools were reorganized as ESIS Schools and the 14th Polish-Ukrainian-German School on Fracture Mechanics (Ternopil, Ukraine, 2015) became at the same time the 2th ESIS School on Fracture Mechanics (the first one was held in together with ECF20 in Trondheim, Norway). The tradition to hold such Schools together with ECF was initiated here. Correspondingly the 3rd School was held in Catania (Italy) together with ECF21. At the same time TC13 assists to carry out the separate Summer Schools between European Conferences on Fracture. So, the 4th School was held in 2017 in Dubrovnik (Croatia) on the base of Zagreb University (Prof. Zeljko Bozic).

Signing of the Agreement between NASU (NASU President B. Paton) and ESIS (ESIS President E. Gdoutos) in 2009 became very important for the partnership of Ukrainian National Group with ESIS. This agreement foresees some scientific and organizational events for the coming years, the main of which was the organization of two Greek-Ukrainian Symposia on Fracture Mechanics. Such symposia were held in Greece (Xanthi, 2010) and in Ukraine (Lviv, 2011).

Signing of the Agreement on cooperation between NASU and ESIS, Kyiv, 2009. From left to right: B. Paton, V. Panasyuk, I. Dmytrakh, E. Gdoutos

The activity of Ukrainian National Group feels regular support of ESIS. It concerns, in the first place, the financial support of young research workers from Ukraine for their participation in ECF. The financial support of the 2nd ESIS School which was held in Ukraine also should be noted. It should be mentioned here also, that the Head of Ukrainian National Group V Panasyuk was awarded Griffith Medal of ESIS (2000), and the Head of TC10 Subcommittee H. Nykyforchyn was elected the ESIS Fellow (2012).

Volodymyr Panasyuk
Hryhoriy Nykyforchyn

TECHNICAL COMMITTEES

TC3: Fatigue of Engineering Materials And Structures

Statutes and activities of ESIS Technical Committee No.3 (TC3) - June 2018

1. Name
TC3 : FATIGUE of ENGINEERING MATERIALS and STRUCTURES
Chairmen: Andrea Carpinteri and Les P. Pook
Secretaries: Andrea Spagnoli and Sabrina Vantadori

2. Objectives of TC3
(a) **Special Issue** of '**International Journal of Fatigue'** entitled **'Fatigue in the presence of cracks or notches'** (Guest Editors: Professor Andrea Carpinteri, Parma, Italy, Professor Pedro Moreira, Porto, Portugal, Professor Paulo

Tavares, Porto, Portugal, and Professor Sabrina Vantadori, Parma, Italy), with papers selected from those presented at the International Conference on Structural Integrity 2017 (ICSI 2017), held in Funchal, Madeira, Portugal, 4 - 7 September, 2017.

(b) **Special Issue** of **the Journal 'Frattura ed Integrità Strutturale'** focussed on **'Structural Integrity'** (Guest Editors: Vittorio Di Cocco, Carmine Maletta, Giacomo Risitano, Andrea Spagnoli). Expected publication date: October 2018.

(c) **TC1/TC3 Mini Symposium on 'Defects and Fatigue'** at the European Conference on Fracture 2018 (ECF 22)
26 - 31 August, 2018, Belgrade, Serbia, http://www.ecf22.rs/

(d) **6th International Conference on 'Crack Paths' (CP 2018),** to be held in Verona, Italy, 19th to 21th September, 2018. Chairpersons: Professor Filippo Berto (Trondheim, Norway), Professor Andrea Carpinteri (Parma, Italy), Professor Youshi Hong (Beijing, China), Professor Les P. Pook (Sevenoaks, UK), and Professor Sabrina Vantadori (Parma, Italy).

(e) **12th International Conference on Multiaxial Fatigue and Fracture (ICMFF12),** to be held in Bordeaux, France, 24th to 26th June, 2019. Chairpersons: Professor Andrea Carpinteri (Parma, Italy), Professor Franck Morel (Angers, France), and Professor Thierry Palin-Luc (Talence, France).

3. Achievement of objectives

(a) **Special Issue** of **Engineering Fracture Mechanics (Vol.183, 1-190, 2017)** entitled **"Modern Imaging Techniques in Fracture and Damage Analyses"** (Guest Editors: Andrea Spagnoli, Youshi Hong, Giacomo Risitano, Luca Susmel, Philip Withers and Vittorio Di Cocco), with papers selected from those presented at the 21st European Conference on Fracture (ECF21), held in Catania, Italy, 20th to 24th June, 2016.

(b) **Special Issue** of **Engineering Failure Analysis (Vol.83, 1-239, 2018)** entitled **"21st European Conference on Fracture"** (Guest Editors: Luca Susmel, Andrea Carpinteri, Danie G. Hatting, Donka Angelova, Zeljco Bozic), with papers selected from those presented at the 21st European Conference on Fracture (ECF21), held in Catania, Italy, 20th to 24th June, 2016

Andrea Carpinteri
Les P. Pook

TC4: Polymers, Polymer Composites and Adhesives

The technical committee (TC4) - Fracture of Polymers and Composites, has continued to meet twice a year during. In 2017, the long-standing co-chairs Professors Gordon Williams and Andrea Pavan retired from the committee and new co-chairs were elected- Drs Andreas J Brunner of Empa and Bamber Blackman of Imperial College London.

The new committee co-chairs, Bamber Blackman and Andreas J Brunner

The technical meeting in September 2017 was preceded by the 8th International conference of the Fracture of Polymers, Composites and Adhesives in Les Diablerets, Switzerland. The single session conference over three days was organised the TC4 technical committee and the conference sessions reflected the current activities of the committee. A special issue of Engineeering Fracture Mechanics will be published with selected papers from the conference.

The alpine horns

A technical meeting was also held in Les Diablerets in May 2018. The next meeting will take place at Empa, in Duebendorf, Switzerland between 26-28th September 2018. Looking towards 2019 and beyond, it is planned that the spring meeting each year will move to different locations, hosted by committee members, and the autumn meeting will be held in Les Diablerets.

Special ESIS cake (made by the Eurotel in Les Diablerets)

Current work areas of the committee:

- Notching of polymers for FM testing.
- Jc testing of polymers.
- Environmental stress cracking of polymers.
- Peel testing.
- Structural adhesives testing.
- Laminate peel testing.
- Delamination of composites under: mixed-mode loading, fatigue loading, high rate loading.

All TC meetings will be advertised on the ESIS website and are open to all to attend. Please contact the local organiser or TC4 secretary (Laurent Warnet, l.warnet@utwente.nl) for more details.

Bamber Blackman

TC8: Numerical Methods

The ESIS Technical Committee on Numerical Methods (TC8) has resumed its activities after a long pause. The first meeting was held in Paris at Mines ParisTech in January 2018.

The next meeting will be organized in January 2019 (location and dates to be defined).

TC8 is organizing a special issue for Engineering Fracture Mechanics on "Continuum damage models for ductile fracture". Papers should include a test database, a model for ductile facture and simulations of failure possibly including application to a large structure. The deadline for submission is April 2019. The next meeting will be a good opportunity to discuss papers prepared for the special issue. A round table will be organized to determine future topics for special issues.

Jacques BESSON

TC12: Risk analysis and safety of large structures and components

The next activity will be the symposium entitled "**Risk analysis and Safety of Technical Systems**" organised by Technical Committee 12 "Risk analysis and Safety of Large Structures and Components (RAS TC 12)" of the European Structural Integrity Society within the framework of the 22nd European Conference on Fracture - ECF22 to be held in Belgrade, Serbia, 26-31 August 2018 (see http://www.ecf22.rs/).

This Symposium is intended to be a forum of discussion of the recent advances in maintenance, safety, risk analysis, management and life-cycle performance of a wide range of infrastructures, such as, engineering technical systems, bridges, buildings, dams, railways, underground constructions, wind and transmission towers, offshore platforms, pipelines, naval vessels, ocean structures, nuclear power plants, airplanes and other types of structures including aerospace and automotive structures. Contributions are expected from engineers, metallurgists, material scientists, among others, allowing a very multidisciplinary discussion.

All contributions in the form of extended abstracts will be peer reviewed by the members of ESIS TC12 Technical Committee. A selection of papers presented at this Symposium will be published in a Special Issue of affiliated ESIS journals.

The ESIS technical committee "TC12 - Risk Analysis and Safety of Large Structures and Components" supports the Minisymposium. The annual meeting of TC12 will be performed during the conference event.

In addition to the symposium to be held at Serbia, TC12 is organizing an annual event related to the subject of the technical committee, as well as the creation of an award called the "Robert Moskovic Award".

Doctor **José António Correia** and Prof. **Abílio De Jesus** will be distinguished by the Faculty of Mechanical Engineering and the Faculty of Technology and Natural Sciences of the Wrocław University of Science of Technology (Poland) for their scientific contributions in the areas of fatigue, fracture and structural integrity, particularly in *Fatigue Assessment and Modeling of Metallic Materials and Connections from the Old Riveted Steel Bridges* and *Generalization of Probabilistic Fatigue Models for Several Local Damage Parameters*, respectively, in July 2018.

VI National Conference on Safety and Monitoring of Technological and Environmental Systems organized by the Institute of Computational Technologies of the Siberian Branch of the Russian Academy of Sciences will be held in Krasnoyarsk, Russia on 18th - 21th September, 2018.

The conference is intended to provide a forum for the dissemination of recent research on the following topics:

- Structural Integrity and Safety of Technical Systems;
- Monitoring, Risk Analysis and Safety of Social, Environmental, and Technological Systems.

The conference will also incorporate The Summer School for young researchers and engineers "Fracture Mechanics and Safety of Technical Systems".

Contact information:

53, Mira Street

660049, Krasnoyarsk, Russia

Institute of Computational Technologies of SB RAS, Krasnoyarsk Branch Office

tel: 8 (391) 227-49-86

e-mail: sstsconf@gmail.com

http://conf.ict.nsc.ru/ru/page/SSTS-2018

José Correia, Vladimir Moskvichev and Aleksandar Sedmak

TC14: Integrity of Biomedical and Biological Materials

1) The **next meeting of ESIS Technical Committee 14** "Integrity of Biomedical and Biological Materials" will be held during the 22nd European Conference on Fracture ECF 22 in Belgrade, Serbia, 26-31 August 2018. The committee will also organise its first Symposium "Damage and Fracture of Biological and Biomedical Materials" within the framework of ECF22.

2) A Special Issue of **Engineering Fracture Mechanics** "Damage and Fracture of Biological and Biomedical Materials" with Guest Editors Prof. Vadim V. Silberschmidt (Loughborough University, UK) and Prof. Jose Manuel Garcia Aznar (University of Zaragoza, Spain) is in preparation, with the submission date for manuscripts of 31 October 2018. It will consist of papers by the world-leading researchers in this area, including selected papers presented at ECF 22 in Belgrade (see above).

3) TC 14 will organise the **International Conference on Stents: Materials, Mechanics and Manufacturing** to be held on 15-17 July 2019 in London, UK.

The aim of this Conference is to bring together specialists in biomedical engineering, biomechanics, materials science, experimental mechanics, modelling and various aspects of processing and manufacturing as well as medical practitioners to discuss advances in stent technologies.

The topics of the Conference include, but are not limited to, the following:

- Metallic and polymeric materials for stents;
- Mechanical properties of stents;
- Development of biodegradable stents;
- Modelling and simulations of stent deformation;
- Stent design;
- Stent manufacturing;
- Stent failure and fracture;
- In-vitro and in-vivo studies;
- Biocompatibility of stents;
- Stent-vessel interaction;
- Fluid-solid interaction;
- In-stent restenosis;
- Biological and clinical issues related to stents;
- Stent deployment and delivery;
- Medical-imaging-based assessment.

Special Session **"Design, Manufacturing and Evaluation of Shape-MemoryAlloy Stents"** will be organised within the framework of this conference.

More information is available at http://moamrg.co.uk/ICS3M2019.

Vadim V. Silberschmidt

CALENDAR OF TC MEETINGS & ACTIVITIES

TC4	September 26-28 2018	Regular Semi-Annual meeting	Dübendorf, Switzerland	andreas.brunner@empa.ch
TC14	July 15-17, 2019	TC14 Meeting International Conference on Stents: Materials, Mechanics and Manufacturing	London, UK	http://moamrg.co.uk/ICS3M2019
TC15	September 4-6, 2019	First European Conference Structural Integrity of Additively Manufactured Materials	Trondheim (Norway)	https://www.esiam.eu/

CALENDAR OF CONFERENCES & WORKSHOPS

August 26-31, 2018	22nd European Conference of Fracture (**ECF22**)	Belgrade, Serbia	http://www.ecf22.rs/
August 24-26, 2018	Summer School in the scope of ECF22.	Belgrade, Serbia	ecf22conference@gmail.com
May 15-17, 2019	19th International ASTM/ESIS Symposium on Fatigue and Fracture Mechanics (42nd National Symposium on Fatigue and Fracture Mechanics)	Denver, CO	http://www.astm.org/ASTM-ESISCFP2019.

22nd European Conference on Fracture
ECF 22
LOADING AND ENVIRONMENT EFFECTS ON STRUCTURAL INTEGRITY
26 – 31 August 2018
SUMMER SCHOOL 25-26 August 2018,
Belgrade, Serbia, www.ecf22.rs

Deadline to submit papers EXTENDED to 31 July.

Over 625 abstracts have been accepted for ECF22, promising another successful ESIS event. All important topics of Fracture Mechanics and Structural Integrity are covered, including a number of mini-symposia, with many inspiring titles. Registration is still going on, and we would like to remind participants to do it as soon as possible, so that we can plan the conference in optimum way. **Another important issue is uploading of papers, with deadline 31 July.** We will accept late papers as well, since the Proceedings will be published electronically, but can't guarantee publishing in Procedia Structural Integrity for papers sent later than 31st July. In any case, follow strictly the instructions for paper submission.

Registration and fees

Registration fee *	Before 20.8.2018	After 26.8.2018
Regular	580 €	630 €
ESIS member	500 €	550 €
Students	150 €	200 €
Accompanying persons	150 €	200 €

* on-site cash payment will be possible

The registration fee includes conference material, welcome reception, conference banquet, refreshments and lunch during conference days. Payment is possible by bank transfer, credit cards, pay-pal and on-site in cash, see www.ecf22.rs.

The Summer School has attracted a lot of attention, so far there are 35 registered participants. Since we can handle up to 50 people in the laboratory (Saturday 25.8 afternoon), we will have to follow the order of registration if there will be more than 50 applicants. So, please hurry up with registration. The following topics will be covered:

Experimental Fracture Mechanics - John Landes, Francesco Iacoviello
Interface Fracture Mechanics - Leslie Banks-Sills, Bamber Blackman
J-integral - on the occasion of the 50th anniversary - James Rice, USA
Fee, 150 €, includes lectures, refreshments and buffet lunch.

Imporant dates

Submission of Papers:	**31.7.2018**
Deadline for Registration:	**20.8.2018**
On-site Registration	**from 25.8.2018**

Plenary lecturers are carefully chosen to cover the most attractive topics nowadays. The introductory lecture by Prof. James Rice will focus on dynamic fracture related to earthquakes, a topic which affects us all, so its importance cannot be overestimated:
James Rice, USA, Perspectives on dynamic fracture arising from the study of earthquake ruptures
Jovo Jarić, Serbia, Conservation laws of J-integral type
Youshi Hong, China, The State of the Art in Very-High-Cycle Fatigue Research
Uwe Zerbst, Germany, Application of fracture mechanics to S-N curve prediction. Requirements and perspectives
Dražan Kozak, Croatia & **Nenad Gubeljak**, Slovenia, Fracture behavior of wrought and additive manufactured implant's alloy
William Curtin, Switzerland, Mechanisms of Hydrogen Embrittlement: Insights from Atomistic Studies
Meinhard Kuna, Germany, Micromechanical Modeling of Fracture in Metallic Materials
Yonggang Huang, USA, Soft Network Composite Materials with Deterministic and Bio-Inspired Designs
Robert Ritchie, USA, Damage Tolerance in Biological and Metallic Material
Takayuki Kitamura, Japan, Challenge toward Nanometer Scale Fracture Mechanics

Proceedings and Publication
Abstracts will be published in the form of ECF22 e-book and available during the registration. Full papers will be published in Proceedia Structural Integrity journal by Elsevier in the form of ECF22 Proceedings. Authors of selected papers will be invited to submit extended versions of papers for a special issue of "Engineering Fracture Mechanics", "Engineering Failure Analysis", "International Journal of Fatigue" or "Theoretical and Applied Fracture Mechanics", as well as Structural Integrity and Life (DIVK Journal) journals.
Minisymposia will also take place with the following topics and people in charge:
Siegfried Schmauder & Željko Božić, Multiscale Damage Analysis of Fatigue and Fracture of Metals
Vadim Silberschmidt , Damage and Fracture of Biological and Biomedical Materials
Filippo Berto & Luca Susmel, Structural integrity of Additive Manufactured materials
Petro Yasniy & Liviu Marsavina, Teaching of Structural Integrity
Jacques Besson, Numerical Methods in Fracture Mechanics
Uwe Zerbst, Stefano Beretta & Andrea Carpinteri, Defects and fatigue
Yuri Petrov & Vadim Silberschmid, Fracture and Structural Transformations under High Rate and Impact Loading
Peter Trampus, Non-destructive methods in Fracture Mechanics
Jose Antonio Correia & Vladimir Moskvichev, Risk Analysis and Safety of Technical Systems
Milos Đukic, William Curtin & Zhiliang Zhang, Recent Advances on Hydrogen Embrittlement Understanding and Future Research Framework
Giacomo Risitano, Energy Methods for Fatigue Assessment
Rostand Moutou Pitti & Octavian Pop, Damage and fracture mechanics in wood material

We will do our best to present Belgrade and Serbia in a way that you will not forget the last week in August 2018 and that you will wish to come back. Many events are scheduled during the conference:
Welcome reception on Sunday
Culture dinner on Monday
Sightseeing tours by boat on Tuesday and by bus on Wednesday,
Conference dinner on Thursday.
In addition, there will be a number of excursions around Belgrade and out of town, every day from Monday until Friday, covering the most important historical and cultural sites in Serbia:
Vinča archeological site - 5500 BC,
Viminacium, once the capital of the Roman province Mesia Superior,
Lepenski Vir archeological site - 7500 BC,
Fruska Gora monasteries and Novi Sad – European cultural capitol in 2021,
beautiful old cities Petrovaradin and Sremski Karlovci,
medieval monasteries in central Serbia, including Manasija, Resava, Zica.
Post conference tours (one or two day, 1st and/or 2nd September) will also be offered.

We would also want to remind you to reserve hotel booking and travel arrangement. We have reserved a number of rooms in 6 hotels, nearby the venue, including **Metropol Palace, the venue**, with reduced prices for ECF22.
Please keep in mind that rooms will be booked in order of request, so visit the ECF22 web-site (http://www.ecf22.rs/accommodation.html) and act as soon as possible. Anyhow, in close proximity of the venue, there are many other options, including private flats (the best of it one can find on www.booking.com). As for travel arrangements, **Belgrade airport** is the best option, since it is directly connected with major European cities, and also with major cities in near east Asia, New York and Beijing. For connecting flights, there are excellent options via many European cities, just to mention those with two flights per day - Zurich, Munich, Frankfurt, Paris, London, Prague, Rome. Also check low cost companies (although fares for Belgrade are typically low, anyhow).

For more details visit www.ecf22.rs or send an email to ecf22conference@gmail.com

ESIS Website

www.structuralintegrity.eu

- **become a member of ESIS and take advantage of all the "Members Only" resources on this Web site**
- **register automatically as a Member and pay the fee by PayPal system**
- **obtain your username and password for accessing the private area for downloading EGF-ESIS books and Procedures**
- **exchange new ideas, advancements and documents**

Advantages of being an ESIS member

- participation in TC activities and access to TC documents;
- full on-line access to ESIS procedures;
- full on-line access to former EGF-ESIS books;
- support for ESIS activity.

how to renew?
see page 29 or
www.structuralintegrity.eu

FRACTURE MECHANISMS *vs.* MECHANICAL FIELD PARAMETERS

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Abstract

Experimental and numerical analyses of fracture mechanisms are presented. Tests were performed on five different geometries designed to provide a variety of stress triaxiality levels, Lode factors and critical strains and stresses at the moment of final failure. Specimens were machined from three different materials and tested at three different temperatures. Numerical analyses were performed after careful calibration of the true stress–logarithmic strain uniaxial curves. Calibration was performed according to the modified Bai–Wierzbicki procedure.

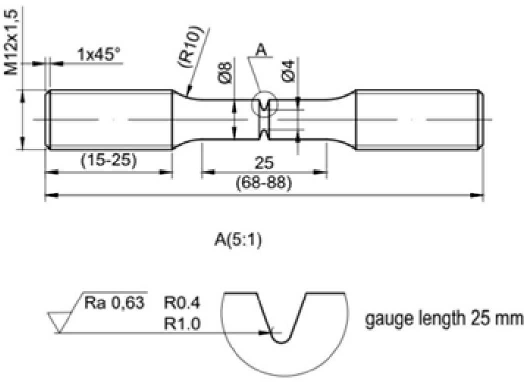
Introduction

The classical linear and nonlinear fracture mechanics failure criteria are based on local or global fracture characteristics derived from continuum mechanics analysis. The critical values of the stress intensity factor, energy release rate, J integral, and crack tip opening displacement, measured according to standards, are not material constants but depend on the in- and out-of-plane constraints. They assume conservative values tens percent lower than the real values. Therefore, there have been several efforts to develop methods to estimate critical values that are much less conservative but they assume values leading to more economical results, e.g., [1-4]. Another approach, termed the local approach, takes into account the evolution of the failure processes at the micro- or nanoscale starting from the nucleation of voids or micro-cracks from inclusions. Within the local approach, three theories have been proposed. Beremin [5] started a series of research mostly in France and the USA, e.g., [6–13], based on the estimation of failure probability due to void or micro-crack nucleation, growth and coalescence. Another series of papers originating from Gurson [14] described a phenomenological yield function containing the void volume fraction. This approach was further generalized by Needleman, Tvergaard and others [15–21] to include various aspects of void growth and coalescence. The third group of research originated from the Coulomb–Mohr hypothesis [22–26]. This programme was launched by the Bao–Wierzbicki paper concerning the critical strain concept and failure due to voids' nucleation–growth–coalescence processes. In all three different local approaches, the evolution of physical processes at the microscale is controlled by mechanical fields represented by several physical quantities. They are as follows: the effective accumulated plastic strain; the normal stress tensor component perpendicular to the fracture surface; the stress triaxiality factor $\eta = \sigma_m/\sigma_e$; and the Lode angle, $\cos(3\theta) = (r/\sigma_e)^3 = \xi = 27/2 \cdot J_3/\sigma_e^3$, where σ_m and σ_e are the first stress tensor invariant and effective stress, respectively, where $\sigma_e = \sqrt{3J_2}$, J_2 is the second stress deviator invariant, and J_3 is the third stress deviator invariant, s_{ij} represent the components of the stress deviator, $r = [27/2\det(s_{ij})]^{1/3} = [27/2(\sigma_1-\sigma_m)(\sigma_2-\sigma_m)(\sigma_3-\sigma_m)]^{1/3}$. In this study, the equivalent Lode parameter L is used: $L = (2\sigma_{II} - \sigma_I - \sigma_{III})/(\sigma_I - \sigma_{III})$, and the relation between ξ and L is as follows: $\xi = L(9-L^2)/\sqrt{(L^2+3)^3}$.

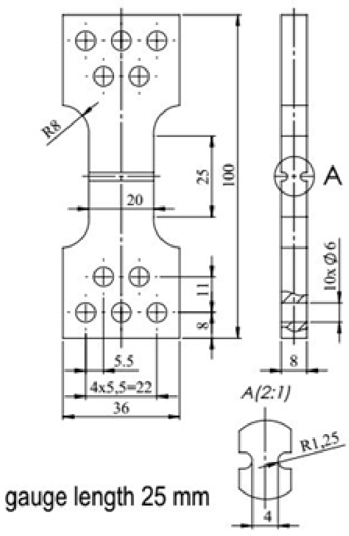
The results presented here are part of a greater research programme not yet completed. However, we suggest that the results are sufficiently interesting to be presented at this early stage. We attempt to identify the failure mechanisms with certain parameters of the mechanical fields; specifically, the cleavage fracture mechanism is expected to act when the normal stress component is greater than the critical value over a certain area, also greater than the critical value [27]. The ductile fracture mechanism occurring through void nucleation–growth–coalescence depends on plastic strain and stress triaxiality [28, 29]. It is often assumed that this process starts when the effective plastic strain reaches the critical value. However, this value depends on the stress triaxiality, Lode angle and certain other not-yet-identified properties of the material. An open question remains: can the failure mechanism be uniquely predicted using the mechanical field parameters defined above?

Materials, specimens, test temperatures, and numerical tools

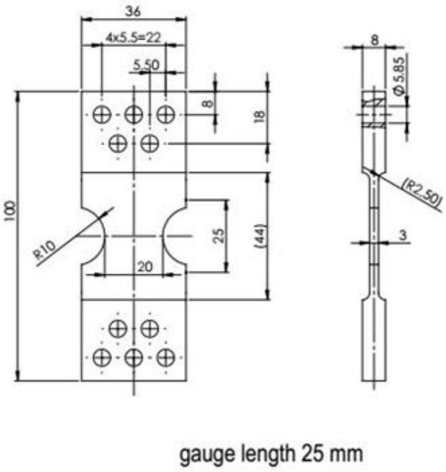
The specimen shapes were selected to cover a wide range of triaxiality factors and Lode parameters *L* or *ξ*. However, because of the purposes of the research programme, we were interested in relatively large (positive) values of the *η* factor and positive values of the *L* or *ξ* factors. The specimen shapes are shown in Fig. 1.



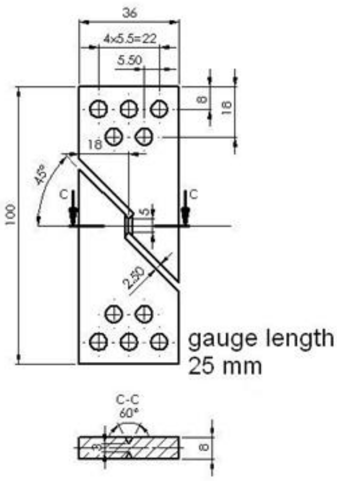
a) Symbol C04 or C1



b) Symbol PN



c) Symbol PR



d) Symbol S

Fig.1. Specimens' shapes tested in the experimental program

In the case of the specimen shown in Fig. 1a, two radii of notches were machined: R = 0.4 mm (symbol C04) and R = 1.0 mm (symbol C1) to induce the ductile fracture nucleation process in two different locations.

The specimens were machined from S355JR steel after three different heat treatments. The properties measured in uniaxial tensile tests are shown in Table 1.

To induce various levels of plasticity, the specimens were tested at three different temperatures: +20°C, −20°C, and −50°C. The *η* and *L* factors were recorded as follows: a) two notched cylindrical specimens with R = 0.4 mm ($\eta \approx$ from 0.5 to 1.0, L ≈ from 0.6 to 1.0) and R = 1 mm ($\eta \approx$ from 0.4 to 1.4, L ≈ from 0.85 to 1.0), b) a plate with two symmetrical notches, R = 1 mm; ($\eta \approx 0.4$, L = 0.4), c) R = 10 mm ($\eta \approx 0.5$, L = 0.5), and d) pure shear ($\eta \approx 0.4$, *L* = 0).

Table 1. Heat treatments and tensile properties of the tested S355JR steel at 20°C

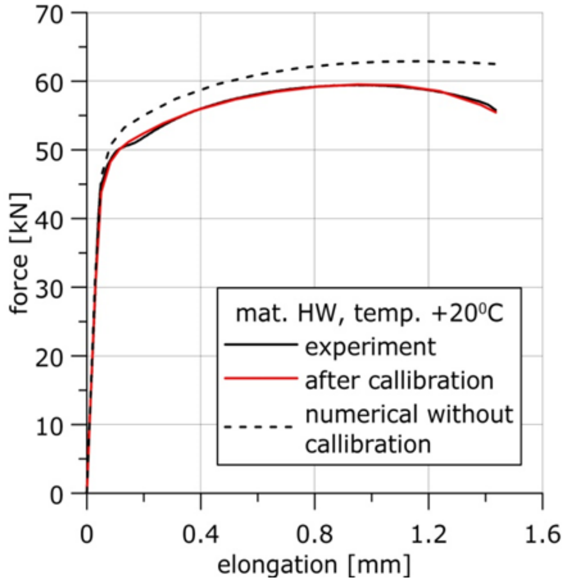
Sym-bol	Heat Treat-ment	Microst-ructure	E [GPa]	R_{eH} [MPa]	R_{eL} [MPa]	R_m [MPa]
N	Normalized at 950°C	Ferrite–pearlite	197[a] 198[b]	375 380	367 378	496 614
NW	Normalized and annealed (600°C, 150h)	Ferrite containing spheroidized carbide particles	210 211	382 393	368 380	470 588
HW	Quenched in oil and annealed (600°C, 150h)	Ferrite containing spheroidized carbide particles	197 198	412 415	406 411	511 603

[a] in the first line, values are obtained from the nominal stress–strain curve
[b] in the second line, values are obtained from the true stress–logarithmic strain curve

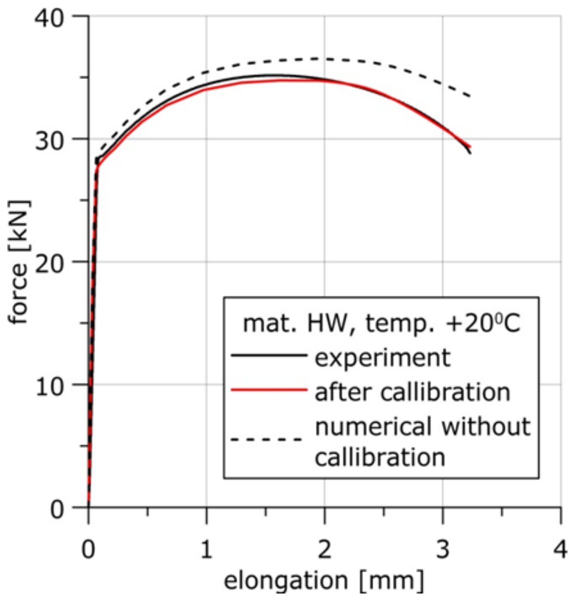
During numerical computations, the finite elements from the ABAQUS standard library were used. In case of specimens C04 and C1, 4-node, reduced-integration, axisymmetric, solid elements were used (symbol CAX4R). Since large gradients of the computed quantities were not expected, the size of the element next to the notch was 0.138 mm. Other two cases (PN and PR specimens) were modelled using linear 3D hexagonal elements with reduced integration (C3D8R). The sizes of the element in direction of the greatest stress gradient were 1/20 of the width of the specimen, i.e., 1.0 mm for the PR specimen and 0.086 mm for the PN specimen. In the case of the S specimen, C3D8R elements were used, and the size of the element in the shear region was 0.2 mm. The symmetries of the modelled specimens were taken into account to reduce the required computation time. The specimens were loaded by displacements applied at the distance determined by the gauge length (see Fig. 1).

Calibration of the uniaxial true stress–logarithmic strain curves

During all 34 test variants, large and very large plastic deformations were observed before final failure. Thus, calibration of the uniaxial true stress–logarithmic strain curves was necessary since when the data obtained in the standard uniaxial loading tests were incorporated into ABAQUS, the differences between the experimentally and numerically obtained force–elongation curves were large; representative curves are shown in Fig. 2.



a)



b)

Fig. 2. Experimental and numerical curves before and after calibration. (a - specimen PN, b - specimen PR.

The lower the temperature, the lower were the differences between the experimental and numerical results; however, calibration was almost always necessary. From the several available calibration strategies, the Bai–Wierzbicki method was selected and modified. Equation (1) is one of the equations published by Wierzbicki et al. [24] to calibrate the uniaxial tensile curves.

$$\sigma_{yld} = \bar{\sigma}(\bar{\varepsilon}_p)\left[1 - c_\eta(\eta - \eta_0)\right]\left[c_\theta^s + \left(c_\theta^{ax} - c_\theta^s\right)\left(\gamma - \frac{\gamma^{m+1}}{m+1}\right)\right] \quad (1)$$

where $\bar{\sigma}(\bar{\varepsilon}_p)$ is the function between the effective stress and the effective accumulated plastic strain $\bar{\varepsilon}_p$ and η_0 is a reference value of the triaxiality coefficient; η_0 = 1/3 for the uniaxial tensile test. The γ function represents a curve drawn along the deviatoric surface between the contours defined by the Huber–von Mises and Tresca criteria in the principal stress space. The γ function satisfies the inequality $0 \le \gamma \le 1$; $\gamma = 0$ for plane stress or pure shear, and $\gamma = 1$ for axial symmetry. Bai and Wierzbicki postulated that the γ function takes the following form:

$$\gamma = \frac{\cos(\pi/6)}{1-\cos(\pi/6)}\left[\frac{1}{\cos(\theta-\pi/6)}-1\right] = \\ = 6.464\left[\sec(\theta-\pi/6)-1\right] \tag{2}$$

The shape of the function (1) is not the only one proposed by Wierzbicki and co-workers. In Eq. 1, the quantity c_θ^{ax} is defined as follows:

$$c_\theta^{ax} = \begin{matrix} c_\theta^t & for & \bar{\theta} \ge 0 \\ c_\theta^c & for & \bar{\theta} < 0 \end{matrix} \tag{3}$$

Eq. 1 contains four parameters that must be experimentally determined: c_θ^t, c_θ^c, c_θ^s and m. However, at least one of them is equal to unity. If $\bar{\sigma}(\bar{\varepsilon}_p)$ is found through a uniaxial tensile test using cylindrical specimens, then $c_\theta^t = 1$. If a uniaxial compression test is performed, then $c_\theta^c = 1$, and in the case of a shear test, $c_\theta^s = 1$. All four parameters can be selected in such a way that one obtains either the Huber–von Mises or Tresca yield surface.

Both η and L parameters change over the critical plane and over time during the loading process; thus, the average values of these quantities over the critical plane are introduced into Eq. 1. However, these quantities change during specimen loading, and in the model, they are computed according to Eq. 4, which involves the η function (the linear approximation).

$$\eta = \eta_i - \left(\frac{\eta_i - \eta_f}{\varepsilon_{pl\_avr\_final}}\right)\varepsilon_{pl\_avr} \tag{4}$$

where index i denotes the initial state, index f denotes the final state, $\varepsilon_{pl\_avr\_final}$ is the average value of the effective plastic strains at the critical plane before the failure and ε_{pl_avr} is the actual average effective plastic strain in the critical plane. A similar formula was used for the Lode parameter. The average values over the critical plane are assumed since the force–elongation curve represents the average response of the specimen to the external loading.

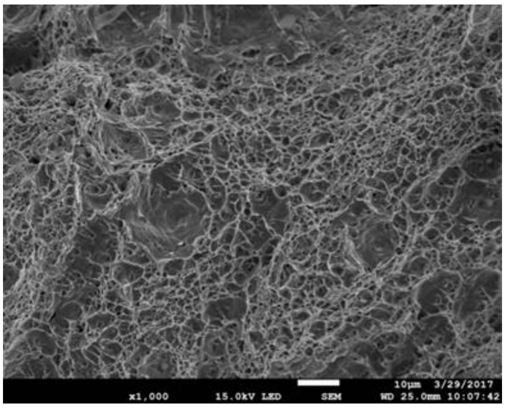
In addition, the coefficient c_η is adjusted when necessary. At the final stage of loading, the voids within the loaded specimens rapidly grow and coalesce. The force–elongation curve drops sharply. Eq. 5 describes this phenomenon.

$$c_\eta = \alpha\left[1 + H(\varepsilon_{pl\_o})(\varepsilon_{pl} - \varepsilon_{pl\_o})\right]^\zeta \tag{5}$$

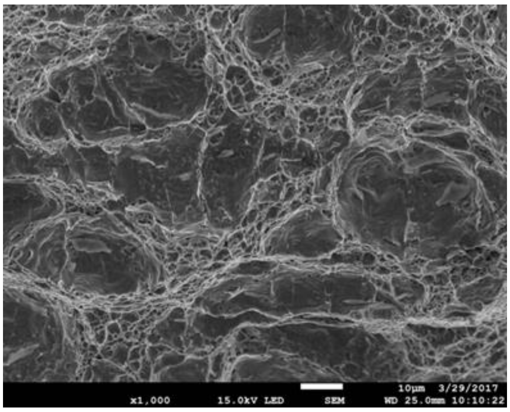
where ε_{pl_o} denotes the presumed value of the effective plastic strain at the onset of rapid void growth. According to our observations within the experimental programme, this quantity can be selected from the range of 0.3–0.7 depending on the specimen shape, material and test temperature. $H(\varepsilon_{pl\_o})$ is the Heaviside function. Coefficient α is a constant, typically smaller than 0.1, that is determined experimentally through curve fitting. In addition, the ζ power exponent is determined experimentally. The correction term shown by Eq. 5 replaces the Gurson–Needlemen–Tvergaard model [14–21] to some degree. This correction is not as precisely defined but can be more easily calibrated. All details of the curve calibration and conclusions following from those processes are published elsewhere [30].

Failure mechanisms

During the experimental tests, several fracture mechanisms were observed that depended on the specimen shape, material and test temperature. The failure mechanism observed most often was failure due to void nucleation–growth–coalescence. This process was observed at all tested temperatures. In some cases, the process was inhibited at low temperatures (−80°C or −100°C; these results are not shown in this presentation). Voids grew along surfaces perpendicular to the external loading and along surfaces inclined to the external loading direction. The purpose of this stage of research was to determine the values of all parameters computed: η, ε_e^{pl}, σ_{22}, and L at the critical moment. It was assumed that the initiation of the rapid failure process due to void coalescence started at the last or next-to-last step of integration (loading). Rapid cleavage fracture started at the last step of integration. No irregularities were observed along the force–elongation curves, indicating the sudden jumps of cleavage fracture during the loading process before the last step of integration. The locations of cleavage fracture initiation could be identified to some extent by analysing the fracture surface images and the orientation of the river pattern on the cleavage planes. The locations of the ductile fracture initial spot were usually not discernible by observation of the fracture surface using a scanning electron microscope. However, the locations could sometimes be identified by observing domains with larger caverns on a fracture surface, as shown in Fig. 3.



a) Next to the notch



b) Center

Fig.3. Specimen C1 a) caverns close to the bottom of the notch, b) caverns in the central part of the specimen. Material HW, temp. +20°C

However, such an interpretation can be misleading due to the irregular distribution of inclusions. Large MnS particles and chains of these particles were observed in this steel. In most cases, both within the cylindrical and rectangular (cross–section) specimens, the differences between the sizes and shapes of caverns were not detectable. Thus, a working hypothesis is required to localize the critical spot. The origin of this hypothesis is the result of Rice and Tracy [29] concerning the rate of growth of the isolated spherical void surrounded by an ideally plastic material. Their numerical results were well approximated by the following formula: $\frac{\dot{R}_0}{R_0} \cong 0.263\dot{\varepsilon}\exp\left(\frac{\sigma_m}{2\sigma_0}\right)$. Since the entire critical cross section of the loaded specimen is stretched at the same time, we propose comparing the quantity representing, in a rough approximation, the extension of the voids' radii, recorded along the fractured surface at the presumed moment of the rapid evolution of damage. The simplified formula is as follows:

$$\Delta R = \Delta\varepsilon_e^{pl}\exp(\eta) \tag{6}$$

Selected results concerning two cylindrical specimens with various radii of the circumferential notch are shown in Fig. 4 and Table 2.

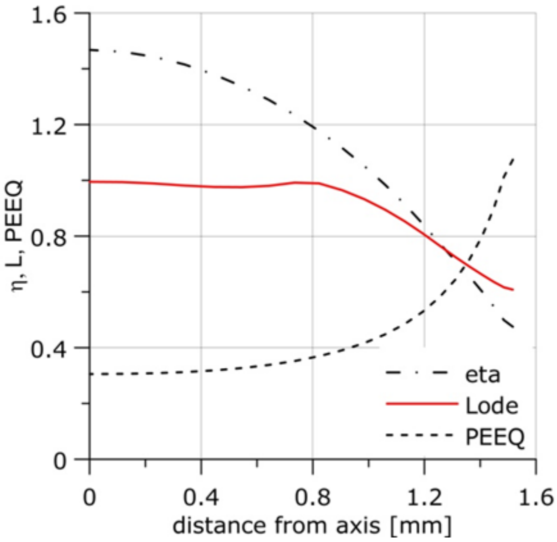


Fig. 4a. Distribution of η, L, and ε_e^{pl}. Specimen C04, material N, temp. −20°C, last step of integration

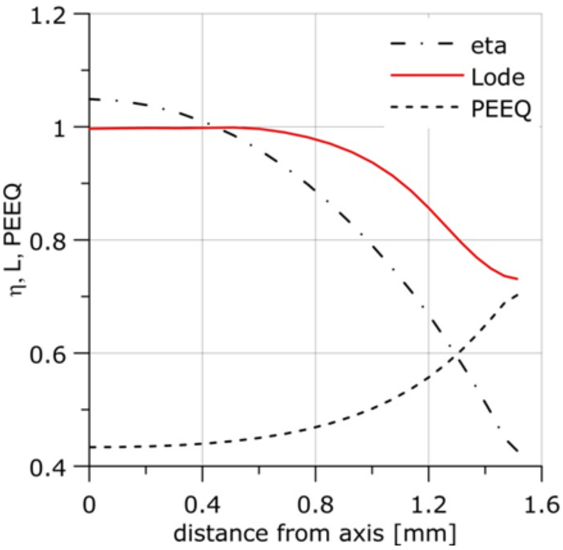


Fig. 4b. Distribution of η, L, and ε_e^{pl}. Specimen C1, material N, temp. −20°C, last step of integration

We conclude from the results listed in Table 2 that the final ductile failure process started at the specimen centre for the cylindrical specimen with a circumferential notch and radius at the notch bottom of R = 1.0 mm and next to the notch for the notch radius of R = 0.4 mm. Another example is presented below. It concerns the specimen shown in Fig. 1c. In Fig. 5, the scheme of the "critical" plane is shown, and in

Fig. 6, the distributions of the selected mechanical field parameters are presented.

Table 2. Values of the mechanical field parameters at the critical moment

R=0.4 mm	ε_e^{pl}	η	L	σ	ε_e^{pl} exp(η)
Specimen centre	0.305	1.467	0.995	1477	**1.32**
Next to the notch	1.07	0.475	0.608	1011	**1.72**

R=1.0 mm	ε_e^{pl}	η	L	σ	ε_e^{pl} exp(η)
Specimen centre	0.433	1.05	0.996	1386	**1.24**
Next to the notch	0.7	0.427	0.73	999	**1.07**

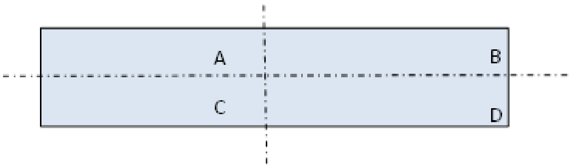


Fig. 5. Scheme of the critical plane of the specimen shown in Fig. 1c.

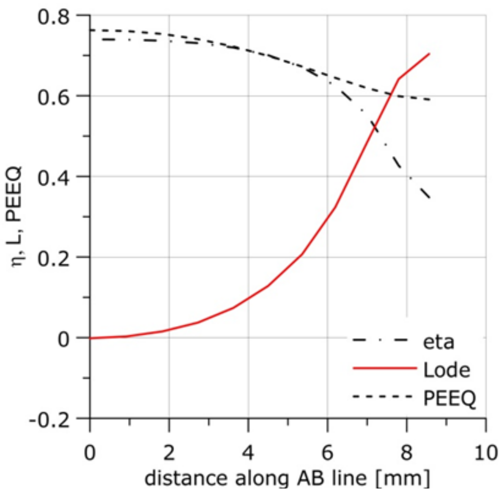


Fig. 6a. Distribution of η, L, and ε_e^{pl} along line AB in Fig. 5. Specimen PR, material N, temp. −20°C, last step of integration

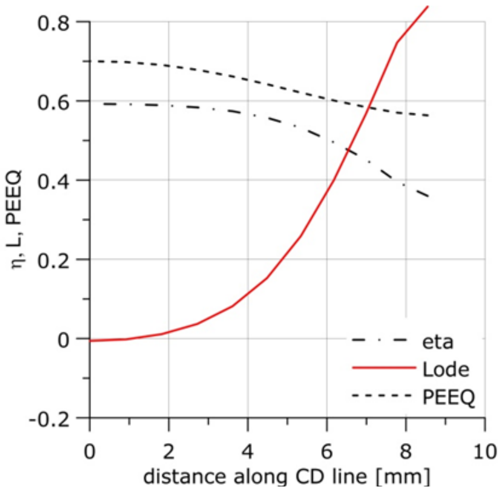


Fig. 6b. Distribution of η, L, and ε_e^{pl} along line CD in Fig. 5. Specimen PR, material N, temp. −20°C, last step of integration.

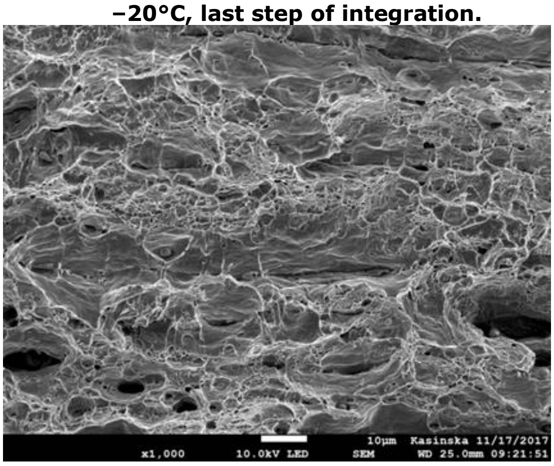


Fig. 6c. Fracture surface around point A in Fig. 5.

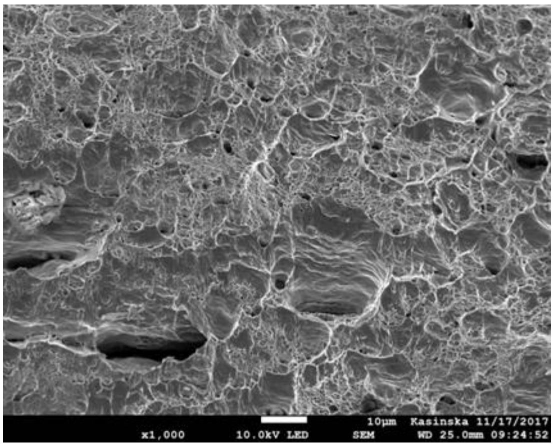


Fig. 6d. Fracture surface close to point C along line AC in Fig. 5

In Table 3, the values of the mechanical field parameters at the critical moment are shown at the characteristic points along the fractured surface.

Table 3. Values of the mechanical field parameters at the critical moment (Specimen PR)

	ε_e^{pl}	η	L	σ	ε_e^{pl} exp(η)
Point A (Fig.5)	0.76	0.74	−0.00146	1034	1.59
Point B (Fig.5)	0.59	0.347	0.7	775	0.83
Point C (Fig.5)	0.7	0.59	−0.00576	896	1.26
Point D (Fig.5)	0.56	0.36	0.83	790	0.8

According to Table 3, the final failure of the specimen started in the central part of the specimen (point A in Fig. 5).

In the images shown in Figs 7b and 7c, one can discern the spots where ductile failure occurred not by the void evolution process but by dislocation slip along the slip faces. At these spots, the Lode factor is equal to zero. This value of the Lode parameter is characteristic of a pure shear failure process.

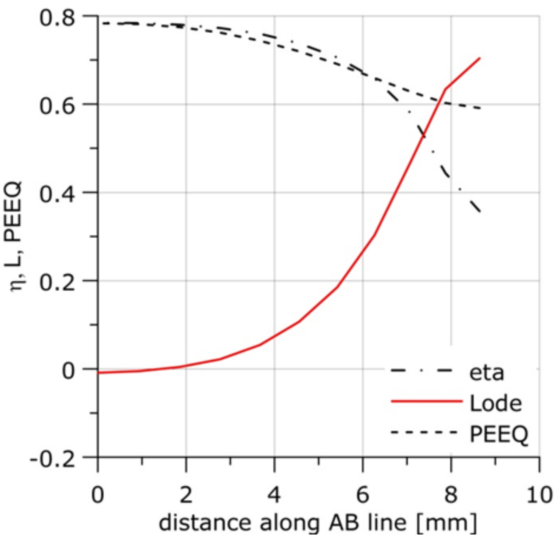


Fig. 7a. Distribution of η, L, ε_e^{pl} along AB line in Fig.5. Specimen PR, material HW, temp. −50⁰C, last step of integration

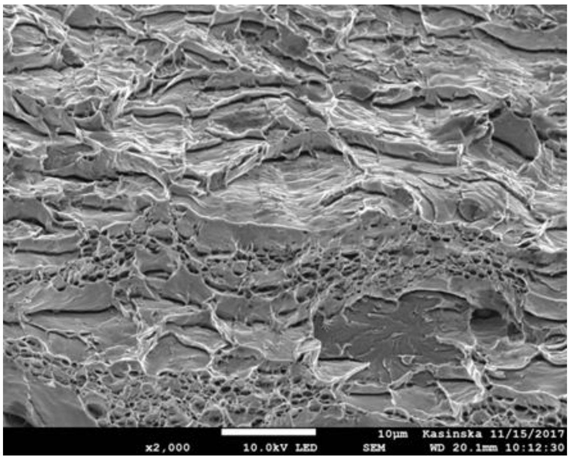


Fig.7b. Fracture surface around point A in Fig.5, Material HW, temp. −20⁰C

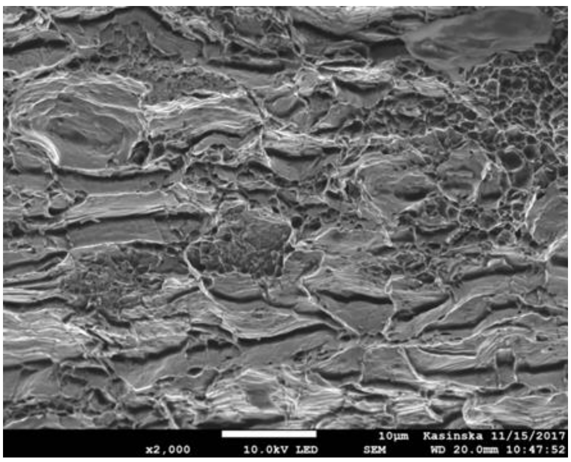


Fig.7c. Fracture surface around point A in Fig.5, Material HW, temp. −50⁰C

When the temperature is lowered, we might hypothesize that the failure mechanism would change from ductile to cleavage. However, this transition did not occur in all specimen shapes tested. Specimens C1 and PR never failed by the cleavage mechanism in the temperature range from +20°C to −50°C (they did fail in this way at lower temperatures). Examples of cleavage surfaces are shown in Fig. 8.

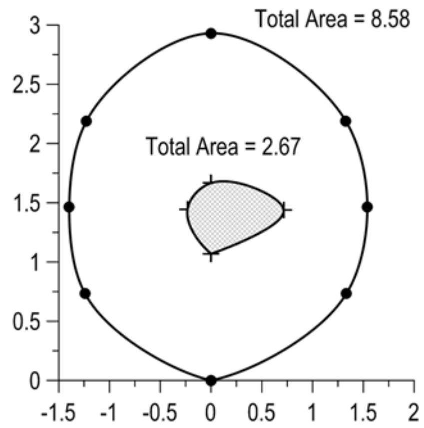


Fig. 8a, Specimen C04, Material N, temp. −50⁰C, Ductile zone inside

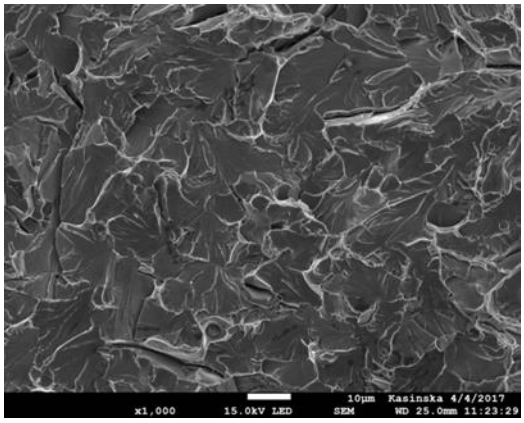


Fig. 8b, Specimen C04, Material N, temp. −50⁰C, Cleavage fracture surface

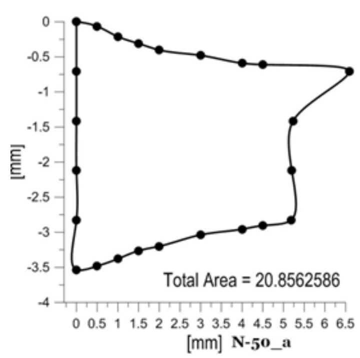


Fig. 8c, Specimen PN; Material N, temp.

−50°C, Cleavage area shape and size

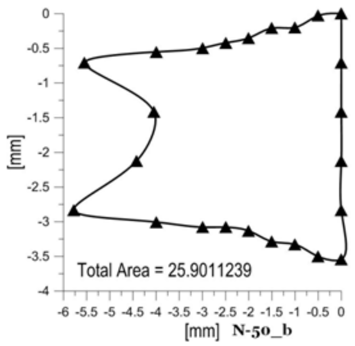


Fig. 8d, Specimen PN; Material N, temp. −50°C, Cleavage area shape and size

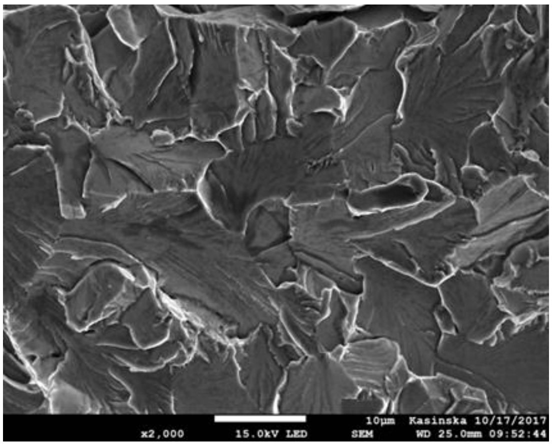


Fig.8e. Cleavage surface. Specimen PN; Material N, temp. −50°C

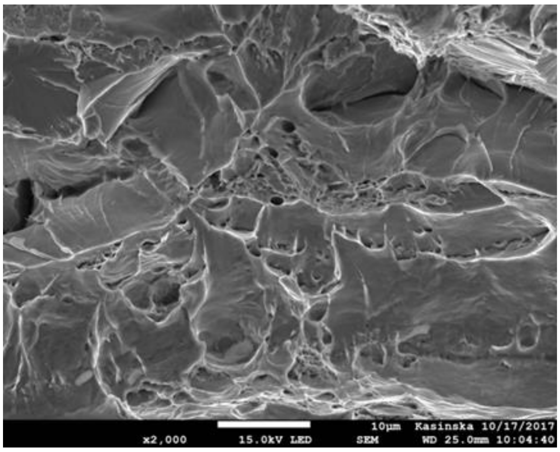


Fig.8f. Cleavage surface, close do the ductile failure surfaces. Specimen PN; Material N, temp. −50°C

Evolution of the cleavage failure mechanism and the analysis of this process in terms of mechanical field parameters are not unique—at least the authors cannot currently propose a novel and noncontroversial hypothesis. The mechanism depends strongly on the history of plastic deformation evolution and the evolution of void growth. Consensus is that this process is controlled by the normal stress tensor component and a scale parameter (i.e., a critical length or area). In the case of the N material and a temperature of −50°C, two specimens (namely, the PN and C04 specimens) failed by cleavage after intensive void evolution. Specimen C1 failed according to the ductile failure mechanism. The stress tensor components normal to the fracture surface are shown for all four specimen geometries—C04, C1, PN, and PR—in Fig. 9. Since specimen C1 failed due to the ductile mechanism, normal stresses within this specimen are expected to be lower than in the C04 and PN specimens. It happens in between the two vertical lines 1 and 2 in Fig. 9. Along the abscissa, the normalized distance from the specimen centre is measured. Thus, the critical stress is sought between lines 1 and 2. Observations of the cleavage surface in PN specimens suggest that the cleavage started at the normalized distance of 0.72, corresponding to a distance of approximately 6.6 mm from the specimen centre. If this estimation is correct, then the critical stress is approximately 1240 MPa, and the origin of cleavage lies 1.29 mm from the centre of the C04 specimen.

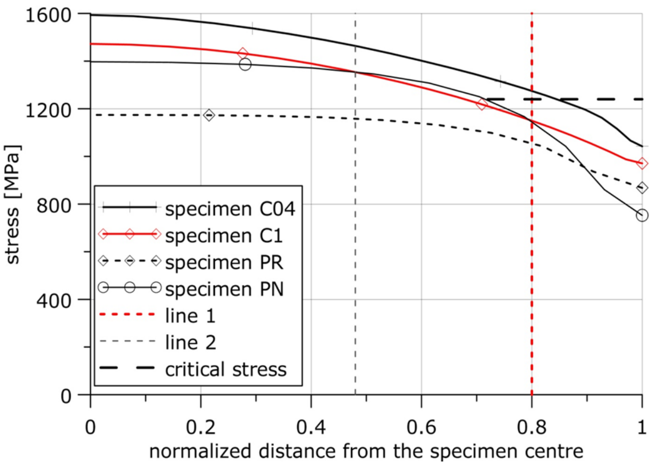


Fig.9. Stress vs. normalized distance computed at the critical moment

The analysis concerning the estimation of the critical stress, shown in Fig. 9, was not successful in all tested materials and temperatures. Observation of the evolution of all mechanical field parameters during the loading processes can lead to controversial conclusions. The answers for the two questions formulated below are not unique and will be discussed during a separate presentation in this conference [31]

1) Why are caverns not observed on a cleavage fracture surfaces? Are voids not nucleated in the domain where the cleavage fracture is nucleated at the last step of loading?

2) Why is cleavage not initiated in the domain where ductile failure is observed, even though the opening stress level is higher than the presumed critical stress?

Failure of the S specimens was due to the pure shear mechanism (see Fig. 10), and the onset of failure can be predicted using the measured values of the critical equivalent plastic strains. In this case, both η and L are equal to zero.

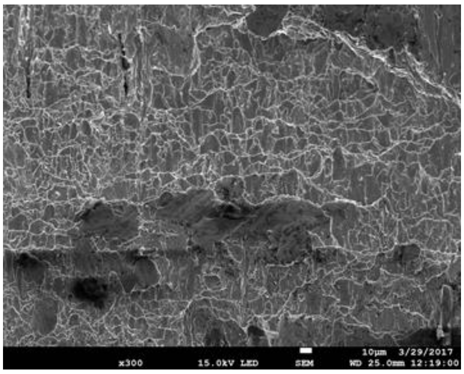


Fig.10. Material HW, temp.+20^{0}C, the failure surface of the S specimen

All numerical results along with the experimental observations were used to create the surfaces of the critical effective plastic strain in the ($\varepsilon_{e\_cr}^{pl}$, η, L) space. A representative surface is shown in Fig. 11. More details will be published in a paper submitted for publication [32]. No efforts have been made to identify these surfaces using the Bao–Wierzbicki critical strain surfaces.

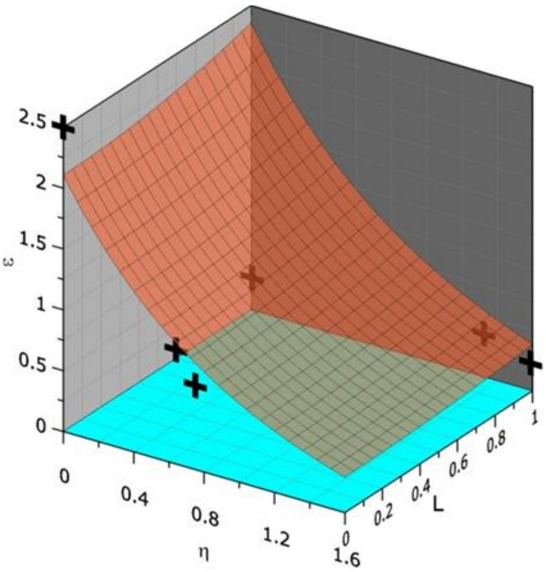


Fig.11. Positive quarter of fracture locus

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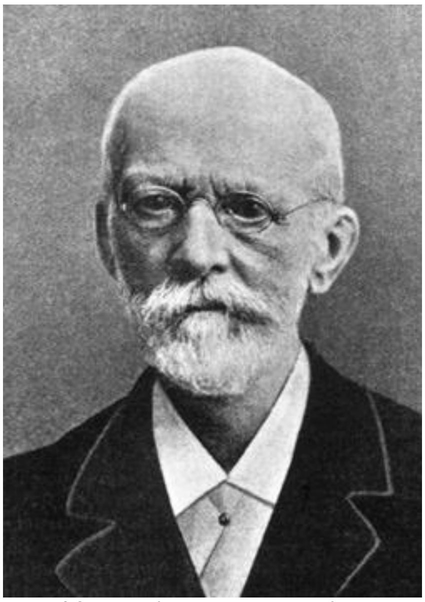
Newsletter #62-2018

FATIGUE OF COMPONENTS

AUGUST WÖHLER (1819-1914)
A Historical Review

Harald Zenner, Karsten Hinkelmann

DVM - Special Publication



(c) Deutsches Museum München

August Wöhler was an interesting and unique character, influenced by the 19th century Industrial Revolution, especially railway development. The spread of this new technology caused numerous problems. Fractures arose on axles, wheels and rails at stresses below the component's static fracture strength. Through systematic tests August Wöhler was able to prove that repeated stresses far below the static strength, might lead to fractures. The present article gives a brief overview of Wöhler's biography and his achievements.

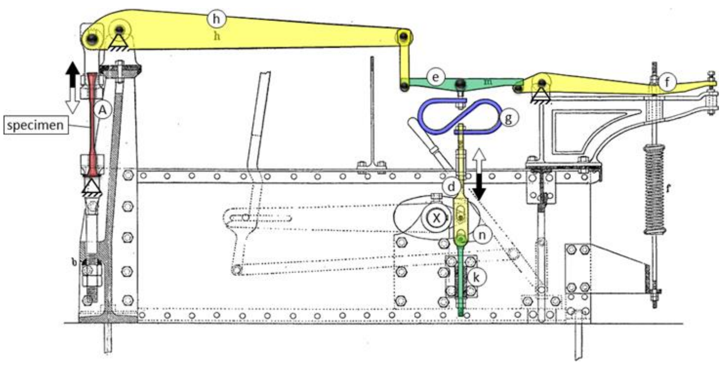
In the field of technology, good biographies are relatively rare. Except for those written by individuals referring to personal acquaintance, most facts get lost. For A. Wöhler, there are two very authentic biographies. The first biography was published in 1914, the year of August Wöhler's death. It is by L. Troske, a former employee of A. Wöhler. The second biography was published in 1918 by Wöhler's grandson R. Blaum.

A short overview of Wöhler´s curriculum vitae with important life stages will be given.

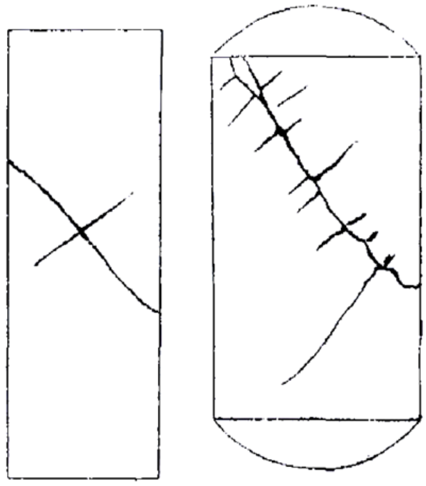
Wöhler's famous experimental works date back to the middle of the 19th century. His fatigue tests were conducted over a period of fourteen years and resulted in five publications between 1858 and 1870. Admittedly, Wöhler was not the first who carried out fatigue tests. But he is internationally regarded as the first who studied parameters of dynamic strength methodically.

The five publications mentioned above cover a wide range of topics. Some of them are:

- Load measurements on axles of goods and coal wagons
- Fatigue tests on railway axles and specimens (rotating-bending)
- Static tests with the goal to estimate fatigue strength parameters
- Notch and frequency influence (rotating-bending)
- Influence of mean-loads (flat bending)
- Fatigue strength tests under axial and torsional loading
- Development of a safety concept



Testing machine for cyclic axial loading / Wöhler 1870 / (Illustrations by the authors)



Crack formation and fracture under alternating torsion for cast steel, Wöhler 1870

Wöhler has invented and developed his testing machines by himself and thereby set a precedent. He not only considered the endurance limit but also constructions for a limited number of cycles in use.

His experimental studies meant a lot to August Wöhler. But also very important to him was the reliable strength dimensioning by an exact determination of the permissible stress, a classification of materials (iron and steel) regarding rather characteristic properties than application and the constitution of independent testing institutions, the institutes for materials research and testing.

Both his achievements as well as criticism are presented. For example A. Wöhler did not graph his own results. This has only been done by his successor L. Spangenberg in a linearly scale. The double logarithmic plot was not used until 1910 by O. H. Basquin. Furthermore, there is no single passage drawing a comparison between the fracture surfaces in the test and those in operation. All this cannot diminish his achievements. Walter Schütz summarizes in his "History of Fatigue": *In summary one can only admire the work of Wöhler in its entirety, encompassing the measurement of service loads, the calculation of the corresponding service stresses, the design for finite life including scatter (probability of survival) up to the observation of crack propagation and the quantitative suggestions for the decrease of the notch effect.*

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☐ Enclosed is a copy of bank transfer for € 30 (Euros The bank is: Uncredit banca
The name of the beneficiary is: **ESIS (European Structural Integrity Society)**
the coordinates are:
IBAN: **IT22 N 02008 01160 000020016279**
BIC SWIFT Code: **UNCRITM1AG0**

OR

☐ Please charge to my (**delete as appropriate**) EUROCARD / MASTER CARD / VISA CARD / DINERS CARD / AMERICAN EXPRESS CARD an amount of € 30 (Euros). My card number is:

☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ Exp Date: ☐☐ — ☐☐

Please print clearly

Surname: ______ Name ______ Title(s) ______
Affiliation: ______
Address: ______
______
e-mail: ______ Tel No: ______
Fax No: ______

Signature:

Date:

For ESIS records purposes please give the numbers of the ESIS Technical Committees in which you are most interested

Technical Committee(s):

All ESIS Procedures and books are free for ESIS Members at www.structuralintegrity.eu

Please return this form to:
ESIS Treasurer
Professor Giuseppe Ferro, Dept.
of Structural Engineering,
Politecnico di Torino,
Corso Duca degli Abruzzi 24
10129 Torino, Italy
or complete the web membership form at www.structuralintegrity.eu