Issue 12 October 2014

SFA

About SFA

Objectives

Report from Local centres

Welcome you all to join as members of SFA! Please find the membership form inside; kindly fill in and contact Secretary of SFA through email.

Experts and experiences:

Shri.Sunil Goyal, IGCAR, Kalpakkam

Dr.Vikas Kumar, DMRL, Hyd

Message from our President

Dear Friends and colleagues,

Very nice to meet you all again through this column. Greetings to all of you!!! October month is special for all of us as it is dotted with several festivals. If Dussehra marks the victory of righteous over evil and Diwali marks an eternal journey of mankind from darkness to light symbolizing passage of human being from ignorance to liberation (तमसो मा ज्योतिर्गमय । मृत्योर्मा अमृतं गमय।), whereas Bakrid symbolizes supreme sacrifice.

A failure can be identified as an unwanted event in an organization or a system leading to unexpected and undesirable results. Avoidable errors as well as unavoidable negative outcomes of experiments as well as risk-taking also fall within the scope of a failure. Failures are broadly defined to include both large and small failures which could be either technical (a flaw in the design of a new machine) or interpersonal (such as a failure to give feedback to an employee with a performance problem). Based on the extensive research, it has been commonly observed that the ability of an organization to learn from failures is best measured by how it deals with a variety of outcomes which deviate from expected results, rather than merely focusing on the major disasters. It is common knowledge that the deviations from expected results can be positive or negative, and even positive deviations present opportunities for learning. However, we commonly tend to focus on negative deviations because of the unique psychological and organizational challenges associated with learning from them.

An important reason that most organizations do not learn from failures may be their lack of attention to small, everyday organizational failures, due to the formal 'after-action reviews' triggered by large catastrophic failures. If small failures that are often the 'early warning signs' are detected and addressed at the earliest, it may help in avoiding catastrophic failures in future. Three distinct processes through which organizations can proactively and effectively learn from failures are described here. These are the core organizational activities, given in the increasing order of challenge – organizationally and technically, requiring interpersonal skills. These are, (1) identifying failure: no failure should be denied, distorted or covered up; (2) analyzing failure: this should be carried out with a spirit of openness, patience and tolerance and (3) deliberate experimentation: this should be done purely for the purpose of learning and innovating.

It is recommended that managerial mindset could be tuned to develop a long-term perspective. Leaders are expected to know that failure is a natural byproduct of a healthy process, which involves learning about it and communicating the lessons to all in an organization. Psychological and interpersonal responses towards failures should be based on scientific curiosity, eagerness and belief rather than being self-protective.

As human beings, we are socialized to distance ourselves from failures. Reframing failure from something associated with shame and weakness to something associated with risk, uncertainty and improvement is a critical first step in our learning journey. I am sure that such a philosophy would go in a long way for improving quality, productivity, efficiency and morale of any organization.

I wish you all success in your endeavours!

T. Jayakumar
(President, SFA)

Edited by: Dr.M.G.Pujar & Dr.P.Parameswaran, Metallurgy & Materials Group, IGCAR, Kalpakkam

From the Desk of Editors

Warm greetings! We are happy to present you the twelth issue of the newsletter of Society for Failure Analysis (SFA).

Among the efforts taken to build the society over the last few months, were the activities by our local centres at various places, and workshops organized for inspiring the young engineering students along with various other professional bodies. These efforts have really yielded fruits; therefore, in the last few months, centres of SFA at Surathkal, Hyderabad and Tiruchi organized national events. We will provide a glimpse of the programs conducted at these places in this issue as reports.

We have solicited articles from experts in the important area- Finite Element Analysis (FEA) and life prediction.

We thank the authors for their contributions which are truly significant as far as SFA is concerned.

We take this opportunity to appeal to the Indian industry to use SFA as a forum to share their experiences on trouble shooting. A great way to add content to this newsletter is to include a calendar of upcoming events. The details of important forthcoming international and national events are included along with the books recently published on the topics of the subject.

We value your comments, which really boost our enthusiasm to perform better. Therefore, as always, your views and comments, mailed to pujar@igcar.gov.in or param@igcar.gov.in are welcome. We wish you all a joyful life free from failures!

You may visit our website for your comments/suggestions or any queries : www.sfaindia.org

Kalpakkam (M G Pujar)

30-10-2014 (P .Parameswaran)

Editors

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*We encourage you to join the society, Kindly fill up the application form (enclosed at the end of the newsletter) and contact secretary: post your application with draft to Dr.N.Eswara Prasad, Regional Director, **RCMA,** CEMILAC, Kanchanbagh, Hyderabad, 500 058*

About the society

Aims and Objectives of Society for Failure Analysis

The aims and objectives of the Society shall be:

To serve as National Society to promote, encourage and develop the growth of "Art and Science of Failure Analysis" and to stimulate interest in compilation of a database, for effective identification of root causes of failures and their prevention thereof.

To serve as a common forum for individuals, institutions, organizations and Industries interested in the above.

To disseminate information concerning developments both in India and abroad in the related fields.

To organize lectures, discussions, conferences, seminars, colloquia, courses related to failure analysis and to provide a valuable feed back on failure analysis covering design, materials, maintenance and manufacturing deficiencies / limitations.

To train personnel in investigating failures of engineering components and their mitigation.

To identify and recommend areas of research and development work in the Country relating to failure analysis.

To establish liaison with Government, individuals, institutions and commercial bodies on failure analysis, methodologies and to advise on request.

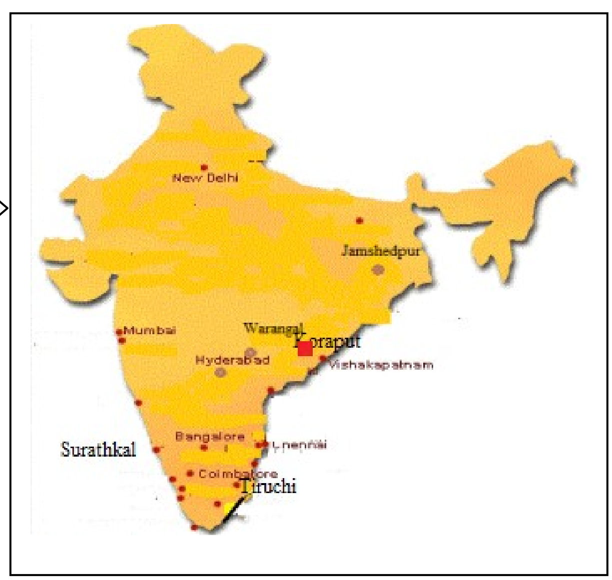
To cooperate with other professional bodies having similar objectives.

To affiliate itself to appropriate international organization(s), for the promotion of common objectives and to represent them in India.

To organize regional chapters in different parts of the country as and when the need arises.

To do all such other acts as the Society may think necessary, incidental or conducive to the attainment of the aims and objectives of the Society.

Know your local centres



Two-days Workshop on Engineering Failure Analysis – Aug., 1-2, 2014, NITK, Surathkal

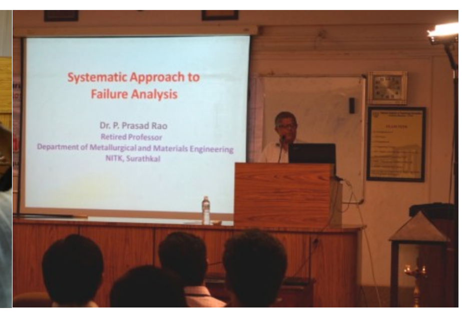
Welcoming the delegates, Prof Jagannatha Nayak, Head, Department of Metallurgical & Materials engineering, NIT, Surathkal spoke on the importance of the subject briefly and recalled his association with IGCAR, Kalpakkam since 1990, expressing happiness regarding the two days' event which would present opportunity for the participants to interact with each other. Prof. K. Rajendra Udupa, Senior Professor, Department of Metallurgical and Materials Engineering, in his presidential address emphasized the need for careful choice of materials, processing route and maintenance for the design of components. Thereafter, Sri.K.V.Kasiviswanathan, Raja Ramanna Fellow, IGCAR made an appeal to all design engineers, plant personnel, heat treatment supervisors, inspectors on the care they should practise to avoid untimely failures. Dr.P.Parameswaran, technical coordinator described the scope of the workshop in detail.

This was followed by the lectures on the first day wherein Sri.Kasiviswanathan introduced failure analysis to the audience, Prof.P.Prasad Rao, Professor (Rtd), Department of Metallurgical and Materials Engineering, NITK, Surathkal, discussed the importance of fracture mechanics based assessment of materials for designing components. This was followed by a lecture on application of finite element methods for failure assessment by Prof.Murugendrappa. A lecture on importance of microstructure for failure analysis was presented by Dr.P.Parameswaran. A demo of preparing specimen replicas and their observation under SEM was conducted in the afternoon where all the student delegates participated with great enthusiasm..

On the second day, Dr.C.K.Mukhopadhyay, IGCAR discussed in details the possible NDT methods and their applications to failure analysis. His lecture was followed by a lecture on high temperature failures by Dr. P. Sampath kumaran, Scientist (Rtd), CPRI, who presented his experiences and presented failures due to creep in power plant components. Dr.C.Manjunatha of NAL discussed in a systematic way the possible loads in various portions of aircrafts and application of fracture mechanics to study and simulate in the particular field. Dr.Subraya Hegde, Department of Metallurgical & Materials Engineering, NITK presented a few case studies describing how failure analysis carried out in a systematic way could bring out the cause of the failure.

The valedictory function was presided over by Prof. K.R. Hebbar, Professor (Rtd), NITK Surathkal who presented the certificates to 75 participants comprising students of the NIT, Surathkal, institutes and a few industries around Mangalore. Prof Udaya Bhat, the convener, proposed a vote of thanks formally acknowledged the President, SA, Director, NITK Surathkal, Chief guest, presidents of the function, all the speakers and the participants

Sri.K.V.Kasiviswanathan* formally inaugurating the workshop by lighting the traditional lamp



Prof. Prasad Rao delivering lecture on systematic approach to failure analysis

Dr. Udaya Bhat K briefing the audience during valedictory and certificate distribution function

*SFA deeply regrets the sudden demise of Sri.K.V.Kasiviswanathan on 26/08/2014

The 7th executive committee meeting of SFA and a half-day meeting on “Characterisation for- and select case studies of failure analysis” on 19th July, 2014 at CEMILAC, Hyderabad

The 7th Executive Committee meeting was held at RCMA (Materials), CEMILAC, Hyderabad on July 19, 2014 and members deliberated on the progress made by the Society for Failure Analysis (SFA) during Jan - June, 2014 under the chairmanship of Dr. T Jayakumar, President, SFA. Dr. A Venugopal Reddy proposed several events, including the formation of SFA, Hyderabad Chapter and conducting a national conference on failure analysis (NCFA-2015), sponsored by the new chapter. Dr. N Eswara Prasad, Secretary and Dr. P Parameswaran, Joint-Secretary, SFA presented the annual report of SFA activities and the members made several proposals, including the means for augmenting membership of the society and formation of new centres of SFA.

Befitting the occasion, a theme workshop on CHARACTERISATION FOR AND SELECT CASE STUDIES OF FAILURE ANALYSIS was conducted, which was attended by all the EC members and also, by 15 practicing failure analysts from DMRL, DRDL, Midhani, NFC, BHEL R&D and BHEL. Three lectures and 4 case studies were presented and all the participants are provided with the participation certificates.

EC meeting in progress

Theme Workshop in progress

Most "impossible" goals can be met simply by breaking them down into bite size chunks, writing them down, believing them, and then going full speed ahead as if they were routine.
Don Lancaster

Life Prediction Technologies for Military Aeroengines

Vikas Kumar* and R.K. Satpathy+

*** Defence Metallurgical Research Laboratory, Hyderabad**
+ Regional Centre for Military Airworthiness (Engines), HAL-Koraput

Catastrophic failure of some of critical components and structures during service, especially in aerospace and nuclear sectors, could be quite hazardous both in terms of human life and financial terms. Life prediction issues become highly complex in case of high performance aeroengines requiring high thrust-to-weight ratios especially in military aircrafts. The components in aeroengines have to operate at much higher stresses and temperatures for extended periods. Under such hostile environment, several damage mechanisms become operative, thus deteriorating total life span of the components. Over a period, several life prediction methodologies have been evolved. All life prediction approaches are result of accumulated experiences empirically relating laboratory, engine rig and in-service data. The lifing methods widely followed usually fall under one of the categories namely Life-to-first-crack (LTFC), Databank lifing, Damage Tolerance lifing, and Damage mechanism-based lifing procedures. Depending on the criticality of the components, various lifing philosophies based on traditional 'Safe Life' as well as state-of-the-art design philosophies such as fracture mechanics based 'Damage Tolerance' and the futuristic based on 'Damage Mechanics' are being adopted.

Recently, DRDO has initiated a comprehensive multidisciplinary project on 'Life Prediction Technologies for Aeroengines' integrating material science, advanced NDI sensor technologies and signature analysis, predictive life modeling and FEM simulation to predict future performance and catastrophic failures of Military aeroengines. The identification of materials deformation and consequent damage mechanisms operative under dominant service environments play an important role for establishment of reliable lifing models. Lifing is based on extensive laboratory specimen level material characterization in terms of fatigue and creep, followed by the scale-up of experimental results to actual components. In addition, several Non-Destructive Evaluation (NDE) methodologies such as DP, ultrasonics (linear- and nonlinear), IR- thermography, acoustic emission and X-ray radiography have also been employed to detect any in-service defects / damage. Finite Element Analysis (FEA) is an indispensable engineering tool for evaluation of the mechanical variables that determine crack initiation and their subsequent growth, apart from material degradation prior to physical failure. Further, to validate laboratory results, Accelerated Mission Tests (AMT) have also been performed on instrumented engine test beds to ensure the durability of the in-service engine through in-situ monitoring of critical engine performance parameters under service simulated loading conditions. The generic procedure is shown in the Fig.1:

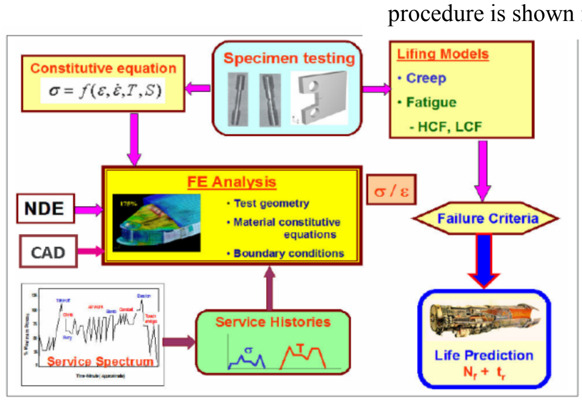


Fig.1. Generic procedure for life prediction

To illustrate the procedure, damage tolerance study has been performed on a high pressure turbine (HPT) disc of an aeroengine. The study was aimed at determining the potential fracture critical locations in the disc and estimation of the thermo-mechanical loads that may result in component failure by crack nucleation. The *ABAQUS* FEA model of the disc, together with fatigue-creep data experimentally generated has been used to simulate the growth of initiated cracks at potential sites such as bolt hole and fir tree area as shown in Fig.2.

However, in real situation, the situation is more complex due to continuous degradation of material under engine's hostile service conditions. In this case, life prediction methodologies, based on Continuum Damage Mechanics (CDM) approach, have provided better predictability. In this approach, a damage function is required in terms of service conditions such as cycles, time, stress/ strain or temperature as input to the CDM based life prediction analysis. Here, the damage process is regarded as the generation and growth of micro-defects within an initially perfect material. The material remains the same but its physical as well as mechanical properties may change with its microscopic degradation. The damage variable, 'D' is a macroscopic measure of the microscopic geometrical deterioration of the material. The direct measurement of damage by means of microscopic observations of the surface of defects is very difficult to perform, practically. A better way is to deduce damage from its influence on measurable properties such as stiffness loss, electrical resistance, ultrasonic velocity, ultrasonic attenuation and micro-hardness change etc. Thus, the parameters for the damage function are experimentally calibrated by NDE based damage measurement techniques during testing of material under service loading conditions. Different NDE techniques such as Acoustic Emission (AE), Infrared Thermography (IRT), Ultrasonic Attenuation and Velocity Measurements, Acoustic Harmonic measurements, Positron Annihilation, Eddy Current technique and Alternating Current Potential Drop (ACPD) techniques etc., have been developed for the assessment of various kinds of damages. Here, damage accumulation has been predicted based on damage function deduced by online ACPD technique, as shown in Fig.3. Damage analysis has been performed using FEM based Zebulon software with coupled elastic and plastic damage models to predict damage critical locations under engine loading conditions.

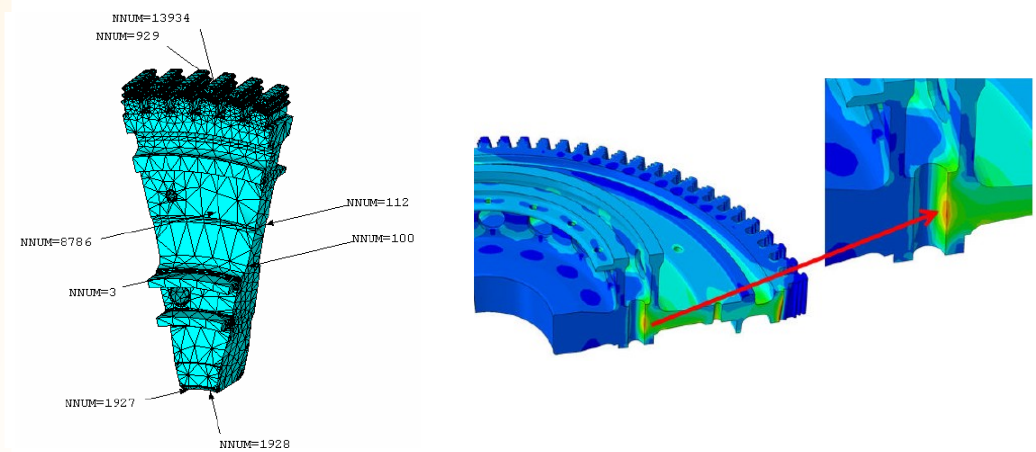


Fig.2.FEA model of turbine disc depicts the potential sites of crack initiation

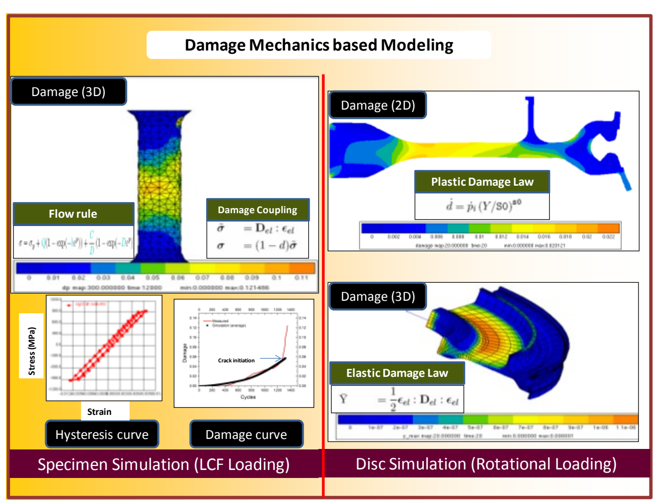


Fig.3. Damage accumulation & prediction of life through FEM based analysis

Assessment of creep failure of components based on finite element analysis

Sunil Goyal, K. Laha, P. Parameswaran and A.K. Bhaduri
Metallurgy and Materials Group
Indira Gandhi Centre for Atomic Research, Kalpakkam

Components operating at relatively higher temperatures generally experience multiaxial stress loading due to (i) change in geometry, (ii) mode of loading or (iii) presence of heterogeneous microstructure as in the case of weld joints [1]. Under such loading conditions, it becomes difficult to obtain the state of stress, strain and damage in the component by analytical methods. Finite element (FE) analysis has been widely used for the estimation of stresses and strains in critical locations of the components for the estimation of mechanical behaviour and life prediction. Incorporation of continuum damage mechanics (CDM) in the FE analysis enables the evolution of the damage in the engineering structures [2,3]. The present article briefly describes the importance of FE-CDM analysis in assessing the creep failure behaviour of components consisting of (i) ferritic steel weld joint having extensive mismatch in mechanical strength and (ii) notches of different sharpness simulating the changes in geometry.

Welded components of ferritic steel

Hardness profile in ferritic steel (2.25Cr-1Mo) weld joint depicting the microstructural inhomogeneity is shown in Fig. 1. The soft intercritical region of heat affected zone (ICHAZ) is sandwiched between the hard fine grain HAZ on one side and base metal on other side. The multiaxial state of stress in weld joint during creep exposure arises due to the different creep behaviour of individual constituents of the weld joint (Fig. 2). The joint suffers premature creep failure in the intercritical region of HAZ (Fig.3(a)), commonly known as 'Type IV' cracking. The failure was associated with extensive creep deformation and cavitation in central region of ICHAZ, Fig. 3(b).

Creep cavitation in materials proceeds with the nucleation of creep cavities at a grain boundary and their growth and linkage into discrete cracks leading to final fracture. The creep cavitation behaviour of the material depends on the components of stresses viz., maximum principal stress, hydrostatic stress and von-Mises stress, which govern the creep deformation and cavitation. It is widely reported that the von-Mises stress controls the deformation and creep cavity nucleation processes, the maximum principal and hydrostatic stress control the continuum cavity growth; whereas the maximum principal stress controls the stress directed diffusion controlled intergranular cavity growth [4]. 3D FE analysis was carried out using ABAQUS 6.10 finite element solver considering creep behaviour (Norton's law) of individual constituents of the weld joint (viz., weld metal, coarse grain, fine grain, intercritical region and base metal) in the materials model to estimate the different components of stresses in the weld joint for assessing the type IV cracking

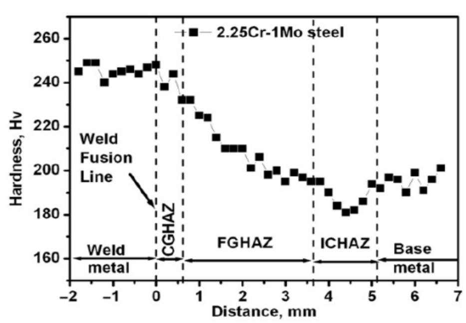


Fig. 1: Variation of hardness across the weld joint.

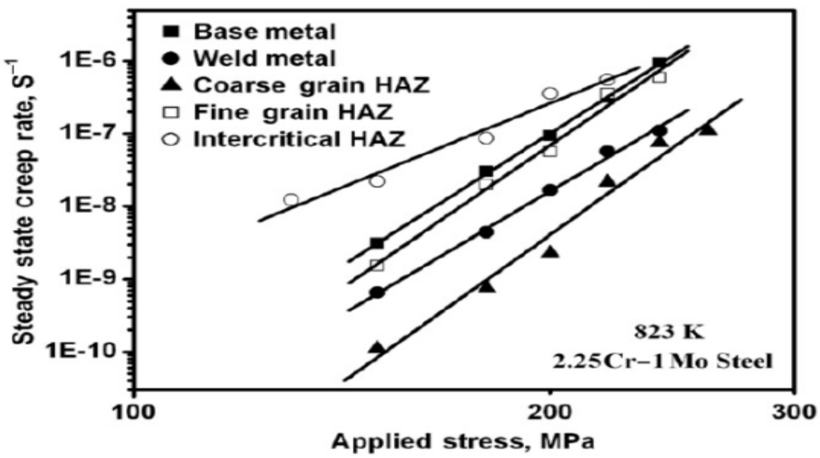


Fig.2: Variation in steady state creep rate of individual constituents of weld joint with stress.

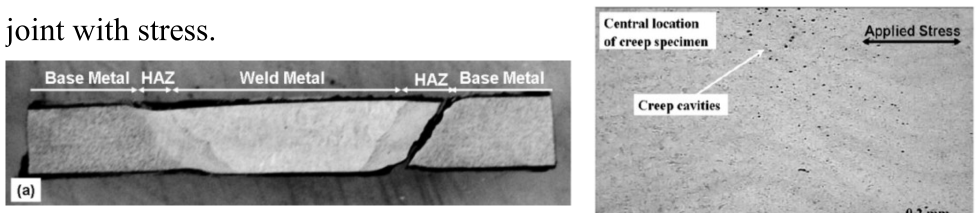


Fig. 3: (a) Failure of weld joint in the intercritical region of HAZ (b) Creep cavitation in the central region of intercritical HAZ.

Distribution of the saturated maximum principal stress and normalized von-Mises stress along the centerline and surface of the weld joint are shown in **Figs. 4(a)** and **4(b)**, respectively. The stresses were found to vary significantly along the length as well as across the diameter of the weld joint. The near-center region was expected to deform in plane strain condition because of the constraint effect by the surrounding material, whereas the near-surface region deformed under plane stress conditions because of the relatively unconstrained free surface. Higher von-Mises stress and principal stress in the central region of the intercritical HAZ (**Fig. 4**) would facilitate a higher creep cavity nucleation and growth respectively resulting in higher creep cavitation, as observed experimentally. The triaxiality factor, a measure of the extent of triaxiality in the weld joint, was found to be higher in the central region of intercritical HAZ compared to that of surface and other regions of the weld joint. The relatively higher value of triaxiality would raise the possibility of more creep cavitation at the centre than the near-surface region (**Fig. 5**).

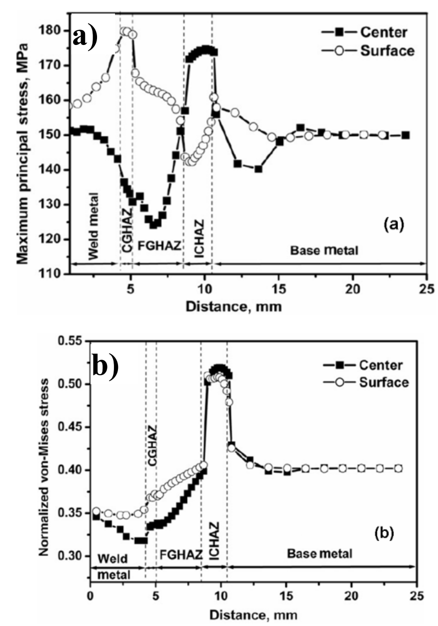


Fig. 4: Variations of (a) maximum principal and (b) von-Mises stress across the weld joint after attaining the stationary state.

An arrow can be shot only by pulling it backward. So when life is dragging you back with difficulties, it means that it's going to launch you into something great.

So just take a deep breath and keep aiming.

Component having sharp change in geometry

Sudden change in geometry of the component has been simulated by the introducing notches of different sharpnesses in cylindrical specimens. The presence of a notch in the specimen increased the creep rupture life and the strengthening effect was found to saturate at relatively sharper notches, **Fig. 6**. Plasticity induced intragranular ductile failure with dimple appearance was observed for relatively shallow notches (low notch acuity ratio), whereas creep cavitation induced intergranular brittle failure was observed for relatively sharper notches (high notch acuity ratio) was observed. The creep damage was found to be initiated at the centre of notch plane for shallow notches, **Fig. 7(a)** and at the notch root for sharper notches (**Figs. 7(b)** and **7(c)**). In order to corroborate the fracture behaviour under multiaxial state of stress, FE analysis of creep damage was carried out using ABAQUS finite element solver incorporating the creep strain rate ($\dot{\varepsilon}_{cij}$) equation (**Eq. 1**) and creep damage rate ($\dot{\omega}$) law (**Eq. 2**) proposed by Kachanov **[5]** in VUMAT subroutine.

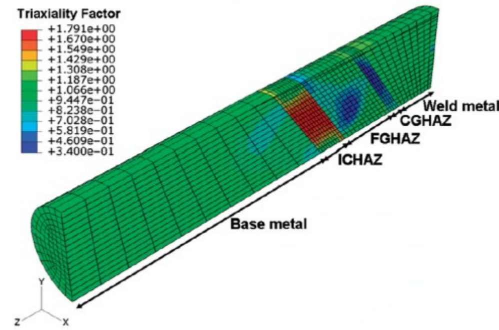


Fig. 5: Distribution of triaxiality factor across the weld joint.

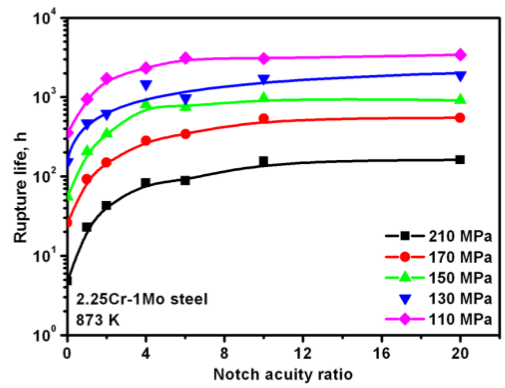


Fig. 6: Variation of creep rupture life of notched specimens of 2.25Cr-1Mo steel.

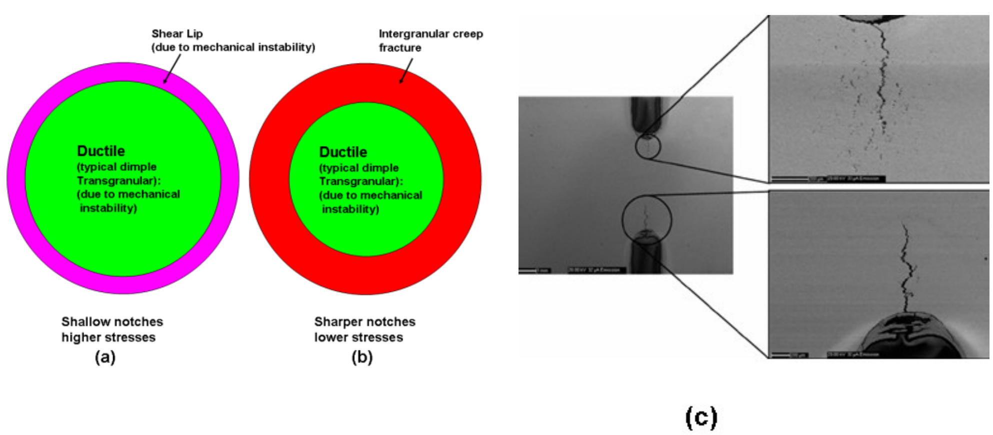


Fig. 7: Schematic of dependence of notch root radius on fracture appearance.

$$\dot{\varepsilon}_{c\,ij} = \frac{3}{2} A\left(\frac{\sigma_{vm}}{1-\omega}\right)^{n-1} \frac{\sigma_{ij}^{'}}{1-\omega} \qquad (1)$$

$$\dot{\omega} = \frac{B\sigma_{rep}^{\chi}}{(1-\omega)^{\phi}} \qquad (2)$$

where A, n, B, χ, ϕ are material constants, σ_{ij}' is the deviatoric stress, σ_{vm} is the von-Mises stress, σ_{rep} is the representative stress, $\dot{\omega}$ is damage rate and ω is the damage parameter varying from 0 to 1 indicating virgin material and fully damaged material respectively. The σ_{rep} (representative stress) is defined by

$$\sigma_{rep} = \sigma_1^{\gamma/m} \sigma_{vm}^{(m-\gamma)/m} \qquad (3)$$

where m and γ are material constants and σ_I and σ_{vm} are the maximum principal stress and von-Mises stress respectively. The multiaxial stress rupture behaviour is determined by a combination of the von-Mises and the maximum principal stresses. The representative stress reduces to the maximum principal stress for $\gamma = m$ and to the von-Mises stress for $\gamma = 0$.

The damage evolutions in the notched specimens having shallow notch (notch acuity ratio of 1) with creep exposure is shown in Fig. 8(a). The damage was found to be initiated at the notch root due to the higher stresses that developed as a result of stress concentration. However, the stress relaxation took place which resulted in shifting of damage towards the centre of notch, Fig. 8(a). At the later stage of creep deformation, when the damage increases, further redistribution of stress takes place for maintaining the strain compatibility with the consequence of more damage at centre of the notch due to the dependence of damage rate on current damage. The shedding of load takes place from centre of the specimen to the less damaged notch root. Finally, the critical damage (ω = 0.5) reaches at the centre of notch resulting in cup and cone type of fracture as observed experimentally, Fig. 8(b). Quite different nature of accumulation of creep damage behaviour was observed in relatively sharper notches. The damage accumulation with creep exposure for relatively sharper notch (notch root radius = 0.5 mm) of the steel is shown in Fig. 9(a). The stress redistribution across the notch throat plane led to the higher stresses at the notch root region. Unlike in shallow notches, the damage continues to accumulate at faster rate in sharper notches in the notch root region till it reaches a critical value, Fig.9(a), leading to creep cavitation, Fig. 9(b). The crack propagates from the notch root

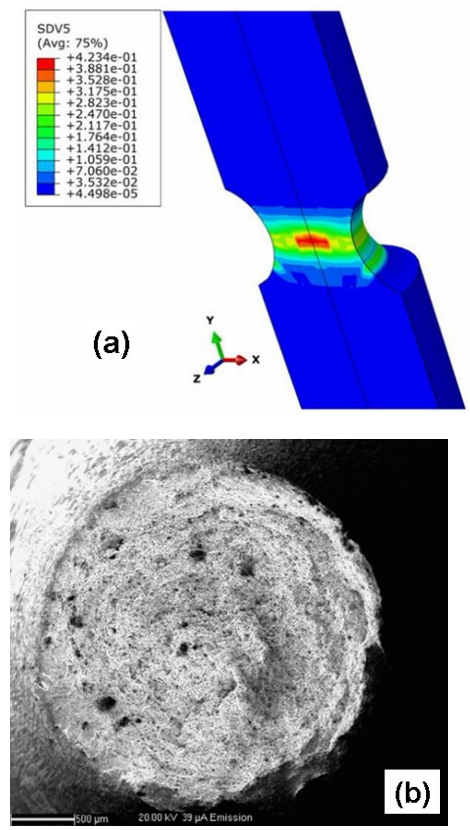


Fig. 8: (a) Estimation of creep damage and (b) fracture appearance in the shallow notches

towards centre resulting in fracture appearance depicted in Fig. 9(c).

Conclusions

Creep damage evolution and fracture in components having multiaxial state of stress resulting from welds and geometrical discontinuities have been assessed based on FE analysis coupled with continuum damage mechanics.

References

[1] Sunil Goyal, K. Laha, K.S. Chandravathi, P. Parameswaran and M.D. Mathew, Finite element analysis of Type IV cracking in 2.25Cr-1Mo steel weld joint based on micro-mechanistic approach, Phil. Mag., 91 (2011) 3128- 3154.

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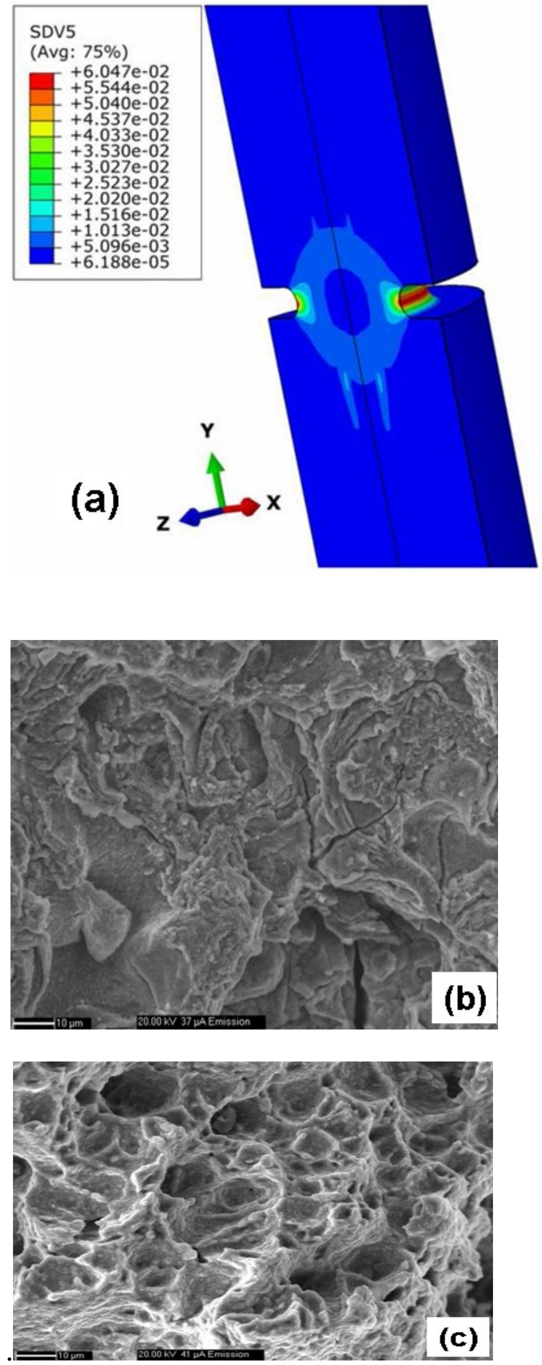

Fig. 9: (a) Estimation of creep damage and (b) fracture appearance at the notch root and (c) centre of notch throat plane in the sharper notches.

Society for Failure Analysis

Application Form

Affix a passport size photograph

Society for Failure Analysis
C/O Centre for Military Airworthiness & certification, RCMA (Materials)
Hyderabad500 058

Phone: 040-24340750; 24348377;
Fax : 040-24341827
E-mail: rdrcma.mat@cemilac.drdo.in

Please √ applicable **member** ☐ **Life Member** ☐

1. **Name in Block Letters**

   First Middle Last

2. **Date of birth**
3. **Father's Name/ Husband's Name**

4 **Present Occupation /Designation and office address:**	**Phone:** **Mobile:** **Fax:** **Email:**

5 **Academic & Professional Qualifications**:

6 **Home address:**	Phone: Mobile: Fax: E-mail

6. **Address for correspondence:** **office** ☐ **Home** ☐

7. **Professional Experience**:
8. **Endorsement by SFA Member**

Name	Membership No.	Signature

9. **Primary Field of Interest: (please mark 1,2,3 in the in order of preference**)

Strategic ☐	**Power** ☐	**Foundry** ☐	**Welding** ☐	**Heavy industry** ☐	**transport** ☐
Design & Failures ☐	**Quality control** ☐	**Petrochemical** ☐	**Consultancy / services** ☐	**Materials and manufacturing**	**Education** ☐

10. **Name of the Chapter you intend to be attached**____
    (Please refer to Chapters' list)
11. **Subscription details:**
    Payment should be made by cheque / DD favoring **"Society for Failure Analysis"**, payable at Hyderabad. Outstation cheques not accepted.

    Amount Rs. Cheque / D.D. No Dated

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Category	Amount Payable		
	Admission Fee (One time)	Yearly Subscription	Total on joining
Member	---	Rs.200 (annual)	Rs.200/-
Life Member	---	Rs.1000	Rs.1000/-

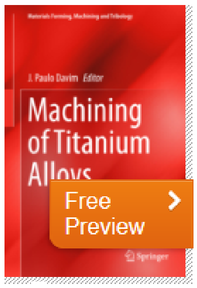
12 **Declaration by the applicant**

If elected, I agree to accept to pay the prescribed yearly subscription, to abide by the Articles of Association of the Society and to promote its aims and objects.

Signature of the Applicant

13.	**Office Use Only**				
	Membership No.		Date of Enrolment		Chapter	
	Amount Paid (Rs)		Receipt No. / Date			

Books/ new journals/ news about our members



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Series: » Materials Forming, Machining and Tribology

Davim, J. Paulo (Ed.)

2014, VII, 150 p. 102 illus., 21 illus. in color.

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eBook	**83,29 €**
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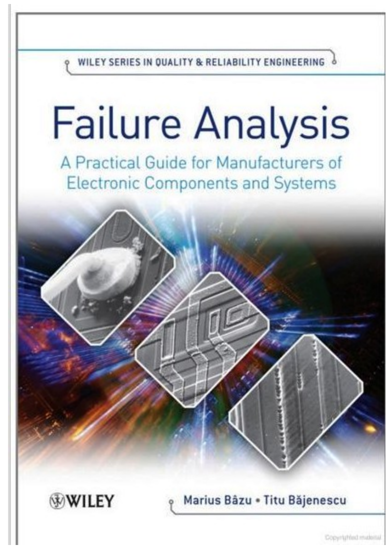


Sri P.Jayapal , Vice president, SFA takes charge as Chief executive, CEMILAC

Thursday, April 10, 2014

Bangalore: Shri P. Jayapal has been appointed as the new Chief Executive of Center for Military Airworthiness and Certification (CEMILAC) an organization of DRDO, Ministry of Defence, Bangalore. He assumed charge from Dr. K. Tamil Mani, Distinguished Scientist and Director General (Aeronautics) who was holding the additional charge as CE, CEMILAC subsequent to his elevation as DG (Aeronautics).

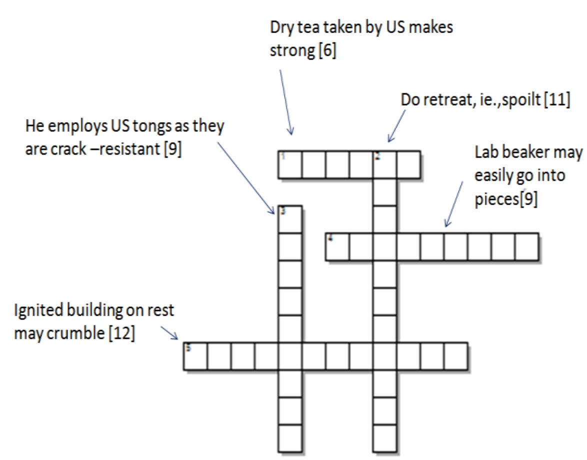
Shri P. Jayapal is an alumnus of MIT, Anna University from where he obtained his B.Tech degree in Aeronautical Engineering (1983) and his Masters. He joined Defence Research and Development Organization (DRDO), in 1985 in Regional Centre for Military Airworthiness, RCMA, (Nasik).

In 1990, he joined RCMA (Helicopters), Bangalore and later took over as Regional Director, RCMA (Helicopters) in the year 2005.He was elevated to the position of Group Director (Aircraft) in CEMILAC, Bangalore.

As Chief Executive (Airworthiness) he is overseeing the Airworthiness Clearance Certification activities on abinitio projects like LCA, ALH, HJT-36, UAVs and several major upgrade programmes of the Defence Services. As the head of the organization, he is responsible for monitoring all Airworthiness activities of 14 RCMAs situated all over India and assuring flight safety of all Military Airborne Vehicles / Stores of the nation.

He is the recipient of Lab Level Technology Group Award 2007 and DRDO AGNI Award for Excellence in Self-Reliance for the year 2001 and 2008.

Cross word on failure analysis terminologies



Events in the pipeline

NAFEMS World Congress 2015
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the 2nd International Conference on Simulation Process & Data Management

Submit your Abstract Today

21-24 June 2015 | San Diego | California | USA

www.nafems.org/congress

Answer to Cross word

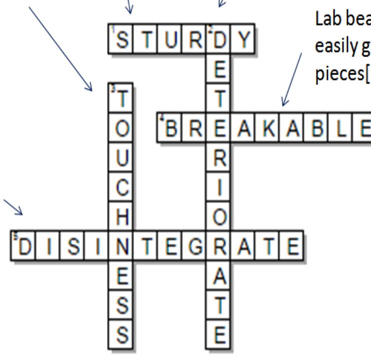
Dry tea taken by US makes strong [6]

Do retreat, ie.,spoilt [11]

He employs US tongs as they are crack –resistant [9]

Lab beaker may easily go into pieces[9]

Ignited building on rest may crumble [12]



Forthcoming SFA events* for the current year (2014-15)

1) **SFA and IIM jointly organizing Mini Symposium on failure analysis at IIM-ATM to be held at College of Engg., Pune, Nov, 12-15, 2014.**
2) **Workshop on Service Performance of engineering materials, IIT Rourkee, Jan 2015.**

***The exact dates would be added as and when the programs get finalized;**

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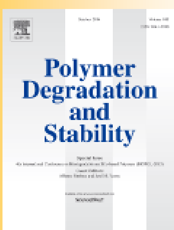

Polymer degradation:
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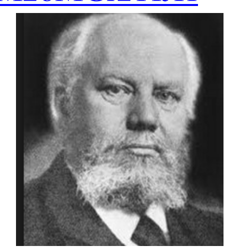

ADOLPH MARTENS
1850-1914
A German testing engineer; a pioneer in the application of the microscope to the study of steel.

For Private circulation only

To

From
Society for Failure Analysis (SFA)
C/O Centre for Military Airworthiness &
Certification, RCMA (Materials)
Kanchanbagh
Hyderabad-500058